November 2016
February 2017
June 11, 2020

C-147 Registration Package for Dagger Containment and Recycling Facility
Section 30 T21S R33E, Lea County

View to east showing from top of eastern berm of containment. Low dunes stabilized by vegetation with no indication of bedrock outcrops

Prepared for:
AMTEX Energy, Inc.
Midland, Texas

Change in Operator to
Advance Energy Partners Hat Mesa, LLC
Houston, TX
September 2017

Prepared by:

R.T. Hicks Consultants, Ltd.
901 Rio Grande NW
F-142
Albuquerque, New Mexico

R. T. HICKS CONSULTANTS, LTD.

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Durango, Co ▲ Carlsbad, NM ▲ Hobbs, NM

June 11, 2020

Ms. Susan Lucas Kamat
NMOCD
1220 S. St. Francis Blvd
Santa Fe, NM
Via Email Susan.LucasKamat@state.nm.us

RE: Advance Energy Partners Dagger Containment and Recycling Facility (formerly Amtex) at Unit Letter H, Section 30, T21S, R33E, Lea County

Dear Ms. Lucas Kamat:

On behalf of Advance Energy Partners Hat Mesa, LLC (AEP), Hicks Consultants submits the attached updated permit/registration application for one In Ground Containment and Recycling Facility, containing requested supplemental information.

This package includes an

- Updated C-147 with current operator information and affirmation signature
- Avian Protection Variance
- Fencing Variance
- Alternative Testing Variance
- 40 Mil HDPE as Alternative Secondary Liner Variance (Including Engineer Stamped Technical Memorandum)
- Stamped letters from Ron Frobel PE discussing the applicability of engineering variances to a wide variety of site conditions for in-ground containments; CV included.

These documents are included immediately following this Transmittal Letter. The former submission is included in its entirety. There are no other changes in C-147 information including Siting Criteria and Facility Checklist information.

As also discussed, within the next several weeks, AEP will submit monthly water usage reports as a part of operational compliance. It is understood that the approval of this facility is temporary based on delivery of this information.

In compliance with 19.15.34.10 of the Rule, with this submission AEP will transmit a copy of this application to the State Land Office who is the owner of the surface upon which the containments is constructed.

If you have any questions or concerns regarding this registration or the attached C-147, please contact me. As always, we appreciate your work ethic and attention to detail.

Sincerely,
R.T. Hicks Consultants

Randall T. Hicks PG
Principal

CC: Advance Energy Partners Hat Mesa, LLC
Ryan Mann SLO

District I
1625 N. French Dr., Hobbs, NM 88240
District II
811 S. First St., Artesia, NM 88210
District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Form C-147
Revised March 31, 2015

Recycling Facility and/or Recycling Containment

Type of Facility: ☒ Recycling Facility ☒ Recycling Containment*****

Type of action: ☒ Permit ☒ Registration
☐ Modification ☐ Extension
☐ Closure ☐ Other (explain) _____

*** At the time C-147 is submitted to the division for a Recycling Containment, a copy shall be provided to the surface owner.**

Be advised that approval of this request does not relieve the operator of liability should operations result in pollution of surface water, ground water or the environment. Nor does approval relieve the operator of its responsibility to comply with any other applicable governmental authority's rules, regulations or ordinances.

1.

Operator: Advance Energy Partners Hat Mesa, LLC. (For multiple operators attach page with information) OGRID #: 372417

Address: 11490 Westheimer Rd. STE 950, Houston TX 77077

Facility or well name (include API# if associated with a well): Dagger Containment and Recycling Facility adjacent to API #30-025-43302

OCD Permit Number: 1RF-459 (For new facilities the permit number will be assigned by the district office)

U/L or Qtr/Qtr H Section 30 Township 21S Range 33E County: Lea

Surface Owner: ☐ Federal ☒ State ☐ Private ☐ Tribal Trust or Indian Allotment

2.

☒ **Recycling Facility:**

Location of recycling facility (if applicable): Latitude 32.448578 Longitude -103.604951 NAD: ☒1927 ☐ 1983 Approx. center Google Earth

Proposed Use: ☒ Drilling* ☒ Completion* ☒ Production* ☒ Plugging *

The re-use of produced water may NOT be used until fresh water zones are cased and cemented

☐ Other, ***requires permit for other uses. Describe use, process, testing, volume of produced water and ensure there will be no adverse impact on groundwater or surface water.***

☒ Fluid Storage

☐ Above ground tanks ☒ Recycling containment ☐ Activity permitted under 19.15.17 NMAC explain type_____

☐ Activity permitted under 19.15.36 NMAC explain type:_____ ☐ Other explain _____

☐ For multiple or additional recycling containments, attach design and location information of each containment

☐ **Closure Report (required within 60 days of closure completion):** ☐ Recycling Facility Closure Completion Date:_____

3.

☒ **Recycling Containment: AMTEX Dagger Containment**

☐ Annual Extension after initial 5 years (attach summary of monthly leak detection inspections for previous year)

Center of Recycling Containment (if applicable): Latitude 32.448578 Longitude -103.604951 NAD: ☒1927 ☐ 1983

☐ For multiple or additional recycling containments, attach design and location information of each containment

☒ Lined ☒ Liner type: Thickness 60 mil HDPE Primary and 40-mil HDPE Secondary ☐ LLDPE ☒ HDPE ☐ PVC ☐ Other _____

☐ String-Reinforced

Liner Seams: ☒ Welded ☒ Factory ☒ Other Field Welds Volume: 337,000 bbl (249,000 bbls below 3-foot Freeboard)

Dimensions: L 480 x W 372 x D 17.7 (at sump)

☐ Recycling Containment Closure Completion Date:_____

4.

Bonding:

☒ Covered under bonding pursuant to 19.15.8 NMAC per 19.15.34.15(A)(2) NMAC **(These containments are limited to only the wells owned or operated by the owners of the containment.)**

☐ Bonding in accordance with 19.15.34.15(A)(1). Amount of bond $_____ **(work on these facilities cannot commence until bonding amounts are approved)**

☐ Attach closure cost estimate and documentation on how the closure cost was calculated.

5.

Fencing:

☐ Four foot height, four strands of barbed wire evenly spaced between one and four feet

☒ Alternate. Please see registration for secondary fence specifications. As an alternative to a 4-foot barbed-wire fence 8-foot meshed-wire fence, topped with barbed wire was utilized to better deter unauthorized wildlife and human access.

6.

Signs:

☒ 12"x 24", 2" lettering, providing Operator's name, site location, and emergency telephone numbers

☐ Signed in compliance with 19.15.16.8 NMAC

7.

Variances:

Justifications and/or demonstrations that the proposed variance will afford reasonable protection against contamination of fresh water, human health, and the environment.

Check the below box only if a variance is requested:

☒ Variance(s): Requests must be submitted to the appropriate division district for consideration of approval. If a Variance is requested, include the variance information on a separate page and attach it to the C-147 as part of the application.

If a Variance is requested, it must be approved prior to implementation.

8.

Siting Criteria for Recycling Containment

Instructions: The applicant must provide attachments that demonstrate compliance for each siting criteria below as part of the application. Potential examples of the siting attachment source material are provided below under each criteria.

General siting

Ground water is less than 50 feet below the bottom of the Recycling Containment. NM Office of the State Engineer - iWATERS database search; USGS; Data obtained from nearby wells. (Figures 1 & 2)	☐ Yes ☒ No ☐ NA
Within incorporated municipal boundaries or within a defined municipal fresh water well field covered under a municipal ordinance adopted pursuant to NMSA 1978, Section 3-27-3, as amended. (Figure 5) - Written confirmation or verification from the municipality; written approval obtained from the municipality	☐ Yes ☒ No ☐ NA
Within the area overlying a subsurface mine. (Figure 7) - Written confirmation or verification or map from the NM EMNRD-Mining and Minerals Division	☐ Yes ☒ No
Within an unstable area. (Figure 8) - Engineering measures incorporated into the design; NM Bureau of Geology & Mineral Resources; USGS; NM Geological Society; topographic map	☐ Yes ☒ No
Within a 100-year floodplain. FEMA map. (Figure 9)	☐ Yes ☒ No
Within 300 feet of a continuously flowing watercourse, or 200 feet of any other significant watercourse, or lakebed, sinkhole, or playa lake (measured from the ordinary high-water mark). (Figure 3) - Topographic map; visual inspection (certification) of the proposed site	☐ Yes ☒ No
Within 1000 feet from a permanent residence, school, hospital, institution, or church in existence at the time of initial application. - Visual inspection (certification) of the proposed site; aerial photo; satellite image (Figure 4)	☐ Yes ☒ No
Within 500 horizontal feet of a spring or a fresh water well used for domestic or stock watering purposes, in existence at the time of initial application. (Figures 1, 2, & 3) - NM Office of the State Engineer - iWATERS database search; visual inspection (certification) of the proposed site	☐ Yes ☒ No
Within 500 feet of a wetland. (Figure 6) - US Fish and Wildlife Wetland Identification map; topographic map; visual inspection (certification) of the proposed site	☐ Yes ☒ No

9.
Recycling Facility and/or Containment Checklist:
Instructions: Each of the following items must be attached to the application. Indicate, by a check mark in the box, that the documents are attached.

- ☒ Design Plan - based upon the appropriate requirements (Appendix B).
- ☒ Operating and Maintenance Plan - based upon the appropriate requirements (Appendix C).
- ☒ Closure Plan - based upon the appropriate requirements (Appendix D).
- ☒ Site Specific Groundwater Data - (pages immediately following application)
- ☒ Siting Criteria Compliance Demonstrations – (pages immediately following application)
- ☒ **Certify that notice of the C-147 (only) has been sent to the surface owner(s)**

10.
Operator Application Certification:

I hereby certify that the information and attachments submitted with this application are true, accurate and complete to the best of my knowledge and belief.

Name (Print): David Harwell Title: Vice President Engineering/Operations

Signature: David Harwell Date: June 11,2020

e-mail address: DHarwell@advanceenergypartners.com Telephone: 832-672-4604

11.
OCD Representative Signature: Victoria Venegas **Approval Date:** 12/17/2020

Title: Engineering Tech. III **OCD Permit Number:** 1RF-459

☒ OCD Conditions

☒ Additional OCD Conditions on Attachment

VARIANCE TO INSTALL BIRD-X MEGA BLASTER PRO AS PRIMARY HAZING PROGRAM FOR AVIAN SPECIES

AVIAN PROTECTION PROGRAM FOR PRODUCED WATER CONTAINMENTS

19.15.34.12 E – Netting

Statement Explaining Why the Applicant Seeks a Variance

The prescriptive mandates of the Rule that are the subject of this variance request are the following subsections NMAC 19.15.34.12 E

E. Netting. The operator shall ensure that a recycling containment is screened, netted or otherwise protective of wildlife, including migratory birds. The operator shall on a monthly basis inspect for and, within 30 days of discovery, report the discovery of dead migratory birds or other wildlife to the appropriate wildlife agency and to the division district office in order to facilitate assessment and implementation of measures to prevent incidents from reoccurring.

The operator proposes use of avian hazing protocol in lieu of netting for in-ground produced water storage containments. The reason for requesting these variances has been two-fold:

1. The capital and O&M cost of the proposed hazing system is significantly less than netting, especially for very large (e.g. > 100,000 bbls total capacity) containments. Increased cost can cause operators to employ fresh water in lieu of recycling produced water where storage is essential.
2. Placement of support structures within large containments can, if the structures fall or fail, create a leak in liner system.

The operator will install and use the Bird-X Mega Blaster Pro as a primary hazing program for avian species. In addition to this sonic device, staff will routinely inspect the containment, at least monthly, for the presence of avian species and, if detected, will use a blank cartridge or shell in a handgun, starter pistol or shotgun as additional hazing. Decoys of birds of prey are placed on the game fence and other roosts around the open water to provide additional hazing.

Demonstration That the Variance Will Provide Equal or Better Protection of Fresh Water, Public Health and the Environment

This effective alternative to netting will provide an economic incentive for operators to store and utilize produced water recycling in lieu of fresh water. This system may also reduce the risk of liner damage related to netting support structures within the containments.

FENCING VARIANCE REQUEST FOR RECYCLING CONTAINMENTS

FENCING VARIANCE FOR PRODUCED WATER CONTAINMENTS

9.15.34.12 D Fencing

Statement Explaining Why the Applicant Seeks a Variance

The prescriptive mandates of the Rule that are the subject of this variance request are the following subsections of NMAC 9.15.34.12 D

> **D.** Fencing.
>
> **(1)** The operator shall fence or enclose a recycling containment in a manner that deters unauthorized wildlife and human access and shall maintain the fences in good repair. The operator shall ensure that all gates associated with the fence are closed and locked when responsible personnel are not onsite.
>
> **(2)** Recycling containments shall be fenced with a four-foot fence that has at least four strands of barbed wire evenly spaced in the interval between one foot and four feet above ground level.

The applicant proposes use of game fence, chain link fence or other fence to deter wildlife access as prescribed by design engineer.

Because feral pigs, javelina and deer are present in the Permian Basin of Chaves, Eddy and Lea Counties, a chain link or game fence is required in order to comply with Section 19.15.34.12 D.1 of the Rule. The specification for fencing provided in 19.15.34.12 D.2 contradicts D.1 because pigs will move beneath the lower strand of a 4-strand, 4-foot high barbed wire fence and deer will jump over. Thus, compliance with D.2 results in a violation of D.1. Compliance with D.1 is the critical component of the Rule.

Demonstration That the Variance Will Provide Equal or Better Protection of Fresh Water, Public Health and the Environment

The operator will provide for a fence to enclose the recycling containment in a manner that deters unauthorized wildlife and human access better than what is defined in the rule. The operator will employ a game fence, chain link or other fence as prescribed by the design engineer rather than a four-foot fence with interval strands, in order to better deter wildlife from passing under, through or over that barrier.

Variances for Alternative Testing Methods

Request for OCD Approval of Alternative Test Methods to Analyze Concentrations of TPH and Chloride

The prescriptive mandates of the Rule that are the subject of this request are the following subsections of NMAC 19.15.17.13 [emphasis added], 19.15.34.14 and 19.15.29. 12 D

> **19.15.17.13 CLOSURE AND SITE RECLAMATION REQUIREMENTS:**
> **D.(5)** The operator shall collect, at a minimum, a five point composite of the contents of the temporary pit or drying pad/tank associated with a closed-loop system to demonstrate that, after the waste is solidified or stabilized with soil or other non-waste material at a ratio of no more than 3:1 soil or other non-waste material to waste, the concentration of any contaminant in the stabilized waste is not higher than the parameters listed in Table II of 19.15.17.13 NMAC.

The referenced Table II, which is reproduced in part below, notes the Method with asterisk signifying: "*Or other test methods approved by the division".

Table II
Closure Criteria for Burial Trenches and Waste Left in Place in Temporary Pits

Depth below bottom of pit to groundwater less than 10,000 mg/l TDS	Constituent	Method*	Limit**
25-50 feet	Chloride	EPA Method 300.0	20,000 mg/kg
	TPH	EPA SW-846 Method 418.1	100 mg/kg

> **19.15.34.14 CLOSURE AND SITE RECLAMATION REQUIREMENTS FOR RECYCLING CONTAINMENTS:**
> **C.** The operator shall test the soils beneath the containment for contamination with a five-point composite sample which includes stained or wet soils, if any, and that sample shall be analyzed for the constituents listed in Table I below.
> **(1)** If any contaminant concentration is higher than the parameters listed in Table I, the division may require additional delineation upon review of the results and the operator must receive approval before proceeding with closure.

The referenced Table I, which is reproduced in part below, notes the Method with asterisk signifying: "*Or other test methods approved by the division".

Table I
Closure Criteria for Recycling Containments

Depth below bottom of containment to groundwater less than 10,000 mg/l TDS	Constituent	Method*	Limit**
51 feet - 100 feet	Chloride	EPA 300.0	10,000 mg/kg
	TPH (GRO+DRO+MRO)	EPA SW-846 Method 8015M	2,500 mg/kg

After sampling solids of more than 50 drilling pits in the Permian Basin, we have observed and reported to OCD on numerous occasions significant problems with non-petroleum drilling additives (e.g. starch) interfering with the laboratory method 418.1. It is not surprising that in many instances we found no correlation between the laboratory results using 418.1 and the results using Method 8015.

We request approval of Method 8015 (GRO + DRO + MRO) for Method 418.1.

> **19.15.29.12 D. CLOSURE REQUIREMENTS.** The responsible party must take the following action for any major or minor release containing liquids.
> **(1)** The responsible party must test the remediated areas for contamination with representative five-point composite samples from the walls and base, and individual grab samples from any wet or discolored areas. The samples must be analyzed for the constituents listed in Table I of 19.15.29.12 NMAC or constituents from other applicable remediation standards.

The referenced Table I, is reproduced in part below.

Table I
Closure Criteria for Soils Impacted by a Release

Minimum depth below any point within the horizontal boundary of the release to ground water less than 10,000 mg/l TDS	Constituent	Method*	Limit**
≤ 50 feet	Chloride***	EPA 300.0 or SM4500 Cl B	600 mg/kg
	TPH (GRO+DRO+MRO)	EPA SW-846 Method 8015M	100 mg/kg
	BTEX	EPA SW-846 Method 8021B or 8260B	50 mg/kg
	Benzene	EPA SW-846 Method 8021B or 8260B	10 mg/kg

We request approval of EPA 300.0 or SM4500 for the analysis of chloride.

Demonstration that OCD Approval Will Provide Equal or Better Protection of Fresh Water, Public Health and the Environment

The purpose of TPH analyses in the Pit Rule is to measure total petroleum hydrocarbons not all non-polar compounds, such as starch or cellulose that can interfere with Method 418.1. While Method 418.1 may provide some useful data for transportation of crude oil or condensate spills to disposal, the addition of non-polar organic materials in drilling fluids, especially for horizontal wells, renders Method 418.1 highly problematic to determine compliance with the Rule. Using Method 8015 for TPH (GRO+DRO+MRO) provides a better measurement of what we believe the Commission intended operators to measure.

In hearings before the Oil Conservation Commission technical arguments were presented regarding the use of SM4500 in lieu of EPA 300.00 for chloride analysis for Rule 29. The Division and the Commission agreed that these two methods provide equal or better protection of fresh water, public health and the environment.

40-MIL HDPE as Alternative Secondary Liner for In Ground Containment

STATEMENT EXPLAINING WHY THE APPLICANT SEEKS A VARIANCE FOR 40 MIL HDPE LINER AS AN ALTERNATIVE SECONDARY LINER FOR IN GROUND RECYCLING CONTAINMENT

Statement Explaining Why the Applicant Seeks Variance

The prescriptive mandates of the Rule that are the subject of this variance request are the following subsections of 19.15.34.12

> **NMAC 19.15.34.12 A.** DESIGN AND CONSTRUCTION SPECIFICATIONS FOR A RECYCLING CONTAINMENT
> **(4)** All primary (upper) liners in a recycling containment shall be geomembrane liners composed of an impervious, synthetic material that is resistant to ultraviolet light, petroleum hydrocarbons, salts and acidic and alkaline solutions. All primary liners shall be 30-mil flexible PVC, 45-mil LLDPE string reinforced or 60-mil HDPE liners. *Secondary liners shall be 30-mil LLDPE string reinforced or equivalent with a hydraulic conductivity no greater than 1 x 10-9 cm/sec.* Liner compatibility shall meet or exceed the EPA SW-846 method 9090A or subsequent relevant publications.

The applicant is requesting a variance for the use of proposed 40-mil HDPE as a secondary liner in place of the 30-mil LLDPE string reinforced liner recommended in Rule 34.

The 40 mil HDPE liner is more available, more cost effective and is easier to field seam than the recommended 30 mil LLDPE string reinforced liner material, while providing an equivalent performance and protection in the setting of appropriate site preparation, a primary liner of 60 mil HDPE material and appropriate drainage layers.

Demonstration That the Variance Will Provide Equal or Better Protection of Fresh Water, Public Health and the Environment

The following technical documents provide supportive data to demonstrate equal or better protection of fresh water, public health and the environment by providing the requisite containment and protection. Technical comparison of the proposed material is compared to what is advised through Rule 34 is discussed. A second memorandum provides clarification that the engineering requirements for site preparation, which ensures functionality of the liner system, is crosscutting to varied locations within the Permian Basin. Siting criteria and stamped plans from design engineer confirm applicability of this liner system to this specific site.

R.K. FROBEL & ASSOCIATES
Consulting Engineers

Technical Memorandum: 40-mil HDPE as Alternative Secondary Liner System for In Ground Recycling Containment Facilities

NMAC 19.15.34.12 A

I have investigated the suitability of application for 40 mil HDPE geomembrane as an equivalent secondary liner to 30 mil scrim reinforced LLDPE (LLDPEr) in the application for In Ground Recycling Containment facilities. *In summary, it is my professional opinion that the specified 40 mil HDPE geomembrane will provide a secondary liner system that is equal to or better than 30 mil scrim reinforced LLDPEr and will provide the requisite protection of fresh water, public health and the environment for many years when engineering design provides requisite site/soil/slope preparation and when used in concert with requisite primary liners and drainage layers.*

It is understood that the lining system under discussion is composed of a 60 mil HDPE Primary liner, geonet drainage layer and a 40 mil HDPE Secondary liner. *In consideration of the secondary lining system application, size of impoundment and depth, design details as well as the chemical nature of typical processed water, it is my professional opinion that the 40 mil HDPE geomembrane will provide the requisite barrier against processed water loss and will function effectively as a secondary liner.*

The following are discussion points that hopefully will exhibit the equivalency of a 40 mil HDPE secondary liner to that of a 30 mil LLDPEr.

The nature and formulation of the 40 mil HDPE resin is the same as the Primary 60 mil HDPE. The major difference is that the 40 mil HDPE is lower in thickness (more flexible and less puncture resistant). However, in covered conditions, HDPE will resist aging and degradation and remain intact for many decades. In fact, a secondary liner of 40 mil HDPE will outlast an exposed 60 mil HDPE liner. According to the Geosynthetic Research Institute (GRI) study on lifetime prediction (GRI Paper No. 6), the half life of HDPE (GRI GM 13) exposed is > 36 years and the half-life of HDPE covered or buried is greater than 100 years. It is understood that in order to ensure compliance of materials, the primary 60 mil HDPE to be used must meet or exceed GRI GM 13 Standards. Likewise, the secondary liner that is not exposed to the same environmental and chemical conditions must meet or exceed GRI GM 13 for non-reinforced HDPE. Adhering to the minimum requirements of the GRI Specifications, 40 mil HDPE when used as a secondary liner will be equally as protective as the primary 60 mil HDPE liner (reference: www.geosynthetic-institute.org/grispecs) and equally as protective as a 30 mil scrim reinforced LLDPEr liner.

Durability of Geomembranes is directly affected by exposure conditions. Buried or covered geomembranes are not affected by the same degradation mechanisms (UV, Ozone, Chemical, Stress, Temperature, etc) as are fully exposed geomembranes. In this regard, the secondary liner material and thickness can be much less robust than the fully exposed primary liner which in this case is 60 mil HDPE. This is also the case for

landfill lining systems where the secondary geomembrane in a bottom landfill cell may be 40 mil HDPE.

Thermal Fusion Seaming Requirements. Thermal seaming and QC seam test requirements for geomembranes are product specific and usually prescribed by the sheet manufacturer. Dual wedge thermal fusion welding is commonly used on HDPE and QC testing by air channel (ASTM D 5820) is fully acceptable and recognized as an industry standard. In this regard, there should be no exception requirement for seaming and QC testing as both the Primary and Secondary geomembranes are HDPE. This is fully covered in comprehensive specifications for both the Primary and Secondary geomembranes (Reference: www.ASTM.org/Standards).

Potential for Leakage through the Primary and Secondary Liners. Leakage through geomembrane liners is directly a function of the height of liquid head above any hole or imperfection. The geonet drainage media provides immediate drainage to a low point or sump and thus no hydrostatic head or driving gradient is available to push leakage water through a hole in the secondary liner. In this regard, secondary geomembrane materials can be (and usually are) much less in thickness and also polymer type. Hydraulic Conductivity through the 40 mil HDPE liner material is extremely low due to the polymer type, structure and crystallinity and exceeds requirements of EPA SW-846 Method 9090A.

Chemical Attack. Chemical attack to polymeric geomembranes is directly a function of type of chemical, temperature and exposure time. Again, the HDPE Primary provides the chemically resistant liner and is QC tested to reduce potential defects or holes. If there is a small hole, the geonet drain takes any leakage water immediately to the sump for extraction. Thus, exposure time is very limited on a secondary liner in addition to low temperature, little volume and virtually no head pressure. In this regard, a chemically resistant geomembrane material such as 40 mil HDPE can be specified for the secondary and is a fully acceptable alternate to 30 mil scrim reinforced LLDPEr.

Mechanical Properties Characteristics. Geomembranes of different polymer and/or structure (i.e., reinforced vs non-reinforced) cannot be readily compared using such characteristics as tensile stress/strain, tear, puncture and polymer requirements. For a 40 mil HDPE liner material to function as a Secondary liner it should meet or exceed the manufacturers minimum requirements for Density, Tensile Properties, Tear, Puncture as well as other properties such as UV resistance. The sheet material must also meet or exceed GRI GM 13 minimum requirements. *In this regard, a 40 mil HDPE will be equivalent to a 30 mil LLDPEr as a secondary liner for the conditions listed below:*

- *The subgrade or compacted earth foundation will be smooth, free of debris or loose rocks, dry, unyielding and will support the lining system.*
- *The side slopes for the containment shall be equal to or less than 3H:1V.*
- *The physical properties and condition of the subgrade or liner foundation*

(i.e., density, slope, moisture) will be inspected and certified by a Professional Engineer that it meets or exceeds specification requirements.

- *Immediately prior to installation, the installation contractor shall inspect and sign off on the subgrade conditions that they meet or exceed the HDPE manufacturer and installers requirements.*
- *A protective geotextile will be placed on the finished and accepted subgrade between subgrade and the 40 mil HDPE Secondary liner.*
- *A 200 mil geonet will be placed over the 40 mil HDPE Secondary Liner.*
- *A 60 mil HDPE Primary liner will be placed over the 200 mil geonet drainage layer.*

If you have any questions on the above technical memorandum or require further information, give me a call at 720-289-0300 or email geosynthetics@msn.com

Sincerely Yours,

R K Frobel

Ronald K. Frobel, MSCE, PE

References:

NMAC 19.15.34.12 A DESIGN AND CONSTRUCTION SPECIFICATIONS FOR A RECYCLING CONTAINMENT

Geosynthetic Research Institute (GRI) Published Standards and Papers 2017
www.geosynthetic-institute.org

ASTM Geosynthetics Standards 2017
www.ASTM.org/Standards

APPLICABILITY OF VARIANCES FOR RECYCLING CONTAINMENTS IN THE PERMIAN BASIN OF NEW MEXICO

R.K. FROBEL & ASSOCIATES
Consulting Engineers

Technical Memorandum: Applicability of Variances for In Ground Lined Containments in the Permian Basin of New Mexico

NMAC 19.15.34.12 A (2)

I have reviewed the historical variances for In Ground Containments in the document titled "Variances for C-147 Registration Packages Permian Basin of New Mexico" (January 2020) and examined the applicable design drawings and permits for the following In Ground containments:

- C-147 Registration Package for Gamma Ridge Recycling Containment and Recycling Facility, Section 14, T24-S, R34-E, Lea County
- C-147 Registration Package for Dagger 2 Recycling Containment and Recycling Facility, Section 30, T21-S, R33-E, Lea County
- C-147 Registration Package for Landes Recycling Containment and Recycling Facility, Section 22, T25-S, T28-E, Eddy County
- C-147 Registration Package for Fez Recycling Containment and Recycling Facility Area (+ 100 acres, Section 8, T25-S, R35-E, Lea County

Locations of the In Ground containments are in Lea and Eddy County and range from west of the Pecos River to slightly west of Jal, NM. All the locations exhibit different surface and subsurface geology, different topography and are of various sizes and volumes. *However, in regard to structural integrity of the base soils that support the geomembrane containment system, the specification requirements are the same.* The foundation soils must be roller compacted smooth and free of loose aggregate over ½ inch. Compaction characteristics must meet or exceed 95% of Standard Proctor Density in accordance with ASTM D 698. This specification requirement is specific and causes the general or earthworks contractor to meet this standard regardless of the site specific geology or topography. Provided that the design drawings and associated specifications call out the minimum requirements for subsoils compaction (i.e., 95% Standard Proctor Density – ASTM D 698), the design engineer or owners representative will carry out soils testing on the foundation materials to provide certainty to the containment owner that the earthworks contractor has met these obligations.

Thus, provided that the contractor meets the minimum specified requirements for foundation soils preparation and density, the location, geology or depth to groundwater will make no difference in regard to geomembrane liner equivalency as demonstrated by the variances presented in this volume and are considered valid for meeting NMOCD Rule 34 requirements for all locations within the Permian Basin of New Mexico.

If you have any questions on the above technical memorandum or require further information, give me a call at 720-289-0300 or email geosynthetics@msn.com

32156 Castle Court / Suite 211 / Evergreen, CO 80439 Ph
303-679-0285 Fx 303-679-8955 geosynthetics@msn.com

Sincerely Yours,

R K Frobel

Ronald K. Frobel, MSCE, PE

References:

NMAC 19.15.34.12 DESIGN AND CONSTRUCTION SPECIFICATIONS FOR A RECYCLING CONTAINMENT

ASTM Standards 2019

RONALD K. FROBEL, MSCE, P.E.

CIVIL ENGINEERING
GEOSYNTHETICS
EXPERT WITNESS
FORENSICS

FIRM: R. K. FROBEL & ASSOCIATES
Consulting Civil / Geosynthetics Engineers

TITLE: Principal and Owner

PROFESSIONAL AFFILIATIONS:

American Society for Testing and Materials (ASTM) -
Founding member of Committee D 35 on Geosynthetics
Chairman ASTM D35 Subcommittee on Geomembranes 1985-2000
ASTM Award of Merit Recipient/ASTM Fellow - 1992
ASTM D18 Soil and Rock - Special Service Award - 2000
Transportation Research Board (TRB) of The National Academies
Appointed Member A2K07 Geosynthetics 2000 - 2003
National Society of Professional Engineers (NSPE) - Member
American Society of Civil Engineers (ASCE) - Member
Colorado Section - ASCE - Member
International Society of Soil Mechanics and Foundation Engineers
(ISSMFE) - Member
International Geosynthetics Society (IGS) - Member
North American Geosynthetics Society (NAGS) - Member
International Standards Organization (ISO) - Member TC 221
Team Leader - USA Delegation Geosynthetics 1985 - 2001
European Committee for Standardization (CEN) - USA Observer
EPA Advisory Committee on Geosynthetics (Past Member)
Association of State Dam Safety Officials (ASDSO) – Member
U. S. Committee on Irrigation and Drainage (USCID) - Member
Technical Advisory Committee - Geosynthetics Magazine
Editorial Board - Geotextiles and Geomembranes Journal
Fabricated Geomembrane Institute (FGI) – Board of Directors
Co-Chairman International Conference on Geomembranes
Co-Chairman ASTM Symposium on Impermeable Barriers
U.S. Naval Reserve Officer (Inactive)
Registered Professional Engineer – Civil (Colorado)
Mine Safety Health Administration (MSHA) Certified

ACADEMIC BACKGROUND:

University of Arizona: M.S. - Civil Engineering - 1975
University of Arizona: B. S. - Civil Engineering – 1969
Wentworth Institute of Technology: A.S. Architecture – 1966

PROFESSIONAL EXPERIENCE:

R. K. Frobel & Associates - Consulting Engineers
Evergreen, Colorado, Principal and Owner, 1988 - Present

Chemie Linz AG and Polyfelt Ges.m.b.H., Linz, Austria
U. S. Technical Manager Geosynthetics, 1985 - 1988

U.S. Bureau of Reclamation, Engineering and Research Center
Denver, Colorado, Technical Specialist in Construction Materials Research and Application, 1978 - 1985

Water Resources Research Center (WRRC), University of Arizona
Tucson, AZ, Associate Research Engineer, 1975 - 1978

Engineering Experiment Station, University of Arizona
Tucson, AZ, Research Assistant, 1974 - 1975

United States Navy, Commissioned Naval Officer, 1970 - 1973

REPRESENTATIVE EXPERIENCE:

R.K. Frobel & Associates: Civil engineering firm specializing in the fields of geotechnical, geo-environmental and geosynthetics. Expertise is provided to full service civil/geotechnical engineering firms, federal agencies, municipalities or owners on a direct contract, joint venture or sub-consultant basis. Responsibilities are primarily devoted to specialized technical assistance in design and application for foreign and domestic projects such as the following:
Forensics investigations into geotechnical and geosynthetics failures; providing expert report and testimony on failure analysis; providing design and peer review on landfill lining and cover system design, mine waste reclamation, water treatment facilities, hydro-technical canal, dam, reservoir and mining projects, floating reservoir covers; oil and gas waste containment; design of manufacturers technical literature and manuals; development and presentation of technical seminars; new product development and testing; MQA/CQA program design and implementation.

