March 2015

C-147 Registration Package for

Hackberry 16 Recycling Containments and Recycling Facility

Section 16, T19S, R31E, Eddy County

View north shows Hackberry 16 SWD Battery and nearby producing well (right). The proposed ASTs (Recycling Containments) will be placed between the producing well and the Battery on existing pads.

Prepared for:
Devon Energy Production Company
Oklahoma City, Oklahoma
and
Rockwater Energy Solutions

Prepared by:

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

R. T. HICKS CONSULTANTS, LTD.

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

March 31, 2015

Ms. Heather Patterson
NMOCD District 2
811 S. First Street
Artesia, New Mexico 88210
Via E-mail and US Mail

RE: C-147 application for Hackberry 16 Recycling Containments and Facility
Devon Energy Production/Rockwater Energy Solutions
Section 16 R19S R31E

Dear Ms. Patterson:

On behalf of Rockwater Energy Solutions and Devon Energy, R.T. Hicks Consultants, Ltd. is pleased to submit the registration for the above-referenced project. Devon Energy has awarded a contract to Rockwater to provide produced water treatment, storage and conveyance for E&P operations in the area surrounding the Hackberry 16 SWD. We anticipate commencing to fill the ASTs (recycling containments) with treated produced water shortly after OCD approves the variance requests.

Please note the following in the C-147 Registration Package:

1. The secondary liner for the AST system is reinforced 40-mil LLDPE, which exceeds the mandate of the Rule.
2. The primary liner system is two (2) liners composed of reinforced 30-mil LLDPE. A variance requests describes why this dual liner system provides equal or better protection of fresh water, public health and the environment.
3. The variance request to allow for less than 3 feet of freeboard in the containment was submitted and approved for a similar AST system approved by OCD under Rule 17 and is included here as a “Previously-Approved Variances.”
4. The variance to the fencing requirement was submitted and approved for a similar AST system approved by OCD under Rule 17 and is also listed here under “Previously-Approved Variances.”
5. Although dated today, the variance request regarding anchor trench and slope requirements is also listed under “Previously-Approved Variances” because the same request was approved by District I for Devon Energy under Rule 17 in 2014. The only difference is the memos the liner thicknesses referenced.
6. The Rockwater SOP for their ASTs is Appendix C of the C-147 and the Design/Construction Plan (Appendix B) and the O&M Plan (Appendix D) are abstracted from this SOP. We recommend that you read Appendix B and D before you examine the SOP.
7. The production pad is the AST’s earthen foundation upon which the system will sit. There will be no ‘Y’ trench for the Hackberry containment and the earthen foundation is sloped, not flat (see Design/Construction Plan and Appendix C).

8. The earthen secondary containment structure that encloses the AST is also the foundation for the secondary liner. Devon Energy has signed the C-147 certifying that the proposed action, with approved variances, complies with OCD Rules.
9. Devon Energy is compliant with the Financial Assurance mandates of the Rule.

The variances were written by Ron Frobel, PE. He was the author of several variances that became part of the new Part 34 Produced Water Recycle Rule (e.g. 45 mil LLDPE primary liner system, 30-mil LLDPE secondary liner system). We are confident that OCD can rapidly approve these variances. As time is of the essence, please contact us if you have any questions or concerns about the variance requests or compliance of the site, construction, operation, or closure to the new Rule.

Once again, District II will be the first to approve containment structures to help New Mexico conserve fresh water by recycling produced water. The first two permitted containment structures were the Lime Rock MWFM Pit and the Mack Permanent Pit – both of which have saved hundreds of thousands of barrels of fresh water.

We look forward to working with you to get these variances approved.

Sincerely,
R.T. Hicks Consultants

Randall Hicks

Copy: Devon Energy
Rockwater Energy Solutions
Ed Martin, State Land Office (surface owner)

Variance Request

R.K. FROBEL & ASSOCIATES
Consulting Engineers

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

March 31, 2015

RE: Technical Memorandum
LLDPE as Alternative Primary Liner System
Devon Energy / Hackberry Modular Impoundment

Dear Mr. Hicks:

At your request, I have investigated the suitability of application for two 30 mil LLDPE non-reinforced geomembranes as an alternative Primary liner in the Devon Energy /Hackberry Modular Impoundment. I have reviewed your C-147 Supplemental Information Report, Modular Tank Drawing, Design and Construction Plan as well as applicable correspondence. In consideration of the Primary lining system application (modular impoundment), size of the impoundment and depth, design details for modular tanks as well as estimated length of up to two years of service time, it is my professional opinion that two 30 mil LLDPE geomembranes will provide the requisite barrier against processed water loss. The two 30 mil LLDPE liners will function equal to or better than 60 mil HDPE, 30 mil PVC or 45 mil LLDPE as a primary liner system. The following are discussion points that will exhibit the attributes for using two 30 mil LLDPE geomembranes as the primary lining system:

The nature and formulation of LLDPE resin is very similar to HDPE. The major difference is that LLDPE is lower density, lower crystallinity (more flexible and less chemical resistant). However LLDPE will resist aging and degradation and remain intact for many years in exposed conditions. Although the lifetime of LLDPE in covered conditions (i.e., secondary liner) will be somewhat reduced with respect to HDPE, a secondary liner of LLDPE will outlast an exposed HDPE liner. In fact, 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 LLDPE (GRI GM 17) exposed is approximately 36 years (the Devon Energy Modular Impoundment life span is expected to be only 2 years maximum). It is understood that in order to ensure compliance of materials, 60 mil HDPE must meet or exceed GRI GM 13. Likewise, the primary or secondary liner must meet or exceed GRI GM 17 for non-reinforced LLDPE. Adhering to the minimum requirements of the GRI Specifications, two 30 mil LLDPE geomembranes when used as a primary liner system in the Devon Modular Impoundment will be equally as protective as a 60 mil HDPE liner.

Flexibility Requirements. 30 mil LLDPE geomembranes are less stiff and far more flexible than HDPE or 45 mil reinforced LLDPE and in this regard are preferred for installations in vertical wall tanks such as the Devon Modular Impoundment. LLDPE

provides a very flexible sheet that enables it to be fabricated into large panels, folded for shipping and installed on vertical walls transitioned to flat bottom. LLDPE will conform to the tank dimensions under hydrostatic loading.

Thermal Fusion Seaming Requirements. Thermal seaming and QC seam test requirements for geomembranes are product specific and usually prescribed by the sheet manufacturer. Both dual wedge and single wedge thermal fusion welding is commonly used on LLDPE and QC testing by air channel (ASTM D 5820) or High Pressure Air Lance (ASTM D 4437) is fully acceptable and recognized as industry standards. In this regard, there should be no exception or recommended practice for seaming and QC testing in the OCD rules. This would be fully covered in comprehensive specifications for both the Primary and Secondary geomembranes that would be reviewed by OCD.

Potential for Leakage through the Primary Liners. Leakage through geomembrane liners is directly a function of the height of liquid head above any hole or imperfection. The drainage media provides immediate drainage to a low point or outside the Modular Impoundment and thus no hydrostatic head or driving gradient is available to push leakage water through a hole. In this regard, secondary geomembrane materials can be (and usually are) much less robust in both thickness and polymer type.

Leakage through any Primary geomembrane is driven by size of hole and depth and will be detected by the increase of waste water in the drainage system and the volume being pumped out of the secondary containment. In this regard and for this variance, the Primary consists of 2 layers of 30 mil LLDPE geomembrane which will out perform a single layer of HDPE or LLDPE for potential leakage. Thus, if a leak occurs through the top layer, it will be effectively contained by the second layer. If required, location of holes in the Primary can be found by Electrical Leak Location Survey (ELLS) using a towed electrode (ASTM D 7007). Holes found can then be repaired and thus water seepage into the Secondary will be kept to a minimum. Dependent on OCR requirements for Action Leakage Rate (ALR), the leakage volumes may only be monitored. For example, a typical ALR is < 20 gpad whereas a rapid and large leak (RLL) may be > 100 gpad. Most states specify maximum ALR values for waste water impoundments usually in the range of 100 to 500 gpad. However, New Mexico does not specify any ALR for waste water impoundments (GRI Paper No. 15).

HDPE can not be prefabricated into large panels and thus 30 mil LLDPE offers the following for Primary Liner Modular Containment:

- Prefabrication in factory controlled conditions into very large panels (up to 35,000 sf) results in ease of installation, less or no thermal fusion field seams and less on site QC and CQA.

- Large prefabricated panels of 30 mil LLDPE will provide better control of thermal fusion welding in a factory environment that will improve the liner system integrity for the long term.

- The LLDPE geomembrane provides superior flexibility, lay flat characteristics and conformability which allows for more intimate contact with the underlying drainage media and tank walls.

- Two layers of the 30 mil LLDPE provide redundancy. Additionally, the bottom layer provides protection for the top layer during installation as well reduction in leakage due to pinholes (no driving head on the second 30 mil liner)

- Ease of installation of large prefabricated custom size panels results in a greater reduction of installation time and associated installation and QC costs.

- The LLDPE geomembrane is easily repaired using the same thermal fusion bonding method without the need for special surface grinding/preparation for extrusion welding used in repair of HDPE geomembranes.

In summary, it is my professional opinion that the double 30 mil LLDPE geomembranes will provide a Primary liner system that is equal to or better than a single 60 mil HDPE, 30 mil PVC or 45 mil reinforced LLDPE liner and will provide the requisite protection of fresh water, public health and the environment for many years and especially for the estimated two year life of the Devon Energy / Hackberry Modular Impoundment.

If you have any questions on the above technical memorandum or require further information, give me a call at 303-679-0285 or email geosynthetics@msn.com

Sincerely Yours,

R K Frobel

Ronald K. Frobel, MSCE, PE

References:

C-147 Supplemental Information
Devon Energy Modular Impoundment
Prepared by Hicks Consultants and Rockwater Energy Solutions

Title 19, Chapter 15, Part 34 NMAC (2015 Revision)

Geosynthetic Research Institute (GRI) Published Standards and Papers 2013

ASTM Standards 2013

Attachments:

R. K. Frobel C. V.

Previously-Approved Variances

R.K. FROBEL & ASSOCIATES
Consulting Engineers

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

March 31, 2015

RE: Technical Memorandum
Slopes and Anchor Trench Variance
NMAC 19.15.34.12.A(2) & (3)
Devon Energy / Hackberry Modular Impoundment

Dear Mr. Hicks:

At your request, I have reviewed the suitability of application of two 30 mil LLDPE geomembranes as an alternative Primary liner system for the Devon Energy / Hackberry Modular Impoundment. In consideration of liners in traditional pits, the NMOCD rules require a maximum 2H:1V slope and anchorage at the top of slope in soil backfill anchor trench. I have also reviewed your C-147 Supplemental Information Report, Modular Tank Drawing, Design and Construction Plan as well as applicable correspondence. In consideration of the LLDPE Primary lining system application (Modular Impoundment), size of impoundments and depth, design details for modular tanks as well as the fact that this is an above ground storage tank (not constructed in an excavated or raised embankment pit), it is my professional opinion that the LLDPE geomembranes will provide the requisite barrier against potential produced water loss and will function within the vertical walls of the Modular Impoundment the same as or better than an in-ground pit with slopes. The following are discussion points that will exhibit the positive attributes of a Modular Impoundment System:

Side Slope

The design of soil side slope (inclination) is a geotechnical engineering design consideration. Liquid impoundments such as fresh water or process water containments are usually built within an excavation or with raised earthen embankments. For a liquid impoundment with an exposed liner system, the slope soils and construction dictate slope inclination and very detailed slope stability analysis may be required to determine if slope failure within the embankment will occur once loaded with impounded water. Slope failure may also occur during construction or when the impoundment is empty. A maximum slope is usually specified and is dependent on soil type and cohesive strength, saturated or unsaturated conditions, etc. Detailed analysis for slope stability can be found in “Designing with Geosynthetics” by R.M Koerner as well as many geotechnical books.

A modular impoundment, on the other hand, consists of a professionally designed steel tank ring with vertical walls. There is no slope to consider as the segmental steel sections are set vertically. Design of steel tanks as regards hydrostatic loading, wind loading,

seismic loads, etc. are thoroughly referenced with detailed procedures in the design code - American Petroleum Institute (API) 650-98 "Welded Steel Tanks for Oil Storage". There are no requirements for maximum slope inclination other than perhaps 90 degrees or vertical wall.

Anchor Trench

All earthen impoundments with a geomembrane lining system require some form of top of slope anchor, the most common of which is an excavated and backfilled anchor trench usually set back at least 3 ft from the top of slope. Again, there are detailed procedures for anchor trench design in "Designing with Geosynthetics" by R.M Koerner.

A Modular Impoundment requires mechanical anchoring of the geomembrane at the top of the vertical steel wall using standard liner clips that prevent the geomembrane or geomembrane layers from slipping down the side wall. There are no requirements for an "anchor trench" as this is not an in-ground impoundment.

In summary, it is my professional opinion that two 30 mil LLDPE geomembranes installed within the vertical walls of a Modular Impoundment will provide the requisite protection of fresh water, public health and the environment for many years and especially for the estimated two year life of the Devon Energy / Hackberry Modular Impoundment. In particular, there is no requirement for a maximum interior slope angle of 2H:1V due to the fact that this impoundment is a steel tank with vertical walls. Additionally, there is no requirement for an anchor trench as the geomembrane is attached to the top of the Modular Impoundment vertical walls with large steel clips.

If you have any questions on the above technical memorandum or require further information, give me a call at 303-679-0285 or email geosynthetics@msn.com

Sincerely Yours,

R K Frobel

Ronald K. Frobel, MSCE, PE

References:

C-147 Supplemental Information
Devon Energy / Hackberry Modular Impoundment Design and Construction Plan
Prepared by R. T. Hicks Consultants Ltd.

NMOCD Recycling Rule, Title 19, Chapter 15 – Produced Water, Drilling Fluids and Liquid Oil Field Waste – Section 19.15 Part 34 (2015)

American Petroleum Institute (API) 650-98 "Welded Steel Tanks for Oil Storage"

Koerner, R.M., 2005 "Designing With Geosynthetics" Prentice Hall Publishers

Attachments:

R. K. Frobel C.V.

From:	Randall Hicks
To:	"Kristin Pope"
Subject:	FW: Devon Energy West Tank (Tank 2) MWFM Modular Impoundment Form C-144
Date:	Monday, March 16, 2015 10:37:22 AM

From: Oberding, Tomas, EMNRD [mailto:Tomas.Oberding@state.nm.us]
Sent: Tuesday, November 25, 2014 10:48 AM
To: Andrew Parker
Cc: Henderson, Jason E.; 'Bruening, Josh'; clayton@blm.gov; 'James Amos'; 'Randall Hicks'
Subject: RE: Devon Energy West Tank (Tank 2) MWFM Modular Impoundment Form C-144

Aloha Mr. Parker et al,

Again, thank you for submitting this application.

OCD grants conditional approval. Please obtain confirmation from the BLM.

The OCD permit number is:
P1-06572

Let me know if you have any questions or updates.
Mahalo
-Doc

Tomáš 'Doc' Oberding, PhD
Senior Environmental Specialist – New Mexico Oil Conservation Division
Energy, Minerals and Natural Resources Department
1625 N. French Dr.
Hobbs, NM 88240
(O): (575) 393-6161 ext 111
(C): 575-370-3180
(F): (575) 393-0720
E-Mail: tomas.oberding@state.nm.us
Website: http://www.emnrd.state.nm.us/ocd/

From: Andrew Parker [mailto:andrew@rthicksconsult.com]
Sent: Tuesday, November 25, 2014 8:38 AM
To: Oberding, Tomas, EMNRD
Cc: Henderson, Jason E.; 'Bruening, Josh'; clayton@blm.gov; 'James Amos'; 'Randall Hicks'
Subject: Devon Energy West Tank (Tank 2) MWFM Modular Impoundment Form C-144

Dr. Oberding:

Attached is the C-144 permit package for Devon Energy's MWFM modular impoundment identified as Tank 2 (West Tank). The location for the West Tank MWFM Modular Impoundment is located in Section 13 T26 R34E.

The contents of the attached C-144 permit package is duplicated from the November 24, 2014 Tank 1 (East Tank) submittal. Please note that Tank 2 will be associated with the Rattlesnake Fed Unit 8H well (API 30-025-40067) as highlighted on Table 1 in the attached C-144 package.

R.T. Hicks Consultants will be meeting with the BLM and a representative from Devon Energy either next week or the week after to present the attached C-144 submission. The BLM is copied on this transmission.

_____

Andrew Parker
RT Hicks Consultants
Durango Field Office
(970) 570-9535

Freeboard [NMAC 19.15.17.F(3)]

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 19.15.17.11.F:

> **F.** Multi-well fluid management pits. An operator shall maintain and operate a multi-well fluid management pit in accordance with the following additional requirements.
> **(3)** The operator shall maintain at least three feet of freeboard for the pit.

With respect to lined earthen impoundments that may hold 25 acre feet of produced water, a 3-foot freeboard stipulation makes sense. For example, wave action and other factors could focus stress on the upper portion of the levee or the liner system in these large impoundments. The fully netted, 158-foot diameter steel tank (modular impoundment) does not share the same characteristics as these large earthen pits and we believe 3-feet of freeboard is not necessary. Moreover, meeting the 3-foot freeboard requirement significantly reduces the storage capacity of a single modular impoundment – negatively impacting the economics of using produced water in lieu of fresh water for E&P activities.

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

The attached letter from Mr. Frobel describes how the proposed 2-foot freeboard limit in the permit application for the modular impoundment provides the same protection afforded by the 3-foot freeboard mandate for a large earthen pit. The attached equations and supporting email from Mr. Jason Henderson, PE, shows that a 2-foot freeboard limit on the steel impoundment meets the manufacturer's design criteria.

R.K. FROBEL & ASSOCIATES
Consulting Engineers

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

November 20, 2014

RE: Technical Memorandum
Freeboard Variance
NMAC 19.15.17.F(3)
Devon Energy MWFM Modular Impoundment

Dear Mr. Hicks:

At your request, I have reviewed the suitability of application of 40 mil LLDPE geomembrane as an alternative Primary and Secondary liner for the Devon Energy Multi-Well Fluid Management (MWFM) Modular Impoundment. In consideration of liners in traditional pits, the NMOCD rules require a freeboard of at least 3.0 ft. I have also reviewed your C-144 Supplemental Information Report, Modular Tank Drawing, Design and Siting characteristics as well as applicable correspondence. In consideration of the LLDPE Primary and Secondary lining system application (Modular Impoundment), size of impoundments and depth, design details for modular tanks as well as the fact that this is an above ground storage tank (not constructed in an excavated or raised embankment pit), it is my professional opinion that the 40 mil LLDPE geomembranes will provide the requisite barrier against potential processed water loss and will function within the vertical walls of the Modular Impoundment with a 2.0 ft freeboard the same as or better than an in-ground pit with slopes and a 3.0 ft freeboard requirement. The following are discussion points a Modular Impoundment System:

Freeboard Requirements

Liquid impoundments such as fresh water or process water containments are usually built within an excavation or with raised earthen embankments. For a liquid impoundment with an exposed liner system, the slope soils and construction dictate slope inclination and very detailed slope stability analysis may be required to determine if slope failure within the embankment will occur once loaded with impounded water. Freeboard or the vertical height between the maximum water surface elevation and the top of slope is important for earthen impoundments. Specified freeboard requirements take into consideration high precipitation events and prevent wave run-up on slopes that result in over-topping and potential saturation of embankments. This is particularly important on large earthen impoundments. Detailed design considerations including freeboard requirements for lined earthen impoundments can be found in “Designing with Geosynthetics” by R.M Koerner as well as other publications on reservoir design.

A modular impoundment, on the other hand, consists of a professionally designed steel tank ring with vertical walls. There is no slope to consider as the segmental steel sections are set vertical. Design of steel tanks as regards hydrostatic loading, wind loading, seismic loads, etc. are thoroughly referenced with detailed procedures in the design code - American Petroleum Institute (API) 650-98 "Welded Steel Tanks for Oil Storage". There are requirements for operational freeboard to prevent over-topping but due to the relatively small surface area and fetch of cylindrical tanks, wave heights are much less than large earthen impoundments. Thus freeboard is usually within the range of 0.5 to 2 ft. I have reviewed the Tank Design Calculation Summary and as regards the structural stability of the tank walls, a freeboard of 0.5 ft was assumed. Thus the variance request of 2.0 ft for a Modular Impoundment is well within the Tank Design requirements.

In summary, it is my professional opinion that two 40 mil LLDPE geomembranes installed within the vertical walls of a Modular Impoundment will provide the requisite protection of fresh water, public health and the environment for many years and especially for the estimated two year life of the Devon Energy MWFM Modular Impoundment. In particular, the design freeboard of 2.0 ft will provide requisite storage volume and prevent overtopping due to wind and wave action, potential seismic events and high precipitation.

If you have any questions on the above technical memorandum or require further information, give me a call at 303-679-0285 or email geosynthetics@msn.com

Sincerely Yours,

R K Frobel

Ronald K. Frobel, MSCE, PE

References:

C-144 Supplemental Information
Devon Energy Modular Impoundment
Prepared by R. T. Hicks Consultants Ltd.

NMOCD Recycling Rule, Title 19, Chapter 15 – Produced Water, Drilling Fluids and Liquid Waste 2014 – Section 19.15

American Petroleum Institute (API) 650-98 "Welded Steel Tanks for Oil Storage"

Koerner, R.M., 2005 "Designing With Geosynthetics" Prentice Hall Publishers

Attachments:

R. K. Frobel C.V.

The modular impoundment is designed for use with fluids that are 8.34 pounds/gallon (62.4 pounds per cubic foot) or lighter. Exceeding this specification for fluid weight at full tank capacity (12') could lead to failure at the connection plate(s).

Assuming a freeboard of 0.5 ft (minimum modular impoundment freeboard requirement) the Hyrdo Pressure (p) of water is 718 pounds per square foot (psf), where

$$p = Design\ Denisty\ X\ Height$$
$$= 62.4\ PCF * 11.5\ ft$$

$$(design\ density = \ 8.34 \frac{lb}{gal}\ X\ \ 7.48\ \frac{ft^3}{gal})$$

The density of the conditioned produced water is 9.3 pounds/gallon. Assuming a freeboard of 3-ft (19.15.17.12.F(3) NMAC) , the Hyrdo Pressure (p) of conditioned produced water is 626 psf, where

$$p = Design\ Denisty\ X\ Height$$
$$= 69.64\ PCF * 9\ ft$$

$$(design\ density = \ 9.3 \frac{lb}{gal}\ X\ \ 7.48\ \frac{ft^3}{gal})$$

Using conditioned produced water with the Pit Rule freeboard requirements of 3-feet results in a Hydro Pressure 92 psf less than the engineered design.

The operator asks the District Division to allow for a 2-foot freeboard, which yields a Hydro Pressure (p) of 696.4 psf, where

$$p = Design\ Denisty\ X\ Height$$
$$= 69.64\ PCF * 10\ ft$$

$$(design\ density = \ 9.3 \frac{lb}{gal}\ X\ \ 7.48\ \frac{ft^3}{gal})$$

Andrew Parker

From: Henderson, Jason E. <Jason.Henderson@CES-FluidMgmt.com>
Sent: Monday, November 17, 2014 11:58 AM
To: 'Andrew Parker (andrew@rthicksconsult.com)'; ''Randall Hicks' (r@rthicksconsult.com)'
Subject: CES - Frac Tanks New Mexico
Attachments: Engineering Calculations - Pool Tanks.pdf; SKMBT_C55013021610260.pdf; SKMBT_C55013021807050.pdf

Randall,

These are the Pinnacle specs. If you look at the engineering calculations, provided the State requests this information, you will see the following:

Hydro Pressure, p = Design Density * H = 62.4 PCF * 11.5 = 718 psf – Which is the water density based on 8.34 lb/gal * 7.48 ft^3/gal
Since the state restricts me to 3 feet of freeboard then my Hydro Pressure on produced water is as follow:
9.3 lbs/Gal * 7.48 Ft^3/gal * 9ft = 626 psf which is 92psf less than this engineer's design thus I can use this tank for produced water under the conditions the state requires.

I could actually fill this tank to 10.3 feet with 9.3 lbs/gal produced water without comprising the engineer's design constraints. (9.3 lbs/Gal * 7.48 Ft^3/Gal *10.3 Ft = 715.51psf which is less that tank design max load of 718 psf)

Thank You,

Jason Henderson, P.E.
Director, Water and Disposal Solutions
Complete Energy Services Water Transfer & Treatment
Fluid Management Division
4727 Gaillardia Parkway, Suite 250 | Oklahoma City, OK | 73142
Direct: (405) 748-2221 | Mobile: (405) 365-0952 | Fax: (405) 748-2202
Email: jhenderson@CES-fluidmgmt.com

Variance Requests (19.15.17.15)

The applicant (Devon Energy) asks the Division District for the approval of the variances listed below. We conclude that the variance requests provide equal or better protection of fresh water, public health and the environment.

Fencing 19.15.17.11.D

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 19.15.17.11.

D. Fencing.

(1)The operator shall fence or enclose a pit or below-grade tank in a manner that deters unauthorized access and shall maintain the fences in good repair. Fences are not required if there is an adequate surrounding perimeter fence that prevents unauthorized access to the well site or facility, including the pit or below-grade tank. During drilling or workover operations, the operator is not required to fence the edge of the pit adjacent to the drilling or workover rig.

And

(3) The operator shall fence any other pit or below-grade tank to exclude livestock 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 Pit Rule is obviously written for earthen, lined pits and below grade tanks, not free-standing modular impoundments. The modular impoundment meets the prescriptive mandates in the first sentence of D(1): “”The operator shall fence or enclose a pit or below-grade tank in a manner that deters unauthorized access…”.

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

The 12-foot tall steel tank clearly deters unauthorized access. This same 12-foot high steel wall of the tank excludes livestock and wildlife. The applicant concludes the 12-foot high steel walls provide equal or better protection as fencing.

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: _Devon Energy Production Company, L.P. _____(For multiple operators attach page with information) OGRID #:___6137_____

Address: __333 W. Sheridan, Oklahoma City, OK 73102-8260_____

Facility or well name (include API# if associated with a well): _Hackberry 16 Recycling Containments and Facility API# Not Applicable_____

OCD Permit Number: _____(For new facilities the permit number will be assigned by the district office)

U/L or Qtr/Qtr _____M_____ Section _____16_____ Township ____19S_____ Range ____31E_____ County: __Eddy_____

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

2.

☒ **Recycling Facility:**

Location of recycling facility (if applicable): Latitude ___32° 39' 15.84" N _____ Longitude ___103° 52' 53.72" W _____ NAD: ☐1927 ☒ 1983

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:**

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

Center of Recycling Containment (if applicable): Latitude __ 32° 39' 16.96" N _____ Longitude __103° 52' 54.76" W _____ NAD: ☐1927 ☒ 1983

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

☒ Lined ☒ Liner type: Thickness _two 30_mil (Primary) one 40-mil (Secondary) ☒ LLDPE ☐ HDPE ☐ PVC ☐ Other __

☒ String-Reinforced

Liner Seams: ☐ Welded ☒ Factory ☐ Other _____ Volume: _41,000 each_ bbl Dimensions: __diameter 158 ft, height 12 ft __

☐ 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 specify___See previously-approved variance _____

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. *See Figures 1 and 2* NM Office of the State Engineer - iWATERS database search; USGS; Data obtained from nearby wells	☐ 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. *See 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. *See Figure 7* - Written confirmation or verification or map from the NM EMNRD-Mining and Minerals Division	☐ Yes ☒ No
Within an unstable area. *See 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 *See 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). *See 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 *See 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. *See Figures 1 and 2* - NM Office of the State Engineer - iWATERS database search; visual inspection (certification) of the proposed site	☐ Yes ☒ No
Within 500 feet of a wetland. *See 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 D*
- ☒ Closure Plan - based upon the appropriate requirements. *Appendix E*
- ☒ Site Specific Groundwater Data -
- ☒ Siting Criteria Compliance Demonstrations –
- ☒ **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): Jeff Sawyer Title: Water Management Engineer

Signature: Date: March 31, 2015

e-mail address: jeff.sawyer@dvn.com Telephone: (405) 228-3066

11.

OCD Representative Signature: **Approval Date:**

Title: **OCD Permit Number:**

☐ OCD Conditions

☐ Additional OCD Conditions on Attachment

Siting Criteria (19.15.34.11 NMAC)

Geologic Setting of the Regional Fresh-Water Bearing Formations

The interbasin region of the northeastern High Plains of Eddy County is characterized on the surface by stabile and semi-stable sand dunes, playas, caliche terraces, and sparse vegetation consisting of grasses and shrubs. The Hackberry Produced Water Recycling Containments and Facility (Site) lies just beyond the eastern escarpment of Nimenim Ridge, northeast of the city of Carlsbad. Nimenim Ridge lies directly west of the site and separates the Clayton Basin from the sandy dunes of the Querecho Plains and Laguna Valley. The surface here consists mainly of dune sand (stable and semi-stable) with an occasional exposure of underlain caliche terraces. Thickness of surface sand ranges from a few inches to 30 feet.

Groundwater is generally of poor quality and is primarily found in Triassic and Permian-aged rocks, the oldest from the Rustler Formation consisting of limestone, gypsum/anhydrite, interbedded with green and sandy clay with some dolomite. Rustler wells are mostly used for the potash industry and livestock with some used domestically. Groundwater from these wells is typically high in chloride and sulfate. Sandstones and redbeds of the Dockum group overlay the Rustler formation at the Site. The quality of groundwater from the Santa Rosa sandstone, generally, is better than the older, underlying Rustler.

Cenozoic Era rocks in the area consist of the Tertiary age Ogallala Formation and Quaternary age eolian and alluvium deposits. The Ogallala Formation consists of terrestrial sediments (sand with some clay, silt and gravel) and a thin layer Quaternary age sands blanket the Ogallala across most of the area; however, the Ogallala and associated alluvium groundwater is only present in the Site locale in small areas of high plains in the northeast part of Eddy County. Wells completed in the Ogallala and Quaternary alluvium offer the best quality of groundwater found in this region.

The Clayton Basin, a collapse feature, is located approximately 6 miles southwest of the Site. Once a closed basin, upper Permian deposition is now developed for commercial potash operations. Regionally, groundwater flow trends in a southwesterly direction toward the Pecos River, but is impeded by the Clayton Basin and other collapse features in the area. Groundwater gradient is relatively flat with local drainage trending toward these basins. East of Nimenim Ridge, the area has no local drainage features except for some playas, short arroyos, and minor flanks of the larger basins, largely due to the evaporation and transpiration effects of the thick Mescalero Sands at the surface.

http://geoinfo.nmt.edu/publications/openfile/downloads/0-99/95/ofr_95.pdf
http://pbadupws.nrc.gov/docs/ML0424/ML042430324.pdf

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 Site.

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

1. The location of the proposed Site as a blue square.
2. Water wells from the USGS database as color-coded triangles that indicated 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.
4. 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.
5. GWR-3 (and similar) is from Ground Water Report #3. OFR-95 (and similar) is from Open File Report #95.

Figure 2 is a regional topographic base map that depicts the potentiometric surface contours of groundwater from Ground-Water Report #3 (GWR-3) *Geology and Ground-Water Resources of Eddy County, New Mexico*, by G.E. Hendrickson and R.S. Jones (1952). The potentiometric contours are labeled in feet above sea level (ASL). Figure 2 also shows:

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

Site Geology

The Site is located on an outcrop of Quaternary Age eolian and piedmont deposits (Qe/Qp on Figure 1). These fine-grained sands, along with the Quaternary piedmont deposits and Quaternary lacustrine/playa deposits (Qp and Qpl on Figure 1), are present covering the underlying eroded Tertiary or Triassic age rocks. Permian Salado deposits southwest of the Site (Clayton Basin) are of commercial importance to the local potash industry. Motorcyclists and all-terrain vehicle enthusiasts take advantage of the large stable sand dunes at the BLM Hackberry Lake Off-Highway Vehicle recreation area located 1.5 miles southeast of the Site.

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

Water Table Elevation

Several water wells were identified in the area surrounding the Site, with the closest ones located approximately 2 miles from the site (see Figure 1). The primary data for the wells are from the

OSE Waters database. As stated previously, the groundwater elevations provided for the OSE wells are likely based on driller log notes rather than measurements made under static conditions.

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:

- Some wells such as Misc-260 and Misc-266 are located in close proximity to each other, but have been verified to be two wells by aerial photographs, site visits, and/or topographic maps.