Polyfelt Ges.m.b.H., Linz, Austria and Denver Colorado: As U.S. technical manager, primary responsibilities included technical development for the Polyfelt line of geosynthetics for the U.S. civil engineering market as well as worldwide applications.

U.S. Bureau of Reclamation, Denver, Colorado: As technical specialist, responsibilities included directing laboratory research, design and development investigations into geosynthetics and construction materials for use on large western water projects such as dams, canals, power plants and other civil structures. Included were material research, selection and testing, specification writing, large scale pilot test programs, MQA/CQA program design and supervision of site installations. Prime author or contributor to several USBR technical publications incorporating geosynthetics.

University of Arizona, Tucson, Arizona: As research engineer at the Water Resources Research Center, responsibilities included research, design and development of engineering materials and methods for use in construction of major water projects including potable water reservoirs, canals and distribution systems. Prime author or contributor to several WRRC technical publications.

Northeast Utilities, Hartford, Connecticut: As field engineer for construction at Northeast Utilities, responsibilities included liason for many construction projects including additions to power plants, construction of substations, erection of fuel oil pipelines and fuel oil storage tanks. Responsibilities also included detailed review, inspection and reporting on numerous construction projects.

U.S. Navy: Commissioned Naval Officer – Nuclear Program

PUBLICATIONS: Over 85 published articles, papers and books.

CONTACT DETAILS:

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R. K. Frobel & Associates
Consulting Civil/Geosynthetics Engineers
PO Box 2633
Evergreen, Colorado 80439 USA
Phone 720-289-0300
Email: geosynthetics@msn.com

R. T. HICKS CONSULTANTS, LTD.

901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

February 12, 2018

Ms. Olivia Yu and Mr. Bradford Billings
NMOCD District 1
1625 French Drive
Hobbs, NM 88240
Via E-Mail

RE: Advance Energy, Dagger Containment C-147 Registration

Dear Ms. Yu and Mr. Billings:

On behalf of Advance Energy, R.T. Hicks Consultants submits the attached registration update to allow OCD to track conformance of registered containments to specific stipulations of the Rule. This submission includes the following changes to the original submission:

1. An equivalency demonstration written by experts for the proposed 40-mil HDPE secondary liner. Although the language of the Rule is clear[1] and OCD has approved this change as a variance for others, we have re-named the equivalency demonstration a variance.
2. Form C-147 with the registration and permit box checked for the recycling facility and containment.

Appendix A includes the following elements that should be included as "variances" for the purpose of OCD's database:

3. The Avian Protection Plan, which has been approved by OCD for other containments and meets the requirement of the rule
4. A game fence, in lieu of a 4-strand barbed wire fence.

We included the original cover letter as it provides the demonstration that construction and use of the registered containment is consistent with the Rule. If you have any questions or concerns regarding this amendment to the registration or the attached C-147, please contact me. As always, we appreciate your work ethic and attention to detail.

Sincerely,
R.T. Hicks Consultants

Randall Hicks
Principal

Copy: Advance Energy

[1] Secondary liners shall be 30-mil LLDPE string reinforced or equivalent with a hydraulic conductivity no greater than 1 x 10-9 cm/sec

R. T. HICKS CONSULTANTS, LTD.

Artesia ▲ Carlsbad ▲ Durango ▲ Midland
901 Rio Grande Blvd NW ▲ Suite F-142 ▲ Albuquerque, NM 87104 ▲ 505.266.5004 ▲ Fax: 505.266-0745

November 4, 2016

Ms. Kristen Lynch
Dr. Tomas Oberding
NMOCD District 1
1625 French Drive
Hobbs, NM 88240
Via E-Mail

Mr. Ed Martin
New Mexico State Land Office
PO Box 1148
Santa Fe, NM. 87504
Via E-Mail

RE: AMTEX Energy Dagger Recycling Facility and Containment
C-147 Registration Package

Dear Dr. Oberding, Ms. Lynch, and Mr. Martin:

Enclosed is a C-147 registration for a recycling facility and containment located in Section 30 T21S R33E. We believe the attached package meets all of the criteria specified in NMOCD Rules.

We look forward to working with you. For any questions your first point of contact should be Mr. William Savage of AMTEX (432-770-0913). Pettigrew and Associates provided certain engineering services on this project.

Sincerely,
R.T. Hicks Consultants

Randall Hicks
Principal

Copy: AMTEX Energy, Inc.
Pettigrew and Associates

PETTIGREW
& ASSOCIATES PA
ENGINEERING | SURVEYING | TESTING
DEFINING QUALITY SINCE 1965

November 8, 2016

William J. Savage, President
Amtex Energy, Inc.
P.O. Box 3418
Midland, Texas 79702

Subject: Onsite Observations – Dagger Recycling Containment and Recycling Facility
Section 30, Township 21 South, Range 33 East, NMPM, Lea County, NM

Dear Mr. Savage:

On November 3, 2016 a site observation was performed to determine whether the integrity berms, trenches and the access road along the top of the berm were in compliance with New Mexico Administrative Code (NMAC) Title 19, Chapter 15, Part 34. Additionally, an as-built survey provided by Asel Surveying was reviewed to confirm the slopes of the inner and outer levees of the pond were in compliance with the rule. Results of that site visit are outlined below.

1. The liner foundation for the containment was determined to meet the mandates of Rule 34, as
    a. the foundation is a firm an unyielding base.
    b. the foundation is smooth and free of rocks thus a geotextile between the liner and foundation is not required.
    c. there is adequate room for the installation of anchor trenches at the top of the berm and room for inspection and maintenance.

2. The survey confirms the levee of the containment meets the mandates of Rule 34, as
    a. the interior slope of the levee is 2H:1V or better.
    b. the exterior slope of the levee is 3H:1V or better.

3. The containment is adequately protected from run-on of stormwater, as the north and east levees are built up a minimum of 10 feet. The south and west levees follow the natural topography and are trenched approximately 2', diverting any stormwater from running into the pond. Additionally, a small 12" berm is in place between the fence and the diversion trench.

Should you have any questions or concerns regarding this correspondence, please let me know.

Sincerely,

Erica M. Hart, PG
Project Manager

Copy: R.T. Hicks Consultants

Statement Explaining Why the Applicant Seeks ~~Equivalency~~6ÁÒÉÁÎÃÅ

The prescriptive mandates of the Rule that are the subject of this demonstration of equivalency are the following with *emphasis* added:

> **19.15.34.12 A. (4)** All primary (upper) liners in a recycling containment shall be geomembrane liners composed of an impervious, synthetic material that is resistant to ultraviolet light, petroleum hydrocarbons, salts and acidic and alkaline solutions. All primary liners shall be 30-mil flexible PVC, 45-mil LLDPE string reinforced or 60-mil HDPE liners. *Secondary liners shall be 30-mil LLDPE string reinforced or equivalent with a hydraulic conductivity no greater than 1 x 10-9 cm/sec.* Liner compatibility shall meet or exceed the EPA SW-846 method 9090A or subsequent relevant publications.

There are several reasons for requesting OCD agree that 40-mil HDPE for the secondary liner is equivalent to 30 mil LLDPEr. In addition to the reasons described in detail in the attached documents of support are the following logistical reasons:

1. The 30-mil LLDPEr is comprised of two 15-mil panels of LLDPE that are bonded together with the string mesh between. A minor concern is a puncture to the upper panel could allow fluid to wick along the string mesh. Thus, chemicals that may be slightly deleterious to 30-mil LLDPE can attack the 15-mil upper panel from the top surface and from the fluid in the wet mesh. A single layer of HDPE eliminates this potential problem.
2. Non-destructive testing of liner seams is not possible with the string-reinforced LLDPE material.
3. HDPE is more available in the market that LLDPEr

As the installed cost of the 30-mil LLDPEr is essentially the same as the smooth 40-mil HDPE, economics is not a factor in the decision to use HDPE in lieu of LLDPE.

We believe that the attached documents provide the demonstration that 40-mil HDPE is equivalent to 30-mil LLDPEr as a secondary liner. Some attributes of LLDPE superior to HDPE and some are inferior. On balance, we believe that performance is equivalent, based upon our reading of the attached documents and consideration of the logistical concerns listed above.

4898 Tarry Glen Drive
Suwanee, GA 30024

(404) 596-1838

November 3, 2017

Mr. Rod Kirch
Exterme Plastics Plus
15931 Interstate 35 Frontage Road
Moore, TX 78057

Project: Containment Liner

RE: Hydraulic Performance of HDPE

Dear Rod:

40-mil HDPE provides equal or better protection of fresh water, public health and the environment than 30-mil string reinforced LLDPE. Also the 40-mil HDPE liner has a hydraulic conductivity no greater than 1 x 10^{-9} cm/sec. Liner compatibility shall meet or exceed the EPA SW-846 method 9090A or subsequent relevant publications.

Respectfully,

Clay Reichert, P.E.
Technical Manager

R.K. FROBEL & ASSOCIATES
Consulting Engineers

Mr. Randall Hicks, PG
R.T. Hicks Consultants Ltd.
901 Rio Grande NW
Suite F-142
Albuquerque, New Mexico 87104

November 26, 2017

RE: Technical Memorandum
40 mil HDPE Geomembrane Equivalency as a Secondary Liner System
Merchant Recycling Containment and Recycling Facility
Lea County, New Mexico

Dear Mr. Hicks:

At your request, I have investigated the suitability of application for 40 mil HDPE geomembrane as an equivalent secondary liner to 30 mil scrim reinforced LLDPE (LLDPEr) in the Merchant Recycling Facility Containment Design. In summary, it is my professional opinion that the specified 40 mil HDPE geomembrane will provide a secondary liner system that is equal to or better than 30 mil scrim reinforced LLDPEr and will provide the requisite protection of fresh water, public health and the environment for many years and especially for the estimated design and operation life of the Merchant Recycling Containment.

I have reviewed your C-147 Registration Package and the Design documentation provided by R.T Hicks Consultants. It is understood that the lining system is composed of a 60 mil HDPE Primary liner, geonet drainage layer and a 40 mil HDPE Secondary liner. In consideration of the secondary lining system application, size of impoundment and depth, design details as well as the chemical nature of typical processed water, it is my professional opinion that the 40 mil HDPE geomembrane will provide the requisite barrier against processed water loss and will function effectively as a secondary liner. The following are discussion points that hopefully will exhibit the equivalency of a 40 mil HDPE secondary liner to that of a 30 mil LLDPEr.

<u>The nature and formulation of the 40 mil HDPE resin is the same as the Primary 60 mil HDPE</u>. The major difference is that the 40 mil HDPE is lower in thickness (more flexible and less puncture resistant). However, in covered conditions, HDPE will resist aging and degradation and remain intact for many decades. In fact, a secondary liner of 40 mil HDPE will outlast an exposed 60 mil HDPE liner. According to the Geosynthetic Research Institute (GRI) study on lifetime prediction (GRI Paper No. 6), the half life of HDPE (GRI GM 13) exposed is > 36 years and the half-life of HDPE covered or buried is greater than 100 years (the Merchant Recycling Facility life span is expected to be only 10 years maximum). It is understood that in order to ensure compliance of materials, the primary 60 mil HDPE to be used must meet or exceed GRI GM 13 Standards. Likewise, the secondary liner that is not exposed to the same environmental and chemical conditions must meet or exceed GRI GM 13 for non-reinforced HDPE. Adhering to the

minimum requirements of the GRI Specifications, 40 mil HDPE when used as a secondary liner will be equally as protective as the primary 60 mil HDPE liner (reference: www.geosynthetic-institute.org/grispecs) and equally as protective as a 30 mil scrim reinforced LLDPEr liner.

Durability of Geomembranes is directly affected by exposure conditions. Buried or covered geomembranes are not affected by the same degradation mechanisms (UV, Ozone, Chemical, Stress, Temperature, etc) as are fully exposed geomembranes. In this regard, the secondary liner material and thickness can be much less robust than the fully exposed primary liner which in this case is 60 mil HDPE. This is also the case for landfill lining systems where the secondary geomembrane in a bottom landfill cell may be 40 mil HDPE.

Thermal Fusion Seaming Requirements. Thermal seaming and QC seam test requirements for geomembranes are product specific and usually prescribed by the sheet manufacturer. Dual wedge thermal fusion welding is commonly used on HDPE and QC testing by air channel (ASTM D 5820) is fully acceptable and recognized as an industry standard. In this regard, there should be no exception requirement for seaming and QC testing as both the Primary and Secondary geomembranes are HDPE. This is fully covered in comprehensive specifications for both the Primary and Secondary geomembranes (Reference: www.ASTM.org/Standards).

Potential for Leakage through the Primary and Secondary Liners. Leakage through geomembrane liners is directly a function of the height of liquid head above any hole or imperfection. The geonet drainage media provides immediate drainage to a low point or sump and thus no hydrostatic head or driving gradient is available to push leakage water through a hole in the secondary liner. In this regard, secondary geomembrane materials can be (and usually are) much less in thickness and also polymer type. Hydraulic Conductivity through the 40 mil HDPE liner material is extremely low due to the polymer type, structure and crystallinity and exceeds requirements of EPA SW-846 Method 9090A.

Chemical Attack. Chemical attack to polymeric geomembranes is directly a function of type of chemical, temperature and exposure time. Again, the HDPE Primary provides the chemically resistant liner and is QC tested to reduce potential defects or holes. If there is a small hole, the geonet drain takes any leakage water immediately to the sump for extraction. Thus, exposure time is very limited on a secondary liner in addition to low temperature, little volume and virtually no head pressure. In this regard, a chemically resistant geomembrane material such as 40 mil HDPE can be specified for the secondary and is a fully acceptable alternate to 30 mil scrim reinforced LLDPEr.

Mechanical Properties Characteristics. Geomembranes of different polymer and/or structure (i.e., reinforced vs non-reinforced) can not be readily compared using such characteristics as tensile stress/strain, tear, puncture and polymer requirements. For a 40 mil HDPE liner material to function as a Secondary liner it should meet or exceed the manufacturers minimum requirements for Density, Tensile Properties, Tear, Puncture as

well as other properties such as UV resistance. The sheet material must also meet or exceed GRI GM 13 minimum requirements. In this regard, a 40 mil HDPE will be equivalent to a 30 mil LLDPEr as a secondary liner for the conditions listed below:

- The subgrade or compacted earth foundation will be smooth, free of debris or loose rocks, dry, unyielding and will support the lining system.
- The side slopes for the containment shall be equal to or less than 3H:1V.
- The physical properties and condition of the subgrade or liner foundation (i.e., density, slope, moisture) will be inspected and certified by a Professional Engineer that it meets or exceeds specification requirements.
- Immediately prior to installation, the installation contractor shall inspect and sign off on the subgrade conditions that they meet or exceed the HDPE manufacturer and installers requirements.
- A protective geotextile will be placed on the finished and accepted subgrade between subgrade and the 40 mil HDPE Secondary liner.
- A 200 mil geonet will be placed over the 40 mil HDPE Secondary Liner.
- A 60 mil HDPE Primary liner will be placed over the 200 mil geonet drainage layer.

If you have any questions on the above technical memorandum or require further information, give me a call at 720-289-0300 or email geosynthetics@msn.com

Sincerely Yours,

R K Frobel

Ronald K. Frobel, MSCE, PE

References:

C-147 Registration Package
Merchant Recycling and Containment
Section 35 T 21 SR 33 E Lea County
November 2016

Design Documents
Merchant Recycling and Containment

Geosynthetic Research Institute (GRI) Published Standards and Papers 2017
www.geosynthetic-institute.org

ASTM Geosynthetics Standards 2017
www.ASTM.org/Standards

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Houston, Texas 77073
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TF 800.435.2008

GSE ENVIRONMENTAL™

November 2, 2017

Attn: Mr. Rod Kirch

Project: Containment Liner

RE: UV Resistance and Chemical Resistance of HDPE

Dear Rod,

Polyethylene (PE) has a simple chain structure with a repeating unit,-(CH2)-. Its physical properties are greatly dependent upon the chain length, structure, and density. HDPE is a semi-crystalline polymer which consists of amorphous (disorder region) and crystalline (ordered structure phases). Due to the long linear chain structure, the degree of crystallinity of HDPE is much higher than LLDPE. The differences in crystallinity can affect the oxidation behavior partly because the diffusion of oxygen through the amorphous region is much easier than through the crystalline region.

Regarding the UV resistance of the two type of polyethylene, attached is the GRI White Paper #6, Geomembrane Lifetime Prediction: Unexposed and Exposed Condition. On page 10, the authors stated "The nature of the LLDPE resin and its formulation is very similar to HDPE. The fundamental difference is that LLDPE is a lower density, hence lower crystallinity, than HDPE;e.g., 10% versus 50%. This has theeffect of allowing oxygen to diffuse into the polymer structure quicker, and likely decreases Stages A and C. How much is uncertain since no data is available, but it is felt that the lifetime of LLDPE will be somewhat reduced with respect to HDPE." On page 23, Table 6, it listed the lifetime prediction of various types of geomembrane, including 1.5mm HDPE and 1.0mm LLDPE.

According to Geosynthetics from David I. Cook in Table 6, page 17, the chemical resistance of HDPE is rated "Excellent" and LLDPE is rated "Good". We also attached part of the report, p.15 to 18, for your information.

Please feel free to contact me if you have any question.

Sincerely,

Connie Wong, Ph.D.,
Support Engineer
cowong@gseworld.com

These EN requirement standards instruct manufacturers to declare the mean value and tolerance of certain product characteristics. The required characteristics depend on the end use and function (separation, filtration, etc.) of the fabric. These characteristics are determined by some of the test methods listed in **Table 3**. Some tests (referred to as H tests in the standards) are mandatory, i.e., required by Mandate M/107 issued by the European Community to the European standardisation committee for geotextiles, CEN 189. Some (referred to as A tests in the standards) are relevant to all conditions of use. The A tests are not legally required but are commercially important. A third test category (S) is relevant to specific conditions of use.

For more information and detail on the CPD and CE marking of geotextiles, the reader is recommended to consult a relevant and useful web site on quality and standardisation of geotextiles (www.vinci-quality.com).

It should be noted that 'geotextile related products' includes all other categories of geosynthetic except geomembranes and GCLs. The latter two groups are now known as 'geosynthetic barriers' and are in a separate CPD sector from geotextiles and related products.

The application standards for geosynthetic barriers are, at the time of writing, still at the provisional stage (prENs). There are five provisional geosynthetic barrier standards (www.vinci-quality.com):

- prEN 13361 reservoir and dam construction
- prEN 13362 canal construction
- prEN 13491 fluid barrier in tunnel and underground structures
- prEN 13492 liquid waste containment
- prEN 13493 solid and hazardous waste storage

4 Geomembranes

4.1 Description and Manufacturing

Geomembranes are thin, flexible sheets of material with very low permeability. They are manufactured from synthetic or bituminous products and may be strengthened with a fabric or film. Geomembranes are employed invariably as a barrier to prevent the passage of gases and fluids.

A commonly accepted definition of a geomembrane from the ASTM is:

> A geomembrane is a continuous membrane liner or barrier having sufficiently low permeability to control migration of fluids in a constructed project, structure or dam.

The original geomembranes were made of butyl rubber. Nowadays, polyvinyl chloride (PVC) or some form of polyethylene account for a high proportion of the total geomembrane useage. The different types of geomembrane polymer will be discussed in more detail later (Section 4.2).

The manufacture of geomembranes commences with the production of the raw materials, i.e., the polymer resin and a wide range of additives such as stabilisers, plasticisers, softeners, fillers, processing aids etc.

The raw materials can then be processed in three ways:

The first method produces the simplest type of geomembrane; single ply and non-reinforced. In this method the raw materials are blended and compounded before being extruded as sheets or cylinders. The extruder produces sheet material 0.1 to 5 mm thick and 1 to 5 m wide. Calendering, or pressing the sheets between counter rotating rollers, works them into uniform thickness and improves the mechanical properties. Full thickness sheets can also be blown into a large long bubble which is cut and opened into the final sheet form.

In the second method, multi-ply geomembranes are made by laminating several layers together. Laminated geomembranes can be non-reinforced or reinforced by inclusion of a fabric scrim between the layers. The scrim improves the mechanical properties (e.g., tensile and tear strength) of the composite material but does not reinforce the soil on which the geomembrane is placed.

The third production method is known as spread coating. In this method, a geotextile, usually a needle-punched non-woven, is used as a substrate on which the molten polymer is spread into its final thickness.

Geomembrane manufacturing methods are described in more detail in (a.9).

The surface of some geomembranes is roughened or textured, by spraying or embossing, to increase the soil/polymer friction (a.19). Three common techniques are coextrusion, lamination and impingement (a.20):

- Coextrusion uses a blowing agent in the extrudate which expands on cooling to cause a roughened surface.
- In lamination, a sheet containing a foam is adhered to a conventional sheet. The foaming agent provides a froth that produces a rough, textured laminate stuck to the smooth, solid sheet.
- Impingement is the projection of hot particles on to the smooth sheet.

A review of these texturing techniques and a discussion on characterisation of the surface topography has been presented by Zettler and co-workers (7).

4.2 Polymers

The vast majority of geomembranes are thin sheets of flexible thermoplastic or thermosetting polymeric materials. The main polymers used are (a.9):

Thermoplastic polymers

- Polyethylene (PE) – high density (HDPE), medium density (MDPE), linear low density (LLDPE), low density (LDPE), very low density (VLDPE)
- Polypropylene (PP)
- Polyvinyl chloride (PVC)
- Chlorinated polyethylene (CPE)
- Polyamide (PA)

Thermoset polymers

- Isoprene-isobutylene (IIR) or butyl rubber
- Epichlorohydrin rubber
- Ethylene-propylene-diene terpolymer (EDPM)
- Polychloroprene (Neoprene)
- Ethylene-propylene terpolymer (EPT)
- Ethylene-vinyl acetate (EVA)
- Ethylene interpolymer alloy (EIA)

Combination polymers

- PVC-nitrile rubber
- PE-EPDM
- PVC-EVA
- Crosslinked CPE
- Chlorosulfonated polyethylene (CSPE) 'Hypalon'

Others

- Bitumen impregnated geotextiles
- Elastomer impregnated geotextiles
- Aluminium foil coated geomembranes for protection against hydrocarbons (329).

Which geomembrane polymer to choose depends, as usual, on its properties, availability and, of course, on the application and structure in which the geomembrane is to be incorporated. The properties will be discussed in more detail in Section 4.4 (Testing).

No study appears to have been performed which compares the properties of all these polymers as geomembrane sheets. However, **Table 6** (a.21) provides a useful qualitative comparison of geomembrane liners made from eight polymers and, another type of geosynthetic barrier known as a geosynthetic clay liner (GCL). The attributes considered are physical properties, durability, installation damage, seaming and cost.

Table 6 refers to seaming methods, that is to say the techniques used to join together the membrane sheets either at the factory or on site. Production of a leak tight and durable seam is clearly vital otherwise the geomembrane's function as a fluid barrier is lost. There are several general seaming methods. The choice is governed by the polymer and site requirements.

- Solvent: A liquid solvent is brushed between two sheets of membrane followed by pressure to form the seal.
- Adhesive: A glue dissolved in a solvent is applied by brush or roller to the membrane sheets which are brought together after the surface becomes tacky.

Table 6 Geomembranes; comparison of polymers								
Attribute	**HDPE**	**LLDPE**	**PVC**	**EPDM**	**EIA**	**Reinforced CSPE**	**Flexible PP**	**GCL**
Chemical resistance	Excellent	Good	Fair	Good	Excellent (when cured)	Excellent	Excellent	Fair
Hydrocarbon resistance	Good	Good	Fair	Good	Excellent (when cured)	Good	Good	Poor
Weathering; UV resistance	Excellent	Fair	Poor	Excellent	Excellent (when cured)	Excellent	Excellent	Poor
Thermal stability	Poor	Poor	Good	Excellent	Good	Excellent	Good – excellent when reinforced	Good
Tensile properties	Good	Good	Good	Good	Excellent	Excellent	Good – excellent when reinforced	Good
Elongation; uniaxial	Excellent	Excellent	Good	Good	Fair	Good	Excellent	Fair
Elongation; multiaxial	Poor	Excellent	Excellent	Good	Fair	Good	Excellent	Fair
Puncture resistance	Fair	Excellent	Excellent	Good	Excellent	Good	Good	Good
Stress cracking	Fair	Good	Does not occur	Does not occur	Does not occur	Does not occur	Does not occur	Does not occur
Resistance to installation damage	Fair	Fair	Excellent	Excellent	Good	Good	Excellent	Good
Seaming methods	Thermal/ excellent	Thermal/ excellent	Thermal or solvent bonding/ good	Tape seams/good	Thermal/ excellent	Thermal or solvent bonding good	Thermal/ excellent	Laps only
Ease of repair in service	Good	Good	Good	Good	Good	Poor needs adhesives	Excellent	NA
Flexibility	Fair	Excellent	Good	Good	Good	Good	Excellent	NA
Roll cost	Low	Low/ medium	medium	Medium/ high	High	High	Medium	Medium
Reproduced with permission from M. Sadlier (a.21)								

- Thermal: There is a range of thermal methods in which the opposing surfaces are melted by some means such as hot air or electrically heated knife or wedge. The melted surfaces are pressed together by rollers.
- Mechanical: The usual mechanical joining methods are utilisation of sticky tapes or sewing. The sewn seams are subsequently waterproofed.

The solvent and adhesive methods tend to be used for thermoplastic polymers and elastomers such as PVC,

CPE, EDPM, and CSPE. Thermal methods can be employed for most thermoplastic polymers but are especially important for semi-crystalline polyethylene materials like HDPE and LDPE. A more detailed description of geomembrane seaming is given in Chapter 5 of Designing with Geosynthetics by Koerner (a.9).

Some further advantages and disadvantages of specific polymers are now given.

PVC (polyvinyl chloride)

- Tough without reinforcement
- Good seams by dielectric, solvent or heat
- Elasticised for flexibility, plasticiser leaches with time

CPE (chlorinated polyethylene)

- Seams easy to make by dielectric or solvent
- Plasticised with PVC

CSPE (chlorosulfonated polyethylene thermoplastic rubber)

- Good seams by heat or adhesive

Butyl

- Poor field seams
- Low gas permeability

CP (chloroprene/neoprene cured rubber)

- Fair field seams using solvent and tape

HDPE

- Good seams by thermal or extrusion methods
- Low friction surfaces
- High thermal expansion and contraction

MDPE, LDPE and VLDPE

- Good seams by thermal or extrusion methods
- Moderate thermal expansion and contraction

LLDPE

- High friction surface
- Good seams by thermal or extrusion methods
- Large variation in thickness

Further comparative properties are given in **Table 7** which has been generated from information in references a.9 and a.22.

Table 7 Geomembrane polymers: advantages and disadvantages

Factor	PVC	CPE	CSPE	Butyl	CP	HDPE	MDPE LDPE VLDPE	LLDPE
Cost	low	medium	medium	medium to high	high	low	low	medium
Chemical resistance	-	good	good	-	good	excellent	good	very good
Weathering	poor	good	excellent	fair to good	good	-	-	-
High temperature	poor	-	fair	good	good	-	-	-
Cold crack	poor	good	good	-	-	-	-	-
Stress crack	-	-	-	-	-	sensitive	none	none

CP = chloroprene rubber

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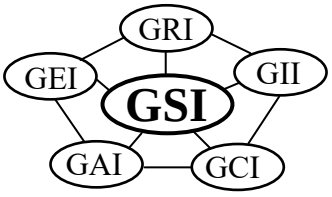

GRI White Paper #6

- on -

Geomembrane Lifetime Prediction:
Unexposed and Exposed Conditions

by

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Geomembrane Lifetime Prediction: Unexposed and Exposed Conditions

1.0 Introduction

Without any hesitation the most frequently asked question we have had over the past thirty years' is "how long will a particular geomembrane last".* The two-part answer to the question, largely depends on whether the geomembrane is covered in a timely manner or left exposed to the site-specific environment. Before starting, however, recognize that the answer to either covered or exposed geomembrane lifetime prediction is neither easy, nor quick, to obtain. Further complicating the answer is the fact that all geomembranes are formulated materials consisting of (at the minimum), (i) the resin from which the name derives, (ii) carbon black or colorants, (iii) short-term processing stabilizers, and (iv) long-term antioxidants. If the formulation changes (particularly the additives), the predicted lifetime will also change. See Table 1 for the most common types of geomembranes and their approximate formulations.

Table 1 - Types of commonly used geomembranes and their approximate formulations (based on weight percentage)

Type	Resin	Plasticizer	Fillers	Carbon Black	Additives
HDPE	95-98	0	0	2-3	0.25-1
LLDPE	94-96	0	0	2-3	0.25-3
fPP	85-98	0	0-13	2-4	0.25-2
PVC	50-70	25-35	0-10	2-5	2-5
CSPE	40-60	0	40-50	5-10	5-15
EPDM	25-30	0	20-40	20-40	1-5

HDPE = high density polyethylene
LLDPE = linear low density polyethylene
fPP = flexible polypropylene
PVC = polyvinyl chloride (plasticized)
CSPE = chlorsulfonated polyethylene
EPDM = ethylene propylene diene terpolymer

* More recently, the same question has arisen but focused on geotextiles, geogrids, geopipe, turf reinforcement mats, fibers of GCLs, etc. This White Paper, however, is focused completely on geomembranes due to the tremendous time and expense of providing such information for all types of geosynthetics.

The possible variations being obvious, one must also address the degradation mechanisms which might occur. They are as follows accompanied by some generalized commentary.