- USGS Well 966 is the only well in Figure 1 to be completed in the Santa Rosa water-bearing formation. The only wells to tap the alluvium/Bolsom aquifers are located in the top-right corner of Figure 1. All other wells appear to be completed in Permian-aged water-bearing formations.

- Misc-260 and Misc-266 appear to be located on the "Slash X" ranch or Lusk Ranch. Evidence of these wells was observed from the road and from aerial photographs but access was not possible on the day of site inspection.

- Misc-262 was active on the day of inspection by supplying drinking water to cattle in nearby water trough; access was possible and depth to groundwater was determined on March 3, 2015 by R. T. Hicks, P.G..

Groundwater depth measurement at Misc-262

Hydrogeology

GWR-3 and data from area wells indicate that Ogallala groundwater is not present as a regional aquifer in the area surrounding the proposed Site location. The only water wells in the mapping area identified as an Ogallala or Alluvium producer area located east of the Site more than 10 miles away.

Based on published potentiometric surface maps (shown in Figure 2), the groundwater elevation at the site is approximately 3,275 ASL. With a surface elevation of 3,466.2 feet ASL, the depth to groundwater below the surface at the site should be approximately 191 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 approximately 1,200 feet north of the site.

Distance to Permanent Residence or Structures

Figure 4 and the site visit demonstrates that the location is not within 1,000 feet from a permanent residence, school, hospital, institution, church, or other structure in existence at the time of initial application.

- The nearest residence is approximately 1.9 miles south.
- The nearest structures are oil/gas well locations.

Distance to Non-Public Water Supply

Figures 1 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 shows the locations of all area water wells; the nearest fresh water well is located 2 miles to the southeast of the site. 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 Carlsbad, NM approximately 30 miles to the west-southwest.
- The closest public well field is located approximately 17 miles to the northeast.

Distance to Wetlands

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

- The nearest designated wetlands is classified as “riverine” by the National Wetlands Inventory and is located 1,100 feet north. Field inspection revealed that this feature does not meet the U.S. Fish and Wildlife nor Environmental Protection Agency definitions of “wetland.”

Distance to Subsurface Mines

Figure 7 and our general reconnaissance of the area demonstrate that the nearest mines are associated with potash mining activity and caliche pits.

- The nearest caliche pit is located approximately 4 miles to the east.

- The distance from the site to the nearest boundary of the potash mine district is 1.75 miles west-northwest.

Distance to High or Critical Karst Areas

Figure 8 shows the location of the Site with respect BLM Karst areas

- The proposed Sites are located within a "low" potential karst area.
- The nearest "medium" potential karst area is located approximately 0.75 miles west.
- We saw no evidence of unstable ground near the proposed Site location during the site inspection.

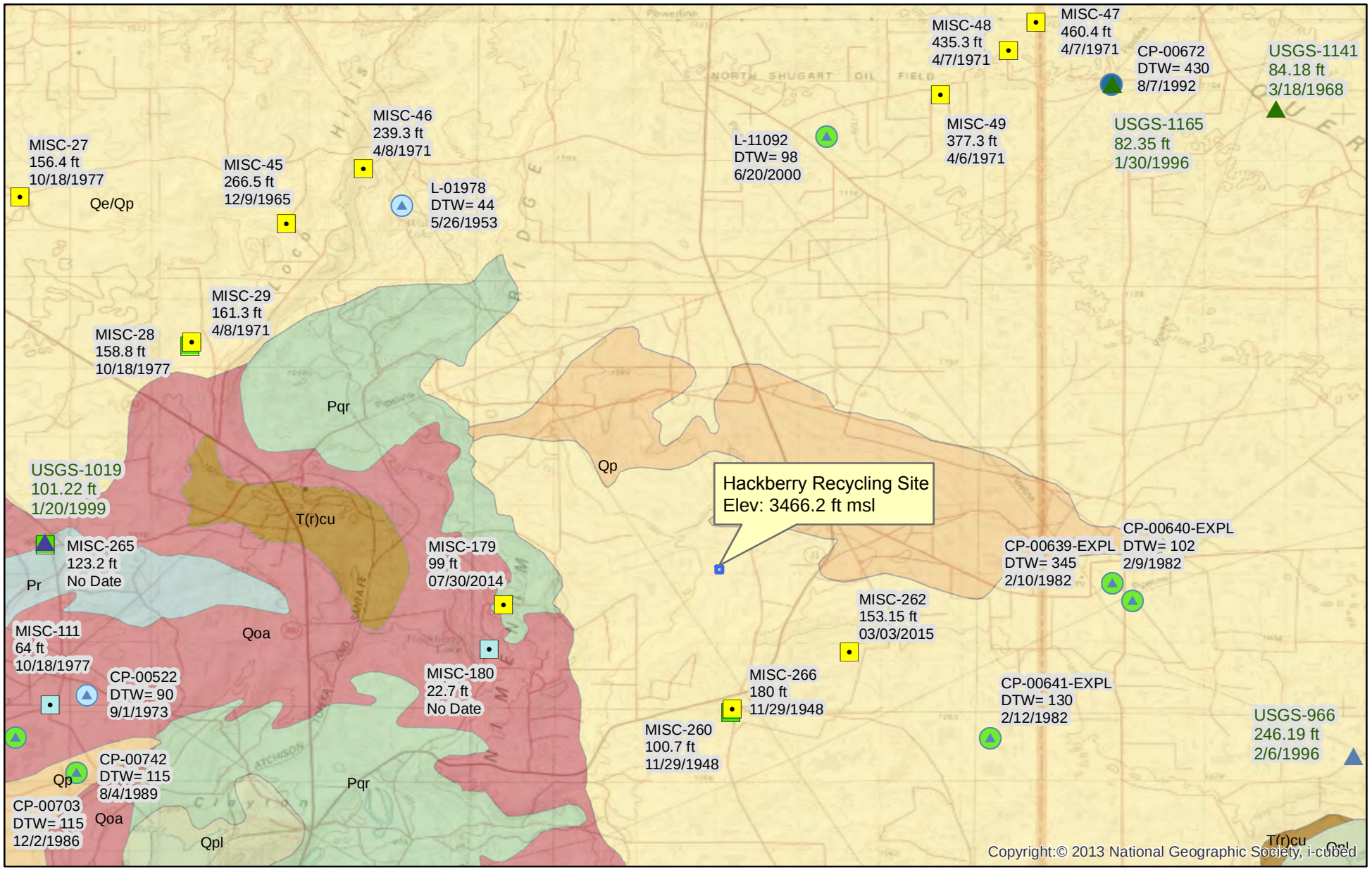
Distance to 100-Year Floodplain

Figure 9 demonstrates that the location is within an area mapped by the Federal Emergency Management Agency as "Zone X" with respect to the Flood Insurance Rate 100-Year Floodplain.

- Areas of Zone X are classified as minimal flood hazard.
- Our field inspection and examination of the topography permit a conclusion that the location is not within any floodplain.

Site Specific Information
Figures

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



N
W E
S

0 1 2
Miles

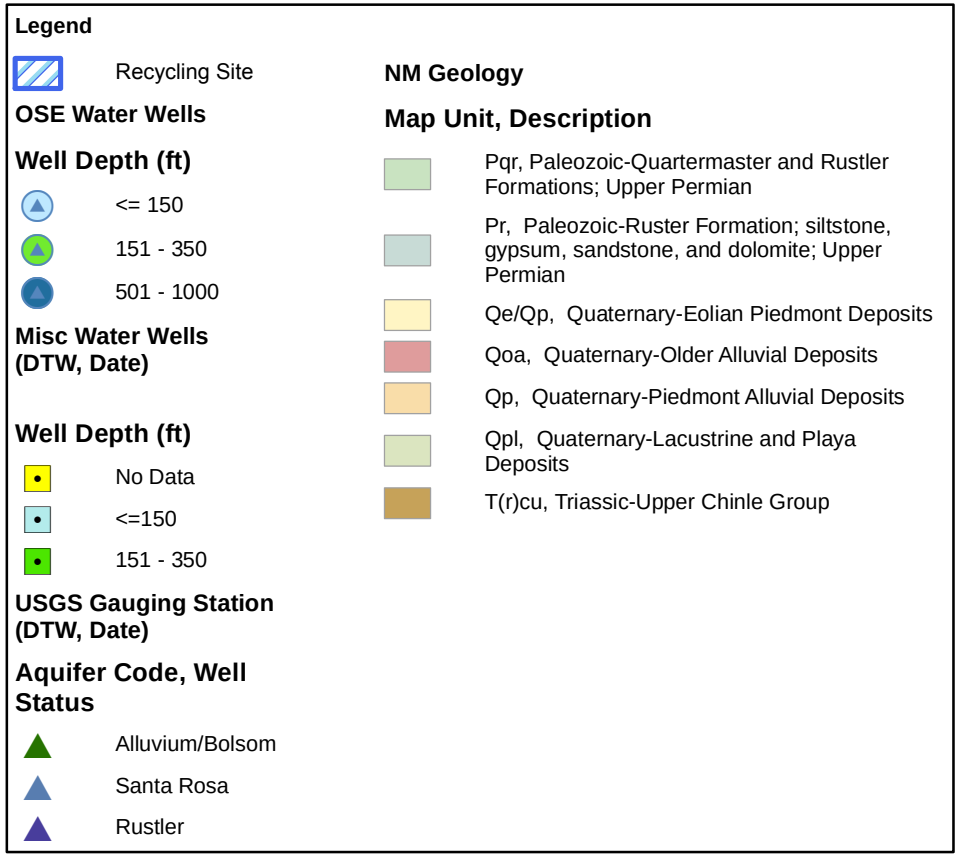
R.T. Hicks Consultants, Ltd
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

Depth To Water and Geology

Figure 1

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015



0 1 2 Miles

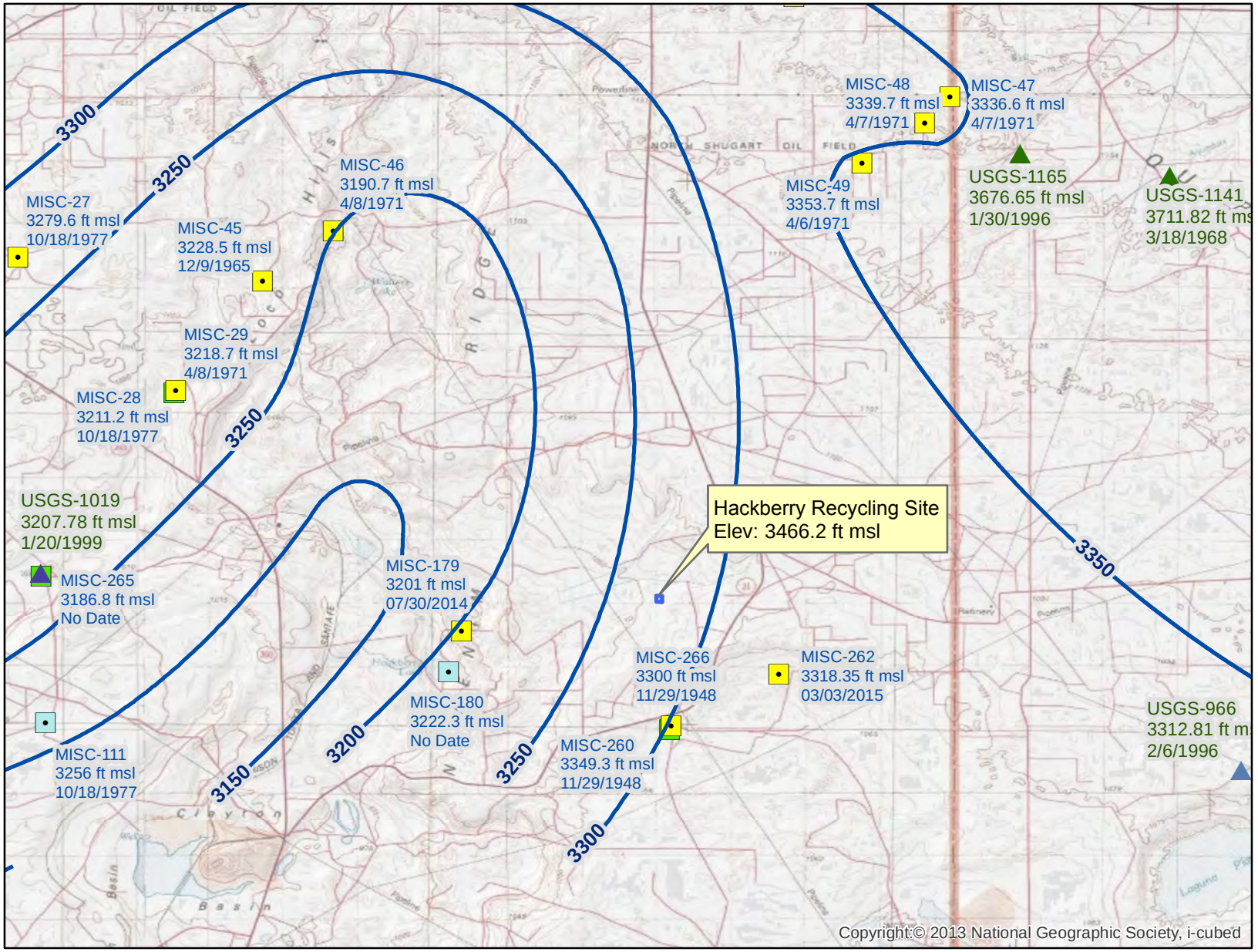
R.T. Hicks Consultants, Ltd
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

Depth To Water and Geology

Figure 1

Devon Energy Production Company, L.P.
Hackberry "16" Produced Water ASTs

March 2015



Legend

Potentiometric Surface (ft msl)

Isocontour

Misc. Water Wells (GW Elev, Date)

TD_ft

No Data

<= 150

151 - 350

USGS Gauging Station (GW Elev, Date)

Aquifer Code, Well Status

Alluvium/Bolsom

Santa Rosa

Rustler

N W E S

0 1 2 Miles

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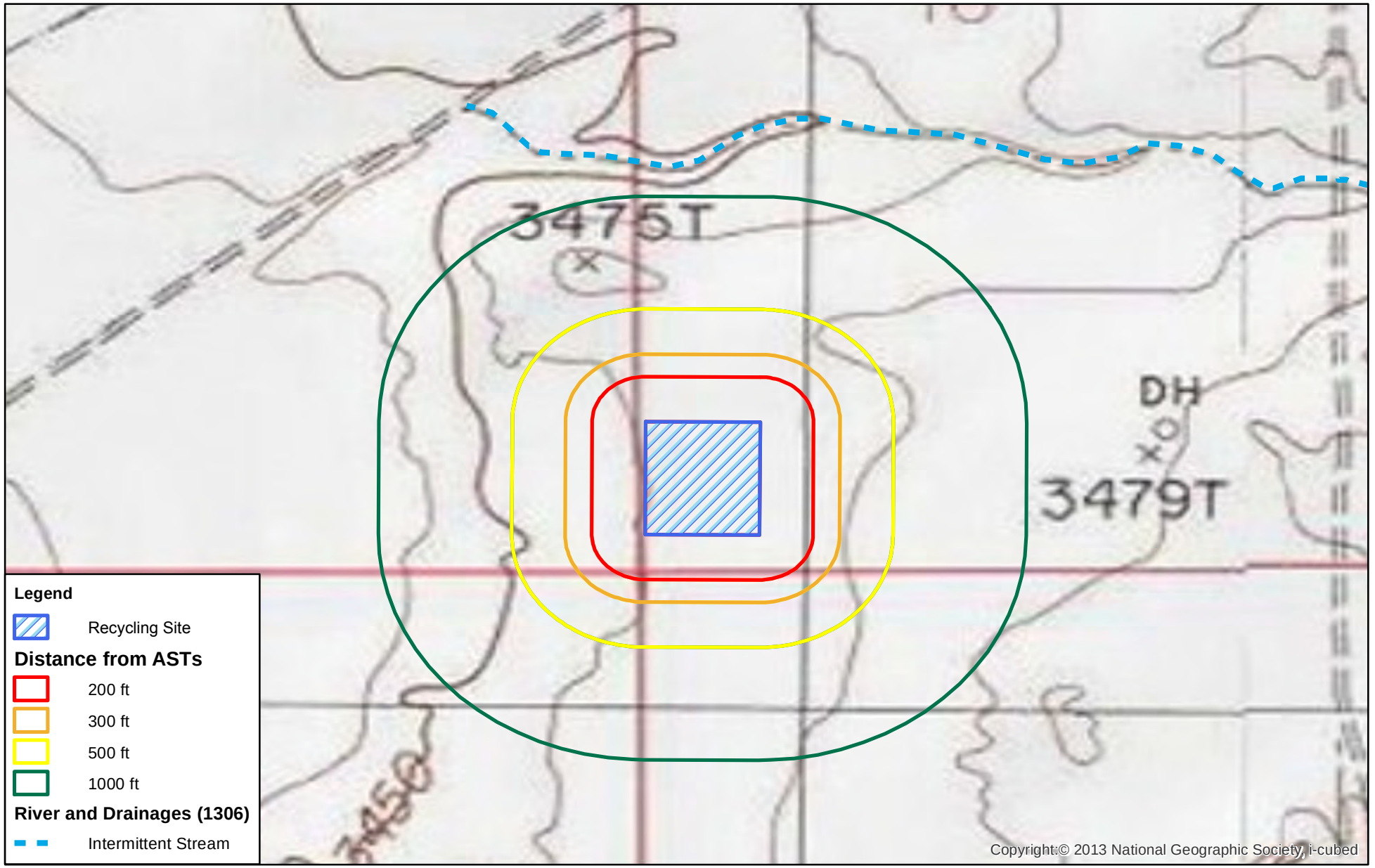
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