- Ultraviolet Light - This occurs only when the geosynthetic is exposed; it will be the focus of the second part of this communication.
- Oxidation - This occurs in all polymers and is the major mechanism in polyolefins (polyethylene and polypropylene) under all conditions.
- Ozone - This occurs in all polymers that are exposed to the environment. The site-specific environment is critical in this regard.
- Hydrolysis - This is the primary mechanism in polyesters and polyamides.
- Chemical - Can occur in all polymers and can vary from water (least aggressive) to organic solvents (most aggressive).
- Radioactivity - This is not a factor unless the geomembrane is exposed to radioactive materials of sufficiently high intensity to cause chain scission, e.g., high level radioactive waste materials.
- Biological - This is generally not a factor unless biologically sensitive additives (such as low molecular weight plasticizers) are included in the formulation.
- Stress State – This is a complicating factor which is site-specific and should be appropriately modeled in the incubation process but, for long-term testing, is very difficult and expensive to acheive.
- Temperature - Clearly, the higher the temperature the more rapid the degradation of all of the above mechanisms; temperature is critical to lifetime and furthermore is the key to

time-temperature-superposition which is the basis of the laboratory incubation methods which will be followed.

2.0 Lifetime Prediction: Unexposed Conditions

Lifetime prediction studies at GRI began at Drexel University under U. S. EPA contract from 1991 to 1997 and was continued under GSI consortium funding until ca. 2002. Focus to date has been on HDPE geomembranes placed beneath solid waste landfills due to its common use in this particular challenging application. Incubation of the coupons has been in landfill simulation cells (see Figure 1) maintained at 85, 75, 65 and 55°C. The specific conditions within these cells are oxidation beneath, chemical (water) from above, and the equivalent of 50 m of solid waste mobilizing compressive stress. Results have been forthcoming over the years insofar as three distinct lifetime stages; see Figure 2.

Stage A - Antioxidant Depletion Time

Stage B - Induction Time to the Onset of Degradation

Stage C - Time to Reach 50% Degradation (i.e., the Halflife)

2.1 Stage A - Antioxidant Depletion Time

The dual purposes of antioxidants are to (i) prevent polymer degradation during processing, and (ii) prevent oxidation reactions from taking place during Stage A of service life, respectively. Obviously, there can only be a given amount of antioxidants in any formulation. Once the antioxidants are depleted, additional oxygen diffusing into the geomembrane will begin to attack the polymer chains, leading to subsequent stages as shown in Figure 2. The duration of the antioxidant depletion stage depends on both the type and amount of the various antioxidants, i.e., the precise formulation.

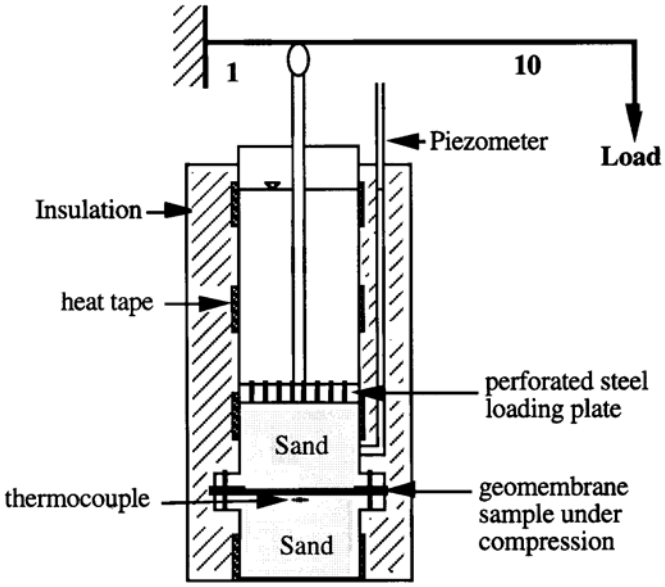


Figure 1. Incubation schematic and photograph of multiple cells maintained at various constant temperatures.

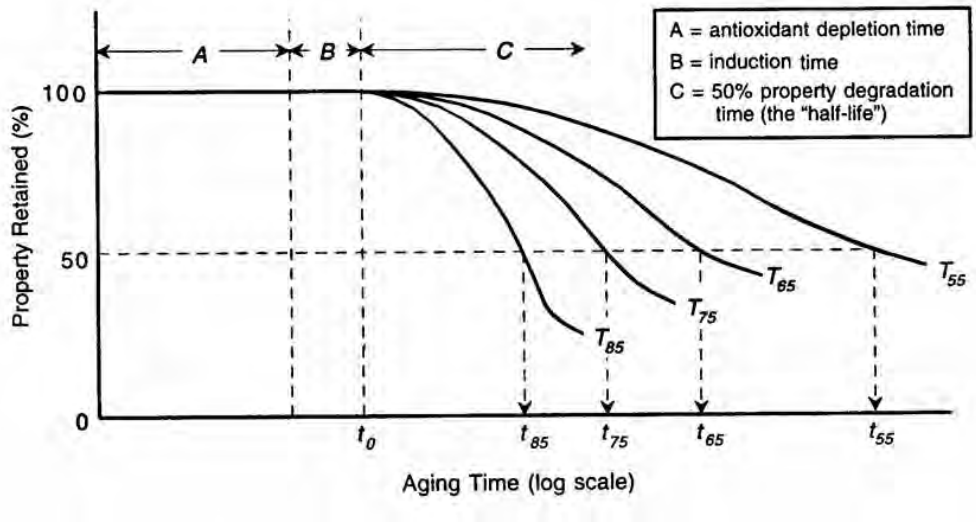


Figure 2. Three individual stages in the aging of most geomembranes.

The depletion of antioxidants is the consequence of two processes: (i) chemical reactions with the oxygen diffusing into the geomembrane, and (ii) physical loss of antioxidants from the geomembrane. The chemical process involves two main functions; the scavenging of free radicals converting them into stable molecules, and the reaction with unstable hydroperoxide (ROOH) forming a more stable substance. Regarding physical loss, the process involves the distribution of antioxidants in the geomembrane and their volatility and extractability to the site-specific environment.

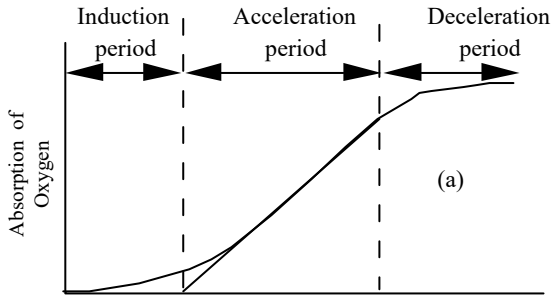
Hence, the rate of depletion of antioxidants is related to the type and amount of antioxidants, the service temperature, and the nature of the site-specific environment. See Hsuan and Koerner (1998) for additional details.

2.2 Stage B - Induction Time to Onset of Degradation

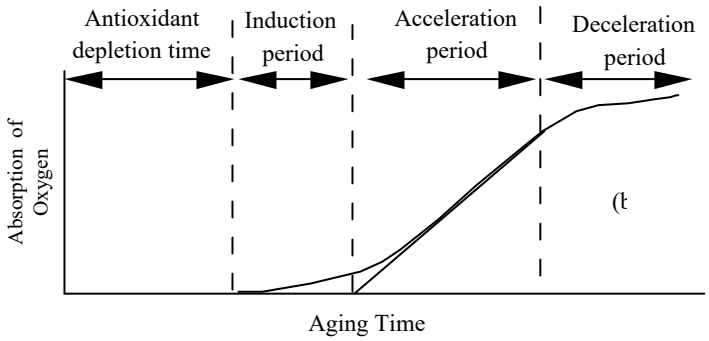
In a pure polyolefin resin, i.e., one without carbon black and antioxidants, oxidation occurs extremely slowly at the beginning, often at an immeasurable rate. Eventually, oxidation occurs more rapidly. The reaction eventually decelerates and once again becomes very slow.

This progression is illustrated by the S-shaped curve of Figure 3(a). The initial portion of the curve (before measurable degradation takes place) is called the induction period (or induction time) of the polymer. In the induction period, the polymer reacts with oxygen forming hydroperoxide (ROOH), as indicated in Equations (1)-(3). However, the amount of ROOH in this stage is very small and the hydroperoxide does not further decompose into other free radicals which inhibits the onset of the acceleration stage.

In a stabilized polymer such as one with antioxidants, the accelerated oxidation stage takes an even longer time to be reached. The antioxidants create an additional depletion time stage prior to the onset of the induction time, as shown in Figure 3(b).



(a) Pure unstabilized polyethylene



(b) Stabilized polyethylene

Figure 3. Curves illustrating various stages of oxidation.

$$RH \rightarrow R\bullet + H\bullet \quad (1)$$

(aided by energy or catalyst residues in the polymer)

$$R\bullet + O2 \rightarrow ROO\bullet \quad (2)$$

$$ROO\bullet + RH \rightarrow ROOH + R\bullet \quad (3)$$

In the above, RH represents the polyethylene polymer chains; and the symbol "•" represents free radicals, which are highly reactive molecules.

2.3 Stage C - Time to Reach 50% Degradation (Halflife)

As oxidation continues, additional ROOH molecules are being formed. Once the concentration of ROOH reaches a critical level, decomposition of ROOH begins, leading to a substantial increase in the amount of free radicals, as indicated in Equations (4) to (6). The additional free radicals rapidly attack other polymer chains, resulting in an accelerated chain reaction, signifying the end of the induction period, Rapopport and Zaikov (1986). This indicates that the concentration of ROOH has a critical control on the duration of the induction period.

$$ROOH \rightarrow RO\bullet OH\bullet \text{ (aided by energy)} \quad (4)$$

$$RO\bullet + RH \rightarrow ROH + R\bullet \quad (5)$$

$$OH\bullet + RH \rightarrow H2O + R\bullet \quad (6)$$

A series of oxidation reactions produces a substantial amount of free radical polymer chains (R•), called alkyl radicals, which can proceed to further reactions leading to either cross-linking or chain scission in the polymer. As the degradation of polymer continues, the physical and mechanical properties of the polymer start to change. The most noticeable change in physical properties is the melt index, since it relates to the molecular weight of the polymer. As for mechanical properties, both tensile break stress (strength) and break strain (elongation) decrease.

Ultimately, the degradation becomes so severe that all tensile properties start to change (tear, puncture, burst, etc.) and the engineering performance is jeopardized. This signifies the end of the so-called "service life" of the geomembrane.

Although quite arbitrary, the limit of service life of polymeric materials is often selected as a 50% reduction in a specific design property. This is commonly referred to as the halflife time, or simply the "halflife". It should be noted that even at halflife, the material still exists and can function, albeit at a decreased performance level with a factor-of-safety lower than the initial design value.

2.4 Summary of Lifetime Research-to-Date

Stage A, that of antioxidant depletion for HDPE geomembranes as required in the GRI-GM13 Specification, has been well established by our own research and corroborated by others, e.g., Sangram and Rowe (2004). The GRI data for standard and high pressure Oxidative Induction Time (OIT) is given in Table 2. The values are quite close to one another. Also, as expected, the lifetime is strongly dependent on the service temperature; with the higher the temperature the shorter the lifetime.

Table 2 - Lifetime prediction of HDPE (nonexposed) at various field temperatures

In Service Temperature (°C)	Stage "A" (years)			Stage "B" (years)	Stage "C" (years)	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT			
20	200	215	208	30	208	446
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40	45	47	46	10	13	69

*Total = Stage A (average) + Stage B + Stage C

Stage "B", that of induction time, has been obtained by comparing 30-year old polyethylene water and milk containers (containing no long-term antioxidants) with currently

produced containers. The data shows that degradation is just beginning to occur as evidenced by slight changes in break strength and elongation, but not in yield strength and elongation. The lifetime for this stage is also given in Table 2.

Stage "C", the time for 50% change of mechanical properties is given in Table 2 as well. The data depends on the activation energy, or slope of the Arrhenius curve, which is very sensitive to material and experimental techniques. The data is from Gedde, et al. (1994) which is typical of the HDPE resin used for gas pipelines and is similar to Martin and Gardner (1983).

Summarizing Stages A, B, and C, it is seen in Table 2 that the halflife of covered HDPE geomembranes (formulated according to the current GRI-GM13 Specification) is estimated to be 449-years at 20°C. This, of course, brings into question the actual temperature for a covered geomembrane such as beneath a solid waste landfill. Figure 4 presents multiple thermocouple monitoring data of a municipal waste landfill liner in Pennsylvania for over 10-years, Koerner and Koerner (2005). Note that for 6-years the temperature was approximately 20°C. At that time and for the subsequent 4-years the temperature increased to approximately 30°C. Thus, the halflife of this geomembrane is predicted to be from 166 to 446 years within this temperature range. The site is still being monitored, see Koerner and Koerner (2005).

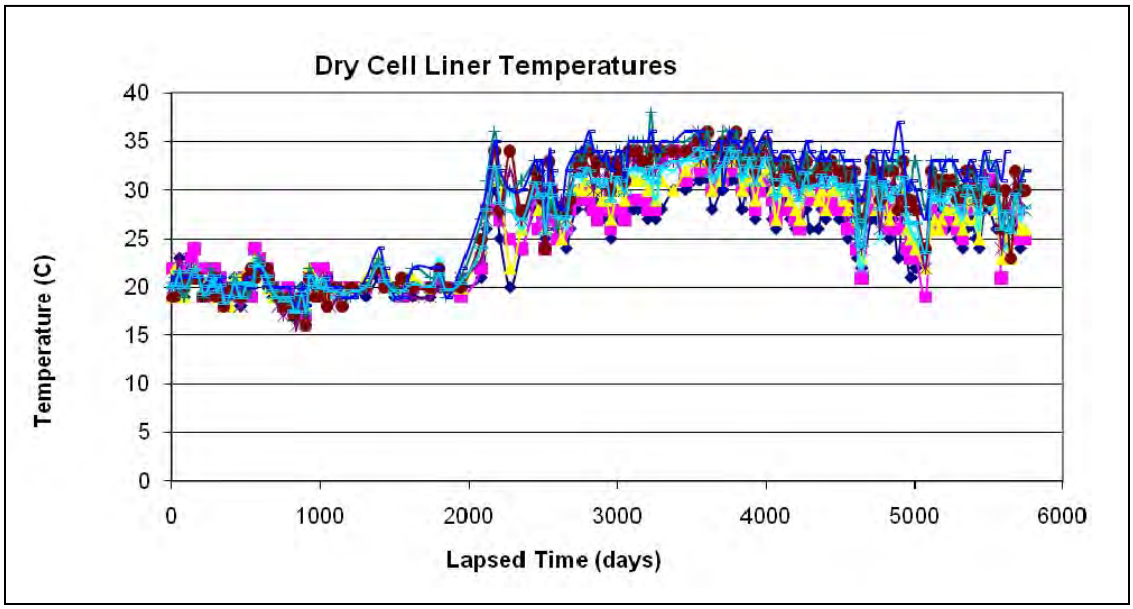


Figure 4. Long-term monitoring of an HDPE liner beneath a municipal solid waste landfill in Pennsylvania.

2.5 Lifetime of Other Covered Geomembranes

By virtue of its widespread use as liners for solid waste landfills, HDPE is by far the widest studied type of geomembrane. Note that in most countries (other than the U.S.), HDPE is the required geomembrane type for solid waste containment. Some commentary on other-than HDPE geomembranes (recall Table 1) follows:

2.5.1 Linear Low Density Polyethylene (LLDPE) geomembranes

The nature of the LLDPE resin and its formulation is very similar to HDPE. The fundamental difference is that LLDPE is a lower density, hence lower crystallinity, than HDPE; e.g., 10% versus 50%. This has the effect of allowing oxygen to diffuse into the polymer structure quicker, and likely decreases Stages A and C. How much is uncertain since no data is available, but it is felt that the lifetime of LLDPE will be somewhat reduced with respect to HDPE.

2.5.2 Plasticizer migration in PVC geomembranes

Since PVC geomembranes necessarily have plasticizers in their formulations so as to provide flexibility, the migration behavior must be addressed for this material. In PVC the plasticizer bonds to the resin and the strength of this bonding versus liquid-to-resin bonding is significant. One of the key parameters of a stable long-lasting plasticizer is its molecular weight. The higher the molecular weight of the plasticizer in a PVC formulation, the more durable will be the material. Conversely, low molecular weight plasticizers have resulted in field failures even under covered conditions. See Miller, et al. (1991), Hammon, et al. (1993), and Giroud and Tisinger (1994) for more detail in this regard. At present there is a considerable difference (and cost) between PVC geomembranes made in North America versus Europe. This will be apparent in the exposed study of durability in the second part of this White Paper.

2.5.3 Crosslinking in EPDM and CSPE geomembrnaes

The EPDM geomembranes mentioned in Table 1 are crosslinked thermoset materials. The oxidation degradation of EPDM takes place in either ethylene or propylene fraction of the co-polymer via free radical reactions, as expressed in Figure 5, which are described similarly by Equations (4) to (6).

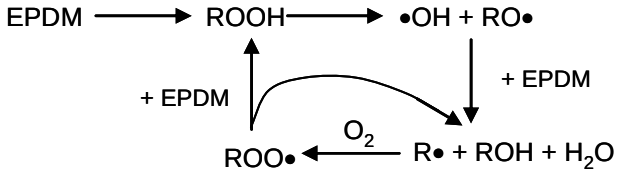


Figure 5. Oxidative degradation of crosslinked EPDM geomembranes, (Wang and Qu, 2003).

For CSPE geomembranes, the degradation mechanism is dehydrochlorination by losing chlorine and generating carbon-carbon double bonds in the main polymer chain, as shown in Figure 6.

The carbon-carbon double bonds become the preferred sites for further thermodegradation or cross-linking in the polymer, leading to eventual brittleness of the geomembrane.

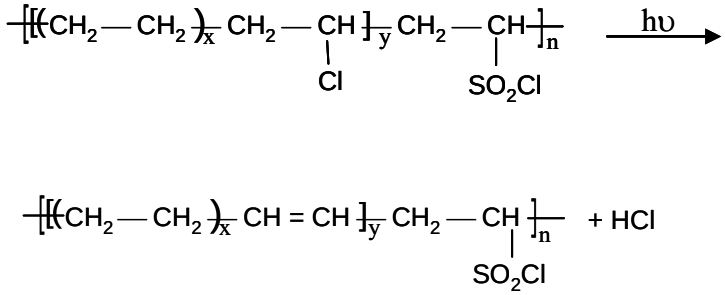


Figure 6. Dechlorination degradation of crosslinked CSPE geomembranes (Chailan, et al., 1995).

Neither EPDM nor CSPE has had a focused laboratory study of the type described for HDPE reported in the open literature. Most of lifetime data for these geomembranes is antidotal by virtue of actual field performance. Under covered conditions, as being considered in this section, there have been no reported failures by either of these thermoset polymers to our knowledge.

3.0 Lifetime Prediction: Exposed Conditions

Lifetime prediction of exposed geomembranes have taken two very different pathways; (i) prediction from anecdotal feedback and field performance, and (ii) from laboratory weathering device predictions.

3.1 Field Performance

There is a large body of anecdotal information available on field feedback of exposed geomembranes. It comes form two quite different sources, i.e., dams in Europe and flat roofs in the USA.

Regarding exposed geomembranes in dams in Europe, the original trials were using 2.0 mm thick polyisobutylene bonded directly to the face of the dam. There were numerous problems encountered as described by Scuero (1990). Similar experiences followed using PVC

geomembranes. In 1980, a geocomposite was first used at Lago Nero which had a 200 g/m^2 nonwoven geotextile bonded to the PVC geomembrane. This proved quite successful and led to the now-accepted strategy of requiring drainage behind the geomembrane. In addition to thick nonwoven geotextiles, geonets, and geonet composites have been successful. Currently over 50 concrete and masonry dams have been rehabilitated in this manner and are proving successful for over 30-years of service life. The particular type of PVC plasticized geomembranes used for these dams is proving to be quite durable. Tests by the dam owners on residual properties show only nominal changes in properties, Cazzuffi (1998). As indicated in Miller, et al. (1991) and Hammond, et al. (1993), however, different PVC materials and formulations result in very different behavior; the choice of plasticizer and the material's thickness both being of paramount importance. An excellent overview of field performance is recently available in which 250 dams which have been waterproofed by geomembranes is available from ICOLD (2010).

Regarding exposed geomembranes in flat roofs, past practice in the USA is almost all with EPDM and CSPE and, more recently, with fPP. Manufacturers of these geomembranes regularly warranty their products for 20-years and such warrants appear to be justified. EPDM and CSPE, being thermoset or elastomeric polymers, can be used in dams without the necessity of having seams by using vertical attachments spaced at 2 to 4 m centers, see Scuero and Vaschetti (1996). Conversely, fPP can be seamed by a number of thermal fusion methods. All of these geomembrane types have good conformability to rough substrates as is typical of concrete and masonry dam rehabilitation. It appears as though experiences (both positive and negative) with geomembranes in flat roofs should be transferred to all types of waterproofing in civil engineering applications.

3.2 Laboratory Weatherometer Predictions

For an accelerated simulation of direct ultraviolet light, high temperature, and moisture using a laboratory weatherometer one usually considers a worst-case situation which is the solar maximum condition. This condition consists of global, noon sunlight, on the summer solstice, at normal incidence. It should be recognized that the UV-A range is the target spectrum for a laboratory device to simulate the naturally occurring phenomenon, see Hsuan and Koerner (1993), and Suits and Hsuan (2001).

The Xenon Arc weathering device (ASTM D4355) was introduced in Germany in 1954. There are two important features; the type of filters and the irradiance settings. Using a quartz inner and borosilicate outer filter (quartz/boro) results in excessive low frequency wavelength degradation. The more common borosilicate inner and outer filters (boro/boro) shows a good correlation with solar maximum conditions, although there is an excess of energy below 300 nm wavelength. Irradiance settings are important adjustments in shifting the response although they do not eliminate the portion of the spectrum below 300 nm frequency. Nevertheless, the Xenon Arc device is commonly used method for exposed lifetime prediction of all types of geosynthetics.

UV Fluorescent devices (ASTM D7238) are an alternative type of accelerated laboratory test device which became available in the early 1970's. They reproduce the ultraviolet portion of the sunlight spectrum but not the full spectrum as in Xenon Arc weatherometers. Earlier FS-40 and UVB-313 lamps give reasonable short wavelength output in comparison to solar maximum. The UVA-340 lamp was introduced in 1987 and its response is seen to reproduce ultraviolet light quite well. This device (as well as other types of weatherometers) can handle elevated temperature and programmed moisture on the test specimens.

Research at the Geosynthetic Institute (GSI) has actively pursued both Xenon and UV Fluorescent devices on a wide range of geomembranes. Table 3 gives the geomembranes that were incubated and the number of hours of exposure as of 12 July 2005.

Table 5 - Details of the GSI laboratory exposed weatherometer study on various types of geomembranes

Geomembrane Type	Thickness (mm)	UV Fluorescent Exposure*	Xenon Exposure*	Comment
1. HDPE (GM13)	1.50	8000 hrs.	6600 hrs.	Basis of GRI-GM13 Spec
2. LLDPE (GM17)	1.00	8000	6600	Basis of GRI-GM-17 Spec
3. PVC (No. Amer.)	0.75	8000	6600	Low Mol. Wt. Plasticizer
4. PVC (Europe)	2.50	7500	6600	High Mol. Wt. Plasticizer
5. fPP (BuRec)	1.00	2745**	4416**	Field Failure at 26 mos.
6. fPP-R (Texas)	0.91	100	100	Field Failure at 8 years
7. fPP (No. Amer.)	1.00	7500	6600	Expected Good Performance

*As of 12 July 2005 exposure is ongoing
**Light time to reach halflife of break and elongation

3.3 Laboratory Weatherometer Acceleration Factors

The key to validation of any laboratory study is to correlate results to actual field performance. For the nonexposed geomembranes of Section 2 such correlations will take hundreds of years for properly formulated products. For the exposed geomembranes of Section 3, however, the lifetimes are significantly shorter and such correlations are possible. In particular, Geomembrane #5 (flexible polypropylene) of Table 3 was an admittedly poor geomembrane formulation which failed in 26 months of exposure at El Paso, Texas, USA. The reporting of this failure is available in the literature, Comer, et al. (1998). Note that for both UV Fluorescent and Xenon Arc laboratory incubation of this material, failure (halflife to 50% reduction in strength and elongation) occurred at 2745 and 4416 hours, respectively. The comparative analysis of laboratory and field for this case history allows for the obtaining of acceleration factors for the two incubation devices.

3.3.1 Comparison between field and UV Fluorescent weathering

The light source used in the UV fluorescent weathering device is UVA with wavelengths from 295-400 nm. In addition, the intensity of the radiation is controlled by the Solar Eye irradiance control system. The UV energy output throughout the test is 68.25 W/m^2.

The time of exposure to reach 50% elongation at break was as follows:

= 2745 hr. of light
= 9,882,000 seconds

Total energy in MJ/m^2 = 68.25 W/m^2 × 9,882,000
= 674.4 MJ/m^2

The field site was located at El Paso, Texas. The UVA radiation energy (295-400 nm) at this site is estimated based on data collected by the South Florida Testing Lab in Arizona (which is a similar atmospheric location). For 26 months of exposure, the accumulated UV radiation energy is 724 MJ/m^2 which is very close to that generated from the UV fluorescent weatherometer. Therefore, direct comparison of the exposure time between field and UV fluorescent is acceptable.

Field time = 26 Months vs. Fluorescent UV light time: = 3.8 Months **Thus, the acceleration factor is 6.8.**

3.3.2 Comparison between field and Xenon Arc weathering

The light source of the Xenon Arc weathering device simulates almost the entire sunlight spectrum from 250 to 800 nm. Depending of the age of the light source and filter, the solar energy ranges from 340.2 to 695.4 W/m^2, with the average value being 517.8 W/m^2.

The time of exposure to reach 50% elongation at break

= 4416 hr. of light
= 15,897,600 seconds

Total energy in MJ/m^2 = 517.8 W/m^2 × 15,897,600
= 8232 MJ/m^2

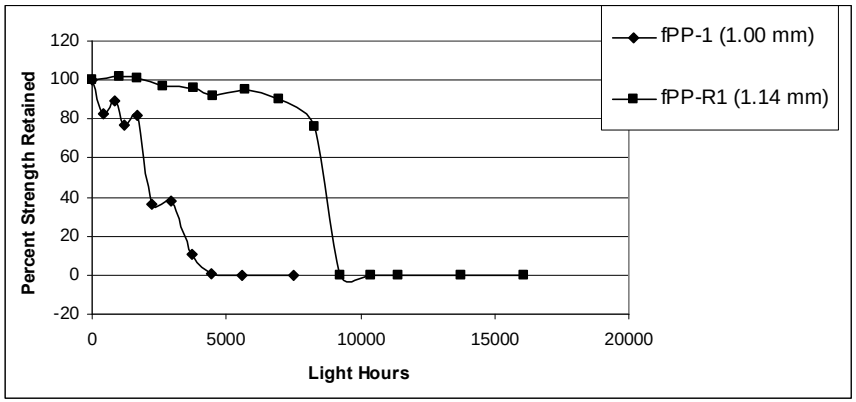
The solar energy in the field is again estimated based on data collected by the South Florida Testing Lab in Arizona. For 26 months of exposure, the accumulated solar energy (295-800 nm) is 15,800 MJ/m^2, which is much higher than that from the UV Fluorescent device. Therefore, direct comparison of halflives obtained from the field and Xenon Arc device is not anticipated to be very accurate. However, for illustration purposes the acceleration factor based on Xenon Arc device would be as follows:

Field vs. Xenon Arc : **Thus, the acceleration factor is 4.3.**
= 26 Months = 6.1 Months

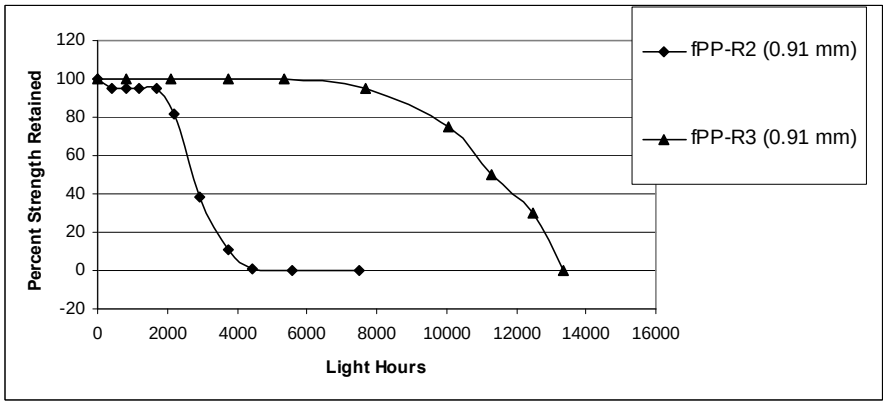
The resulting conclusion of this comparison of weathering devices is that the UV Fluorescent device is certainly reasonable to use for long-term incubations. When considering the low cost of the device, its low maintenance, its inexpensive bulbs, and ease of repair it (the UV Fluorescent device) will be used exclusively by GSI for long-term incubation studies.

3.3.3 Update of exposed lifetime predictions

There are presently (2011) four field failures of flexible polypropylene geomembranes and using unexposed archived samples from these sites their responses in laboratory UV Fluorescent devices per ASTM D7328 at 70°C are shown in Figure 5. From this information we deduce that the average correlation factor is approximately *1200 light hours ≃ one-year in a hot climate.* This value will be used accordingly for other geomembranes.



(a) Two Sites in West Texas



(b) Two Sites in So. Calif.

Lab-to-Field Correlation Factors
(ASTM D7238 @ 70°C)

Method	Thickness (mm)	Field (yrs.)	Location	Lab (lt. hr.)	Factor (lt. hrs./1.0 yr.)
fPP-1	1.00	≃ 2	W. Texas	1800	900
fPP-R1	1.14	≃ 8	W. Texas	8200	1025
fPP-R2	0.91	≃ 2	So. Calif.	2500	1250
fPP-R3	0.91	≃ 8	So. Calif.	11200	1400
					1140*

*Use 1200 lt. hr. = 1.0 year in hot climates

Figure 5. Four field failures of fPP and fPP-R exposed geomembranes.

Exposure of a number of different types of geomembranes in laboratory UV Fluorescent devices per ASTM D7238 at 70°C has been ongoing for the six years (between 2005 and 2011) since this White Paper was first released. Included are the following geomembranes:

- Two black 1.0 mm (4.0 mil) unreinforced flexible polypropylene geomembranes formulated per GRI-GM18 Specification; see Figure 6a.
- Two black unreinforced polyethylene geomembranes, one 1.5 mm (60 mil) high density per GRI-GM13 Specification and the other 1.0 mm (40 mil) linear low density per GRI-GM17 Specification; see Figure 6b.
- One 1.0 (40 mil) black ethylene polypropylene diene terpolymer geomembrane per GRI-GM21 Specification; see Figure 6c.
- Two polyvinyl chloride geomembranes, one black 1.0 mm (40 mil) formulated in North America and the other grey 1.5 mm (60 mil) formulated in Europe; see Figure 6d.