Potentiometric Surface and Groundwater Elevation at Nearby Water Wells

Figure 2

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015



N
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0 300 600
Feet

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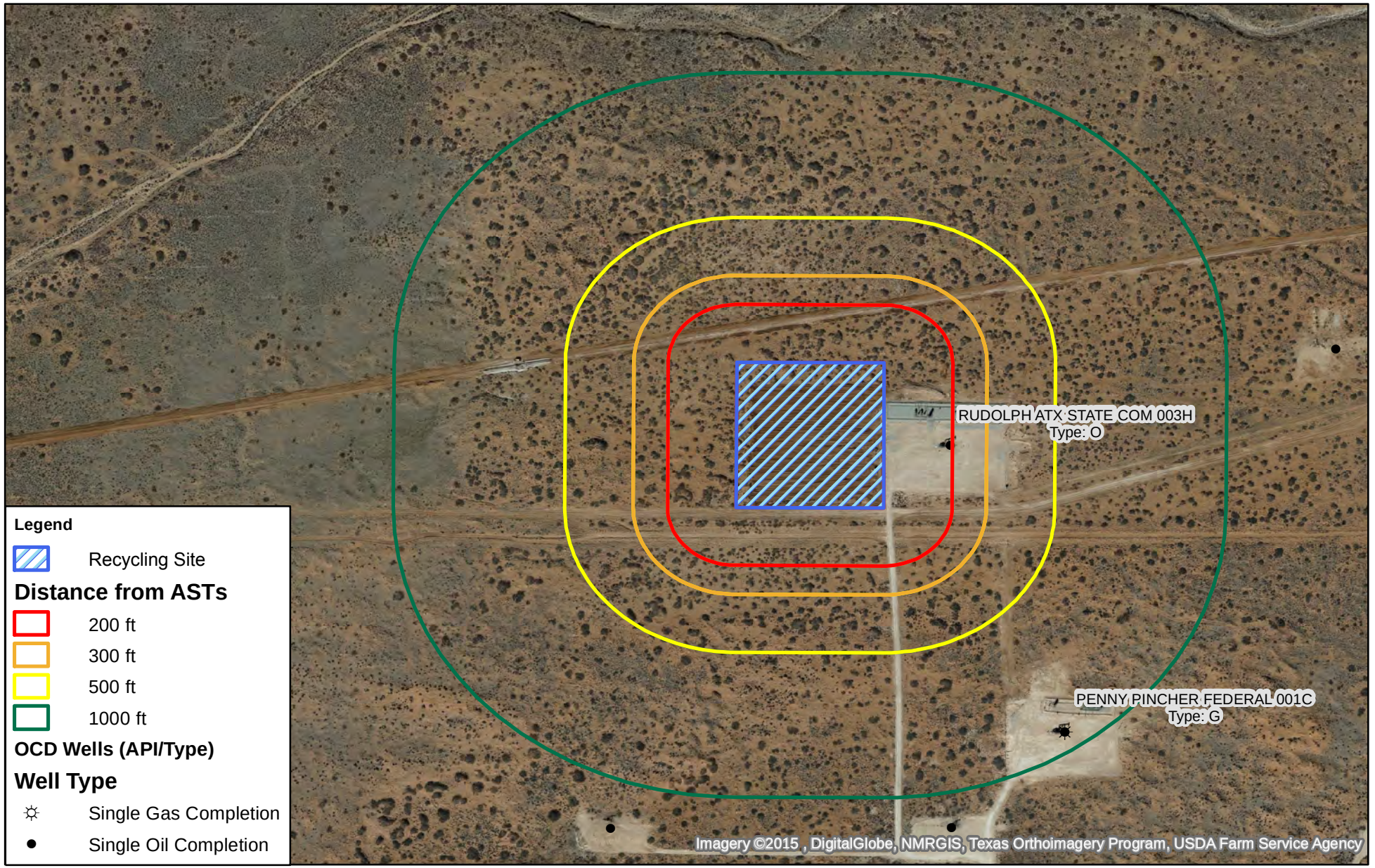
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

Surface Water and Topography

Figure 3

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015



Legend

Recycling Site

Distance from ASTs

200 ft

300 ft

500 ft

1000 ft

OCD Wells (API/Type)

Well Type

Single Gas Completion

Single Oil Completion

N

W E

S

0 250 500

Feet

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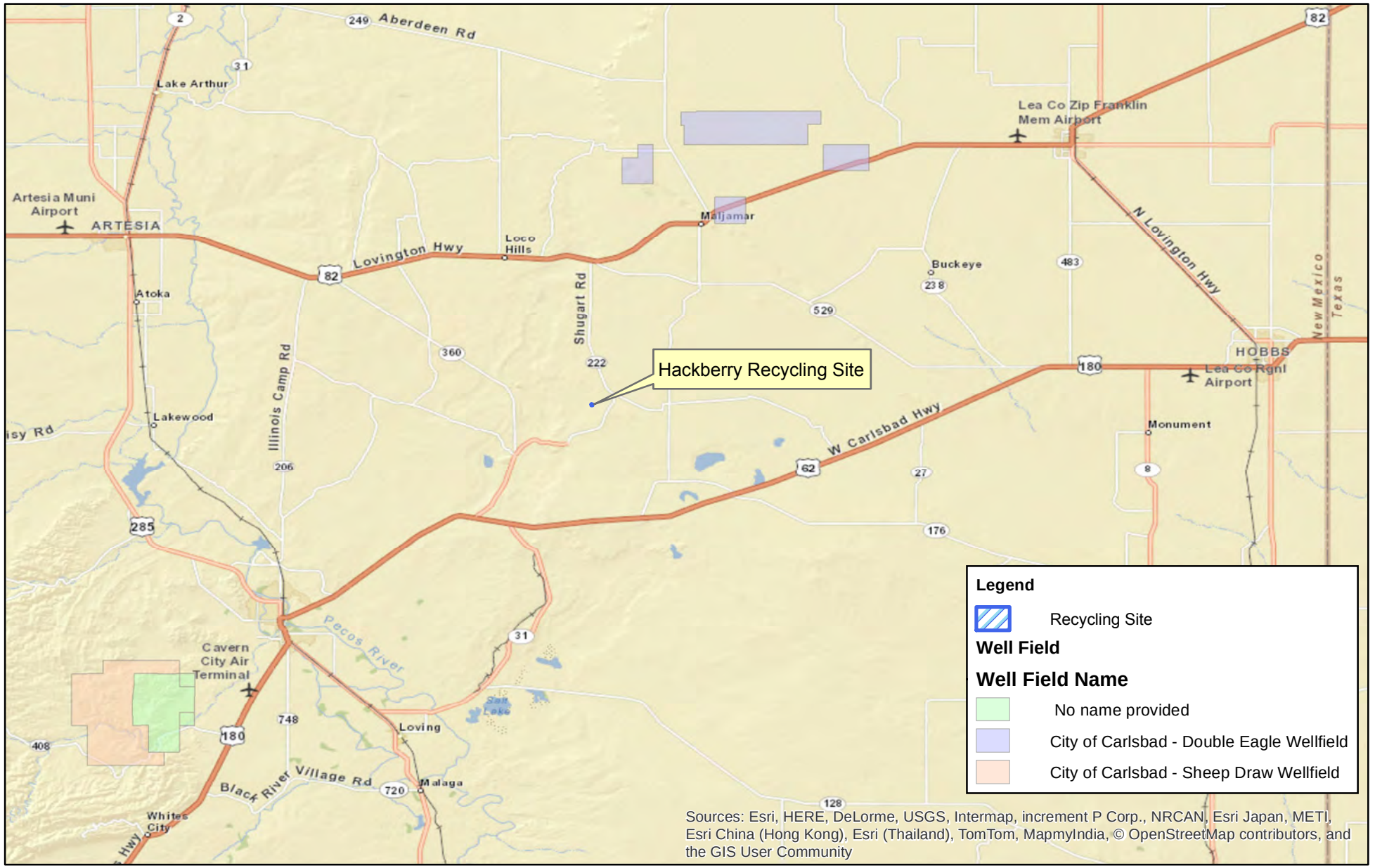
Albuquerque, NM 87104
Ph: 505.266.5004

Nearby Structures

Figure 4

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015



N W E S

0 5 10 Miles

R.T. Hicks Consultants, Ltd
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Albuquerque, NM 87104
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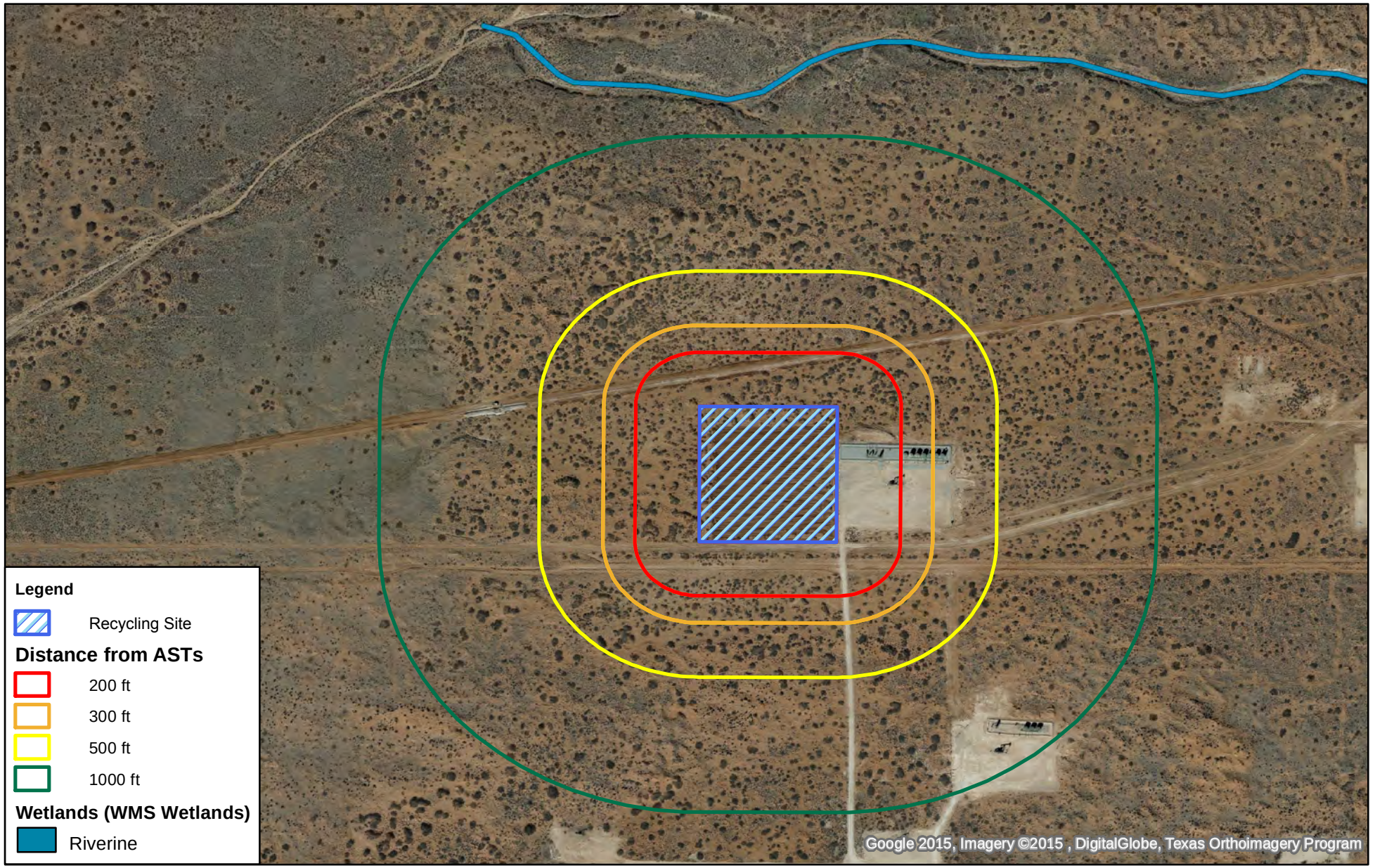
Nearby Municipalities and Well Fields

Figure 5

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015



N
W E
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Feet

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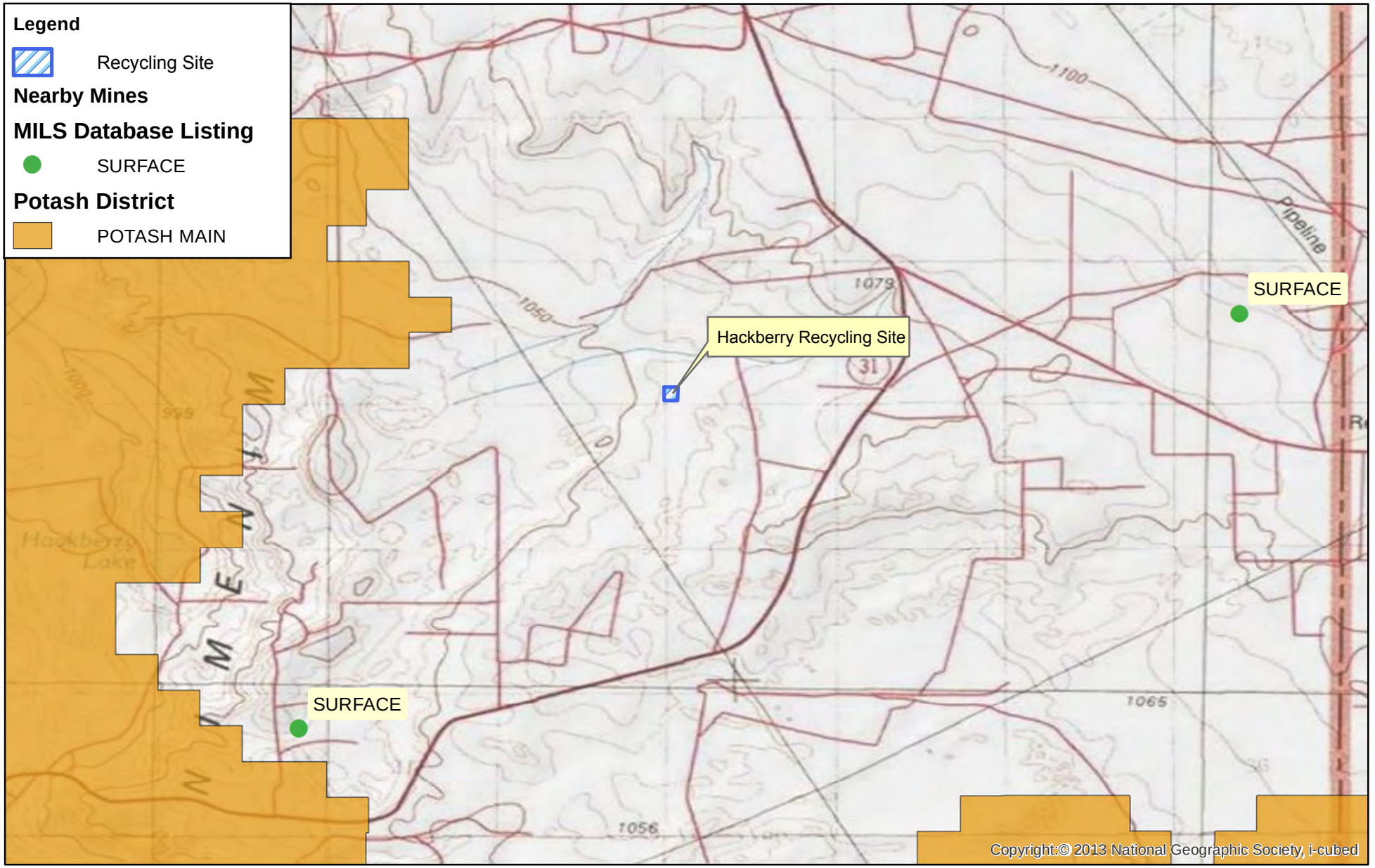
Albuquerque, NM 87104
Ph: 505.266.5004

Nearby Wetlands

Figure 6

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015



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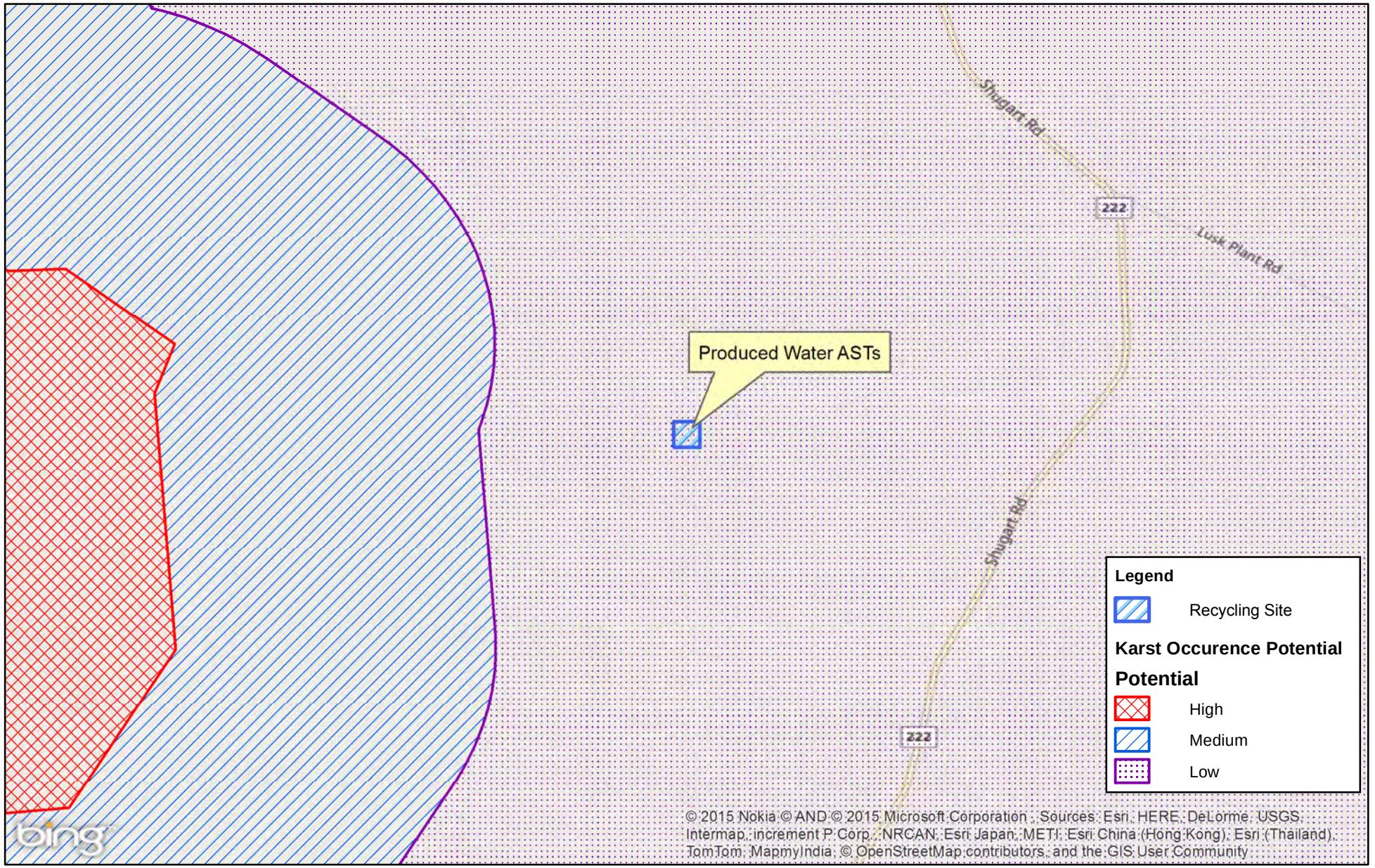
R.T. Hicks Consultants, Ltd
901 Rio Grande Blvd NW Suite F-142
Albuquerque, NM 87104
Ph: 505.266.5004

Nearby Mines and Minerals

Figure 7

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015



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0 0.25 0.5
Miles

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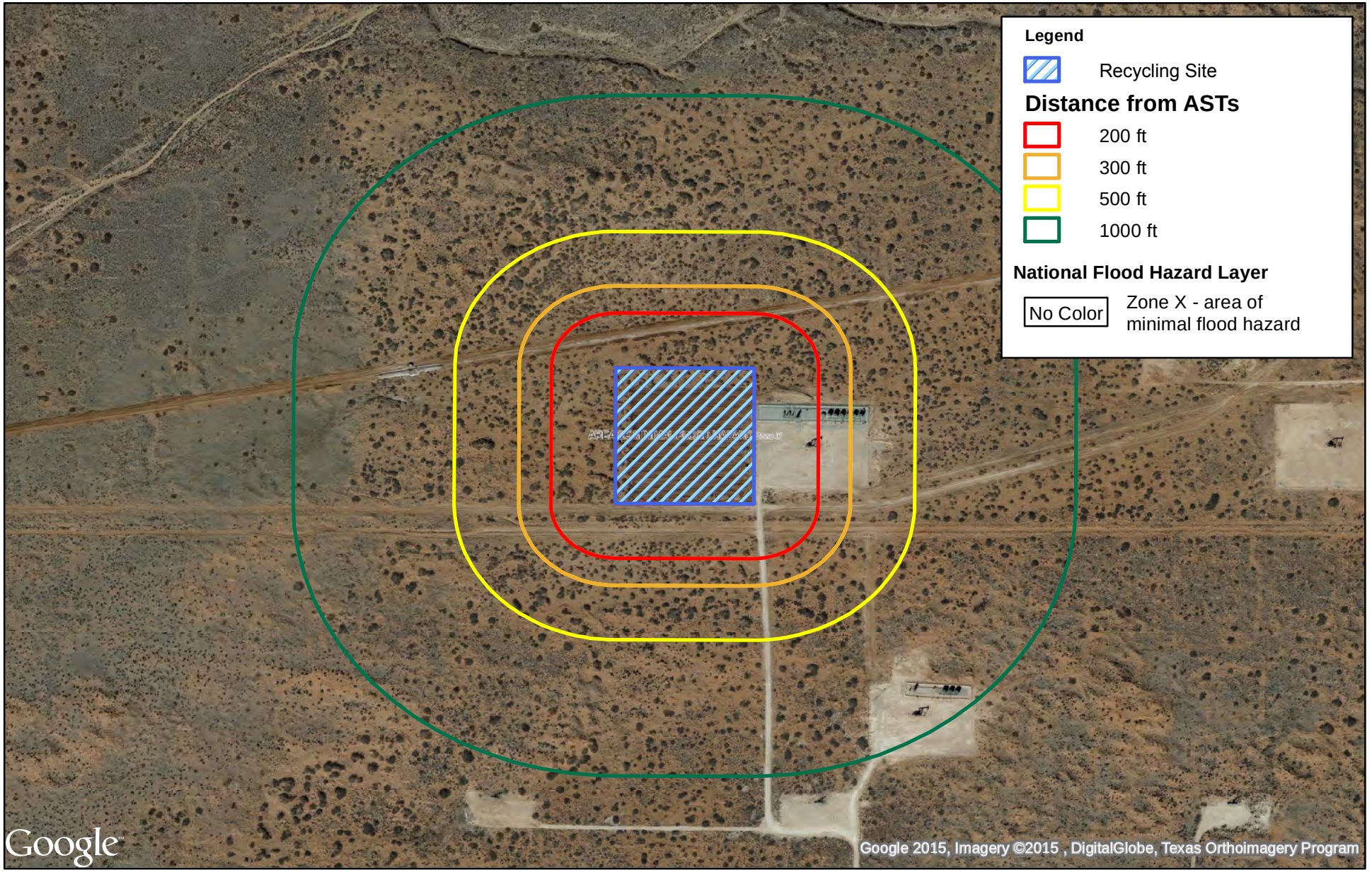
Albuquerque, NM 87104
Ph: 505.266.5004

Karst Potential

Figure 8

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015



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

N
W E
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0 250 500
Feet

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

FEMA Flood Map

Figure 9

Devon Energy Production Company, L.P.
Hackberry Recycling Containments and Facility

March 2015

C-102 Survey
and Site Inspection Photographs

District I
1625 N. French Dr., Hobbs, NM 88240
Phone: (575) 393-6161 Fax: (575) 393-0720
District II
811 S. First St., Artesia, NM 88210
Phone: (575) 748-1283 Fax: (575) 748-9720
District III
1000 Rio Brazos Road, Aztec, NM 87410
Phone: (505) 334-6178 Fax: (505) 334-6170
District IV
1220 S. St. Francis Dr., Santa Fe, NM 87505
Phone: (505) 476-3460 Fax: (505) 476-3462

State of New Mexico
Energy, Minerals & Natural Resources Department
OIL CONSERVATION DIVISION
1220 South St. Francis Dr.
Santa Fe, NM 87505

Form C-102
Revised August 1, 2011
Submit one copy to appropriate District Office

☐ AMENDED REPORT

WELL LOCATION AND ACREAGE DEDICATION PLAT

1 API Number	2 Pool Code	3 Pool Name
30-015-41783	97975	~~DEVONIAN;SILURIAN;ORDOVICIAN~~ SWD; DEV-FUS-MON-SIMP. ELL
4 Property Code	**5 Property Name**	**6 Well Number**
40216	HACKBERRY 16 SWD	1
7 OGRID No.	**8 Operator Name**	**9 Elevation**
6137	DEVON ENERGY PRODUCTION COMPANY, L.P.	3466.2

10 Surface Location

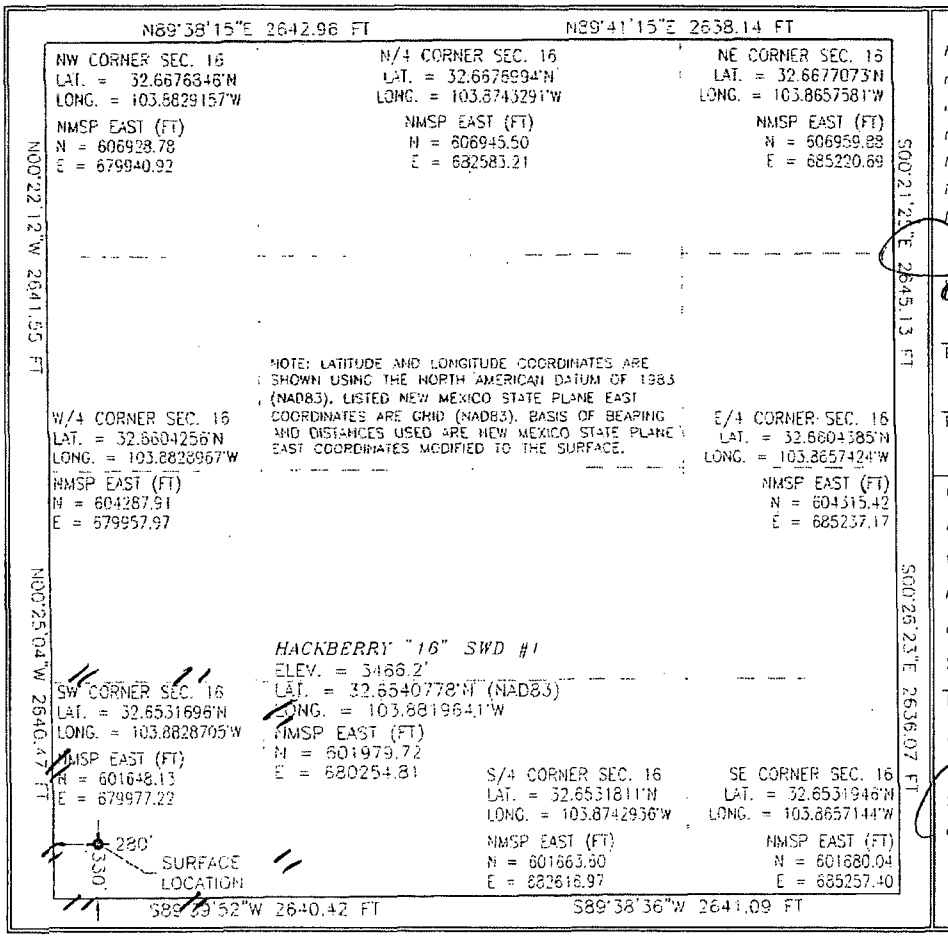
UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	North/South line	Feet from the	East/West line	County
M	16	19 S	31 E		330	SOUTH	280	WEST	EDDY

11 Bottom Hole Location If Different From Surface

UL or lot no.	Section	Township	Range	Lot Idn	Feet from the	North/South line	Feet from the	East/West line	County

12 Dedicated Acres	13 Joint or Infill	14 Consolidation Code	15 Order No.
40			

No allowable will be assigned to this completion until all interests have been consolidated or a non-standard unit has been approved by the division.



16 OPERATOR CERTIFICATION

I hereby certify that the information contained herein is true and complete to the best of my knowledge and belief, and that this organization either owns a working interest or unleased mineral interest in the land including the proposed bottom hole location or has a right to drill this well at this location pursuant to a contract with an owner of such a mineral or working interest, or to a voluntary pooling agreement or a compulsory pooling order heretofore entered by the division.

Judy Barnett 11/5/13
Signature Date

Judy A. Barnett Sr. Regulatory Specialist
Printed Name

E-mail Address

18 SURVEYOR CERTIFICATION

I hereby certify that the well location shown on this plat was plotted from field notes of actual surveys made by me or under my supervision, and that the same is true and correct to the best of my belief.