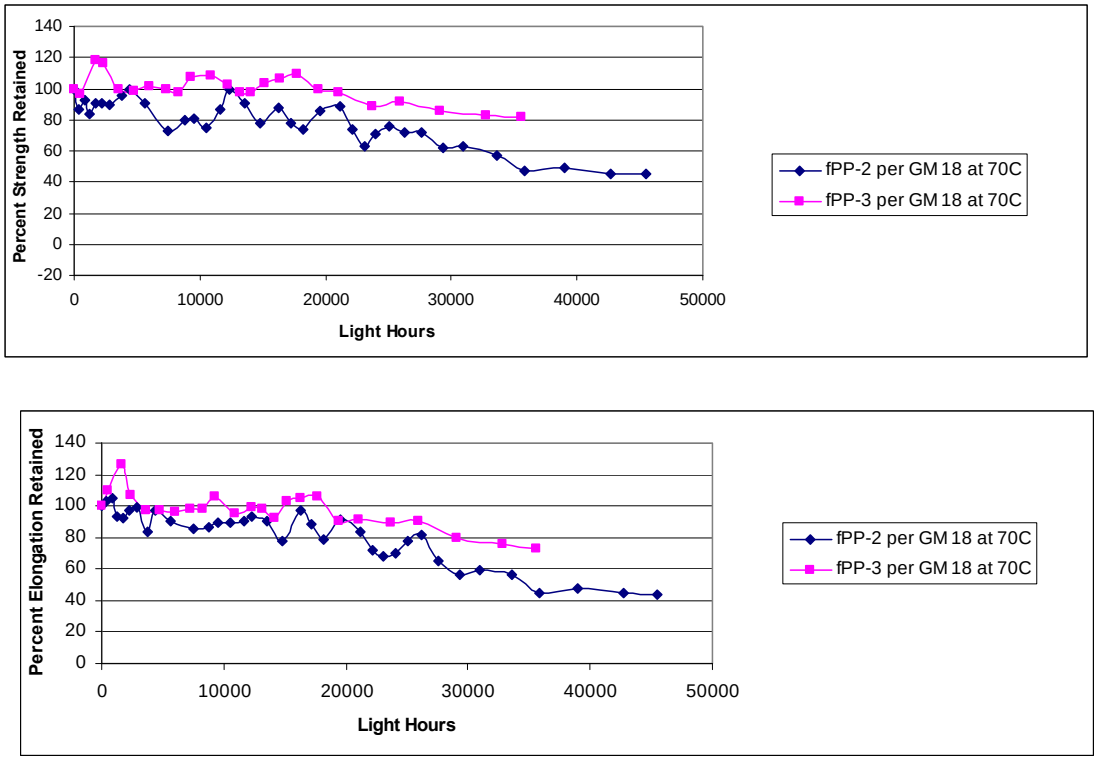
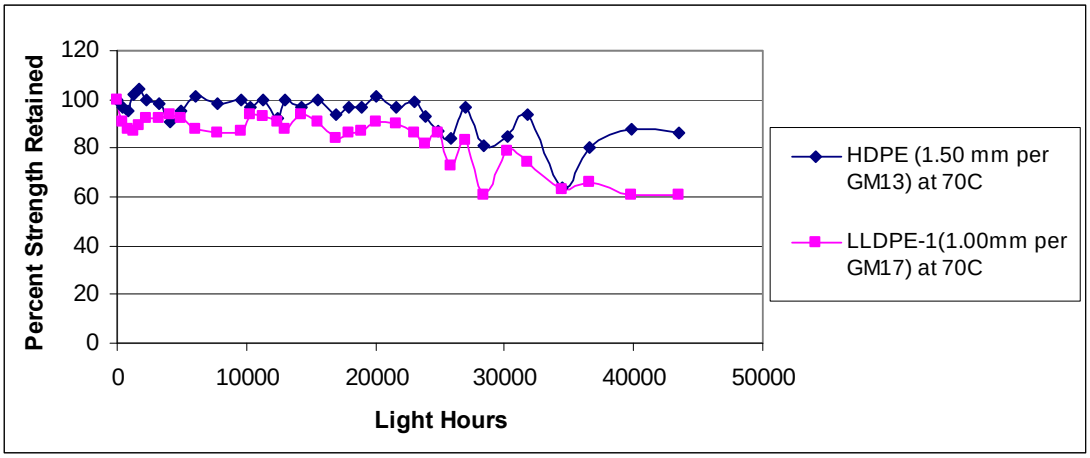


Figure 6a. Flexible polyethylene (fPP) geomembrane behavior.



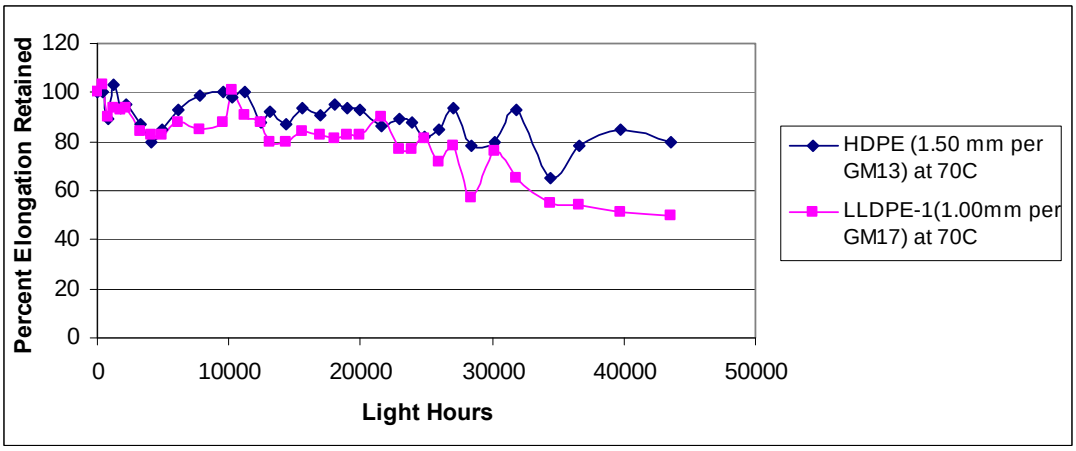
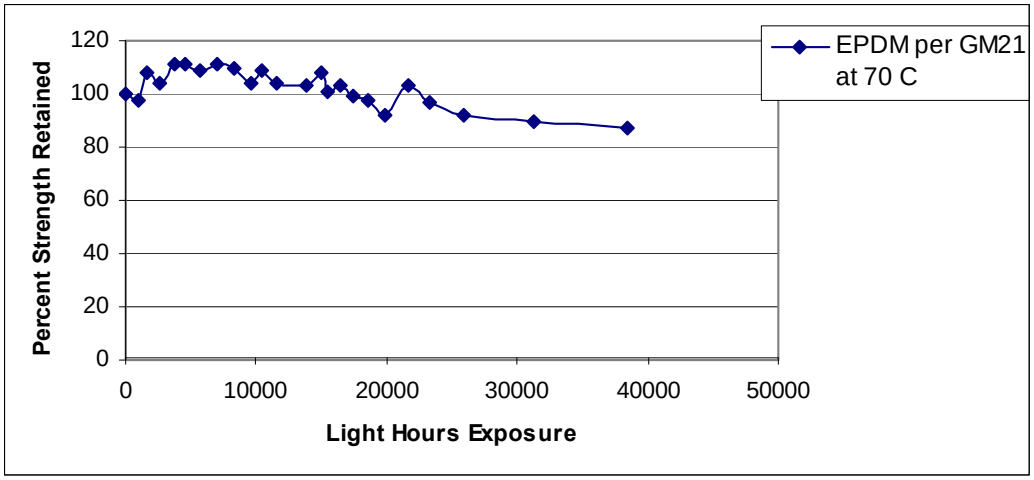


Figure 6b. Polyethylene (HDPE and LLDPE) geomembrane behavior.



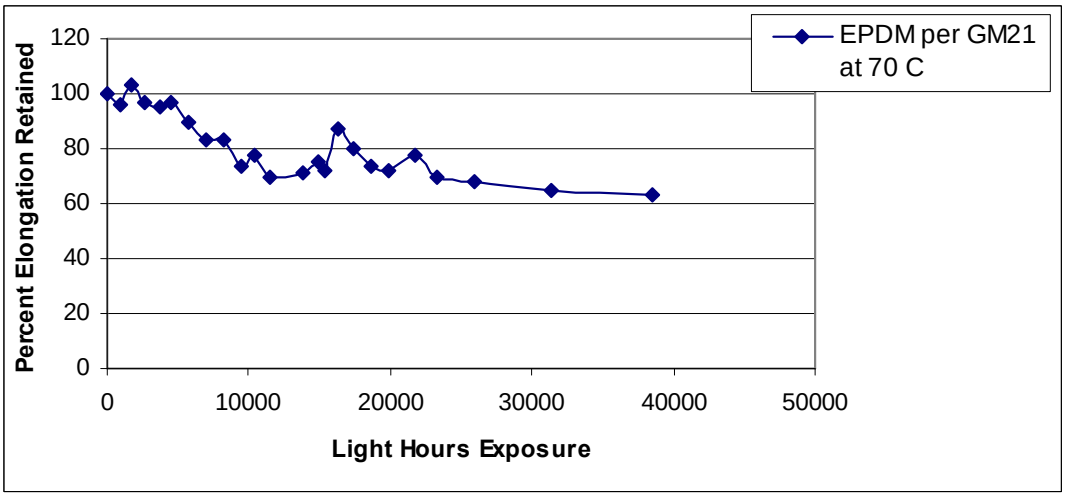


Figure 6c. Ethylene polypropylene diene terpolymer (EPDM) geomembrane.

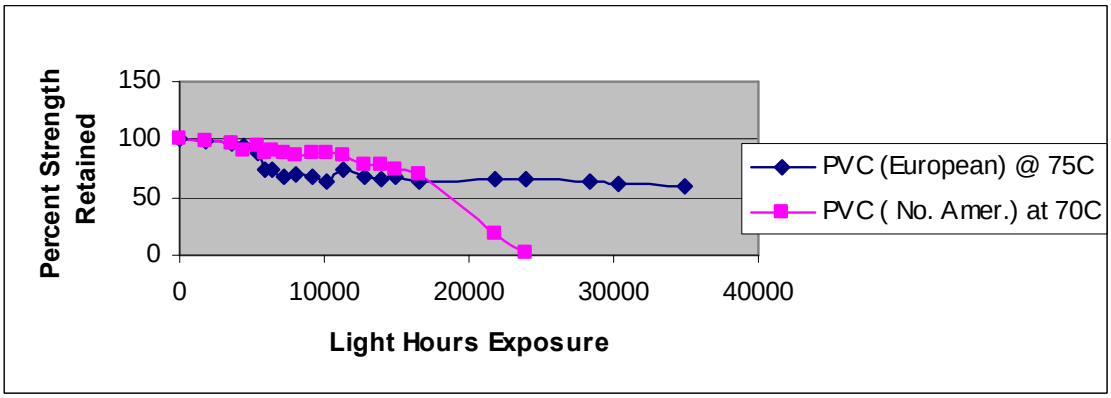


Figure 6d. Polyvinyl chloride (PVC) geomembranes.

From the response curves of the various geomembranes shown in Figure 6a-d, the 50% reduction value in strength or elongation (usually elongation) was taken as being the "halflife". This value is customarily used by the polymer industry as being the materials lifetime prediction value. We have done likewise to develop Table 6 which is our predicted values for the designated exposed geomembrane lifetimes to date.

Table 6 – Exposed lifetime prediction results of selected geomembranes to date

Type	Specification	Prediction Lifetime in a Dry and Arid Climate
HDPE	GRI-GM13	> 36 years (ongoing)
LLDPE	GRI-GM17	≃ 36 years (halflife)
EPDM	GRI-GM21	> 27 years (ongoing)
fPP-2	GRI-GM18	≃ 30 years (halflife)
fPP-3	GRI-GM18	> 27 years (ongoing)
PVC-N.A.	(see FGI)	≃ 18 years (halflife)
PVC-Eur.	proprietary	> 32 years (ongoing)

4.0 Conclusions and Recommendations

This White Paper is bifurcated into two very different parts; covered (or buried) lifetime prediction of HDPE geomembranes and exposed (to the atmosphere) lifetime prediction of a number of geomembrane types. In the covered geomembrane study we chose the geomembrane type which has had the majority of usage, that being HDPE as typically used in waste containment applications. Invariably whether used in landfill liner or cover applications *the geomembrane is covered.* After ten-years of research Table 2 (repeated here) was developed which is the conclusion of the covered geomembrane research program. Here it is seen that HDPE decreases its predicted lifetime (as measured by its halflife) from 446-years at 20°C, to 69-years at 40°C. Other geomembrane types (LLDPE, fPP, EPDM and PVC) have had

essentially no focused effort on their covered lifetime prediction of the type described herein. That said, all are candidates for additional research in this regard.

Table 2 - Lifetime prediction of HDPE (nonexposed) at various field temperatures

In Service Temperature (°C)	Stage "A" (years)			Stage "B" (years)	Stage "C" (years)	Total Prediction* (years)
	Standard OIT	High Press. OIT	Average OIT			
20	200	215	208	30	208	446
25	135	144	140	25	100	265
30	95	98	97	20	49	166
35	65	67	66	15	25	106
40	45	47	46	10	13	69

*Total = Stage A (average) + Stage B + Stage C

Exposed geomembrane lifetime was addressed from the perspective of field performance which is very unequivocal. Experience in Europe, mainly with relatively thick PVC containing high molecular weight plasticizers, has given 25-years of service and the geomembranes are still in use. Experience in the USA with exposed geomembranes on flat roofs, mainly with EPDM and CSPE, has given 20^{+}-years of service. The newest geomembrane type in such applications is fPP which currently carries similar warranties.

Rather than using the intricate laboratory setups of Figure 1 which are necessary for covered geomembranes, exposed geomembrane lifetime can be addressed by using accelerating laboratory weathering devices. Here it was shown that the UV fluorescent device (per ASTM D7238 settings) versus the Xenon Arc device (per ASTM D 4355) is equally if not slightly more intense in its degradation capabilities. As a result, all further incubation has been using the UV fluorescent devices per D7238 at 70°C.

Archived flexible polypropylene geomembranes at four field failure sites resulted in a correlation factor of 1200 light hours equaling one-year performance in a hot climate. Using this

value on the incubation behavior of seven commonly used geomembranes has resulted in the following conclusions (recall Figure 6 and Table 6);

- HDPE geomembranes (per GRI-GM13) are predicted to have lifetimes greater than 36-years; testing is ongoing.
- LLDPE geomembranes (per GRI-GM17) are predicted to have lifetimes of approximately 36-years.
- EPDM geomembranes (per GRI-GM21) are predicted to have lifetimes of greater than 27-years; testing is ongoing.
- fPP geomembranes (per GRI-GM18) are predicted to have lifetimes of approximately 30-years.
- PVC geomembranes are very dependent on their plascitizer types and amounts, and probably thicknesses as well. The North American formulation has a lifetime of approximately 18-years, while the European formulation is still ongoing after 32-years.

Regarding continued and future recommendations with respect to lifetime prediction, GSI is currently providing the following:

(i) Continuing the exposed lifetime incubations of HDPE, EPDM and PVC (European) geomembranes at 70°C.

(ii) Beginning the exposed lifetime incubations of HDPE, LLDPE, fPP, EPDM and both PVC's at 60°C and 80°C incubations.

(iii) With data from these three incubation temperatures (60, 70 and 80°C), time-temperature-superposition plots followed by Arrhenius modeling will eventually provide information such as Table 2 for covered geomembranes. This is our ultimate goal.

(iv) Parallel lifetime studies are ongoing at GSI for four types of geogrids and three types of turf reinforcement mats at 60, 70 and 80°C.

(v) GSI does not plan to duplicate the covered geomembrane study to other than the HDPE provided herein. In this regard, the time and expense that would be necessary is prohibitive.

(vi) The above said, GSI is always interested in field lifetime behavior of geomembranes (and other geosynthetics as well) whether covered or exposed.

Acknowledgements

The financial assistance of the U. S. Environmental Protection Agency for the covered HDPE lifetime study and the member organizations of the Geosynthetic Institute and its related institutes for research, information, education, accreditation and certification is sincerely appreciated. Their identification and contact member information is available on the Institute's web site at <<geosynthetic-institute.org>>.

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C-147 and
Site Specific Information

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

District I
1625 N. French Dr., Hobbs, NM 88240
District II
811 S. First St., Artesia, NM 88210
District III
1000 Rio Brazos Road, Aztec, NM 87410
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505

State of New Mexico
Energy Minerals and Natural Resources
Department
Oil Conservation Division
1220 South St. Francis Dr.
Santa Fe, NM 87505

Form C-147
Revised March 31, 2015

Recycling Facility and/or Recycling Containment

Type of Facility: ☒ Recycling Facility ☒ Recycling Containment*****

Type of action: ☒ Permit ☒ Registration
☐ Modification ☐ Extension
☐ Closure ☐ Other (explain) _____

*** At the time C-147 is submitted to the division for a Recycling Containment, a copy shall be provided to the surface owner.**

Be advised that approval of this request does not relieve the operator of liability should operations result in pollution of surface water, ground water or the environment. Nor does approval relieve the operator of its responsibility to comply with any other applicable governmental authority's rules, regulations or ordinances.

1.
Operator: AMTEX Energy, Inc. (For multiple operators attach page with information) OGRID #: 000785
Address: PO Box 3418, Midland, Texas 79702
Facility or well name (include API# if associated with a well): Dagger Containment and Recycling Facility adjacent to API #30-025-43302
OCD Permit Number: _____(For new facilities the permit number will be assigned by the district office)
U/L or Qtr/Qtr H Section 30 Township 21S Range 33E County: Lea
Surface Owner: ☐ Federal ☒ State ☐ Private ☐ Tribal Trust or Indian Allotment

2.
☒ **Recycling Facility:**
Location of recycling facility (if applicable): Latitude 32.448578 Longitude -103.604951 NAD: ☒1927 ☐ 1983 Approx. center Google Earth
Proposed Use: ☒ Drilling* ☒ Completion* ☒ Production* ☒ Plugging *
The re-use of produced water may NOT be used until fresh water zones are cased and cemented
☐ Other, ***requires permit for other uses. Describe use, process, testing, volume of produced water and ensure there will be no adverse impact on groundwater or surface water.***
☒ Fluid Storage
☒ Above ground tanks ☒ Recycling containment ☐ Activity permitted under 19.15.17 NMAC explain type_____
☐ Activity permitted under 19.15.36 NMAC explain type:_____ ☐ Other explain _____
☐ For multiple or additional recycling containments, attach design and location information of each containment
☐ **Closure Report (required within 60 days of closure completion):** ☐ Recycling Facility Closure Completion Date:_____

3.
☒ **Recycling Containment: AMTEX Dagger Containment**
☐ Annual Extension after initial 5 years (attach summary of monthly leak detection inspections for previous year)
Center of Recycling Containment (if applicable): Latitude 32.448578 Longitude -103.604951 NAD: ☒1927 ☐ 1983
☐ For multiple or additional recycling containments, attach design and location information of each containment
☒ Lined ☒ Liner type: Thickness 60 mil HDPE Primary and 40-mil HDPE Secondary ☐ LLDPE ☒ HDPE ☐ PVC ☐ Other _____
☐ String-Reinforced
Liner Seams: ☒ Welded ☒ Factory ☒ Other Field Welds Volume: 337,000 bbl (249,000 bbls below 3-foot Freeboard)
Dimensions: L 480 x W 372 x D 17.7 (at sump)
☐ Recycling Containment Closure Completion Date:_____

4.

Bonding:

☒ Covered under bonding pursuant to 19.15.8 NMAC per 19.15.34.15(A)(2) NMAC **(These containments are limited to only the wells owned or operated by the owners of the containment.)**

☐ Bonding in accordance with 19.15.34.15(A)(1). Amount of bond $_____ **(work on these facilities cannot commence until bonding amounts are approved)**

☐ Attach closure cost estimate and documentation on how the closure cost was calculated.

5.

Fencing:

☐ Four foot height, four strands of barbed wire evenly spaced between one and four feet

☒ Alternate. Please see registration for secondary fence specifications. As an alternative to a 4-foot barbed-wire fence 8-foot meshed-wire fence, topped with barbed wire was utilized to better deter unauthorized wildlife and human access.

6.

Signs:

☒ 12"x 24", 2" lettering, providing Operator's name, site location, and emergency telephone numbers

☐ Signed in compliance with 19.15.16.8 NMAC

7.

Variances:

Justifications and/or demonstrations that the proposed variance will afford reasonable protection against contamination of fresh water, human health, and the environment.

Check the below box only if a variance is requested:

☒ Variance(s): Requests must be submitted to the appropriate division district for consideration of approval. If a Variance is requested, include the variance information on a separate page and attach it to the C-147 as part of the application.

If a Variance is requested, it must be approved prior to implementation.

8.

Siting Criteria for Recycling Containment

Instructions: The applicant must provide attachments that demonstrate compliance for each siting criteria below as part of the application. Potential examples of the siting attachment source material are provided below under each criteria.

General siting

Ground water is less than 50 feet below the bottom of the Recycling Containment. NM Office of the State Engineer - iWATERS database search; USGS; Data obtained from nearby wells. (Figures 1 & 2)	☐ Yes ☒ No ☐ NA
Within incorporated municipal boundaries or within a defined municipal fresh water well field covered under a municipal ordinance adopted pursuant to NMSA 1978, Section 3-27-3, as amended. (Figure 5) - Written confirmation or verification from the municipality; written approval obtained from the municipality	☐ Yes ☒ No ☐ NA
Within the area overlying a subsurface mine. (Figure 7) - Written confirmation or verification or map from the NM EMNRD-Mining and Minerals Division	☐ Yes ☒ No
Within an unstable area. (Figure 8) - Engineering measures incorporated into the design; NM Bureau of Geology & Mineral Resources; USGS; NM Geological Society; topographic map	☐ Yes ☒ No
Within a 100-year floodplain. FEMA map. (Figure 9)	☐ Yes ☒ No
Within 300 feet of a continuously flowing watercourse, or 200 feet of any other significant watercourse, or lakebed, sinkhole, or playa lake (measured from the ordinary high-water mark). (Figure 3) - Topographic map; visual inspection (certification) of the proposed site	☐ Yes ☒ No
Within 1000 feet from a permanent residence, school, hospital, institution, or church in existence at the time of initial application. - Visual inspection (certification) of the proposed site; aerial photo; satellite image (Figure 4)	☐ Yes ☒ No
Within 500 horizontal feet of a spring or a fresh water well used for domestic or stock watering purposes, in existence at the time of initial application. (Figures 1, 2, & 3) - NM Office of the State Engineer - iWATERS database search; visual inspection (certification) of the proposed site	☐ Yes ☒ No
Within 500 feet of a wetland. (Figure 6) - US Fish and Wildlife Wetland Identification map; topographic map; visual inspection (certification) of the proposed site	☐ Yes ☒ No

9.

Recycling Facility and/or Containment Checklist:

Instructions: Each of the following items must be attached to the application. Indicate, by a check mark in the box, that the documents are attached.

- ☒ Design Plan - based upon the appropriate requirements (Appendix B).
- ☒ Operating and Maintenance Plan - based upon the appropriate requirements (Appendix C).
- ☒ Closure Plan - based upon the appropriate requirements (Appendix D).
- ☒ Site Specific Groundwater Data - (pages immediately following application)
- ☒ Siting Criteria Compliance Demonstrations – (pages immediately following application)
- ☒ **Certify that notice of the C-147 (only) has been sent to the surface owner(s)**

10.

Operator Application Certification:

I hereby certify that the information and attachments submitted with this application are true, accurate and complete to the best of my knowledge and belief.

Name (Print): William J. Savage Title: President

Signature: William J. Savage Date: November 4, 2016

e-mail address: bsavage@amtexenergy.com Telephone: (432) 770-0913

11.

OCD Representative Signature: _____ **Approval Date:** _____

Title: _____ **OCD Permit Number:** _____

☐ OCD Conditions _____

☐ Additional OCD Conditions on Attachment

Geologic Setting of the Regional Fresh-Water Bearing Formations

The recycling containment site is located within the northwest portion of the San Simon Swale, which is on the eastern edge of the Pecos Valley Physiographic Province. Regionally, the San Simon Swale drains from the northwest to the southeast, toward the San Simon Sink, located approximately fifteen miles to the southeast of the site. The San Simon Swale in this area is approximately six miles wide extending from Grama Ridge on the northeast to Antelope Ridge on the southwest (see adjacent map insert). Hat Mesa, to the west of the site, forms an extension of Grama Ridge that protrudes into the San Simon Swale, and is similar to Grama Ridge in both surface geology and elevation. Approximately 330 feet of topographic relief is present from the top of Hat Mesa (3,910 feet ASL) to the valley floor (3,580 feet ASL) located three miles to the south of the site. The elevation of Antelope Ridge is much lower than Hat Mesa, approximately 3750 feet ASL.

Groundwater in the area within and surrounding the San Simon Swale is found only in Mesozoic and Cenozoic Era rocks that were deposited since approximately 235 million years ago. The oldest of these are the Triassic age Dockum Group. They consist of conglomerates, cross-bedded sandstones, claystones, and siltstones that were deposited in a continental fluvial environment over the evaporites of the late Permian Ochoan Series, which had filled the Delaware Basin by that time.

Any Jurassic or Cretaceous age rocks that were deposited above the Triassic have subsequently been removed by erosion leaving an irregular surface on the Triassic rocks. Cenozoic Era rocks in the area consist of the Tertiary age Ogallala Formation and Quaternary age eolian and piedmont deposits. The Ogallala Formation consists of terrestrial sediments (sand with some clay, silt and gravel) that were deposited on the Triassic age rocks. Generally, the Ogallala is capped by a caliche layer, observed at Grama Ridge to the north and Hat Mesa to the west, being resistant to the erosion that shaped the San Simon Swale.

The Ogallala and associated alluvium aquifers are the primary groundwater source where they are present at the higher elevations outside of the San Simon Swale. Water wells drilled within the San Simon Swale target only the Triassic age rocks and are designated by the USGS as producing from either Chinle or Santa Rosa aquifers.

Distance to Groundwater

Figure 1, Figure 2, and the discussion presented below demonstrates that groundwater (fresh water as defined by NMOCD Rules) at the location is greater than 100 feet beneath the containment.

Figure 1 is an area geologic base map that depicts regional topography (metric contour units) and includes the water wells located nearest to the containment site for which information is available, regardless of how comprehensive or useful. It also shows:

1. The location of the recycling containment as a blue rectangle.
2. Water wells from the USGS database as color-coded triangles that indicate the producing aquifer (see Legend).
3. Water wells from the New Mexico Office of the State Engineer (OSE) database as a small blue triangle inside a colored circle that indicates the well depth (see Legend). Please note, OSE wells are often miss-located in the WATERS database as older wells are plotted in the center of the quarter, quarter, quarter, of the Section Township and Range. Topographic maps and/or aerial photographs verified all of the OSE well locations included on this map.
4. Water wells, which are not documented in the public databases but were identified by field inspection or other published reports are shown as a dot inside a color-coded (depth) square.
5. Depth to water and gauging dates from the most recent and reliable measurement for each well is provided adjacent to the well symbol. It should be noted that in most cases the depth to water provided by the OSE database are from drillers log notes estimated at the time of completion, rather than actual field measurements.

Figure 2 is a regional geologic base map (metric contour units) that depicts the potentiometric surface contours of the shallow-most aquifer surrounding the site. The potentiometric contours are labeled in feet above sea level (ASL). The water wells plotted include only the USGS database and published report water wells from Figure 1 for which a reliable depth to water measurement has been recorded. Figure 2 also shows:

1. The location of the containment as a blue rectangle.
2. Groundwater elevations and gauging dates from the most recent available static water level measurement for each well.

Site Geology

The proposed containment is located on an outcrop of Quaternary Age eolian and piedmont deposits (Qe/Qp on Figure 1). These fine-grained sands and clays, along with the Quaternary piedmont deposits and Quaternary lacustrine/playa deposits (Qp and Qpl on Figure 1), are present as a thin covering of the underlying eroded Tertiary or Triassic age rocks. Based on information from Ground-Water Report 6 (GWR-6) *Geology and Ground-Water Conditions in Southern Lea County, New Mexico* by Alexander Nicholson and Alfred Clebsch (1961) and the survey elevation of the site (3,790 feet ASL), the Triassic age rocks are present approximately 121 feet below the proposed containment location.

The surface drainage is generally to the northeast, however the area is covered by low stabilized sand dunes and no continuously flowing or any other significant watercourses are present.

Water Table Elevation

Twenty-five water wells were identified in the area surrounding the containment site (see Figure 1 and 2). A summary of the available water well data, with respect to groundwater elevation, is provided on the table below. In addition to data from the USGS, published, and field verified well information, which is generally considered reliable, the table also includes wells listed on the OSE Waters database. As stated earlier, the groundwater elevations provided for these OSE wells are likely based on driller log notes rather than measurements made under static conditions.

	Well Location						Well Source Information							Groundwater Elevation Data						
Well Numbers (see Map)	Township (south)	Range (east)	Section	Quarter Section OSE protocol (64,	16,	4)	NM-OSE Database	USGS Database	Open File Rpt. 95	GW Report No. 3	GW Report No. 6	USGS Topo Sheet	Aerial Photograph	Field Verification	Surface Elevation (published)	Surface Elevation (Topo Sheet)	Well Total Depth (published)	Depth to Water (published)	Groundwater Elev. (published)	Groundwater Elev. (using topo elev.)	Gauging Date
USGS-888	21	33	2	1	4	4		✓	✓		✓	✓	--	--	3,768	3,768	102	87.5	3,681	3,681	2/22/96
CP 01316/Misc-241	21	33	2	3	2	4	✓					--	--	--		3,780	1,364	1,046		2,734	5/28/14
Misc-237	21	33	2	1	3	2	✓					--	--	--		3,800	1,250	1,025		2,775	5/15/14
USGS-882	21	33	11	1	1	1		✓	✓			✓	--	--	3,820	3,812	195	142.4	3,678	3,670	2/22/96
CP 00578	21	33	11	4	4	3	✓		✓				✓	--		3,795	165	150		3,645	1/6/79
Misc- 72	21	33	18	2	1	1			✓		✓	✓	--	--	3,900	3,885		143	3,757	3,742	6/21/54
Misc- 73	21	33	18	2	1	1			✓			✓	--	--	3,892	3,882	160	148.43	3,744	3,734	11/16/65
USGS-841	21	33	18	4	1	1		✓	✓			✓	--	--	3,855	3,855	123	115.75	3,739	3,739	2/20/96
Misc-71	21	33	25	3	2	4			✓			✓	--	--	3,666	3,662		58.95	3,607	3,603	2/4/71
CP 01349	21	33	27	2	3	1	✓					--	--	--			1188	572			7/18/14
CP 01357	21	33	27	4	3	1	✓						--	--			1286	578			8/26/14
USGS-798	21	33	28	4	2	1		✓	✓		✓	✓	--	--	3,688	3,688	224	178.85	3,509	3,509	2/21/96
CP 00854	21	33	33	1	1	2	✓						✓	--		3,665	950	600		3,065	6/22/96
CP 01356	21	33	33	4	2	2	✓					✓	--	--		3,638	1098	555		3,083	8/9/14
CP 01411	21	33	34		2	2	✓						--	--			1149	800			10/14/14
USGS-893	21	34	5	4	4	1		✓				✓	--	--	3,708	3,708		91.1	3,617	3,617	3/13/96
CP 00791	21	34	6	4	2	4	✓					✓	--	--		3,732	85	55		3,677	6/16/93
USGS-853	21	34	8	2	2	4	✓	✓	✓		✓	✓	--	--	3,705	3,705	120	101.3	3,604	3,604	2/13/96
USGS-716	22	32	14	4	2	3	✓	✓				✓	✓	--	3,717	3,718	435	382.65	3,334	3,335	2/20/96
C 02821/C 02096	22	32	14	4	2	3	✓					✓	✓	--		3,718	540	340		3,378	6/23/01
USGS-604	22	33	12	4	3	1		✓						--	3,531		400	324.95	3,206		3/13/96
USGS-719	22	33	13	1	3	2		✓	✓			✓	--	--	3,514	3,515	508	391.13	3,123	3,124	2/20/96
USGS-744	22	34	8	2	3	2		✓				✓	--	--	3,578	3,573	35	30.84	3,547	3,542	2/16/96
CP 01362	22	34	18	3	4	4	✓						--	--			1032	613			11/4/14
CP 01455	22	34	18	4	1	4	✓						--	--			1033	615			1/22/15

✓ Indicates well was verified, (blank) indicates well not verified, and -- indicates no attempt to verify

Initially, an attempt was made to identify each well using USGS topographic maps. The surface elevation of each well identified on the topographic maps was compared to the published surface elevation, if available. Wells that could not be verified using maps were searched for using current and historic satellite photographs in an effort to identify windmills, tanks, or roads associated with the well. The following comments should be noted from Figure 1 and the table:

- Well USGS-604 is properly located on Figure 1 and Figure 2 according to the USGS latitude and longitude. However, the USGS database information indicates that the well is located in T-23-S instead of T-22-S. The USGS topographic map identifies the "Allred Well" at this location. The datum elevation (3,531 feet) is consistent with the maps at both locations, so the well has been included on the table and figures for this evaluation.
- The "Rogers" well is shown on the USGS topographic map as a twin to USGS-719, but no depth to water information is available so it is not included on the table or Figures.