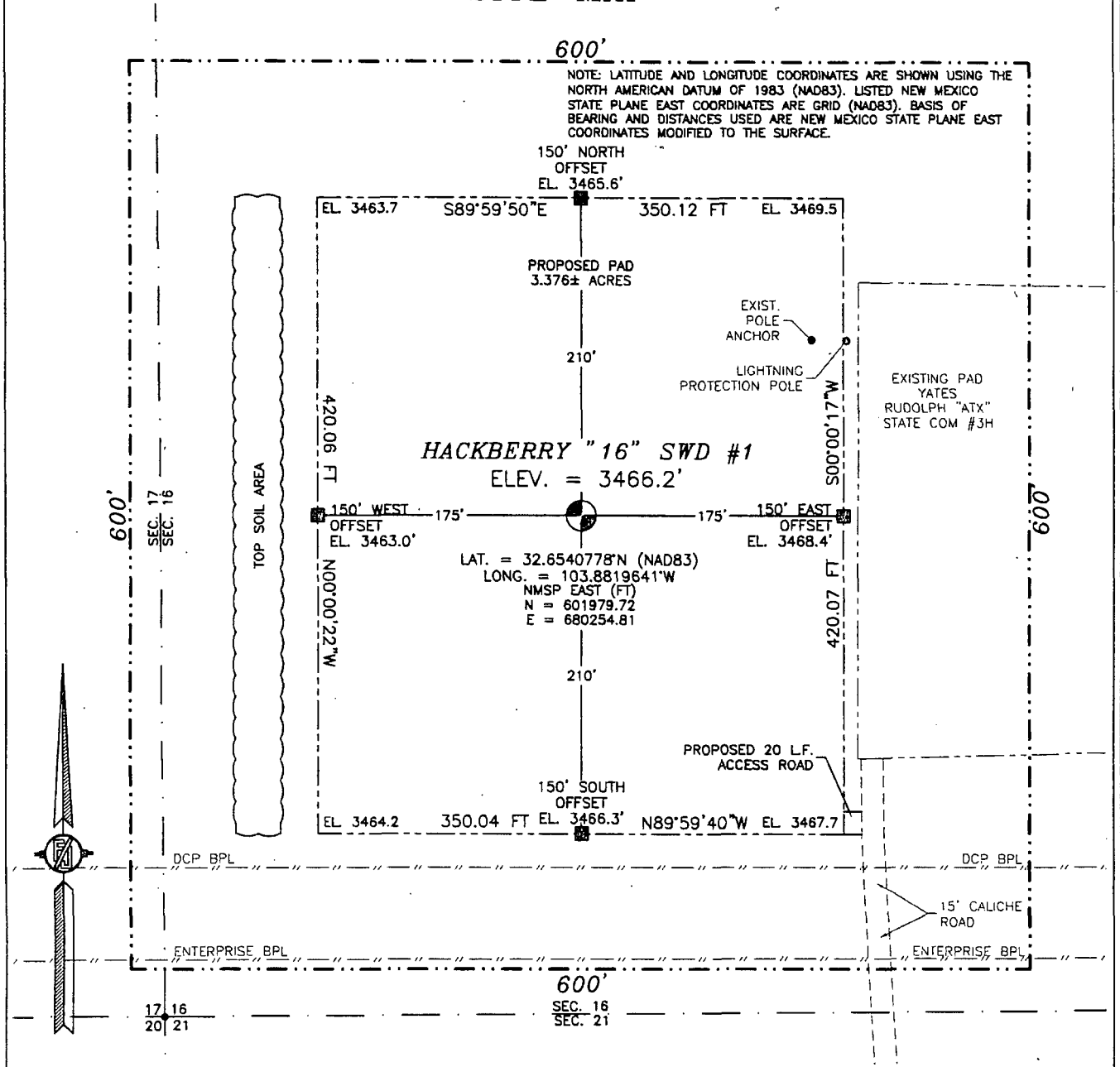
SEPTEMBER 16, 2013
Date of Survey

(12797)
Signature and Seal of Professional Surveyor:

FRED MONTE PARAMILLO
Certificate Number: FRED MONTE PARAMILLO, PLS 12797

SURVEY NO. 2261A

SECTION 16, TOWNSHIP 19 SOUTH, RANGE 31 EAST, N.M.P.M.
EDDY COUNTY, STATE OF NEW MEXICO
SITE MAP



010 50 100 200

SCALE 1" = 100'

DIRECTIONS TO LOCATION

FROM PAVED CR. #222 (SHUGART) AND PAVED CR. #248 (LUSK PLANT RD.) GO SOUTHWEST ON CR. #222 1.6 MILES, TURN RIGHT ON CALICHE LEASE ROAD AND GO WEST-NORTHWEST 0.83 MILES, TURN RIGHT AND GO NORTH 0.2 MILES, TURN LEFT AND GO WEST 255' TURN RIGHT AND GO NORTH 0.22 MILES AND THE SOUTHEAST CORNER OF PROPOSED PAD IS 20' LEFT FOR THIS LOCATION.

DEVON ENERGY PRODUCTION COMPANY, L.P.

HACKBERRY "16" SWD #1

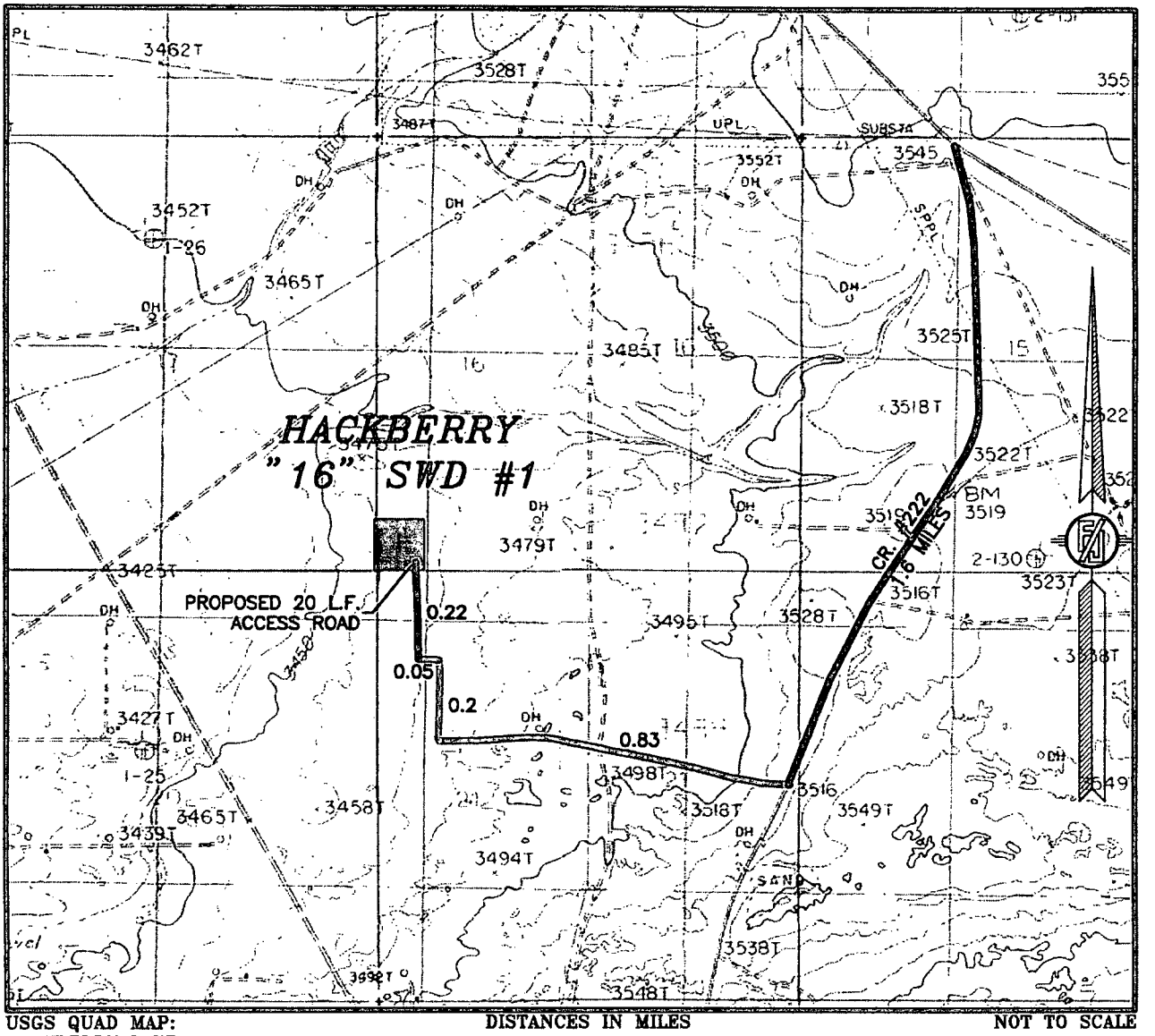
LOCATED 330 FT. FROM THE SOUTH LINE AND 280 FT. FROM THE WEST LINE OF SECTION 16, TOWNSHIP 19 SOUTH, RANGE 31 EAST, N.M.P.M. EDDY COUNTY, STATE OF NEW MEXICO

SEPTEMBER 16, 2013

SURVEY NO. 2261A

MADRON SURVEYING, INC. 301 SOUTH CANAL (575) 234-3341 *CARLSBAD, NEW MEXICO*

SECTION 16, TOWNSHIP 19 SOUTH, RANGE 31 EAST, N.M.P.M.
EDDY COUNTY, STATE OF NEW MEXICO
LOCATION VERIFICATION MAP



USGS QUAD MAP:
HACKBERRY LAKE
GREENWOOD LAKE

DISTANCES IN MILES

NOT TO SCALE

DIRECTIONS TO LOCATION
FROM PAVED CR. #222 (SHUGART) AND PAVED CR. #248 (LUSK PLANT RD.) GO SOUTHWEST ON CR. #222 1.6 MILES, TURN RIGHT ON CALICHE LEASE ROAD AND GO WEST-NORTHWEST 0.83 MILES, TURN RIGHT AND GO NORTH 0.2 MILES, TURN LEFT AND GO WEST 255' TURN RIGHT AND GO NORTH 0.22 MILES AND THE SOUTHEAST CORNER OF PROPOSED PAD IS 20' LEFT FOR THIS LOCATION.

DEVON ENERGY PRODUCTION COMPANY, L.P.
HACKBERRY "16" SWD #1
LOCATED 330 FT. FROM THE SOUTH LINE
AND 280 FT. FROM THE WEST LINE OF
SECTION 16, TOWNSHIP 19 SOUTH,
RANGE 31 EAST, N.M.P.M.
EDDY COUNTY, STATE OF NEW MEXICO

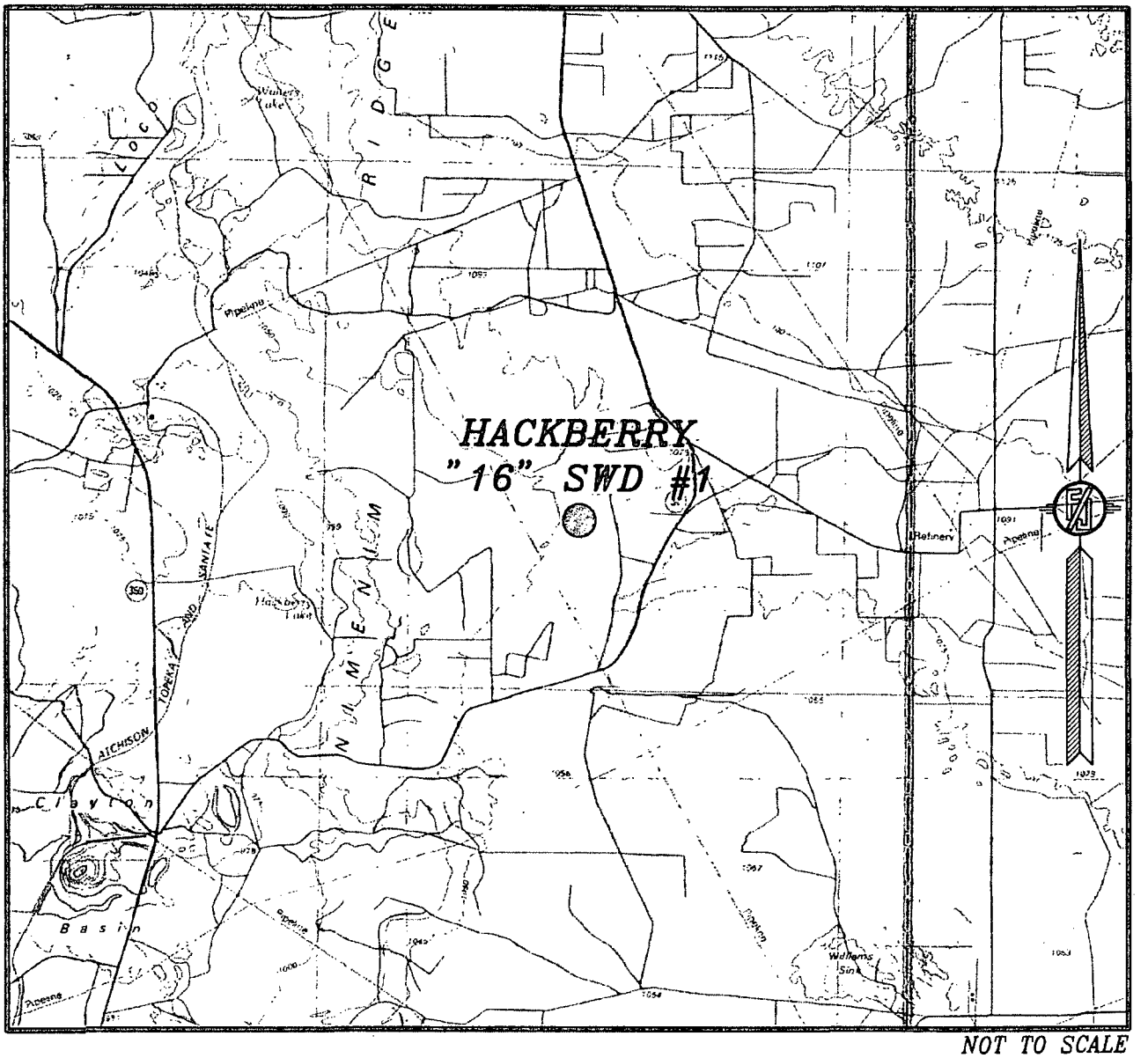
SEPTEMBER 16, 2013

SURVEY NO. 2261A

MADRON SURVEYING, INC. 301 SOUTH CANAL (575) 234-3341 *CARLSBAD, NEW MEXICO*

SECTION 16, TOWNSHIP 19 SOUTH, RANGE 31 EAST, N.M.P.M.
EDDY COUNTY, STATE OF NEW MEXICO

VICINITY MAP



NOT TO SCALE

DEVON ENERGY PRODUCTION COMPANY, L.P.

HACKBERRY "16" SWD #1

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SECTION 16, TOWNSHIP 19 SOUTH,
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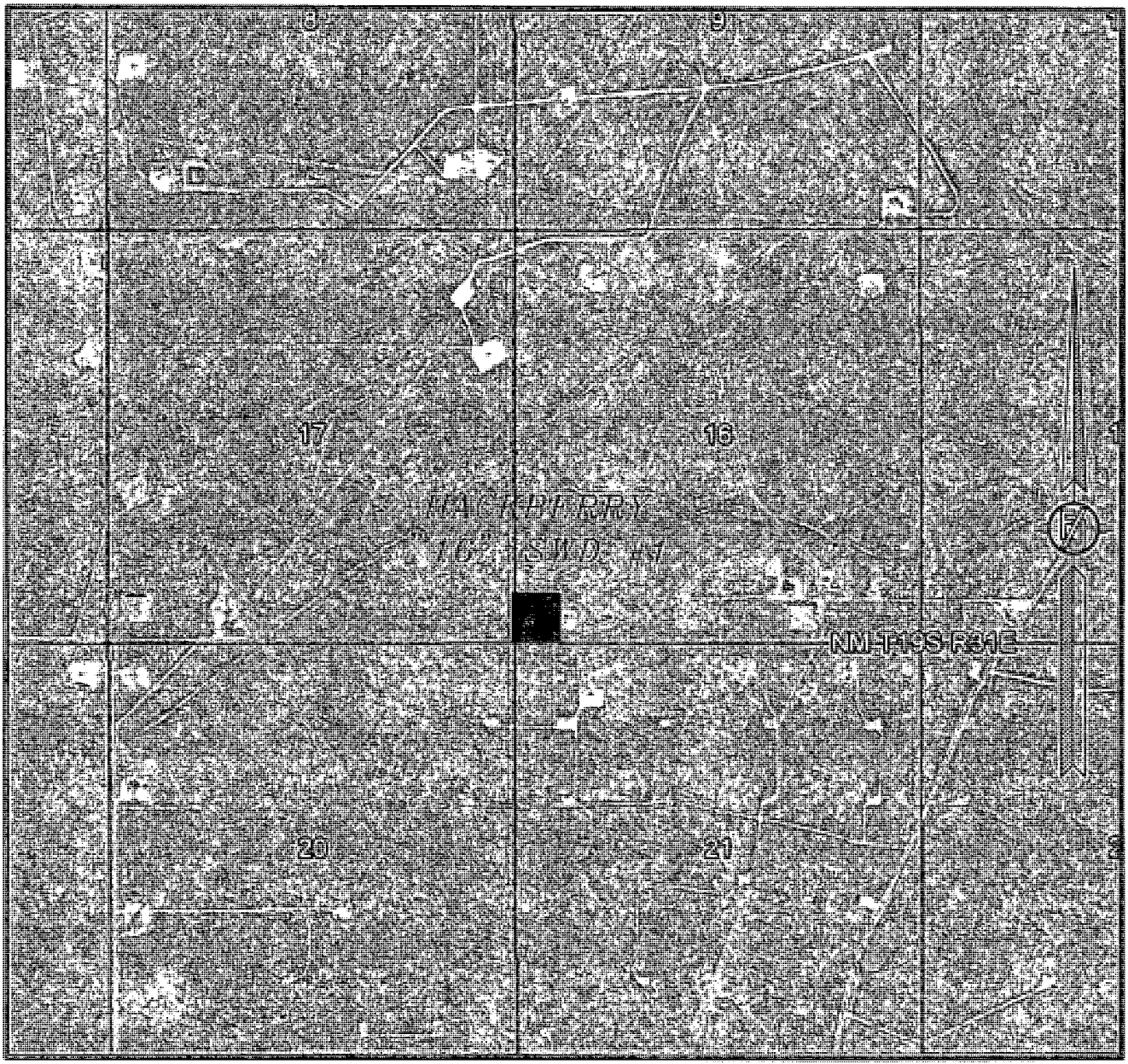
MADRON SURVEYING, INC. 301 SOUTH CANAL (575) 234-3341 CARLSBAD, NEW MEXICO

SECTION 16, TOWNSHIP 19 SOUTH, RANGE 31 EAST, N.M.P.M.
EDDY COUNTY, STATE OF NEW MEXICO

AERIAL PHOTO



NOT TO SCALE
AERIAL PHOTO:
GOOGLE EARTH
MARCH 2012

DEVON ENERGY PRODUCTION COMPANY, L.P.

HACKBERRY "16" SWD #1

LOCATED 330 FT. FROM THE SOUTH LINE
AND 280 FT. FROM THE WEST LINE OF
SECTION 16, TOWNSHIP 19 SOUTH,
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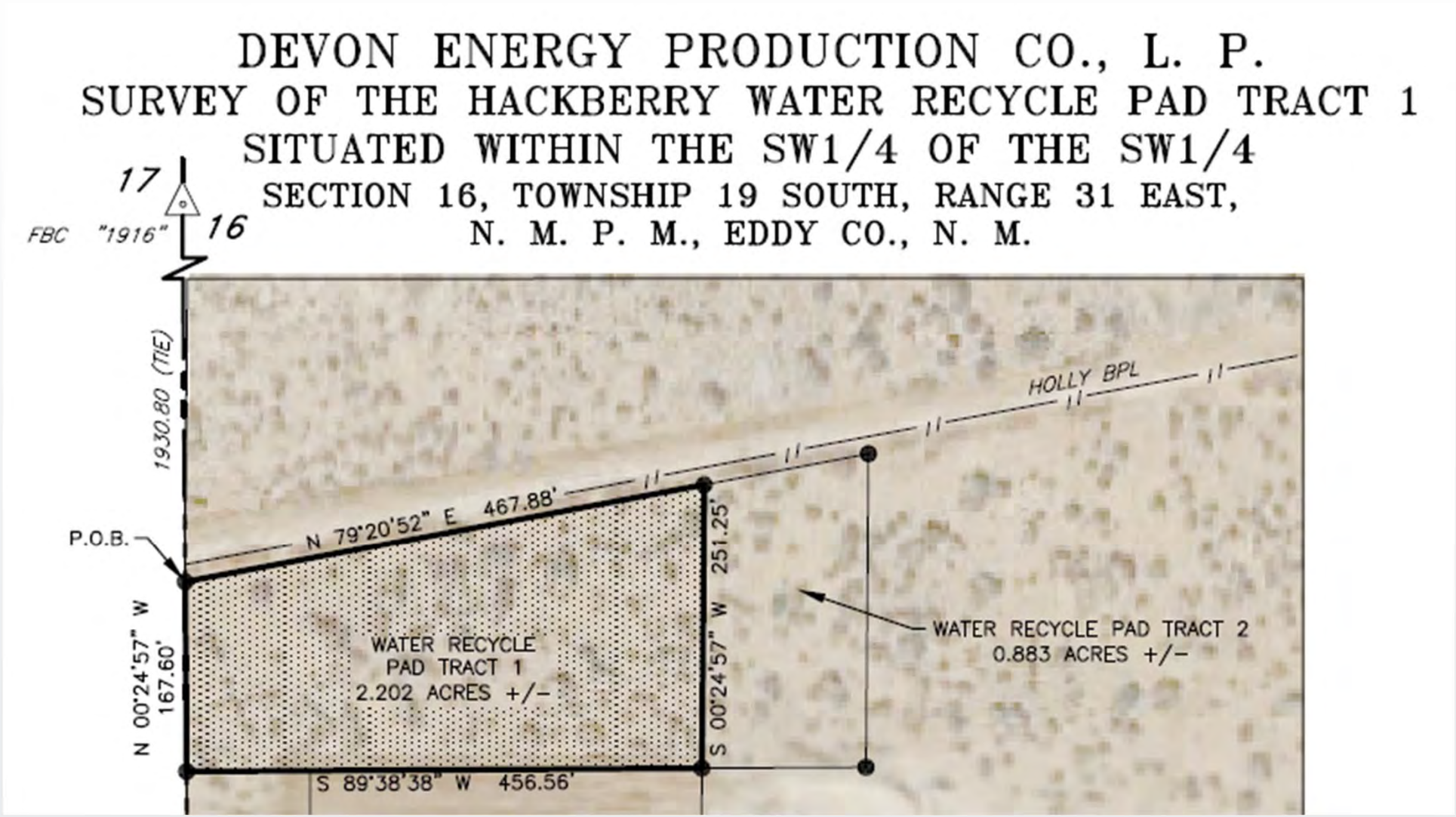
EDDY COUNTY, STATE OF NEW MEXICO

SEPTEMBER 16, 2013

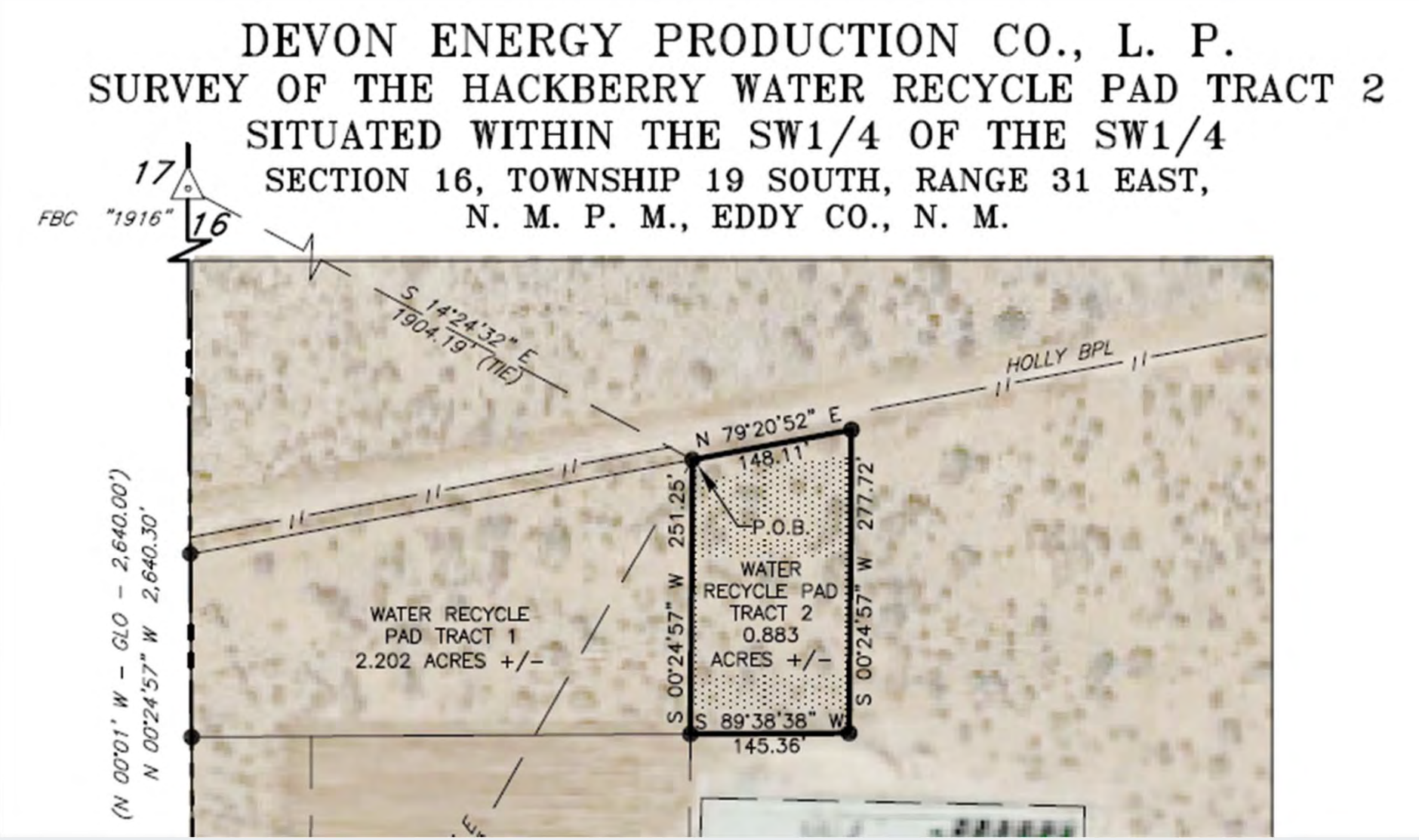
SURVEY NO. 2261A

MADRON SURVEYING, INC. 301 SOUTH CANAL (575) 234-3341 CARLSBAD, NEW MEXICO

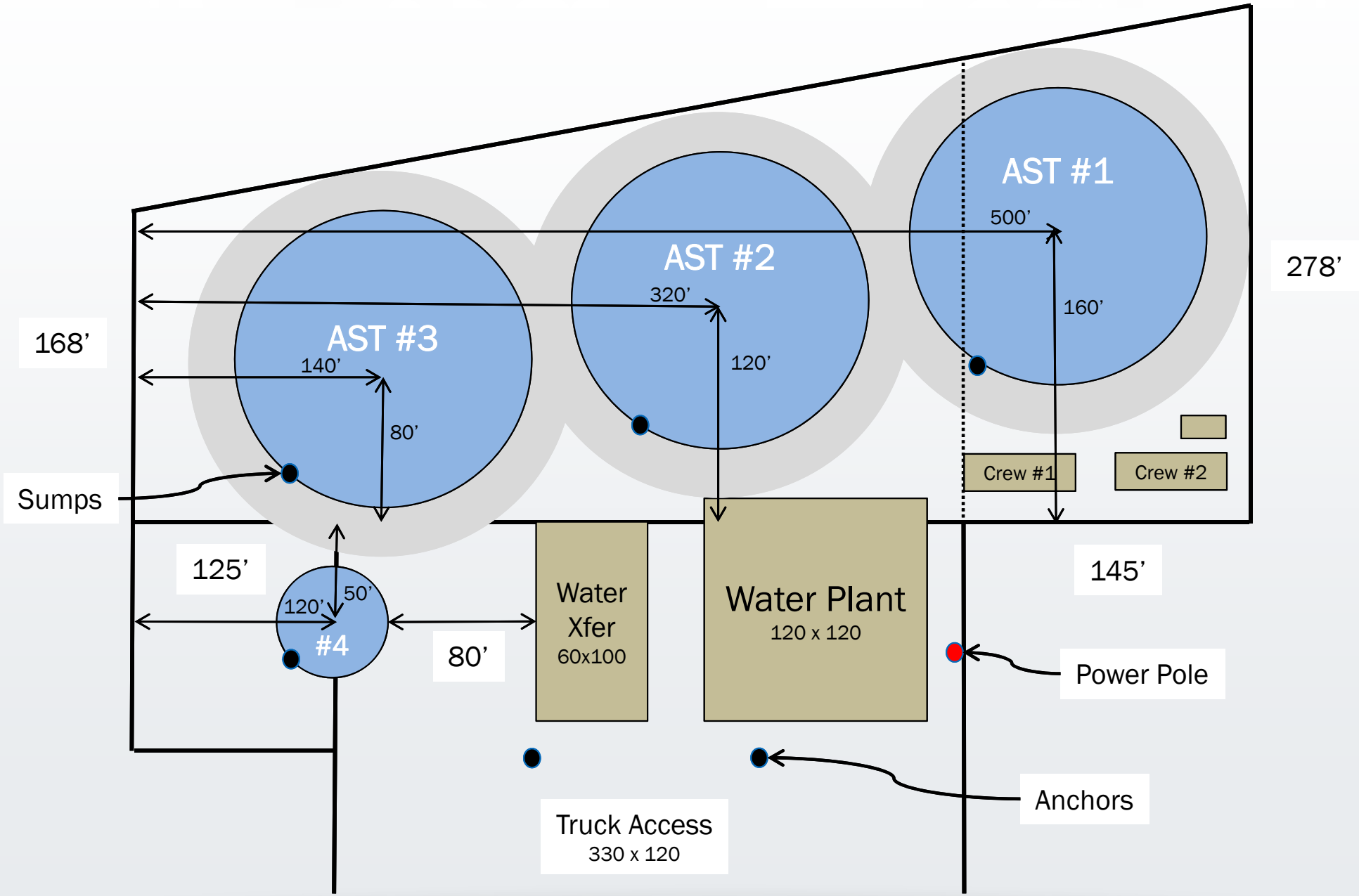
Devon Hackberry SWD
Expanded Padsite Survey – Tract 1



Devon Hackberry SWD
Expanded Padsite Survey – Tract 2



Above Ground Storage (AST) Placement on Devon Hackberry SWD Expanded Padsite



Hackberry Recycling Containments and Facility
Devon/Rockwater
March 3, 2015 Site Visit

View south approx. 215 feet from northern edge of existing well pad

View north-northwest from east edge of existing well pad

View east facing location from property line approx. 275 feet west of SWD well

Appendix A

Certified Engineering Drawings
Liner and Geotextile Specifications

BRAWLER INDUSTRIES, LLC

North America's leading manufacturer of industrial fabrics and liners

BRAWLER® NEW GENERATION CW*

PROPERTIES	ASTM TEST METHOD	30 MIL	
CORE, mil	D5199	30	
DENSITY (g/cm³)	D792	0.938	
CARBON BLACK CONTENT (%)	D1603	2.59	
YEILD ST (lb/in)		MD	TD
		44.0	44.0
BREAK ST (lb/in)		128	127
ELONGATION AT YEILD (%)		44	23
BREAK ELONGATION (%)		1001	966
TEAR (lb)	D1004	16	16
DIMENSIONAL STABILITY % CHANGE	D1204	-0.08%	-0.04%
PUNCTURE, lb	D4833	64	
MULLEN BURST	D751	169	

Data represents nominal values based on ASTMstandard tests and should not be considered as limiting specifications

*CW = Cold Weather- Material is conducive to extremely cold temperatures.

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184 Hwy 59 N, Miles City, MT . 59301
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800.583.6005

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www.brawler.com

BRAWLER®

30 MIL LLDPE CW*

PROPERTIES	TEST METHOD	ROLL AVERAGES
THICKNESS mils, (mm)	ASTM D5199	31.2 (0.78)
DENSITY g/cm^3	ASTM D792 or ASTM D1505	0.939 MAX
**TENSILE STRENGTH lbf/in. width, (N/mm width)	ASTM D6693 1. Tensile Strength at Break 2. % Elongation at Break	165 (29) 1000
TEAR RESISTANCE lbf, (N)	ASTM D1004	20 (89)
PUNCTURE RESISTANCE lbf, (N)	ASTM D4833	60 (267)
CARBON BLACK %	ASTM D1603 D4218	2-3
CARBON BLACK DISPERSION	ASTM D5596	PASS
OXIDATIVE INDUCTION TIME (OTI) or HIGH PRESSURE OTI	ASTM D3895 ASTM D5885	> 100 Min. >400 Min.
OVEN AGING AT 85°C (90 DAYS)	ASTM D5721/ D5885	PASS
UV RESISTANCE (1600 HOURS)	GRI GM11	PASS
MAXIMUM USE TEMPERATURE		180°F 82°C
LOW TEMP, IMPACT FAILURE TEMP	ASTM D746	-70°F <-57°C
DIMENTIONAL STABILITY % CHANGE	ASTM D1204	<2
MULTIAXIAL TENSION % ELONGATION	ASTM D5617	>120
ENVIRONMENTAL STRESS CRACK RESISTANCE HOURS TO FAILURE	ASTM D5397	>400
PERMS grains/ft^2/hr/in. Hg (grams/M^2/day/mm Hg)	ASTM E96 Method 73°F, 50% RH	0.029 (0.019)
FACTORY SEAM REQUIREMENTS		
BONDED SEAM STRENGTH lbf/ in width, (N/ cm width)	ASTM D4545 Mod.***	70 (119)
SEAM PEEL ADHESION lbf/ in width, (N/cm width)	ASTM D4545 Mod.***	60 (93)

*CW = Cold Weather- Material is conducive to extremely cold temperatures.
**Tests are an average of MD and TD directions.
***Seam testing performed at 12" per minute.