Hydrogeology

GWR-6 indicates that Ogallala groundwater is not present as a regional aquifer in the area surrounding the recycling containment, but can be found in wells at higher elevations to the north. The nearest water well, designated by the USGS as an Ogallala producer, is USGS-841, located approximately 2.5 miles to the north-northwest. The groundwater elevation from this well and other Ogallala/Bolson wells was used to produce Figure 2, however all of the wells within this area of the San Simon Swale (off the caprock) produce only from Triassic age rocks.

Based on the potentiometric surface contours created using the available measurements from surrounding wells (Figure 2), we conclude that the groundwater elevation at the containment site is approximately 3,460 feet ASL. With a surface elevation of 3,790 feet ASL and a maximum depth of the containment of 20 feet, the depth to groundwater below the containment floor should be approximately 310 feet.

Distance to Surface Water

Figure 3 and the site visit demonstrates that the location is not within 300 feet of a continuously flowing watercourse, or any other significant watercourse, or within 200 feet of any lakebed, sinkhole, or playa lake (measured from the ordinary high-water mark). No continuously flowing watercourses exist within 300 feet of the location. The nearest surface drainage feature (un-named intermittent stream identified on the USGS quadrangle map) is located 2.0 miles to the southeast and 150 feet lower in elevation from the site, as identified in Figure 3.

Distance to Permanent Residence or Structures

Figure 4 and the site visit demonstrates that the location is not within 300 feet from a permanent residence, school, hospital, institution, church, or other structure in existence at the time of initial application.

Distance to Non-Public Water Supply

Figures 1, 2, and 3 demonstrate that the location is not within 500 horizontal feet of a private, domestic fresh water well or spring that less than five households use for domestic or stock watering purposes, or within 1000 horizontal feet of any other fresh water well or spring, in existence at the time of initial application.

- Figure 1 and 2 shows the locations of all area water wells; the nearest fresh water well is USGS-798, which is located 1.7 miles to the east-northeast. There are no known domestic water wells located within the mapping area.
- Figure 3 shows that no springs are identified within the mapping area.

Distance to Municipal Boundaries and Fresh Water Fields

Figure 5 demonstrates that the location is not within incorporated municipal boundaries or defined municipal fresh water well fields covered under a municipal ordinance adopted pursuant to NMSA 1978, Section 3-27-3, as amended.

- The closest municipality is Eunice, NM approximately 30 miles to the east.
- The closest public well field is located approximately 27 miles to the north.

Distance to Wetlands

Figure 6 demonstrates the location is not within 500 feet of wetlands.

- The nearest designated wetlands is Dagger Lake; a "Freshwater Pond" located 2.0 miles to the south-southeast (see photograph).

Distance to Subsurface Mines

Figure 7 and our general reconnaissance of the area demonstrate that the nearest mines are caliche pits.

- The nearest caliche pit is located approximately 1.6 miles to the west-northwest.

Distance to High or Critical Karst Areas

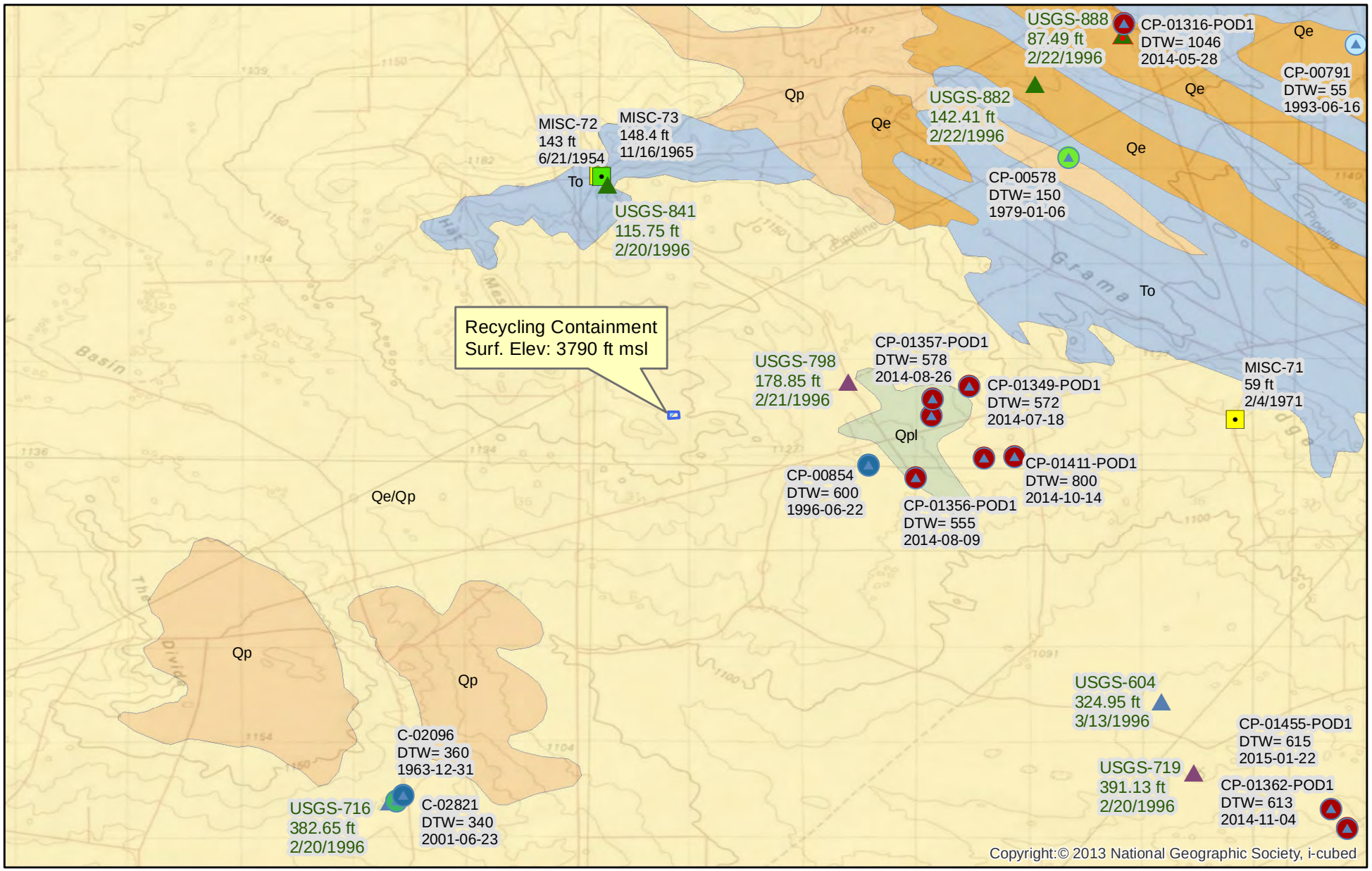
Figure 8 shows the location of the recycling containment with respect BLM Karst areas

- The proposed recycling containment is located within a "low" potential karst area.
- The nearest "high" or "critical" potential karst area is located approximately 12 miles west of the site.
- We saw no evidence of unstable ground near the containment location during the site inspection.

Distance to 100-Year Floodplain

Figure 9 demonstrates that the location is within an area that has not yet been mapped by the Federal Emergency Management Agency with respect to the Flood Insurance Rate 100-Year Floodplain.

- Areas that are not mapped are designated as "Undetermined Flood Hazard" and are generally considered minimal flood risk.
- Our field inspection and examination of the topography permit a conclusion that the location is not within any floodplain.



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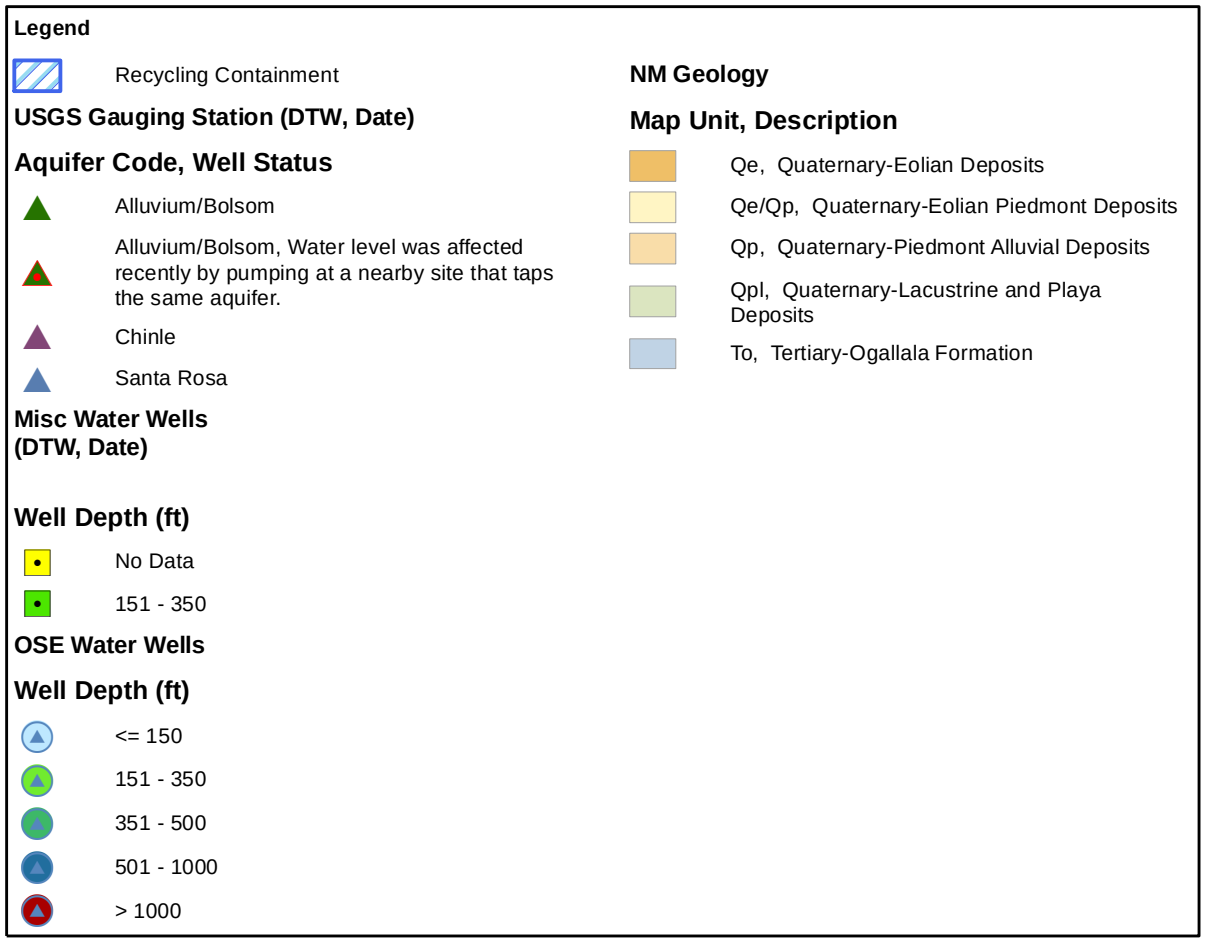
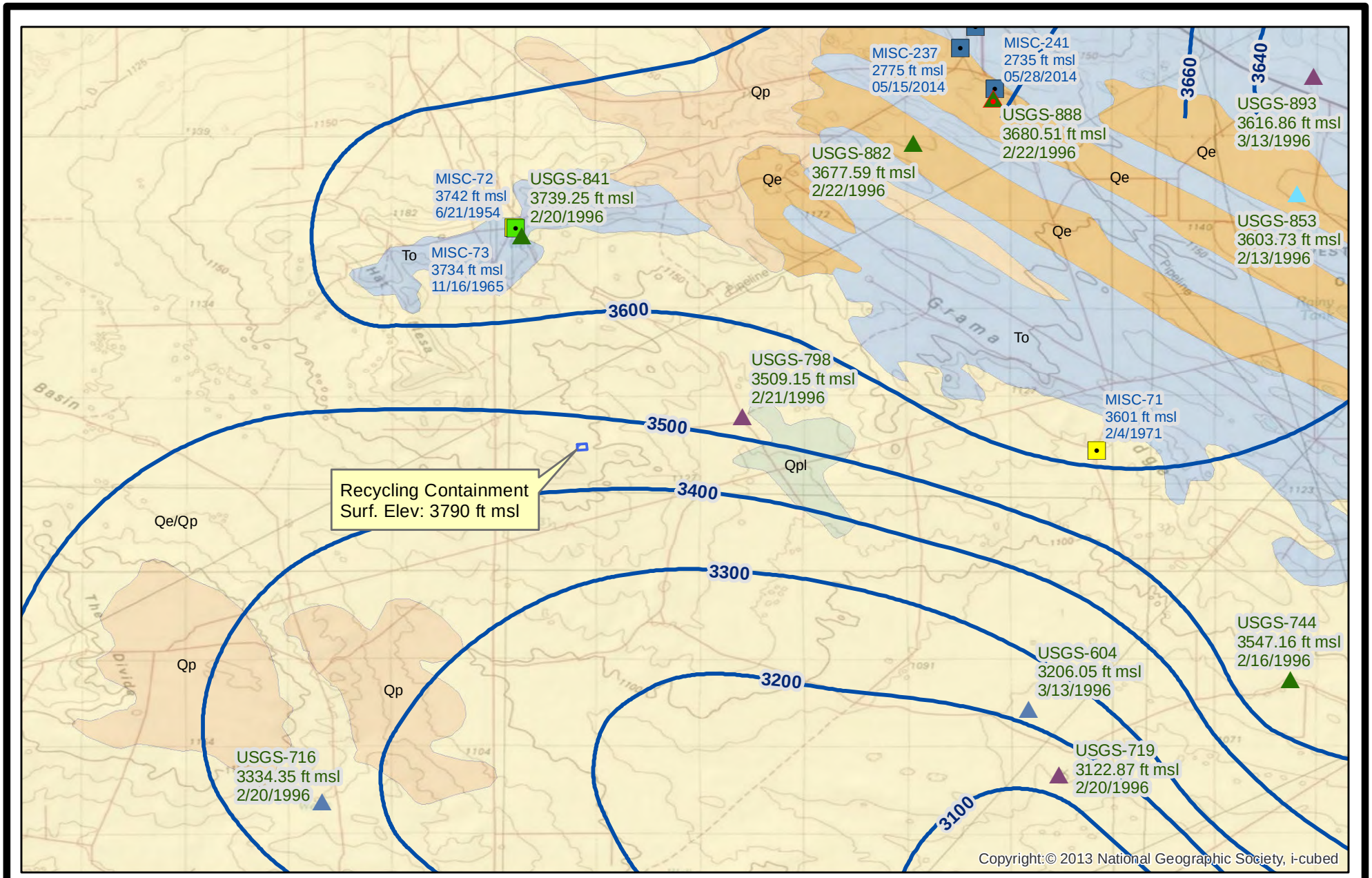
0 1 2 Miles

R.T. Hicks Consultants, Ltd
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

Depth To Water and Geology	Figure 1
Amtex Energy, Inc. - Recycling Containment	October 2016



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Depth To Water and Geology	Figure 1 LEGEND
	Amtex Energy, Inc. - Recycling Containment	October 2016



R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Potentiometric Surface and Groundwater Elevation at Nearby Water Wells	Figure 2
	Amtex Energy, Inc. - Recycling Containment	October 2016

Legend

Recycling Containment

Potentiometric Surface (ft msl)

Isocontour

USGS Gauging Station (GW Elev, Date)

Aquifer Code, Well Status

Alluvium/Bolsom

Alluvium/Bolsom, Water level was affected recently by pumping at a nearby site that taps the same aquifer.

Ogallala

Chinle

Santa Rosa

Misc. Water Wells (GW Elev, Date)

Total Depth (ft)

No Data

151 - 350

> 500

NM Geology

Map Unit, Description

Qe, Quaternary-Eolian Deposits

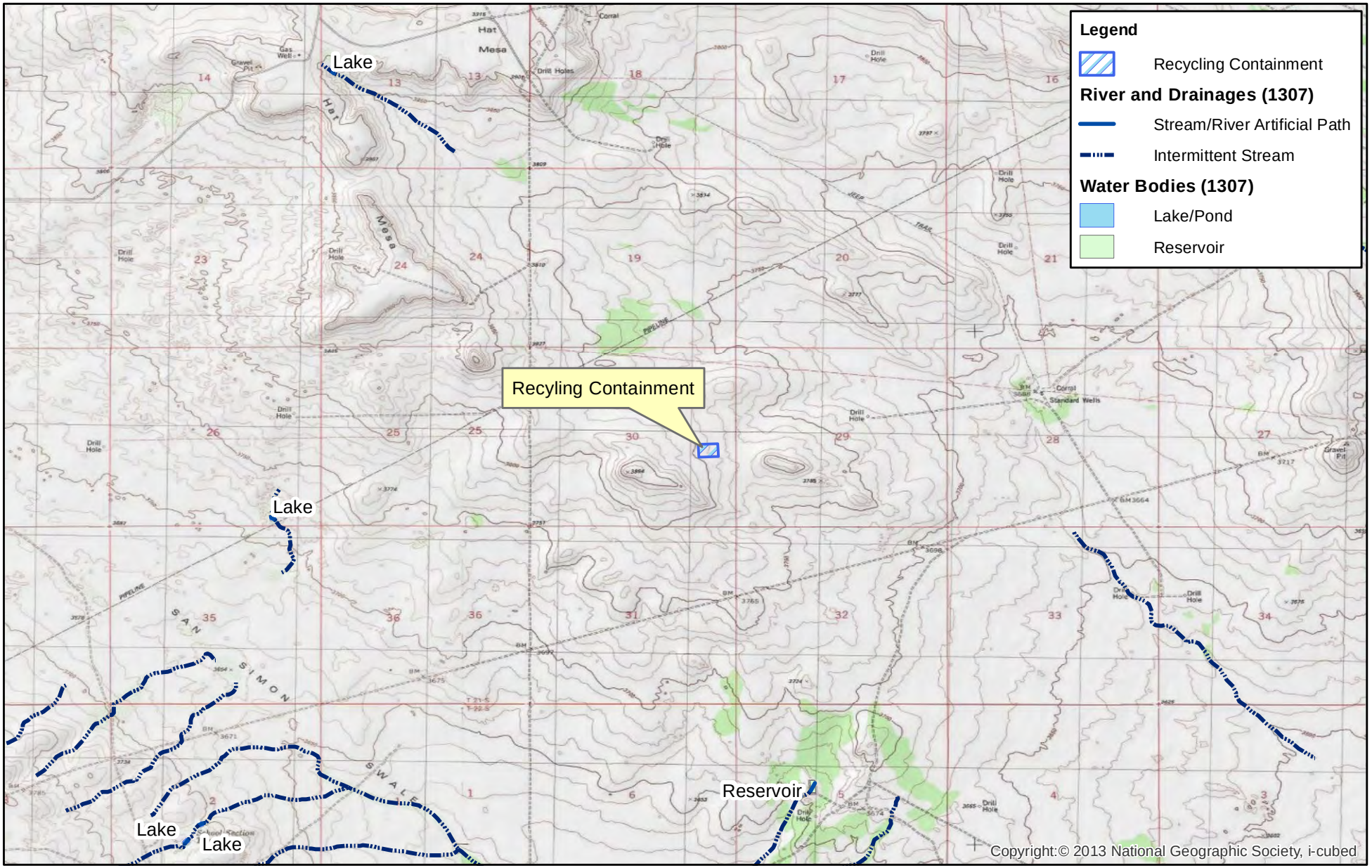
Qe/Qp, Quaternary-Eolian Piedmont Deposits

Qp, Quaternary-Piedmont Alluvial Deposits

Qpl, Quaternary-Lacustrine and Playa Deposits

To, Tertiary-Ogallala Formation

R.T. Hicks Consultants, Ltd 901 Rio Grande Blvd NW Suite F-142 Albuquerque, NM 87104 Ph: 505.266.5004	Potentiometric Surface and Groundwater Elevation at Nearby Water Wells	Figure 2 LEGEND
	Amtex Energy, Inc. - Recycling Containment	October 2016



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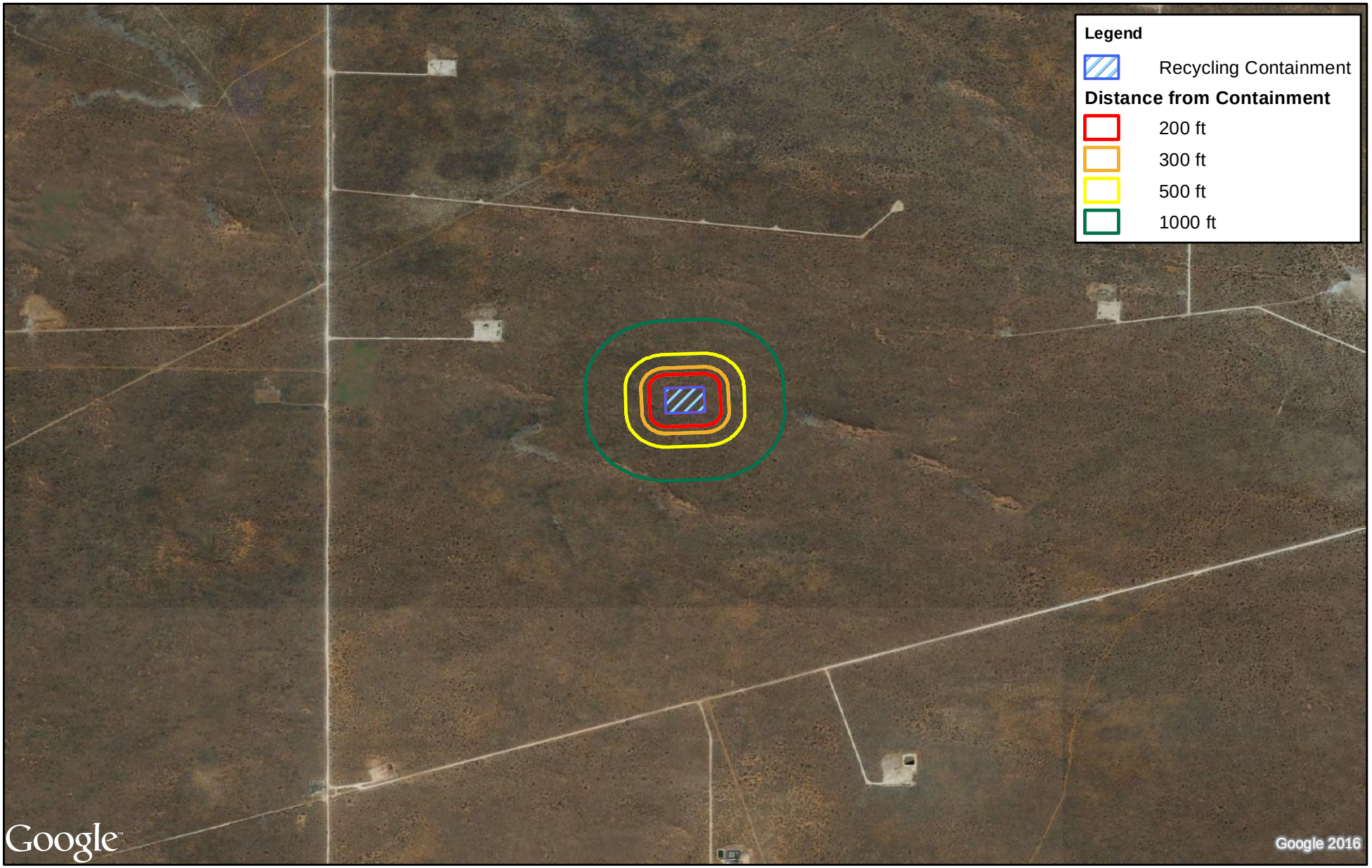
Surface Water and Topography	Figure 3
Amtex Energy, Inc. - Recycling Containment	October 2016



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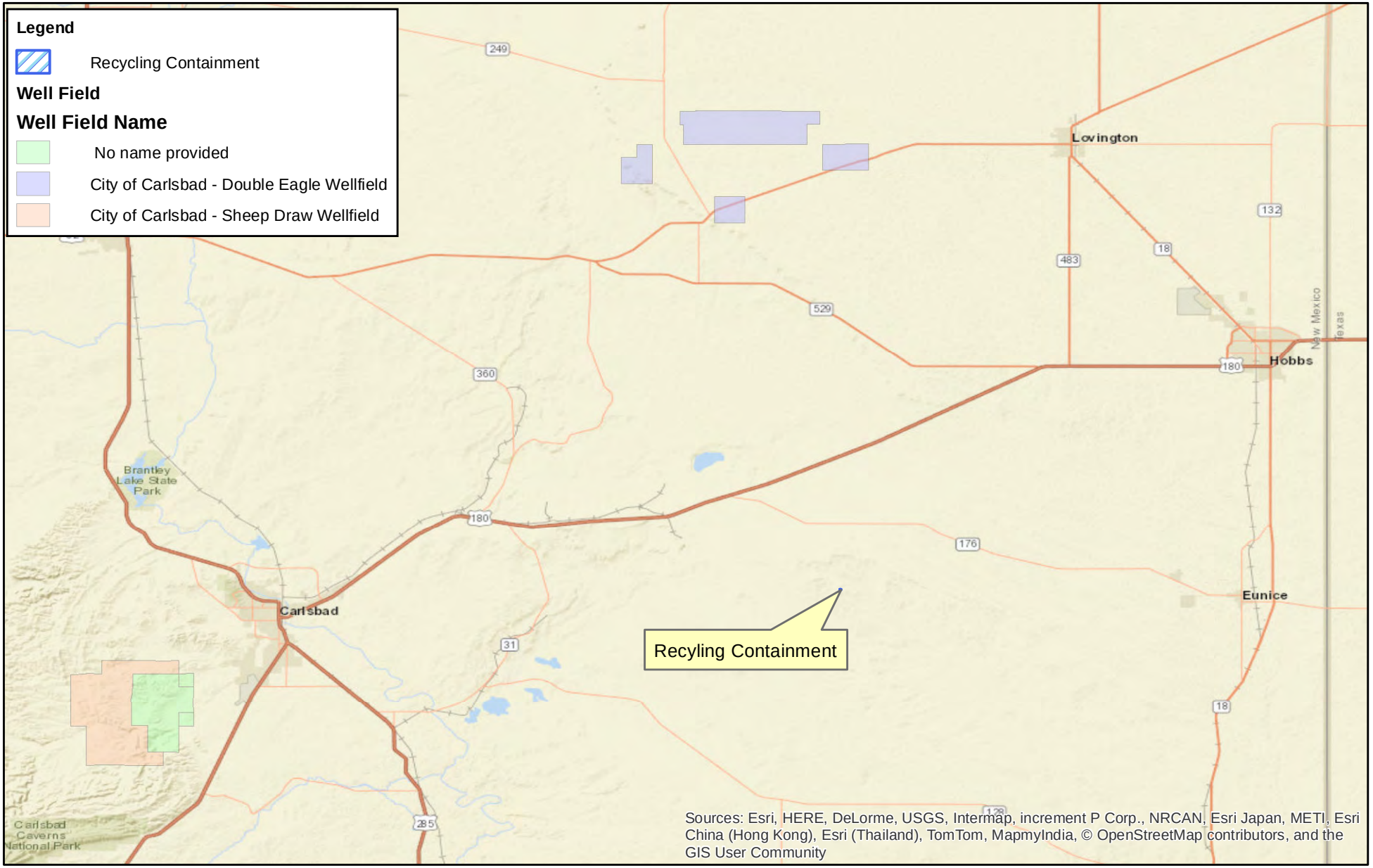
Nearby Structures	Figure 4
Amtex Energy, Inc. - Recycling Containment	October 2016



N W E S

0 5 10 Miles

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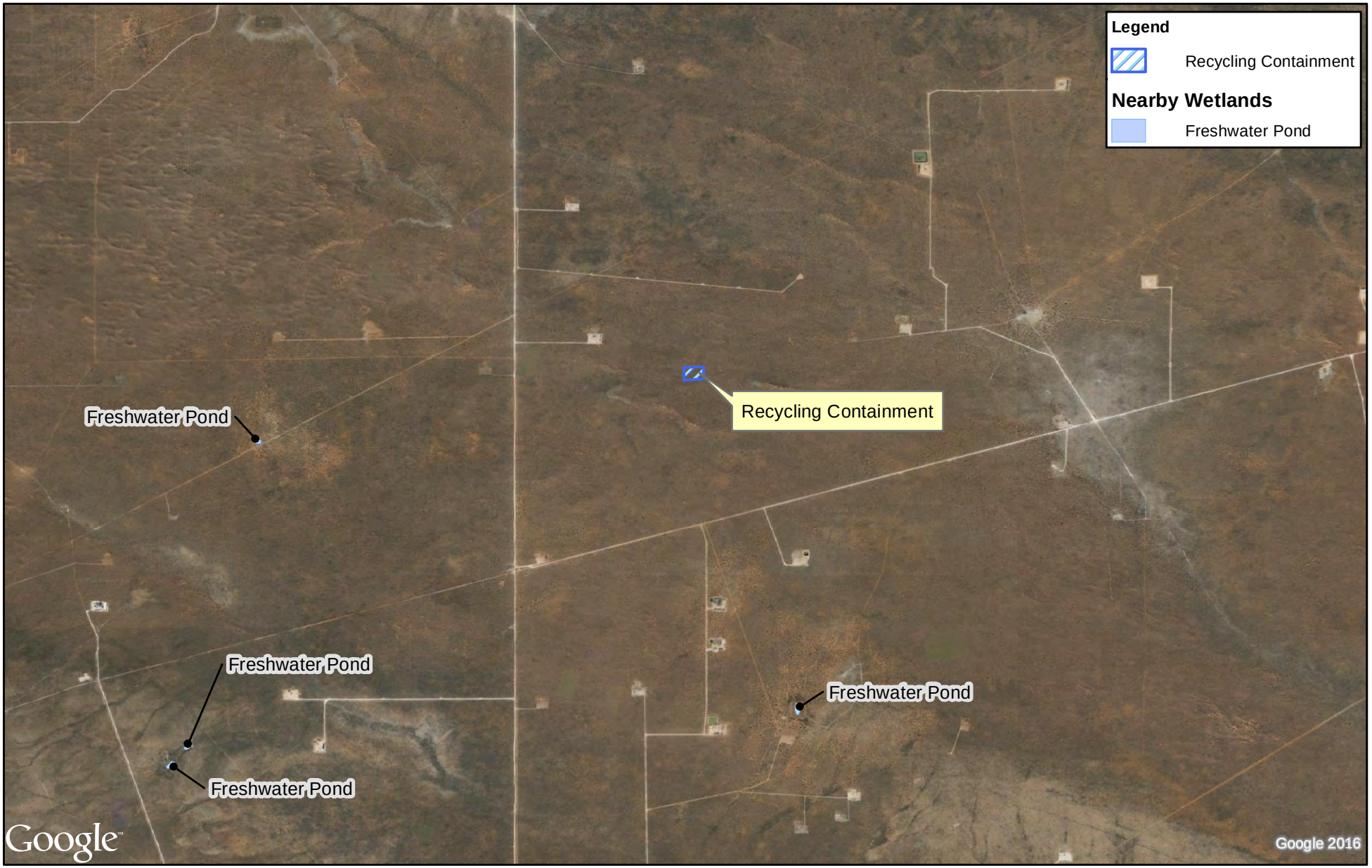
Nearby Municipalities and Well Fields

Figure 5

Amtex Energy, Inc. - Recycling Containment

October 2016



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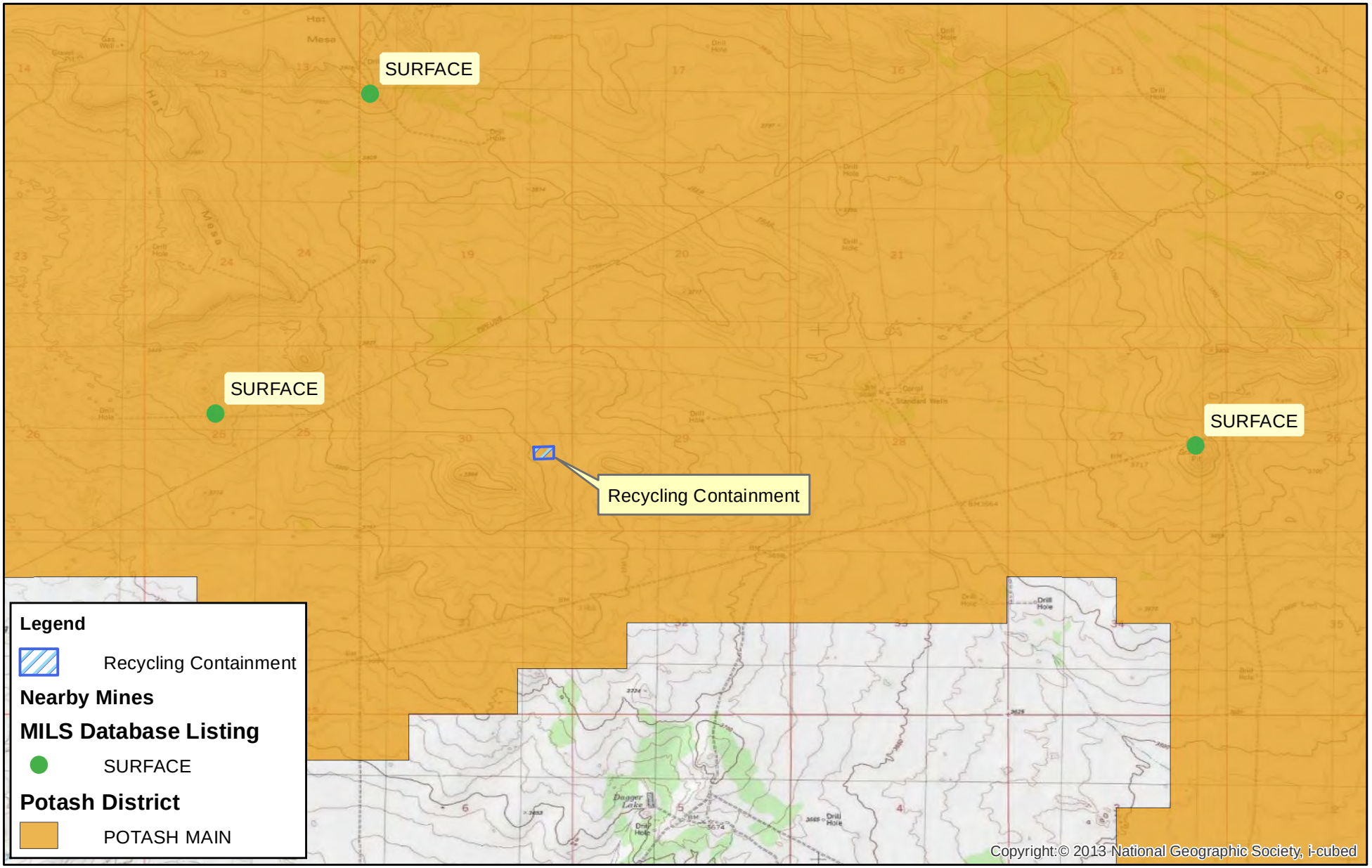
Nearby Wetlands

Figure 6

Amtex Energy, Inc. - Recycling Containment

October 2016



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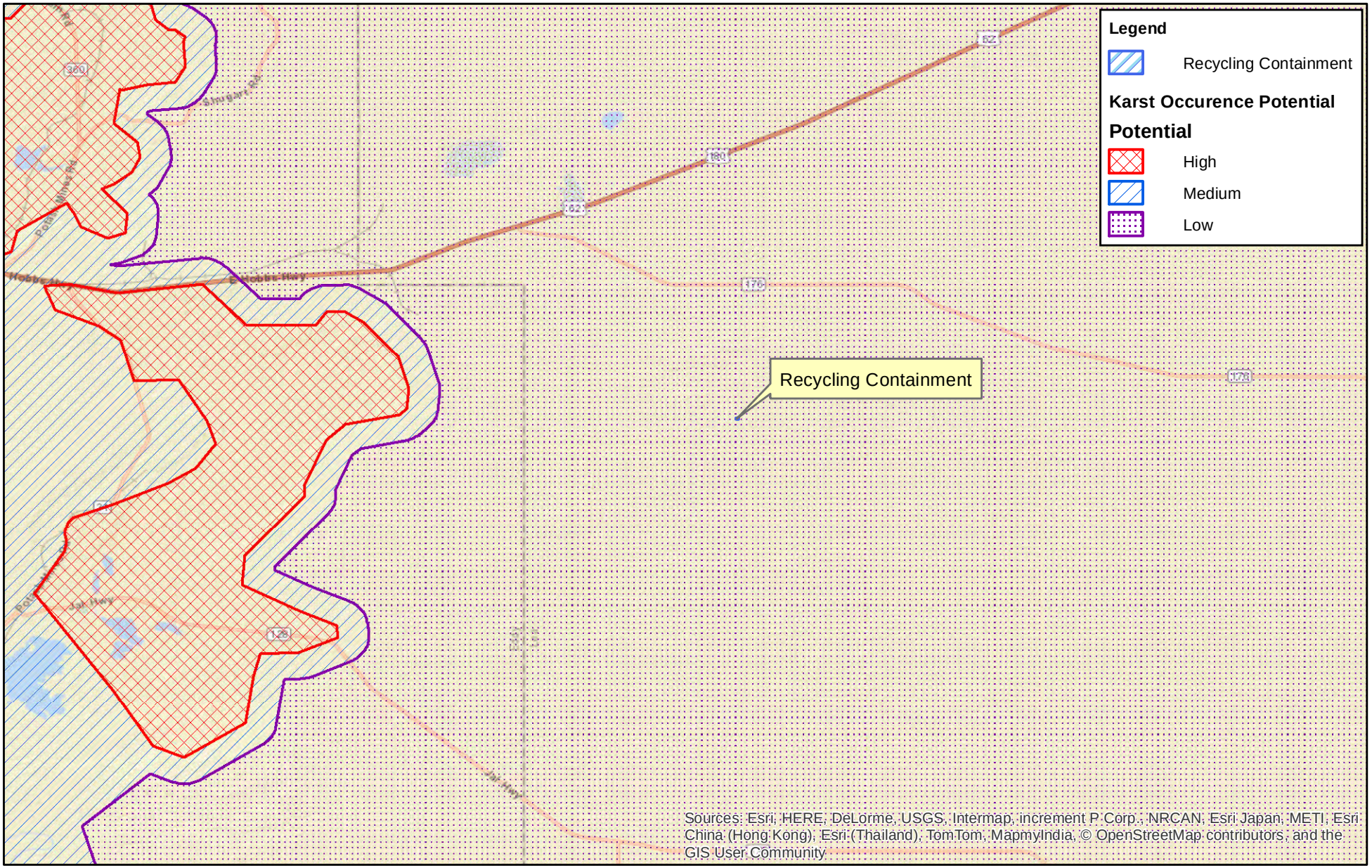
Nearby Mines and Minerals

Figure 7

Amtex Energy, Inc. - Recycling Containment

October 2016



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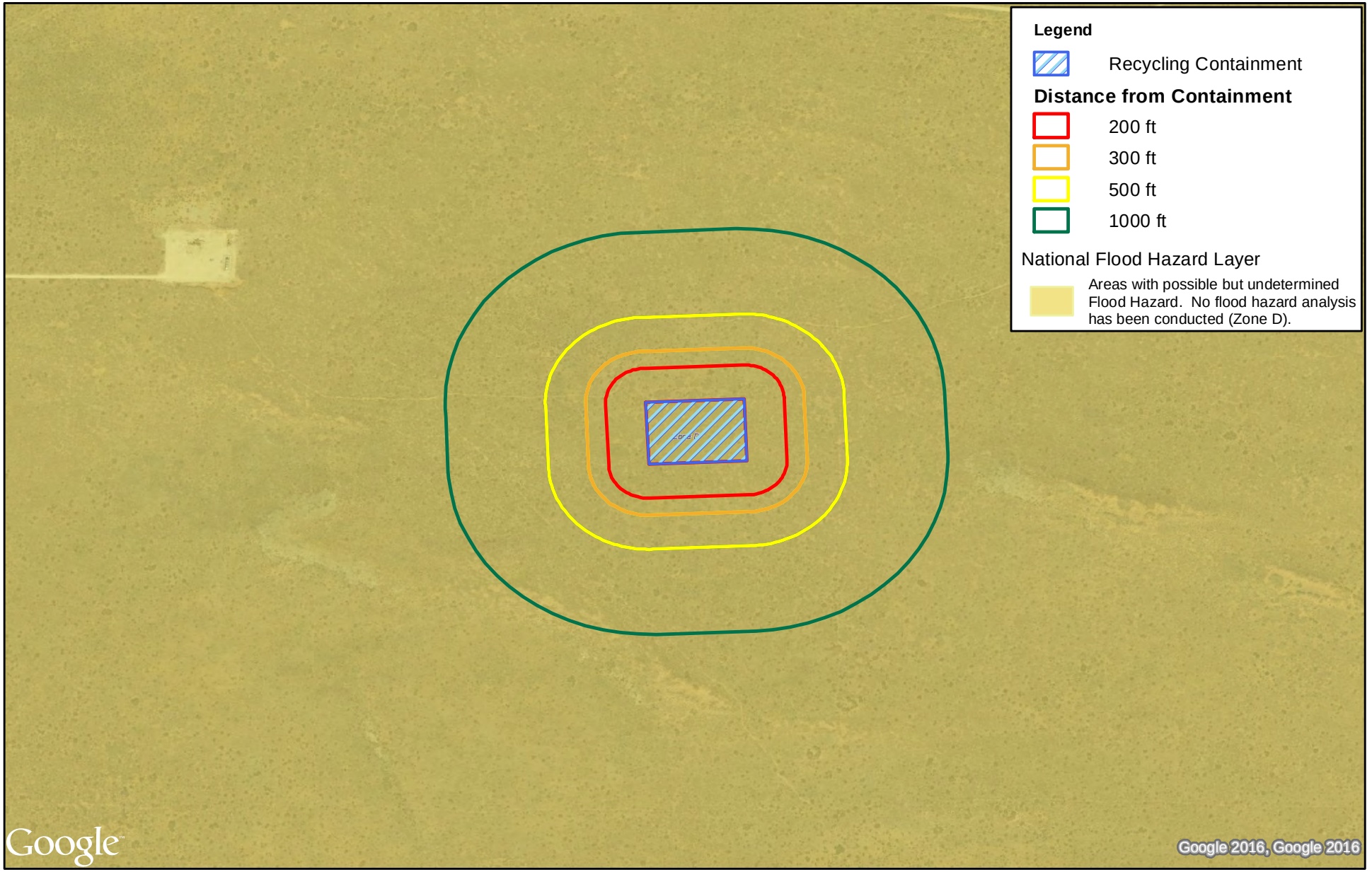
Karst Potential	Figure 8
Amtex Energy, Inc. - Recycling Containment	October 2016



FEMA Source: https://hazards.fema.gov/gis/nfhl/services/public/NFHLWMS/MapServer/WMSServer

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Feet

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Ph: 505.266.5004

FEMA Flood Map	Figure 9
Amtex Energy, Inc. - Recycling Containment	October 2016

View to the west across containment excavation.
Interior walls lower than required 2:1 slope

Typical soil and vegetation surrounding the recycling containment site;
Low, stabilized sand with no rocky outcrops

Relationship to Dagger State COM Well 504H;
view to north along dirt road east of containment

View to the north, dirt road along power line east of containment

Appendix A

Survey of Recycle Pit Topography

Primary Liner Data Sheet (highlighted)

Secondary Liner Data Sheet (highlighted)

Geonet Data Sheet (highlighted)

Liner Installation Manual

Leak Detection and Piping Specifications

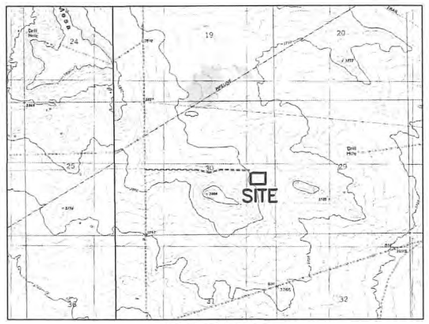
Avian Protection Program

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

AMTEX ENERGY, INC.

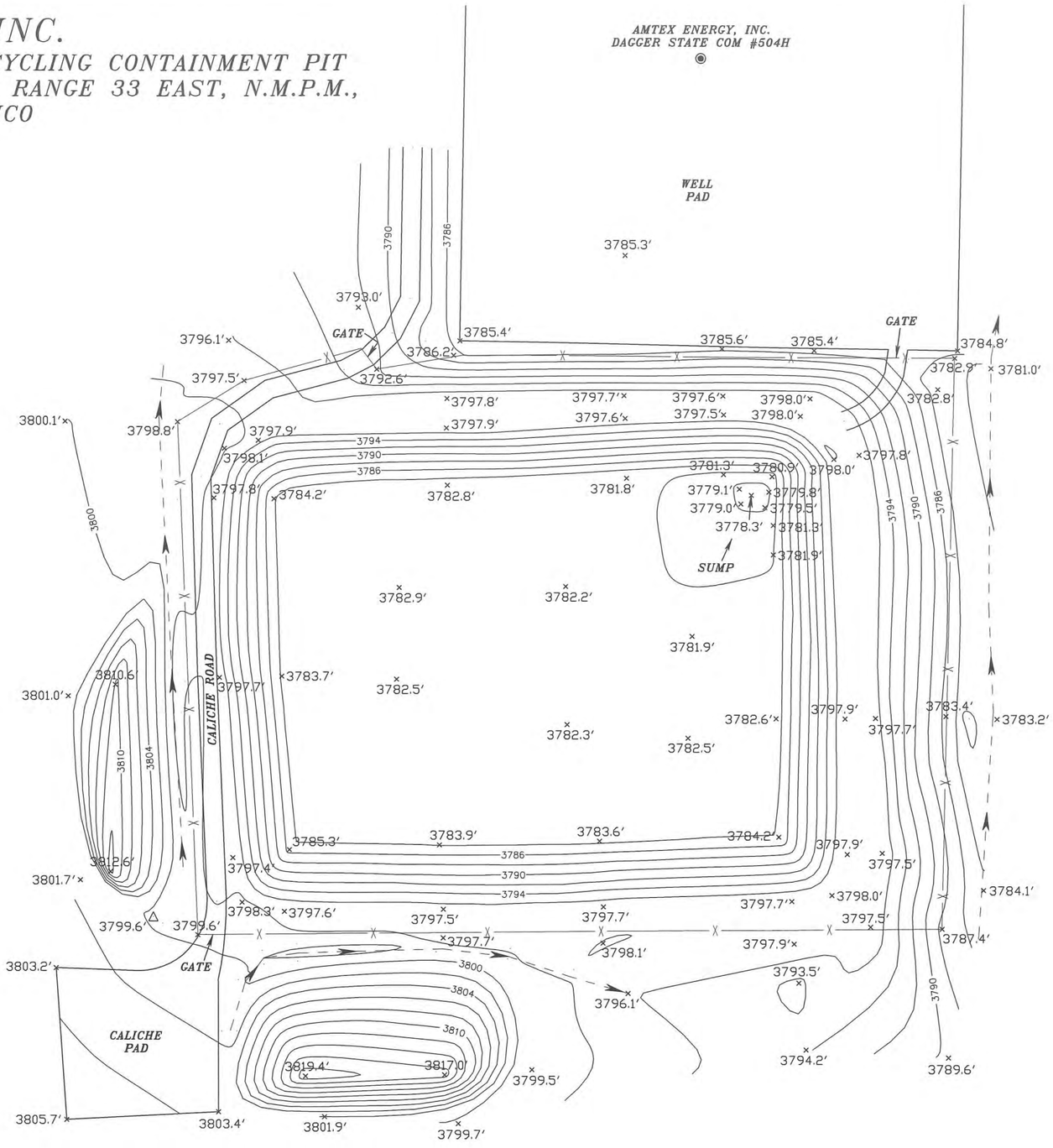
AS-BUILT SURVEY OF A PRODUCED WATER RECYCLING CONTAINMENT PIT LOCATED IN SECTION 30, TOWNSHIP 21 SOUTH, RANGE 33 EAST, N.M.P.M., LEA COUNTY, NEW MEXICO

NORTH



VICINITY MAP

PIT DIMENSION
385' N-S & 480' E-W



LEGEND

- ◉ — DENOTES WELL
- × — DENOTES ELEVATION MARK
- △ — DENOTES CONTROL POINT
- —x— — DENOTES FENCE LINE
- — — — DENOTES DITCH

TERRY J ASEL
NEW MEXICO
15079
REGISTERED PROFESSIONAL LAND SURVEYOR

SURVEYORS CERTIFICATE

I, TERRY J. ASEL, NEW MEXICO REGISTERED PROFESSIONAL LAND SURVEYOR NO. 15079, DO HEREBY CERTIFY THAT I CONDUCTED AND AM RESPONSIBLE FOR THIS SURVEY, THAT THIS SURVEY IS TRUE AND CORRECT TO THE BEST OF MY KNOWLEDGE AND BELIEF, AND MEETS THE "MINIMUM STANDARDS FOR SURVEYING IN NEW MEXICO" AS ADOPTED BY THE NEW MEXICO STATE BOARD OF REGISTRATION FOR PROFESSIONAL ENGINEERS AND SURVEYORS.

Terry J. Asel — N.M. R.P.L.S. No. 15079 — 11/1/2016 DATE

CONTOUR INTERVAL = 2 FT.

100' 0 100' 200 FEET

SCALE: 1"= 100'

P.O. BOX 393 – 310 W. TAYLOR
HOBBS, NEW MEXICO – 575-393-9146

AMTEX ENERGY, INC.	Work Order #161011PIT (Rev. A)
Date Surveyed: 10/11/2016	Surveyed by: Terry Asel
DWG #161011PIT (Rev. A).dwg	Drafted By: Kristie Asel
Scale: 1" = 100'	Sheet 1 of 1

PRODUCT DATA SHEET

GSE HD White/Gray Smooth Geomembrane

Nominal

GSE HD White/Gray is a smooth high density polyethylene (HDPE) geomembrane with a white/gray upper surface. It is manufactured with the highest quality resin specifically formulated for flexible geomembranes. GSE White/Gray has a UV stabilized upper white surface that reflects light, improves damage detection, and reduces wrinkles and sub-grade desiccation. This product is used in applications that require excellent chemical resistance and endurance properties.

AT THE CORE:

An HDPE geomembrane used in applications that require excellent chemical resistance and endurance properties.

Product Specifications

Tested Property	Test Method	Frequency	Nominal Value				
			30 mil	40 mil	60 mil	80 mil	100 mil
Thickness (minimum average), mil	ASTM D 5199	every roll	27	36	54	72	90
Density, g/cm³	ASTM D 1505	200,000 lb	0.940	0.940	0.940	0.940	0.94
Tensile Properties (each direction) Strength at Break, lb/in-width Strength at Yield, lb/in-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in G.L. 1.3 in	20,000 lb	 114 63 700 12	 152 84 700 12	 228 126 700 12	 304 168 700 12	 380 210 700 12
Tear Resistance, lb	ASTM D 1004	45,000 lb	21	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	45,000 lb	54	72	108	144	180
Carbon Black Content, % (Range)	ASTM D 1603*/4218	20,000 lb	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	Note(1)	Note(1)	Note(1)	Note(1)	Note(1)
Notched Constant Tensile Load, hr	ASTM D 5397, Appendix	200,000 lb	300	300	300	300	300
Oxidative Induction Time, mins	ASTM D 3895, 200°C; O_2, 1 atm	200,000 lb	>100	>100	>100	>100	>100
TYPICAL ROLL DIMENSIONS							
Roll Length(2), ft			1,240	940	630	470	370
Roll Width(2), ft			22.5	22.5	22.5	22.5	22.5
Roll Area, ft²			27,900	21,150	14,175	10,575	8,325

NOTES:

- (1)Dispersion only applies to mear spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (2)Roll lengths and widths have a tolerance of ±l%.
- GSE HD is available in rolls weighing approximately 3,900 lb.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77°C when tested according to ASTM D 746.
- *Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

DURABILITY RUNS DEEP

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

PRODUCT DATA SHEET

GSE HD Smooth Geomembrane

Nominal

GSE HD is a smooth high density polyethylene (HDPE) geomembrane manufactured with the highest quality resin specifically formulated for flexible geomembranes. This product is used in applications that require excellent chemical resistance and endurance properties.

AT THE CORE:

An HDPE geomembrane used in applications that require excellent chemical resistance and endurance properties.

Product Specifications

Tested Property	Test Method	Frequency	Nominal Value					
			30 mil	40 mil	60 mil	80 mil	100 mil	120 mil
Thickness (minimum average), mil	ASTM D 5199	every roll	27	36	54	72	90	108
Density, g/cm³	ASTM D 1505	200,000 lb	0.940	0.940	0.940	0.940	0.94	0.94
Tensile Properties (each direction) Strength at Break, lb/in-width Strength at Yield, lb/in-width Elongation at Break, % Elongation at Yield, %	ASTM D 6693, Type IV Dumbbell, 2 ipm G.L. 2.0 in G.L. 1.3 in	20,000 lb	 114 63 700 12	 152 84 700 12	 228 126 700 12	 304 168 700 12	 380 210 700 12	 456 252 700 12
Tear Resistance, lb	ASTM D 1004	45,000 lb	21	28	42	56	70	84
Puncture Resistance, lb	ASTM D 4833	45,000 lb	54	72	108	144	180	216
Carbon Black Content, % (Range)	ASTM D 1603*/4218	20,000 lb	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0-3.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	Note(1)	Note(1)	Note(1)	Note(1)	Note(1)	Note(1)
Notched Constant Tensile Load, hr	ASTM D 5397, Appendix	200,000 lb	500	500	500	500	500	500
Oxidative Induction Time, mins	ASTM D 3895, 200°C; O_2, 1 atm	200,000 lb	>100	>100	>100	>100	>100	>100
TYPICAL ROLL DIMENSIONS								
Roll Length(2), ft			1,240	940	630	470	370	280
Roll Width(2), ft			22.5	22.5	22.5	22.5	22.5	22.5
Roll Area, ft²			27,900	21,150	14,175	10,575	8,325	6,300

NOTES:

- (1)Dispersion only applies to mear spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- (2)Roll lengths and widths have a tolerance of ±l%.
- GSE HD is available in rolls weighing approximately 3,900 lb.
- All GSE geomembranes have dimensional stability of ±2% when tested according to ASTM D 1204 and LTB of <-77°C when tested according to ASTM D 746.
- *Modified.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

GSE ENVIRONMENTAL™

DURABILITY RUNS DEEP

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

PRODUCT DATA SHEET

GSE HyperNet Geonet 150 - 225 mil

GSE HyperNet geonet is a synthetic drainage material manufactured from a premium grade high density polyethylene (HDPE) resin. The structure of the GSE HyperNet geonet is formed specifically to transmit fluids uniformly under a variety of field conditions. The geonet is formulated to be resistant to ultraviolet light for a period of time necessary to complete the installation.

AT THE CORE:

A synthetic geonet engineered specifically to transmit fluids consistently under a variety of field conditions.

Product Specifications

Tested Property	Test Method	Frequency	Minimum Average Roll Value			
			150 mil	175 mil	200 mil	225 mil
Geonet Thickness, mil	ASTM D 5199	1/50,000 ft²	150	175	200	225
Transmissivity, gal/min/ft (m²/sec)	ASTM D 4716	1/540,000 ft²	15 (3.1×10^{-3}) [1]	20 (4.1×10^{-3}) [1]	9.6 (2×10^{-3}) [2]	12 (2.5×10^{-3}) [2]
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94	0.94
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft²	35	40	45	50
Carbon Black Content, %	ASTM D 4218	1/50,000 ft²	2.0	2.0	2.0	2.0
NOMINAL ROLL DIMENSIONS						
Roll Width[3], ft			14.5	15	15	15
Roll Length[3], ft			400	350	330	290
Roll Area, ft²			5,800	5,250	4,950	4,350

NOTES:

- [1]Gradient of 0.1, normal load of 1,000 psf, water at 70° F, between steel plates for 15 minutes. Contact GSE for performance transmissivity value for use in design.
- [2]Gradient of 0.1, normal load of 10,000 psf, water at 70° F, between steel plates for 15 minutes. Contact GSE for performance transmissivity value for use in design.
- [3]Roll widths and lengths have a tolerance of ±1%

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GSE ENVIRONMENTAL™

DURABILITY RUNS DEEP

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

Installation Quality Assurance Manual

Geomembrane Products

GSE

Table of Contents

IQA GEO R03/22/11

1.0 INTRODUCTION

This manual provides an overview of the GSE Installation Quality Assurance procedures consistent with industry accepted practices to ensure that the geomembrane products installed will perform for its intended purpose. In addition, all installation work will be performed in strict accordance per the customer's specifications. Please read the procedures below completely before you begin. If you need further clarification, contact GSE Engineering Support Staff for assistance. Remember safety first and use safe practices always on every project.

2.0 STANDARD TEST METHODS

ASTM D 6392: Standard Test Methods For Determining The Integrity Of Non-Reinforced Geomembrane Seams Produced Using Thermo Fusion Methods

ASTM D 5820: Standard Practice For Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

ASTM D 5641: Standard Practice For Geomembrane Seam Evaluation By Vacuum Chamber

ASTM D 6497: Standard Guide For Mechanical Attachment of Geomembrane to Penetrations or Structures

ASTM D 7240: Standard Practice for Leak Location using Geomembranes with an Insulating Layer in Intimate Contact with a Conductive Layer via Electrical Capacitance Technique (Conductive Geomembrane Spark Test)

GRI Standard GM13: Test Properties, Testing Frequency and Recommended Warranty for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes

GRI Standard GM14: Selecting Variable Intervals for Taking Geomembrane Destructive Seam Samples Using the Method of Attributes

GRI Standard GM17: Test Properties, Testing Frequency and Recommended Warranty for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes

GRI Standard GM19: Standard Specification for Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

3.0 MATERIAL DELIVERY

A. Upon arrival on site, the QA personnel will inventory all materials on the job site.

B. Roll numbers of geomembrane will be logged on the Inventory Check List (Appendix A) and cross-referenced with the Bill of Lading for materials supplied by GSE.

C. Copies of the Inventory Check List and signed Bill of Lading should be sent to the GSE's corporate headquarters while the QA personnel retains the original copies.

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D. Any visible damage to roll materials should be noted on the roll and Inventory Check List.

4.0 EARTHWORK

A. The general contractor is responsible for preparing and maintaining the subgrade. The subgrade should be prepared and maintained per the job specifications.

B. The site manager shall be responsible for assuring that the subgrade surface has been properly prepared for deployment of geosynthetics. After each day's deployment the Subgrade Surface Acceptance form (Appendix B) will be signed by all parties.

5.0 PANEL PLACEMENT

A. Each panel will be assigned a number as described below.

1. When there is one layer, panels may be designated with only a number, i.e...1, 2, 3, 4 etc.

2. When two or more layers are required, use a letter and number, i.e....
   Primary Liner P1, P2, P3, P4 etc...
   Secondary Liner S1, S2, S3, S4 etc...
   Tertiary Liner T1, T2, T3, T4 etc...

B. This numbering system should be used whenever possible. Agreement to a panel numbering system should be made at the pre-construction meeting. However, it is essential that the installer, the owner representative and third party QA inspector agree.

C. Panel numbers shall be written in large block letters in the center of each deployed panel. The roll number, date of deployment and length (gross) should be noted below the panel number. All notes should be made, so that they are easily visible from a distance. On long panels it is beneficial to write information on both ends.

D. Panel numbers shall be logged on the Panel Placement Log (Appendix C) along with the roll number and other information neccessary to complete the form.

E. If there is a partial roll left after deployment, it is important to write the last four digits of the roll number in several locations on the roll along with the estimated length for future identification.

F. Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:

1. Unroll geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage. GSE Conductive should be installed with Conductive layer facing down.

2. Place temporary ballast, such as sangbags, on geomembrane that will not damage the geomembrane and to prevent wind uplift.

3. Personnel walking on geomembrane shall not engage in activities or wear shoes that could

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damage it. Smoking is not permitted on the geomembrane.

4. Do not allow heavy vehicular traffic directly on geomembrane. Rubber tired and tracked ATV's and equipment are acceptable if contact pressure is less than 8 psi.

   a. Protect geomembrane in areas of heavy traffic by placing protective cover over the geomembrane.

   b. Prior to driving on any geomembrane layer, please check for sharp edges, embedded rocks, or other foreign objects that may protrude in the tires and tracks.

   c. Path driven on geomembranes shall be as straight as possible with no sharp turns, sudden stops or quick starts.

   d. Areas where driving occurs shall be continuously and thoroughly inspected throughout the deployment process by the contractor and the third party CQA.

6.0 TRIAL WELDS

A. Seaming apparatus shall be allowed to warm up a minimum of 10 minutes before performing trial welds.

B. Each seaming apparatus along with a welding technician will pass a trial weld prior to use. Trial welds to be performed in the morning and afternoon, as a minimum, as well as whenever there is a power shutdown.

C. Fusion or wedge welds will always be performed or conducted on samples at least 6.0 ft long. Extrusion welds will be done on samples at least 3.0 ft long.

Note: Always perform trial welds in the same conditions that exist on the job. Run the trial welds on the ground, not the installed liner. Do not use a wind break unless you are using one on the job.

D. Operating temperatures should be monitored while welding. The welding technician should verify that the equipment is capable of maintaining temperature while welding.

E. Sampling Procedure

1. Cut five 1.0 in wide specimens from the trial weld sample. Specimens will always be cut using a 1.0 in die cutter, so the peel values may be used for qualitative analysis.

2. When cutting coupons from the trial weld samples, the inside and outside tracks on the coupon should be identified to assist in troubleshooting problems in case the weld fails. The outside track will be defined as the track, which would be peeled if pulling the overlap exposed in a typical installation, or the seam that is closest to the edge of the top sheet. The inside track is the seam closest to the edge of the bottom sheet.

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F. Cutter
1. Only cut one sample at a time to avoid damaging the die cutter.

2. Samples should be free of sand and grit prior to cutting sample.

3. Inspect the die edge weekly for nicks, dents or signs of dullness. Dullness of the cutting edge may damage the units.

4. Remove die when edge has been dulled and lightly reshape it with a medium hand file. When wear is excessive return it for a replacement die.

5. When the cutting board becomes deeply scored and/or interferes with coupon cutting it should be replaced.

6. To adjust the depth of the die cut into the cutting board, after replacing the cutting board or sharpening the die, 0.015 in washer shims can be added or removed between the cutting ram and the ram extension. Only add shims when cutting is difficult due to lack of depth of cut.

G. Trial Weld Testing
1. Allow coupons to cool prior to testing. Avoid separating the coupons while hot as failure of the sheet may be initiated and false readings indicated.

2. In extreme heat the coupons may need to be cooled, using water or an insulated cooler prior to peel testing. Lab conditions specify 70 degrees (plus or minus 4 degrees) Fahrenheit. Coupon temperatures greater than 70 degrees may result in lowered strengths.

3. Visually inspect the coupons for squeeze-out, footprint, pressure and general appearance.

4. Each of the five coupons will be tested in peel on the field tensiometer at a separation rate of 2 in per minute (for HDPE). Shear tests, in addition to the peel tests, will be performed.

H. Pass/Fail Criteria
1. Criteria for passing trial welds will be as follows:
   a. Seam must exhibit film tear bond (FTB). Trial welds should have no incursion into the weld.

   b. Peel and shear values shall meet or exceed the values as listed in Appendix D, Table 1 for HDPE smooth or textured sheet (@ 2 in/min).

   c. Peel and shear values shall meet or exceed the values as listed in Appendix D, Table 2 for LLDPE smooth or textured sheet (@ 20 in/min).

   d. Both tracks of fusion welded samples must pass for the trial weld to be considered acceptable. If any of the five coupons fail due to seam incursion (no FTB) or low strength values, the trial weld must be performed again.

e. The QA personnel will give approval to proceed with welding after observing and recording all trial welds.

2. All trial weld data will be logged on the Trial Weld Log (Appendix E).

3. When logging fusion welded peel values on the Trial Weld Log indicate the values. for the outside track first, followed by the inside track.

4. Speed and temperature settings will be recorded for each machine trial weld as appropriate.

7.0 GEOMEMBRANE FIELD SEAMING

A. The seam number takes the identity of the panels on each side. The seam between panels 1 & 2 becomes seam 1/2.

B. Welding technicians will record their initials, machine number, date and time at the start of every seam and on the Seam Log (Appendix F). The technician should also periodically mark temperatures along the seam and at the end of the seam.

C. Approved processes for field seaming and repairing are fusion welding and extrusion welding. All welding equipment shall have accurate temperature monitoring devices installed and working to ensure proper measurement.

D. Fusion welding shall be used for seaming panels together and is not used for patching or detail work. The site manager shall verify that:

1. The equipment used is functioning properly.

2. All work is performed on clean surfaces and done in a professional manner. No seaming will be performed in adverse weather conditions.

E. Extrusion welding shall be used primarily for repairs, patching and special detail fabricating and may be used for seaming. The site manager shall verify that:

1. Equipment used is functioning properly.

2. Welding personnel are purging the extrusion welders of heat degraded extrudate prior to actual use.

3. All work is performed on clean surfaces and done in a professional manner. No seaming will be performed in adverse weather conditions.

F. For seam preparation, the welding technician shall verify that:

1. Prior to seaming, the seaming area is free of moisture, dust, dirt, sand or debris of any nature.

2. The seam is overlapped properly for fusion welding.

3. The seam is overlapped or extended beyond damaged areas at least 4.0 in when extrusion welding.

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4. The seam is properly heat tacked and abraded prior to extrusion welding.

5. Seams are welded with fewest number of unmatched wrinkles or "fishmouths".

G. No seaming will be performed in ambient air temperatures or adverse weather conditions that would jeopardize the integrity of the liner installation.

8.0 FIELD DESTRUCTIVE TESTING

A. Destructive seam tests shall be performed to evaluate bonded seam strength. The frequency of sample removal shall be one sample per 500 ft of seam, unless site specifications differ. Location of the destructive samples will be selected and marked by the QA technician or third party QA inspector. Field testing should take place as soon as possible after seam is completed.

B. Samples should be labeled in numerical order, i.e. DS-1, DS-2 etc....This should carry thru any layer and or multiple ponds, do not start numbering from 1 again. The size of samples and distribution should be approximately 12 in x 39 in (Size may vary depending on job requirements) and distributed as follows:

1. 12 in x 12 in piece given to QA technician for field testing.
2. 12 in x 12 in piece sent to the GSE's corporate headquarters for testing, if required.
3. 12 in x 12 in piece given to third party for independent testing or to archive.

NOTE: All samples will be labeled showing test number, seam number, machine number, job number, date welded and welding tech number.

C. The sample given to the QA technician in the field shall have ten coupons cut and be tested with a tensiometer adjusted to a pull rate as shown below. The strength of four out of five specimens should meet or exceed the values below, and the fifth specimen must meet or exceed 80% of the value below.

1. Seam must exhibit film tear bond (FTB). Welds should have ≤ 25% incursion into the weld.
2. Peel and shear values shall meet or exceed the values as listed in Appendix D, Table 1 for HDPE smooth or textured sheet (@ 2 in/min).
3. Peel and shear values shall meet or exceed the values as listed in Appendix D, Table 2 for LLDPE smooth or textured sheet (@ 20 in/min).

D. All weld destructive test data will be logged on the Destructive Test Log (Appendix G).

E. When logging fusion welded peel values on the Destructive Test Log, indicate the values for the outside track first, followed by the inside track.

F. Test results will be noted in the Destructive Test Log as Pass (P) or Fail (F).

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G. If a test fails, additional samples will be cut, approximately 10 ft on each side of the failed test, and retested. These will be labeled A (After) & B (Before). This procedure will repeat itself until a sample passes. Then the area of failed seam between the two tests that pass will be capped or reconstructed.

9.0 NON-DESTRUCTIVE TESTING

A. All seams shall be non-destructively tested over their full length using an air pressure or vacuum test. The purpose of this test is to check the continuity of the seam.

B. For air pressure testing, the following procedures are applicable to those seams welded with a double seam fusion welder.

1. The equipment used shall consist of an air tank or pump capable of producing a minimum 35 psi and a sharp needle with a pressure gauge attached to insert into the air chamber.

2. Seal both ends of the seam by heating and squeezing them together. Insert the needle with the gauge into the air channel. Pressurize the air channel to 30 psi. Note time test starts and wait a minimum of 5 minutes to check. If pressure after five minutes has dropped less than 2 psi then the test is successful (Thickness of material may cause variance).

3. Cut opposite seam end and listen for pressure release to verify full seam has been tested.

4. If the test fails, follow these procedures.
   a. While channel is under pressure walk the length of the seam listening for a leak.

   b. While channel is under pressure apply a soapy solution to the seam edge and look for bubbles formed by air escaping.

   c. Re-test the seam in smaller increments until the leak is found.

5. Once the leak is found using one of the proceedures above, cut out the area and retest the portions of the seams between the leak areas per 4a to 4b above. Continue this procedure until all sections of the seam pass the pressure test.

6. Repair the leak with a patch and vacuum test.

C. For vacuum testing, the following procedures are applicable to those seams welded with an extrusion welder.

1. The equipment used shall consist of a vacuum pumping device, a vacuum box and a foaming agent in solution.

2. Wet a section with the foaming agent, place vacuum box over wetted area. Evacuate air from the vacuum box to a pressure suitable to affect a seal between the box and geomembrane. Observe the seam through the viewing window for the presence of soap bubbles emitting from the seam.

3. If no bubbles are observed, move box to the next area for testing. If bubbles are observed, mark the area of the leak for repair per section 11.0 and re-test per section 9.0.

Note: If vacuum testing fusion welded seams, the overlap flap must be cut off to perform the tests

4. All non-destructive tests will be noted in the Non-Destructive Logs (Appendixes H-I).

D. For spark testing GSE Conductive geomembranes, ASTM D 7240 will be the procedure, unless otherwise instructed by the engineer client.

10.0 DEFECTS & REPAIRS

A. All seams and non-seam areas of the geomembrane lining system shall be examined for defects.

B. Identification of the defect should be made using the following procedures:
1. For any defect in the seam or sheet that is an actual breach (hole) in the liner, installation personnel shall circle the defect and mark with the letter P along side the circle. The letter P indicates a patch is required.

2. For any defect that is not an actual hole, installation personnel shall circle the defect indicating that the repair method may be only an extruded bead and that a patch is not required.

3. Each suspect area that has been identified as repair shall be repaired in accordance with section 11.0 and in the non-destructively testing per section 9.0. After all work is completed, the site manager will conduct a final walk-through to confirm all repairs have been completed and debris removed. Only after this final evaluation by the site manager, the owner, and the agent shall any material be placed over the installed liner.

11.0 REPAIR PROCEDURES

A. Any portion of the geomembrane lining system exhibiting a defect that has been marked for repair may be repaired with any one or combination of the following procedures:
1. Patching - used to repair holes, tears, undispersed raw materials in the sheet.

2. Grind and Reweld - used to repair small sections of extrusion welded seams.

3. Spot Welding - Used to repair small minor, localized flaws.

4. Flap Welding - Used to extrusion weld the flap of a fusion weld in lieu of a full cap.

5. Capping - Used to repair failed seams.

B. The following conditions shall apply to the above methods:
1. Surfaces of the geomembrane which are to be repaired shall be prepared according to this section.

2. All surfaces must be clean and dry at the time of the repair.

3. All seaming equipment used in repairing procedures shall be qualified.

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4. All patches and caps shall extend at least 4 in beyond the edge of the defect, and all patches must have rounded corners.

5. All cut out holes in liner must have rounded corners of 3.0 in minimum radius.

C. Patches should be labeled in numerical order, i.e. RP-1, RP-2, etc... This should carry through any layer and/or multiple ponds, and do not start with the number 1 again.

12.0 AS-BUILT DRAWINGS

The installer shall provide the following:

A. As-built drawings will be provided at the completion of the project.

B. As-built drawings will include geomembrane panels and panel numbers with the last four digits of the roll number.

C. Panel numbers and the full roll numbers will correspond with the Panel Placement Log(Appendix C).

D. All destructive testing and repair locations will be placed on the as-built drawings.

Appendix A

Inventory Check List

Project: ____________ QA Tech: ____________ Site Mgr.: ____________ Date: ____________

Project #: ____________ Page: ______ of ______

Material	Roll #	Used	Material	Roll #	Used	Material	Roll #	Used	Material	Roll #	Used

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Subgrade Surface Acceptance

Date: _____

Project: _____ **Site Manager:** _____

Project #: _____

Location: _____ **Partial:** _____ **Final:** _____

This document only applies to the acceptability of surface conditions for installation of geosynthetic products. GSE does not accept responsibility for compaction, elevation or moisture content, nor for the surface maintenance during deployment. Structural integrity of the subgrade and maintenance of these conditions are the responsibility of the owner or earthwork contrator.

_____

_____

_____

_____

_____

For GSE Lining Technology, LLC:

_____

_____

For Owner / Contractor:

_____

_____

Acceptance Number: _____ Area Accepted: _____ s.f. Total Area Accepted to date: _____ s.f.

Appendix C

Panel Placement Log

Project Name: _____

Location: _____ Site Supervisor: _____

Job Number: _____ Type of Material: _____

Q.A. Tech.: _____ Sheet Thickness: _____

Panel Number	Roll Number	Deployment Date	Width (Feet)	Length (Feet)	Square Feet	Square Feet (Cumulative)	A/T 1	A/T 2

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Appendix D

Table 1. HDPE Seam Strength Properties

Material (Mil)	Shear Strength (PPI)	Fusion Peel (PPI)	Extrusion Peel (PPI)
40	81	65	52
60	121	98	78
80	162	130	104
100	203	162	130

Table 2. LLDPE Seam Strength Properties

Material (Mil)	Shear Strength (PPI)	Fusion Peel (PPI)	Extrusion Peel (PPI)
40	60	50	48
60	90	75	72
80	120	100	96
100	150	125	120

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Appendix E

Trial Weld Log

Project Name: ____________________ Site Supervisor: ____________________

Location: ____________________ Type of Material: ____________________

Job Number: ____________________ Sheet Thickness: ____________________

Q.A. Tech.: ____________________

Fusion (ppi): Min. Peel ______ Min. Shear ______

Extrusion (ppi): Min. Peel ______ Min. Shear ______

Trial No.	Date of Trial	Time of Trial	Technicians ID Number	Ambient Temp.	WELDER TYPE	Wedge Mass	Speed Preheat	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Pass Fail

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Appendix F

Seam Log

Project Name: _____

Location: _____ Site Supervisor: _____

Job Number: _____ Type of Material: _____

Q.A. Tech.: _____ Sheet Thickness: _____

Seam Number	Time of Weld	Date of Weld	Type of Weld	Length of Seam	Machine Number	Technician ID Number

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Appendix G

Destructive Test Log

Project Name: _____ Site Supervisor: _____ Fusion (ppi) _____ Extrusion (ppi)

Location: _____ Type of Material: _____ Min. Peel _____ Min. Peel _____

Job Number: _____ Sheet Thickness: _____ Min. Shear _____ Min. Shear _____

Q.A. Tech.: _____

Sample Number	Date Welded	Seam Number	Technician ID Number	Machine Type & No.	Location	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Peel ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Shear ppi	Pass/ Fail

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Appendix H

Repair Log - Vacuum Test

Project Name: _____

Location: _____ Site Supervisor: _____

Job Number: _____ Type of Material: _____

Q.A. Tech.: _____ Sheet Thickness: _____

Repair Number	Weld Date	Machine Number	Tech ID	Location	Test Date	Tech ID	Pass/Fail

Appendix I

Non-Destructive Log - Air Test

Project Name: _____

Location: _____ Site Supervisor: _____

Job Number: _____ Type of Material: _____

Q.A. Tech.: _____ Sheet Thickness: _____

Seam Number	Test Date	Technician ID Number	Air Pressure Test		Test Result (P or F)	Location
			psi start	psi finish		

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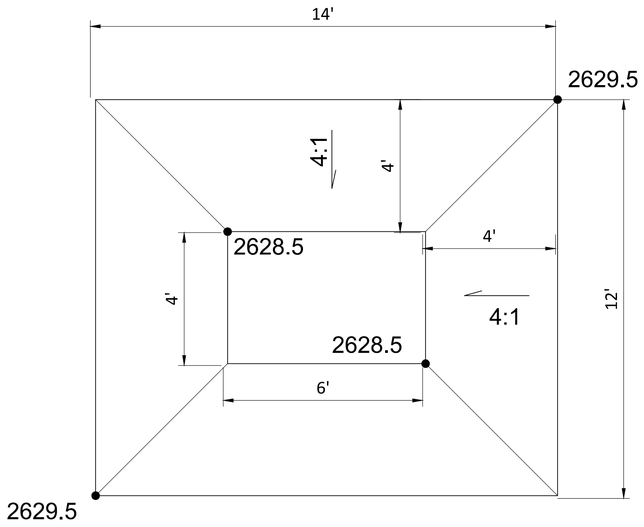
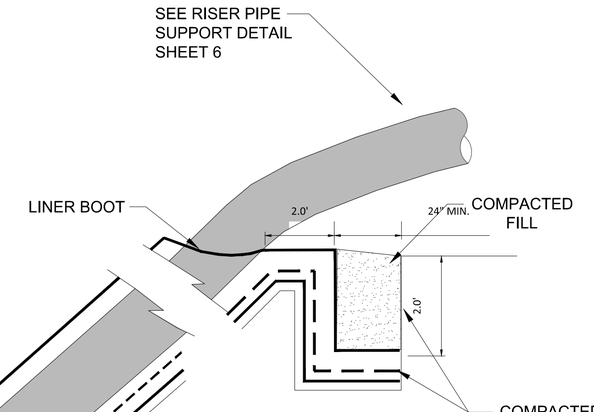


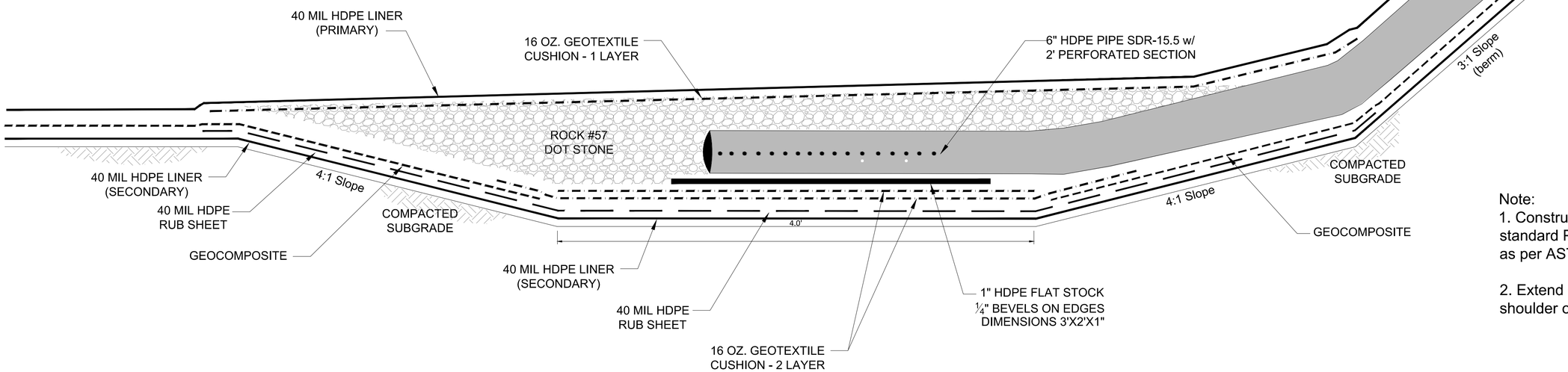
PIT SUMP DETAIL

Not ot Scale



ANCHOR TRENCH DETAIL

Not to Scale



SUMP DETAIL

Not to Scale

Note:
1. Construct compacted subgrade to 90% standard Proctor as per ASTM D-698

2. Extend 40MIL rub sheet 1.0' past top shoulder of sump.

EFFECTIVE WIDE-AREA BIRD CONTROL!

Mega Blaster PRO
sonic bird repeller
covers 30 acres!

- NEMA Rated Case
- Crystal-Clear Digital Sounds

Mega Blaster PRO uses intermittent distress calls to create a "danger zone" that frightens infesting birds away for good.

PREDATOR cries help scare all the birds.

- *Laughing Gull*
- *Ring-Billed Gull*
- *Herring Gull*
- *California Gull*
- *Black-Headed Gull*
- *Glaucous-Winged Gull*
- *Double Crested Cormorant*
- *Marsh Hawk*

Perfect for Landfills, Airfields, Fish Farms, Farm Fields or any multi-acre facility.

Our most powerful system features two high-output amplifiers that drive our specially-designed 20 speaker tower. The intense sound output covers up to 30 acres (12 hectares).

It features solid-state electronics mounted inside a NEMA-type control box, suitable for most any application.

The generating unit mounts easily to a post or pole using the included hardware. The unit comes pre-recorded in four different configurations for the most common bird infestations.

Choose any or all of the 8 sounds, including predators to give the birds even more of a sense of danger. Customize by choosing volume and silent time between sounds.

CONFIGURATIONS AVAILABLE:

- Agricultural
  # MEGA-AG
- Crow / Raven
  # MEGA-CROW
- Woodpecker
  # MEGA-WP
- Marine / Gull
  # MEGA-MAR

Mega Blaster PRO

Complete system includes the generating unit with two built-in high-output amplifiers, 20-speaker tower with audio cables, 40 watt solar panel, battery clips and all mounting hardware.

BIRD-X

The Bird Control 'X'-Perts

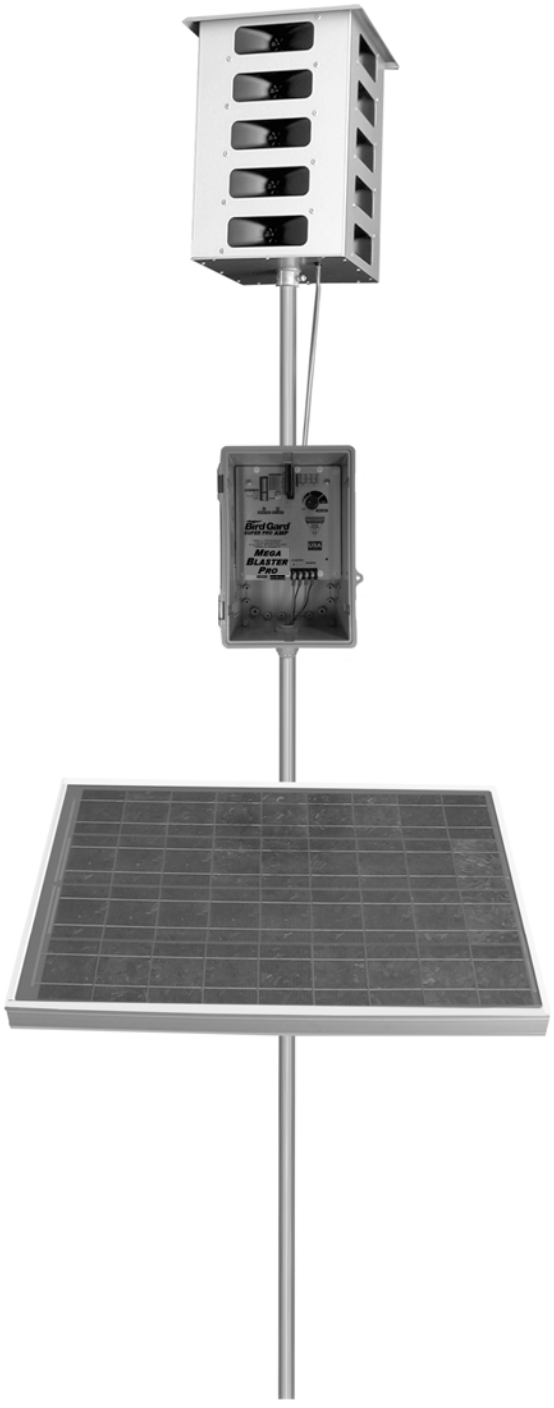
NOTE: This unit is capable of sound output up to 125 decibels. **HEARING PROTECTION IS RECOMMENDED.**

HEARING PROTECTION RECOMMENDED

MEGA BLASTER PRO

BIRD-X

User's Manual



Overview

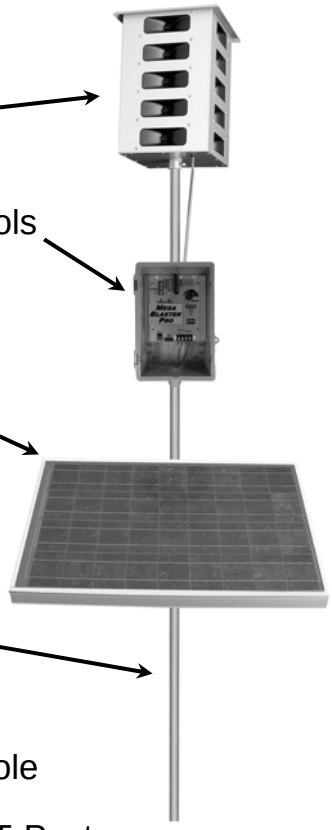
The Bird-X Mega Blaster Pro utilizes the innate power of the natural survival instincts of birds to effectively repel them. Digital recordings of distressed and alarmed birds, along with the sounds made by their natural predators are broadcast through high fidelity weather-resistant speakers over the top of areas. This action triggers a primal fear and flee response. Pest birds soon relocate to where they can feed without feeling threatened.

Your Bird-X Mega Blaster Pro system consists of:

20-Speaker Tower broadcasts the bird sounds

Control Unit produces the bird sounds and contains all operational controls

Solar Panel recharges the 12-volt deep cycle battery



Items needed but <u>not</u> included:

(1) **Mounting Pole** or **Mast** tall enough to raise the 20-Speaker Tower at least 5 feet above the top of the areas, trees or other obstructions

(1) **12-volt Deep Cycle Battery** (RV/Marine) Group 27 or larger wet cell

(1) **T-Post** or similar (Optional) may be needed to support the mounting pole

(1) **Bailing Wire or zip-tie** (Optional) to secure the Mounting Pole to the T-Post

CAUTION: THE MEGA BLASTER PRO IS CAPABLE OF PRODUCING SOUNDS UP TO 125 DECIBELS. PROPER HEARING PROTECTION MUST BE WORN ANYTIME THE UNIT IS TURNED ON.

Bird Control Management Guidelines

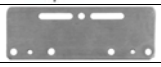
An active bird control management program is a key to successfully repelling pest birds. Bird feeding patterns may take several days or weeks to break. Follow all suggestions for maximum effectiveness. Read all instructions prior to installation.

For best results:

- **It is extremely important to fully protect your entire area from birds.** Any areas not fully protected will allow birds to begin feeding at the fringes of the sound coverage. They will soon become bolder and learn the sounds are nothing to fear. This will cause the effectiveness to diminish. Complete Bird-X product coverage forces birds to leave the area entirely.
- Install the Mega Blaster Pro unit at least two weeks before birds are attracted to your area. It is much easier to keep birds away before they have found a food source than it is to repel them once they have developed a feeding pattern.
- Most birds begin feeding from the perimeter of an area. Place Mega Blaster Pro units so the sound protection covers past the edges of the area.
- Birds will often use tall trees for roosting and observation. If birds are in bordering trees it is necessary to position the units so the sound protection covers the trees as well.
- Mount the 20-Speaker Tower at least five feet above trees, areas and structures for maximum coverage. The higher the better. Sound will disperse or reflect off structures or foliage. Mount control unit out of direct sun, if possible.
- When first installed, run Mega Blaster Pro units at FULL volume and on SHORT time off periods. This ensures maximum “bird stress” and creates a hostile environment.
- Watch for changes in bird activity and adjust the location of your Mega Blaster Pro unit if needed.
- **Check the battery and unit settings often to insure continuous bird control. Be certain that the system is not turned down or has a dead battery. Field hands or harvesters may turn down the volume.**
- Changing settings and switches often helps to prevent bird habituation. Periodically change the switch settings of the eight sounds (turning them ON or OFF). NEVER turn OFF the distress calls of the target birds you are trying to repel and always keep at least one predator bird sound turned ON.
- If different bird species enter the protected area and begin causing damage contact us immediately for an updated Sound Recording Card designed to repel the new invading birds.
- Remember that the Mega Blaster Pro system is a management tool, and should be used as part of your overall bird control strategy, sometimes in conjunction with other bird control techniques and devices.

Be aware that under extreme drought or other adverse conditions, birds will disregard all deterrents and risks in order to survive

Materials List

Item	Qty		Notes
Mega Blaster Pro Control Box	1		
Sound Recording Card	1		Pre-installed in control box
20-Speaker Tower	1		
Control Box Mounting U-Bolts	2		1/4” x 1” x 2”
Control Box Brackets	2		
40-Watt Solar Panel	1		
Solar Panel Mounting Bracket	1		
Solar Panel Mounting U-Bolts	2		1/4” x 1-1/8” x 2”
Control Box Connector Cable	1		2 Wire, 4 ft. Long
Battery Box	1		

Assembly

Note: You will find it easier to pre-assemble the following components prior to installation in the field.

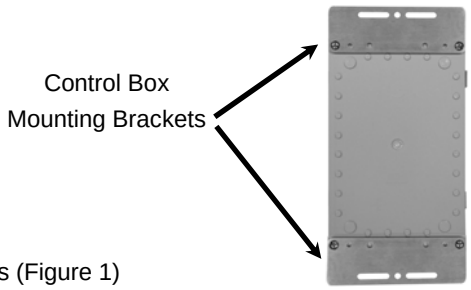


Figure 1

Control Unit

1. Lay the Control Unit face down
2. Attach the two Control Box Mounting Brackets to the back with the included screws (Figure 1)

Solar Panel

3. Install the two Solar Panel Mounting U-Bolts in the Head of the Solar Panel Mounting Bracket (Figure 2)
4. Loosen, but do not remove the Carriage Bolts securing the movable Clamp Plates on the Solar Panel Mount Bracket
5. Lay the solar panel on a flat surface with the glass side down
6. Lay the Mounting Arm across the Solar Panel with the Clamp Plates down. Position the Mounting Arm at an angle so the Clamp Plates slide under the lip of the Solar Panel (Figure 3A)
7. Rotate the Mounting Arm and secure it to the Solar Panel by tightening the Carriage Bolts (Figure 3B)

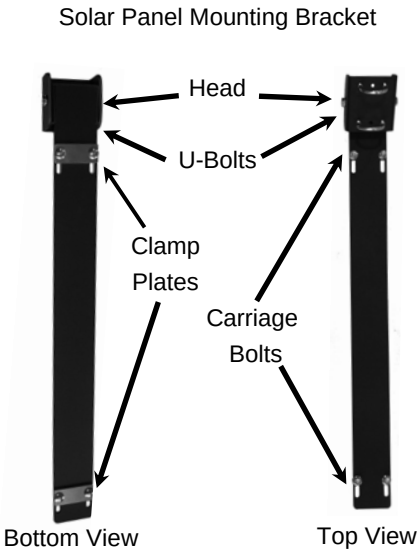


Figure 2

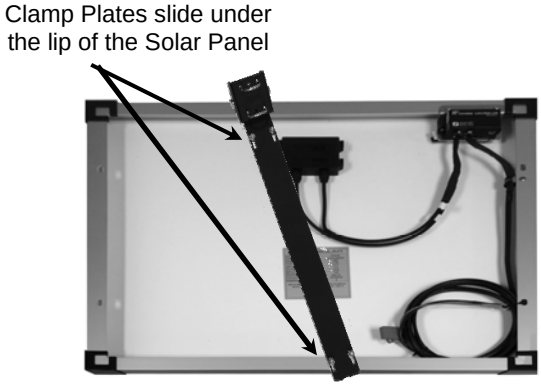


Figure 3A

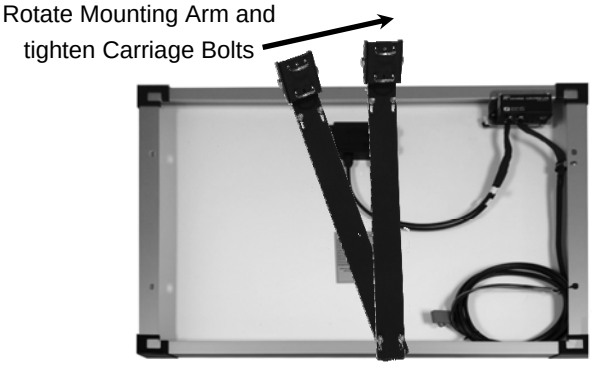


Figure 3B

Placement

Your Mega Blaster Pro will protect an area up to approximately 600 feet in all directions.

Factors to consider when selecting the best location include:

- Birds typically feed from the perimeter of the area and work their way in. Place Mega Blaster Pro units so the sound protection covers all the way to the edges of the area. For larger areas Mega Blaster Pro units should be positioned 400-500 feet inside the area and spaced every 1,200 feet.
- Mount the 20-Speaker Tower at least 5 feet above terrain, areas, trees and other obstacles.
- Placing the Mega Blaster Pro on top of a hill or small rise will give you much better coverage than at the bottom of a valley. The greater the height the further the sounds will travel.
- Wind can blow the sound waves. If the area you need to protect has consistent wind coming from the same direction, position your Mega Blaster Pro more “upwind.”
- Trees surrounding areas provide birds with a safe perch that allows them to fly in, grab food and fly out. It is much more difficult to eliminate bird damage if the birds are able to use the surrounding trees as a staging area for attacks on your areas. Your Mega Blaster Pro unit should be positioned close to any trees bordering your areas. If birds are roosting in the trees at night the TIME OF OPERATION should be set to 24 HOUR.
- Lakes, rivers and wetlands are a favorite resting and hiding place for birds. Your Mega Blaster Pro unit should be placed so the sound thoroughly covers any areas where birds frequent.
- Neighbors, businesses and others may not appreciate hearing the bird sounds. At the limits of the effective range the sounds from your Mega Blaster Pro are at a level people may find annoying. Avoid placing the unit where it becomes a nuisance.

Building a Mounting Pole or Mast

CAUTION: TALL POLES AND MASTS CAN BE HEAVY AND POTENTIALLY DANGEROUS. USE EXTREME CAUTION WHEN CONSTRUCTING OR WORKING AROUND TALL POLES AND MASTS. BIRD-X, INC., ASSUMES NO RESPONSIBILITY FOR DAMAGES OR INJURIES.

Things to consider:

- The 20-Speaker Tower is designed to mount onto a 1 in. (outside diameter) pipe at least 14 in. long. 1 in. conduit works well as it is light, rigid, inexpensive and available in 10 ft. lengths making it ideal for low areas, vineyards and bushes.
- You will want to take down your Mega Blaster Pro unit after harvest and store it in a dry location until the next season.

A suggestion for masts up to 20 feet tall:

1. 3/4 inch Galvanized steel water pipe has a 1 inch outside diameter and is the correct size to fit inside the 20-Speaker Tower. It is often available in 20 ft. lengths from hardware and plumbing supply stores. If these are not available, 10 ft. lengths are common and can be fastened together with a threaded coupler. Assemble the poles on the ground.
2. Slide the 20-Speaker Tower over the pipe and tighten the set screw in the collar at the base.
3. Stand the pole assembly up just inside the drip line of a tree and securely tie the pole to a few heavy branches.
4. Drive a T-Post into the ground at the base of the pole and secure with wire.

For masts taller than 20 feet:

1. Use 20 ft. lengths of galvanized steel water pipe or similar, securely fastened together with threaded reducing couplers.
2. Starting with 3 in. pipe, step the size down with each length of pipe.
3. The last 10 ft. can be 1 in. (O.D.) conduit hose clamped to the final section of galvanized pipe.

A semi-permanent mast support can be made by digging a hole 4 ft. deep and 4 ft. round. In the middle of the hole sink a length of galvanized water pipe large enough that your mast will easily fit inside. Make sure at least 2 ft. of pipe is above ground level. Fill the area around the pipe with packed sand, leaving the last foot filled with concrete to form a cap over the hole. Your mast can be dropped into the galvanized water pipe “receiver” for support. At the end of harvest the mast can be lifted out and positioned on the ground for easy disassembly and storage.

Installation

Note: Foliage, trees, and other obstructions severely reduce the effective range of Mega Blaster Pro units. It is critical that the 20-Speaker Tower is mounted at least 5 feet above all obstructions to achieve the maximum protection.

Mounting Pole or Mast

1. The Mounting Pole or Mast will need to be supported by a T-Post, fence post, tree or other means. The Pole Support should be in place before proceeding.

20-Speaker Tower

2. Lay the 20-Speaker Tower on its side on the ground and cut the zip-tie securing the speaker cables.
3. Slide the 1 in. (outside diameter) Mounting Pole through the Collar at the bottom of the 20-Speaker Tower until it slides over the positioning bolt inside the top of the Tower (Figure 4).
4. Tighten the Set Screw in Collar securely.

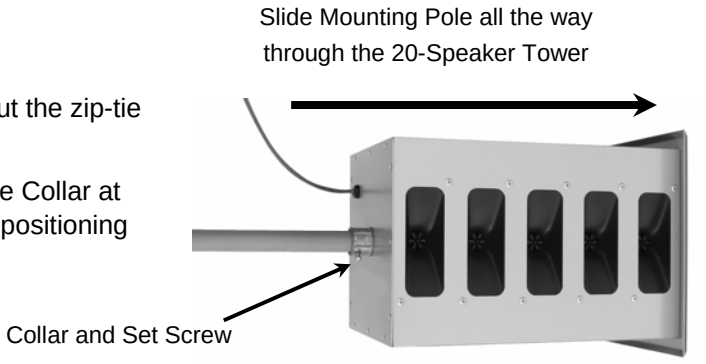


Figure 4

Solar Panel

5. Rest the lower end of the Mounting Pole on the Solar Panel Mounting Bracket approximately three feet from the bottom of the pole with the top of the solar panel facing the 20-Speaker Tower (Figure 5).
6. Lean up the Mounting Pole with the 20-Speaker Tower on top, against the Pole Support and fasten the Mounting Pole to the Pole Support securely with wire or other semi-permanent means.
7. Rotate the solar panel so it receives sunlight.

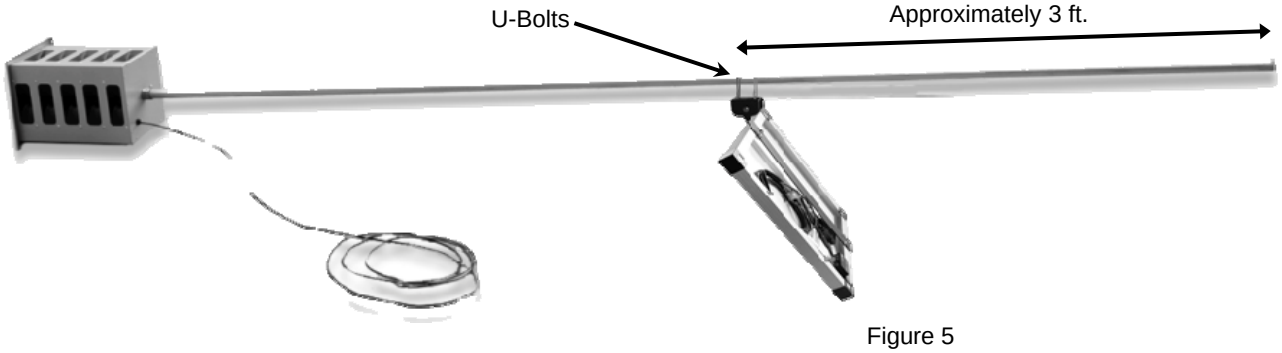


Figure 5

Control Box

8. Attach the Control Box to the Mounting Pole with the U-Bolts.
9. Feed the Speaker Cables through the Cable Strain Relief at the bottom
10. Attach the Speaker Cables from the 20-Speaker Tower to the screws marked “SPEAKER” on the faceplate of the control panel.
11. Locate the Control Box Connector Cable (the grey 2 lead cables) and feed one end through the Cable Strain Relief.
12. Connect the RED wire to the screw marked “+” and the BLACK wire to the screw marked “-” under “12V BATTERY” on the faceplate of the control panel.
13. **MAKE SURE THE POWER SWITCH IS TURNED OFF BEFORE ATTACHING BATTERY.**
14. Connect the other end of the RED wire to the “+” terminal on the 12-volt Deep Cycle battery (not included). Connect the BLACK wire to the “-” terminal on the battery.
15. Hand tighten the Tapered Cinch Nut on the bottom of the Cable Strain Relief to help keep insects and moisture out.

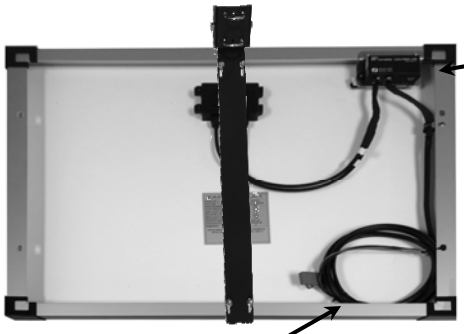
Figure 6

Solar Panel Connections

16. Cut the black zip-ties securing the RED and BLACK wires on the underside of the solar panel. (Figure 7)
17. Connect the RED wire to the “+” terminal on the 12-volt battery and connect the BLACK wire to the “-” terminal on the battery.

NOTE: If you are using a “Sealed Gel” 12-volt battery (instead of a Lead Acid battery) you will need to cut the indicated small BLUE wire on the attached voltage regulator. This prevents Sealed Gel batteries from being overcharged. Failure to cut this wire can result in permanent battery damage. (Figure 8)

Figure 7



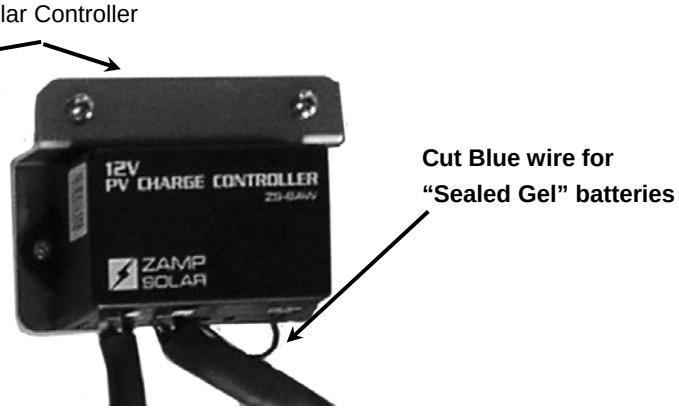


Figure 8

CAUTION: The Mega Blaster Pro is capable of producing sounds up to 125 decibels. Hearing protection must be worn anytime the unit is on!

Settings

Repelling birds requires regular monitoring and active management. Birds are intelligent and highly adaptable so it is important to create and maintain an environment the birds perceive as hostile and dangerous. This is achieved by playing the sounds frequently and at a high volume, otherwise the birds will not be fully repelled and will soon learn to adapt.

Below are the initial settings that should be used when your Mega Blaster Pro is first installed. Please see the "Bird Control Management Guidelines" section for more information.

Recordings

There are eight separate bird sounds contained on the Replaceable Sound Card. The label on the sound card lists each sound with a number corresponding to the eight "RECORDINGS" dip switches to the left of the Sound Card. Initially all RECORDING switches should be turned ON. If the target birds begin returning, periodically change the switch settings for the eight sounds (turning them ON or OFF). ***NOTE:*** **NEVER turn OFF the distress calls of the target birds you are trying to repel and always keep at least one predator bird sound turned ON.**

Mode Settings

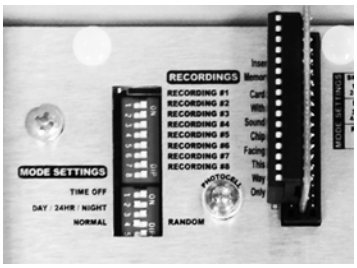
TIME OFF INTERVAL controls the time off periods between each playing of the bird recordings.

Setting	Time Off Duration	Switch #1	Switch #2
SHORT	**17-50 Seconds**	**ON**	**OFF**
MEDIUM	1:00-4:15 Minutes	OFF	ON
LONG	5:00-10:00 Minutes	ON	ON
XLONG	10:00-30:00 Minutes	OFF	OFF

When the Mega Blaster Pro unit is first installed the TIME OFF INTERVAL should be set to SHORT to create the greatest sense of danger and move the birds out of the area the fastest. Once the birds have left the area completely for a week or more you may try increasing the TIME OFF INTERVAL gradually, but you must monitor the birds carefully. Switch back to SHORT at the first sign birds are returning.

TIME OF OPERATION controls when the bird recordings play.

Setting	Switch #3	Switch #4
DAY ONLY	**ON**	**OFF**
24-HOUR	OFF	ON
NIGHT ONLY	ON	ON



Recommended Settings

In most cases birds are only active during the day so the DAY ONLY is recommended. If birds are roosting in bordering trees at night you will need to set the TIME OF OPERATION for 24-HOUR.

RANDOM OPERATION should always be turned **ON**. **VOLUME should be set as high as possible.**

Troubleshooting

Problem	Possible Cause	Solution
No Sound	Volume turned down	Turn volume up
	Dead battery	Charge or replace battery
	Loose battery connection	Verify all battery connections are tight
	All RECORDINGS are turned OFF	Verify all RECORDINGS are switched to ON
	Sound Card not fully seated	Remove sound card and reinstall, making sure it is fully inserted into the socket
	Sound Card is installed backward	Unplug the sound card and reinstall with the label facing to the left
	TIME OF OPERATION set to DAY ONLY without enough light	Change TIME OF OPERATION to 24-HOUR
	Unit was not shut down before the battery was disconnected causing the unit to go into “SAFE MODE”	1. Turn the POWER switch OFF 2. Disconnect the battery 3. Remove the sound card 4. Wait 30 seconds 5. Reinstall sound card 6. Reconnect the battery 7. Turn the POWER switch ON
Was working but stopped	The battery is dead	Connect the battery to a battery charger and see if it will hold a charge. Replace if necessary
	Solar Panel is not getting enough sunlight	Reposition the Solar Panel

Limited Warranty

THIS MEGA BLASTER PRO UNIT IS WARRANTED AGAINST DEFECTS IN MATERIAL AND WORKMANSHIP FOR SIX MONTHS FROM DATE OF PURCHASE (EXTENDED WARRANTY AVAILABLE). BIRD-X WILL REPLACE OR REPAIR, PROVIDED DEFECT OCCURS UNDER NORMAL USE. *RETURNS ACCEPTED ONLY WITH AUTHORIZATION FROM OUR CHICAGO OFFICE.*

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EPA Establishment Number 075130-OR-001

Mega Blaster Pro P/N 655-0065-00 (Rev. 9/2013)

CE

Appendix B

Design/Construction Plan

R.T. Hicks Consultants, Ltd.
901 Rio Grande Blvd. NW, Suite F-142
Albuquerque, NM 87104

C-147 Supplemental Information:Appendix B
Design and Construction Plan – Dagger Containment

Applicable mandates in Rule 34 are underlined. This plan addresses construction of the Amtex Dagger Containment. Appendix A contains the surveyed "as built" drawing of the containment prior to lining and liner and geotextile specifications are attached to this document.

Pettigrew Engineers conducted an inspection of the containment excavation to determine if the design and construction met the criteria set forth in Rule 34. Their statement is included at the end of this plan.

Dike Protection and Structural Integrity

The design and operation provide for the confinement of produced water, to prevent releases and to prevent overtopping due to wave action or rainfall. Additionally, the design prevents run-on of surface water as the containment is surrounded by an above-grade levee (a berm) and diversion ditch (between the levee and the soil stockpile) to prevent run-on of surface water.

Stockpile Topsoil

Where topsoil was present, prior to constructing containment, the operator stripped and stockpiled the topsoil for use as the final cover or fill at the time of closure. The topsoil was stockpiled adjacent to containment levee to the west and southwest, outside of working areas. The operator will take care to limit the height of the soil stockpile to allow the soil to remain aerobic.

Signage

The operator will place an upright sign no less than 12 inches by 24 inches with lettering not less than two inches in height in a conspicuous place on the fence surrounding the containment. The sign is posted in a manner and location such that a person can easily read the legend. The sign will provide the following information:

- the operator's name,
- the location of the site by quarter-quarter or unit letter, section, township and range, and
- emergency telephone numbers

Fencing

The operator will provide for a fence to enclose the recycling containment in a manner that deters unauthorized wildlife and human access. The perimeter fence is a wire mesh and barbed wire fence with four strands evenly spaced in the interval between one foot and four feet above ground level. As stated in the O&M plan, the operator will ensure that all gates associated with the fence are closed and locked when responsible personnel are not onsite.

Netting and Protection of Wildlife

The perimeter fence will be effective in excluding stock and most terrestrial wildlife. The fence (4-strand barbed wire) can include a fine mesh from the base to 1 foot above the ground to exclude the small reptiles (e.g. dune sagebrush lizard) if requested by the surface owner.

The recycling containment will be protective of wildlife, including migratory birds through the implementation of an Avian Protection Plan (attached hereto), routine inspections and the perimeter fence. The O&M plan calls for the operator to inspect for and, within 30 days of discovery, report the discovery of dead migratory birds or other wildlife to the appropriate wildlife agency and to the division district office in order to facilitate assessment and implementation of measures to prevent incidents from reoccurring.

Earthwork

The containment will have a properly constructed foundation and interior slopes consisting of a firm, unyielding base, smooth and free of rocks, debris, sharp edges or irregularities to prevent the liner's rupture or tear. Geotextile may be placed under the liner when needed to reduce localized stress-strain or protuberances that otherwise may compromise the liner's integrity.

Appendix A shows the

a) levee has inside grade no steeper than two horizontal feet to one vertical foot (2H: 1V).
b) levee outside grade is no steeper than three horizontal feet to one vertical foot (3H: 1V)
c) top of the levee is wide enough to install an anchor trench and provide adequate room for inspection and maintenance.
d) The containment floor design calls for a slope of approximately 1% toward the sump in the northeast corner.

Liner and Drainage Geotextile Installation

The containment has a primary (upper) liner and a secondary (lower) liner with a leak detection system appropriate to the site's conditions.

The primary (upper) liner is a geomembrane liner composed of an impervious, synthetic material that is resistant to ultraviolet light, petroleum hydrocarbons, salts and acidic and alkaline solutions. It is 60-mil HDPE. The secondary liner is 40-mil HDPE string reinforced. Liner compatibility meets or exceeds a subsequent relevant publication to EPA SW -846 method 9090A.

The recycling containment design has a leak detection system between the upper and lower geomembrane liners of 200-mil geonet to facilitate drainage. The leak detection system consists of a properly designed drainage and collection and removal system placed above the lower geomembrane liner in depressions and sloped to facilitate the earliest possible leak detection. The containment floor design calls for a slope of approximately 1% toward the sump in the northeast corner. This slope combined with the highly transmissive geonet drainage layer provide for the earliest possible leak detection.

The liners and drainage material will be installed consistent with the Manufacture's specifications (See Appendix C). In addition to any specifications of the Manufacturer, protocols for liner installation include measures to:

i. minimizing liner seams and orient them up and down, not across, a slope of the levee.
ii. use factory-welded seams where possible.
iii. use field seams in geosynthetic material are thermally seamed and prior to field seaming, overlap liners four to six inches.
iv. minimize the number of field seams and comers and irregularly shaped areas.
v. provide for no horizontal seams within five feet of the slope's toe.
vi. use qualified personnel to perform field welding and testing.
vii. avoid excessive stress-strain on the liner
viii. The edges of all liners are anchored in the bottom of a compacted earth-filled trench that is at least 18 inches deep

At points of discharge into the lined earthen containment the pipe configuration effectively protects the liner from excessive hydrostatic force or mechanical damage during filling.

The design show that at any point of discharge into or suction from the recycling containment, the liner is protected from excessive hydrostatic force or mechanical damage. External discharge or suction lines do not penetrate the liner.

Pumping from the containment to hydraulic fracturing operations is the responsibility of stimulation contractors. Typically, lines are permanently placed in the containment with floats attached to prevent damage to the liner system. The containment may be equipped with permanent HDPE stinger (supported by a sacrificial liner or geotextile) for withdrawal of fluid if the owner deems necessary during operations.

External discharge or suction lines do not penetrate the liner.

Geotextile will be placed on the outside levee to provide erosion control.

Leak Detection and Fluid Removal System Installation

The leak detection system, contains the following design elements

a. The 200-mil HyperNet Geonet drainage material between the primary and secondary liner that is sufficiently permeable to allow the transport of fluids to the observation ports (Appendix A).
b. The containment floor is sloped towards the monitoring riser pipe to facilitate the earliest possible leak detection of the containment bottom. A pump may be placed in the observation port to provide for fluid removal.
c. Piping will withstand chemical attack from any seepage; structural loading from stresses and disturbances from overlying water, cover materials, equipment operation or expansion or contraction (see Appendix A).
d. The slope of the interior sub-grade is approximately 1%

Appendix C

Operating and Maintenance Plan

R.T. Hicks Consultants, Ltd.
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Operating and Maintenance Procedures

In this plan, underlined text represents the language of the Rule.

The operator will operate and maintain the lined earthen containment to contain liquids and solids (blow sand and minimal precipitates from the treated produced water) and maintain the integrity of the liner system in a manner that prevents contamination of fresh water and protects public health and the environment as described below. The purpose of the lined earthen containment is to facilitate recycling, reuse and reclamation of produced water derived from nearby oil and gas wells. During periods when water for E&P operations is not needed, produced water will discharge to one of the injection wells in the operator's SWD system. The containment will not be used for the disposal of produced water or other oilfield waste.

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The operation of the containment is summarized below.

A. Via pipeline, produced water generated from nearby oil and gas wells is delivered to a treatment system located as indicated in the C-147.
B. After treatment, the produced water discharges into the containment
C. When required, treated produced water is removed from the containment for E&P operations. At this time, treated produced water will be used for drilling beneath the fresh water zones (beneath surface casing), for well stimulation (e.g. hydraulic fracturing) and other E&P uses as approved by OCD.
D. Whenever the maximum fluid capacity of the containment is reached, treatment and discharge to the containment ceases (see Freeboard and Overtopping Plan, below)
E. The operator will keep accurate records and shall report monthly to the division the total volume of water received for recycling, with the amount of fresh water received listed separately, and the total volume of water leaving the facility for disposition by use on form C-148.
F. The operator will maintain accurate records that identify the sources and disposition of all recycled water that shall be made available for review by the division upon request.
G. The containment shall be deemed to have ceased operations if less than 20% of the total fluid capacity is used every six months following the first withdrawal of produced water for use. The operator will report cessation of operations to the appropriate division district office. The appropriate division district office may grant an extension to this determination of cessation of operations not to exceed six months.

The operation of the lined earthen containment will follow the mandates listed below:

1. The operator will not discharge into or store any hazardous waste (as defined by 40 CFR 261 and NMAC 19.15.2.7.H.3) in the containments.
2. If the containment's primary liner is compromised above the fluid's surface, the operator will repair the damage or initiate replacement of the primary liner within 48 hours of discovery or seek an extension of time from the division district office.
3. If the primary liner is compromised below the fluid's surface, the operator will remove all fluid above the damage or leak within 48 hours of discovery, notify the division district office and repair the damage or replace the primary liner.
4. If any penetration of the containment liner is confirmed by sampling of fluid in the leak detection system (see Inspection and monitoring plan), The operator will

   a. Begin and maintain fluid removal from the leak detection/pump-back system
   b. Notify the district office within 48 hours (phone or email) of the discovery
   c. Identify the location of the leak and
   d. Repair the damage or, if necessary, replace the containment liner
5. The operator will install, or maintain on site, an oil absorbent boom or other device to contain an unanticipated release and the operator will remove any visible layer of oil from the surface of the recycling containment.
6. The operator will report releases of fluid in a manner consistent with NMAC 19.15.29
7. The containment will be operated to prevent the collection of surface water run-on.
8. The operator will maintain the containment free of miscellaneous solid waste or debris.
9. The operator will maintain at least three feet of freeboard for the containment and will use a free-standing staff gauge to allow easy determination of the required 3-foot of freeboard.
10. As described in the design/construction plan, the injection or withdrawal of fluids from the containment is accomplished through a hardware that prevents damage to the liner by erosion, fluid jets or impact from installation and removal of hoses or pipes.
11. The operator shall ensure that all gates associated with the fence are closed and locked when responsible personnel are not onsite.
12. The operator will maintain the fences in good repair

Monitoring, Inspection, and Reporting Plan

The operator will inspect the recycling containment and associated leak detection systems weekly while it contains fluids. The operator shall maintain a current log of such inspections and make the log available for review by the division upon request.

Weekly inspections consist of

- reading and recording the fluid height of staff gauges
- recording any evidence that the pond surface shows visible oil
- visually inspecting the containment's exposed liners
- checking the leak detection system for any evidence of a loss of integrity of the primary liner.

As stated above, if a liner's integrity is compromised, or if any penetration of the liner occurs above the water surface, then the operator will notify the District office within 48 hours (phone or email).

Monthly, the operator will

A. Inspect diversion ditches and berms around the containment to check for erosion and collection of surface water run-on.
B. Inspect the leak detection system for evidence of damage or malfunction and monitor for leakage
C. Inspect the containment for dead migratory birds and other wildlife. Within 30 days of discovery, report the discovery of dead migratory birds or other wildlife to the appropriate wildlife agency and to the division district office in order to facilitate assessment and implementation of measures to prevent incidents from reoccurring.
D. Report to the division the total volume of water received for recycling, with the amount of fresh water received listed separately, and the total volume of water leaving the facility for disposition by use on form C-148.

E. Record sources and disposition of all recycled water

The operator will maintain a log of all inspections and make the log available for the appropriate Division district office's review upon request. An example of the log is attached to this section of the permit application.

Freeboard and Overtopping Prevention Plan

The method of operation of the containment allows for maintaining freeboard with very few potential problems. When the capacity of the containment is reached (3-feet of freeboard), the discharge of treated produced water ceases and the produced water generated by nearby oil and gas wells is managed by one of the injection wells identified in Appendix E.

If rising water levels suggest that 3-feet of freeboard will not be maintained, the operator will implement one or more of the following options

I. Cease discharging treated produced water to the containment
II. Accelerate re-use of the treated produced water for purposes approved by the Division
III. Transfer treated produced water from the containment to injection wells

The reading of the staff gauge typically occurs daily when treatment operations are ongoing and weekly when discharge to the containment is not occurring.

Protocol for Leak Detection Monitoring, Fluid Removal and Reporting

As shown in Appendix A, the leak detection system includes a monitoring system. Any fluid released from the primary liner will flow to the collection sump where fluid level monitoring is possible at the monitoring riser pipe associated with the leak detection system (see Appendix A).

Staff may employ a portable electronic water level meter to determine if fluid exists in the monitoring riser pipe. Obtaining accurate readings of water levels in a sloped pipe beneath a containment can be a challenge. An electrician's wire snake may be required to push the probe to the bottom of the port and the probe may be fixed in a 2-inch pipe "dry housing" to avoid false readings due to water condensation on the pipe. There are many techniques to determine the existence of water in the sumps – including low flow pumps and a simple small bailer affixed to an electrician's snake. The operator will use the method that works best for this containment.

If seepage from the containment into the leak detection system is suspected by a positive fluid level measurement, the operator will

1. Re-measure fluid levels in the monitoring riser pipe on a daily basis for one week to determine the rate of seepage.
2. Collect a water sample from the monitoring riser pipe to confirm the seepage is treated produced water from the containment via field conductivity and chloride measurements.
3. Notify NMOCD of a confirmed positive detection in the system within 48-hours of sampling (initial notification).
4. Install a pump into the monitoring riser pipe sump to continually (manually on a daily basis or via automatic timers) remove fluids from the leak detection

system into the containment until the liner is repaired or replaced.

5. Dispatch a liner professional to inspect the portion of the containment suspected of leakage during a “low water” monitoring event.
6. Provide NMOCD a second report describing the inspection and/or repair within 20 days of the initial notification

If the point of release is obvious from a low water inspection, the liner professional will repair the loss of integrity. If the point of release cannot be determined by the inspection, the liner professional will develop a more robust plan to identify the point(s) of release. The inspection plan and schedule will be submitted to OCD with the second report. The operator will implement the plan upon OCD approval.

Containment Inspection Form

Month **Oct-14**

Day	Weekly	Low Water	Activity	Monthly	Staff Gauge	Comments
1 - Wed						
2	x				8.75	Gate unlocked upon arrival - notified Jerry Smith, no birds in pit
3					10	
4					12	
5			x			Water transfer to frac - pipes are good
6			x			Water transfer to frac - pipes are good
7		x			2.5	No visible liner problems
8					3	
9	x				4	All OK - no oil on surface, no birds in pit
10					5	
11					5	
12					6	
13					7	
14					7.5	
15				x	8	No fluid in leak detection, outer berm and stormater diversion OK, H2S - no alarm,
16					9	
17					9	
18					9.5	
19	x				10	All OK
20					11	
21					12	
22			x			Water transfer to frac - no problems
23			x			Water transfer to frac - no problems
24		x			1.75	No visible liner problems
25					2.25	
26	x				3.75	High wind -liner is good, no birds
27					4.75	
28					5.5	
29					6.75	
30					7.75	
31					8.5	

Appendix D

Closure Plan

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In this plan, underlined text represents the language of the Rule.

After operations cease, the operator will remove all fluids within 60 days and close the containment within six months from the date the operator ceases operations from the containment for use.

The operator shall substantially restore the impacted surface area to

- the condition that existed prior to the construction of the recycling containment or
- to a condition imposed by federal, state trust land or tribal agencies on lands managed by those agencies as these provisions govern the obligations of any operator subject to those provisions,

As this containment will excavate caliche for future use and pay the surface owner (BLM) for the harvest and use of this material. We anticipate the surface owner will impose a closure design that conforms to one of a caliche mine rather than the condition that existed prior to construction. Until a change to closure as a caliche mine is required by BLM, the prescriptive mandates set forth in this plan will be in effect. The operator understands that a variance will be submitted to OCD to allow for any alternative closure protocol.

Excavation and Removal Closure Plan – Protocols and Procedures

The containment is expected to hold a small volume of solids, the majority of which will be windblown sand and dust with some mineral precipitates from the water

1. The operator will remove all liquids from the pits and either:
    a. Dispose of the liquids in a division-approved facility, or
    b. Recycle, reuse or reclaim the water for reuse in drilling and stimulation.
2. The operator will close the recycling containment by first removing all fluids, contents and synthetic liners and transferring these materials to a division approved facility.
3. After the removal of the pit contents and liners, soils beneath the containment will be tested by collection of a five-point (minimum) composite sample which includes stained or wet soils, if any, and that sample shall be analyzed for the constituents listed in Table I of 19.15.34.14.
4. After review of the laboratory results
    a. If any contaminant concentration is higher than the parameters listed in Table I, additional delineation may be required and the operator must receive approval before proceeding with closure.
    b. If all contaminant concentrations are less than or equal to the parameters listed in Table I, then the operator will proceed to
        i. backfill with non-waste containing, uncontaminated, earthen material. Or
        ii. undertake an alternative closure process pursuant to a variance request after approval by OCD

Reclamation and Re-vegetation

a. The operator will reclaim the containment's location to a safe and stable condition that blends with the surrounding undisturbed area.
b. Topsoils and subsoils shall be replaced to their original relative positions and contoured so as to achieve erosion control, long-term stability and preservation of surface water flow patterns.

c. The disturbed area shall then be reseeded in the first favorable growing season following closure of a recycling containment.

Closure Documentation

Within 60 days of closure completion, the operator shall submit a closure report on form C-147, including required attachments, to document all closure activities including sampling results and the details on any backfilling, capping or covering, where applicable. The closure report shall certify that all information in the report and attachments is correct and that the operator has complied with all applicable closure requirements and conditions specified in division rules or directives.

The operator shall notify the division when reclamation and re-vegetation are complete. Specifically the notice will document that all ground surface disturbing activities at the site have been completed, and a uniform vegetative cover has been established that reflects a life-form ratio of plus or minus fifty percent (50%) of pre-disturbance levels and a total percent plant cover of at least seventy percent (70%) of pre-disturbance levels, excluding noxious weeds.