BRAWLER® INDUSTRIES, LLC

North America's leading manufacturer of industrial fabrics and liners

BRAWLER® 8, 10 & 12 oz. NONWOVEN GEOTEXTILE

PROPERTIES	ASTM TEST METHOD	8 oz.	10 oz.	12 oz.
WEIGHT		8 oz/yd^2	10 oz/yd^2	12 oz/yd^2
GRAB TENSILE	D4632	205 lbs	250 lbs	300 lbs
GRAB ELONGATION	D4632	50 %	50 %	50 %
TRAPEZOIDAL TEAR	D4533	80 lbs	100 lbs	115 lbs
PUNCTURE RESISTANCE	D6241	525 lbs	625 lbs	825 lbs
UV RESISTENCE AFTER 500 HRS.	D4355	70 % strength retained	70 % strength retained	70 % strength retained
		HYDRAULIC		
APPARENT OPENING SIZE (AOS)[3]	D4751	80 US std Sieve	100 US std Sieve	100 US std Sieve
PERMITTIVITY	D4491	1.5 sec^{-1}	1.2 sec^{-1}	1.0 sec^{-1}
WATER FLOW RATE	D4491	110 gpm/ft^2	85 gpm/ft^2	75 gpm/ft^2

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Miles City, MT 59301

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3000 Brittmoore
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WEST TEXAS PLASTICS
PO Box 60004
11701 Co. Rd. 125 W
Midland, TX 79711

BRAWLER
TOUGH TARPS...NO BULL

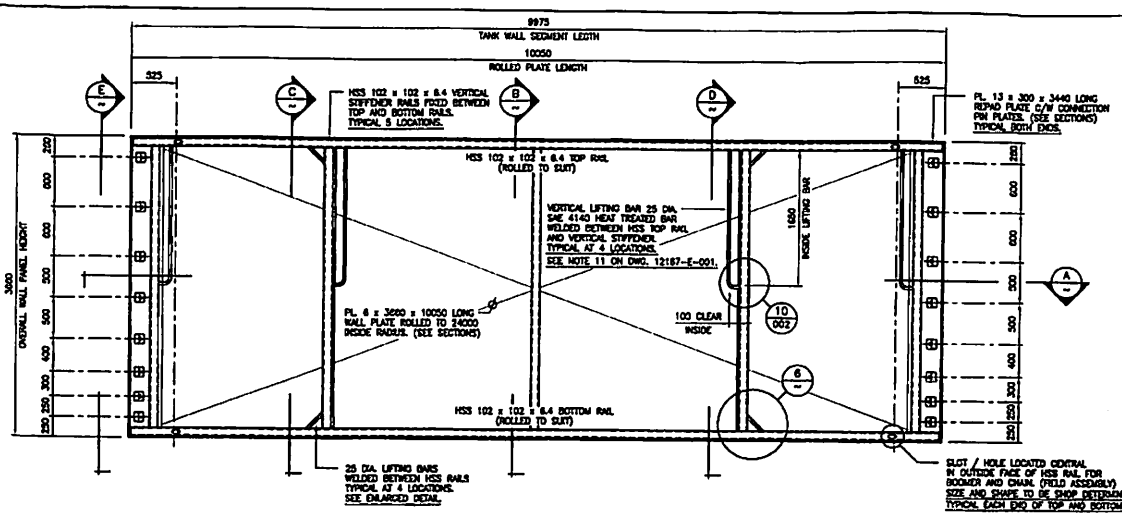
BRAWLER®

20, 30, 40 MIL ULTRA FLEX LLDPE LINEAR LOW DENSITY POLYETHYLENE

PROPERTIES	ASTM TEST METHOD	Frequency	20	30	40
THICKNESS, Mils (Typical)	D5199	Every Roll	20	30	40
THICKNESS, Minumum Average			18	27	36
DENSITY	D1505	200,000 lb	0.92	0.92	0.939
TENSILE PROPERTIES (each direction) Strength at break, lb/in-width (N/mm) Elongation at breack, %	D6693 Type IV Dumbell 2 ipm Gl 2.0 (51mm)	20,000 lb	76 (13) 800	114 (20) 800	152 800
TEAR RESISTANCE	D1004	45,000 lb	11 (48)	16 (71)	22
PUNCTURE RESISTANCE	D4833	45,000 lb	28 (124)	42 (186)	56
CARBON BLACK CONTENT	D1603 4218	20,000 lb	2.0% - 3.0 %	2.0% - 3.0 %	2.0% - 3.0 %
CARBON BLACK DISPERSION	D5596	45,000 lb	Note 1	Note 1	Note 1
OXIDATIVE INDUCTION TIME, min	D3895 200° C O2, 1atm	200,000 lb	>100	>100	>100

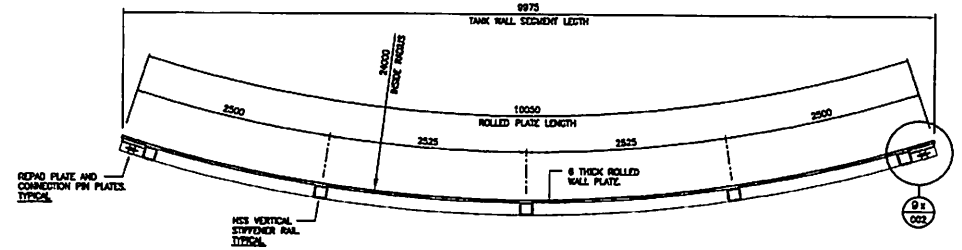
Notes:
1-Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Catagory 1 or 2. No more than 1 view from Catagory 3.
All membranes listed have dimensional stability of ± 2% when tested according to ASTM D1204 abd LTB of 77°C when tested according to ASTM D746

These values are typical and are not intended as limiting specifications

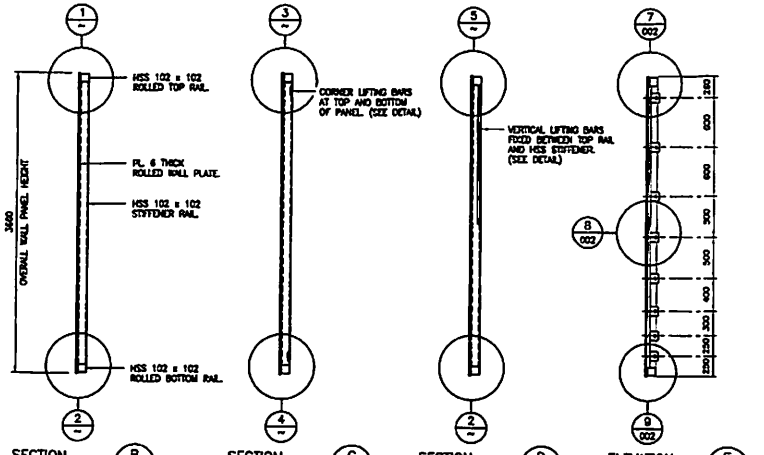


ELEVATION – SHOWING FRAMING TO OUTSIDE FACE OF WALL PANEL
SCALE 1 : 30

(x15 PANELS REQUIRED AS DRAWN)



TYPICAL PLAN SECTION A
SCALE 1 : 30

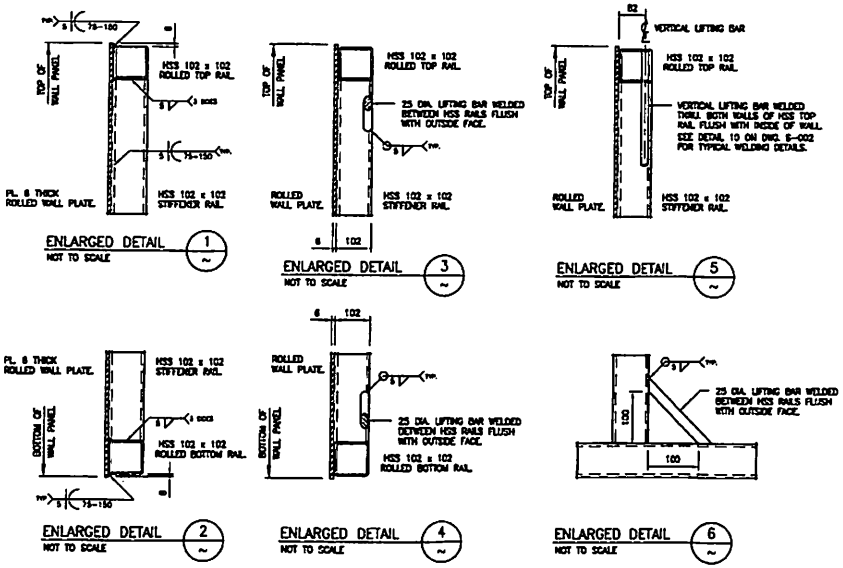


SECTION B SCALE 1 : 30

SECTION C SCALE 1 : 30

SECTION D SCALE 1 : 30

ELEVATION E SCALE 1 : 30



ENLARGED DETAIL 1 NOT TO SCALE

ENLARGED DETAIL 3 NOT TO SCALE

ENLARGED DETAIL 5 NOT TO SCALE

ENLARGED DETAIL 2 NOT TO SCALE

ENLARGED DETAIL 4 NOT TO SCALE

ENLARGED DETAIL 6 NOT TO SCALE

GENERAL NOTES :

1. STRUCTURAL STEEL DESIGN, FABRICATION AND ERECTION SHALL COMPLY WITH THE LATEST EDITION OF :
   - CSA-S16-01 LIMIT STATES DESIGN OF STRUCTURAL STEEL
   - CISC HANDBOOK OF STEEL CONSTRUCTION
   - CSA W59 WELDED STEEL CONSTRUCTION
2. MATERIALS SHALL CONFORM TO THE FOLLOWING GRADES OF CSA G40.21 :
   - HOLLOW STRUCTURAL SECTIONS - 350W
   - W SHAPES - 350W
   - C AND L SHAPES - 300W
   - PLATE AND ALL OTHER SECTIONS - 300W (Fy = 300 MPa / 44 KSI)
3. ALL WELDING SHALL BE IN ACCORDANCE WITH CSA W59-M 'WELDED STEEL CONSTRUCTION (METAL ARC WELDING)'.
4. FRAMING TO BE OF SOLID WELDED CONSTRUCTION (E-4200) COPE FRAMING MEMBERS INTO ONE ANOTHER.

APEGGA PERMIT NO. 2042

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	CHK'D	APP'D	CLIENT APP'D
12167-S-002	TANK WALL PANEL FRAMING DETAILS	A	ISSUED FOR REVIEW	14.12.10	RP	MH		
12167-E-001	TANK ASSEMBLY LAYOUT PLAN & SECTIONS	0	ISSUED FOR CONSTRUCTION	17.12.10	MH			

FILE : 12167-S-001

ENGINEER AND PERMIT STAMPS

Designed :	Date :	Drawn :	Date :	Checked :	Date :
MH	08.12.10	RP	11.12.10	MH	14.12.10

Client : OPEN RANGE ENERGY CORP

Project : 48m dia. MODULAR WATER TANK

TYPICAL TANK WALL PANEL
FRAMING PLAN, ELEVATION, SECTIONS & DETAILS

Job No.	Scale :	Dwg. No.	
12167	AS NOTED	12167-S-001	0

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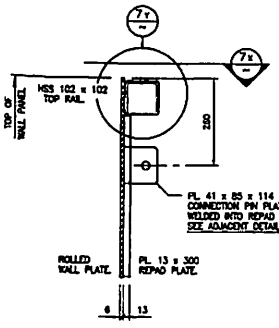
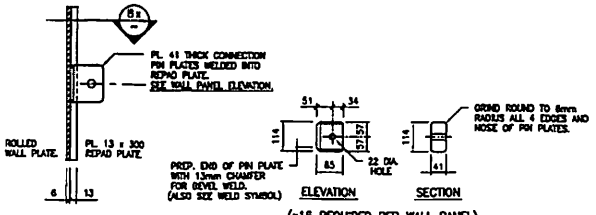
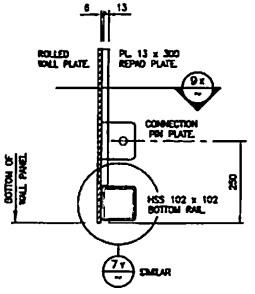


ENLARGED DETAIL 7 / 001
NOT TO SCALE



(x16 REQUIRED PER WALL PANEL)

ENLARGED DETAIL 8 / 001
NOT TO SCALE



ENLARGED DETAIL 9 / 001
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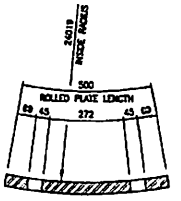
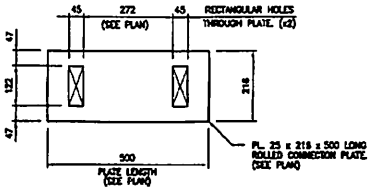


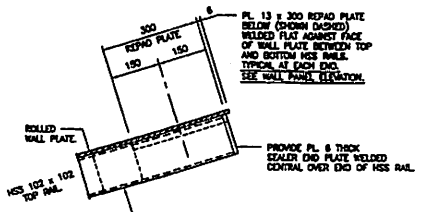
PLAN
(EXAGGERATED SCALE)



ELEVATION

WALL PANEL CONNECTION PLATES
(x8 REQUIRED PER WALL PANEL)

NOTE :
PAINT OUTSIDE FACE OF PLATE FOR IDENTIFICATION PURPOSES ONLY.



PLAN DETAIL 7x / ~
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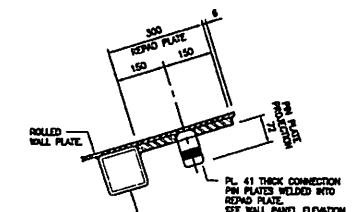
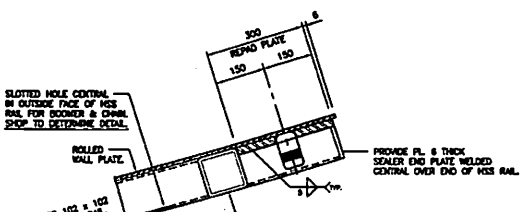
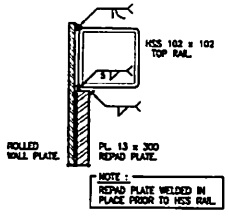


PLAN DETAIL 8x / ~
NOT TO SCALE

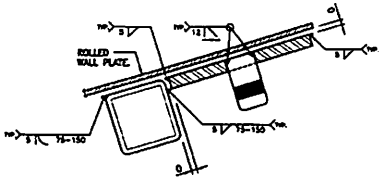


PLAN DETAIL 9x / ~
NOT TO SCALE

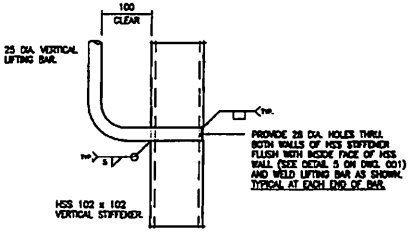


ENLARGED DETAIL 7Y / ~
NOT TO SCALE

EXPLODED TO SHOW WELD DETAILS.



ENLARGED TYPICAL PLAN – EXPLODED TO SHOW WELD DETAILS.
NOT TO SCALE



ENLARGED DETAIL 10 / 001
NOT TO SCALE

APEGGA PERMIT NO. 2042

NOTE :
REFER TO DRAWING 12167-S-001 FOR ALL MATERIAL SPECIFICATIONS AND CONSTRUCTION NOTES.

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	CHK'D	APP'D	CLIENT APP'D
12167-S-001	TANK WALL PANEL FRAMING LAYOUTS	A	ISSUED FOR REVIEW	14.12.10	RP	MH		
		0	ISSUED FOR CONSTRUCTION	17.12.10	MH	MH		

FILE : 12167-S-002

ENGINEER AND PERMIT STAMPS

Designed :	Date :	Drawn :	Date :	Checked :	Date :
MH	08.12.10	RP	11.12.10	MH	14.12.10

Client : OPEN RANGE ENERGY CORP
Project : 48m dia. MODULAR WATER TANK
TYPICAL TANK WALL PANEL FRAMING SECTIONS AND DETAILS

Job No.	Scale :	Dwg. No.	
12167	AS NOTED	12167-S-002	0

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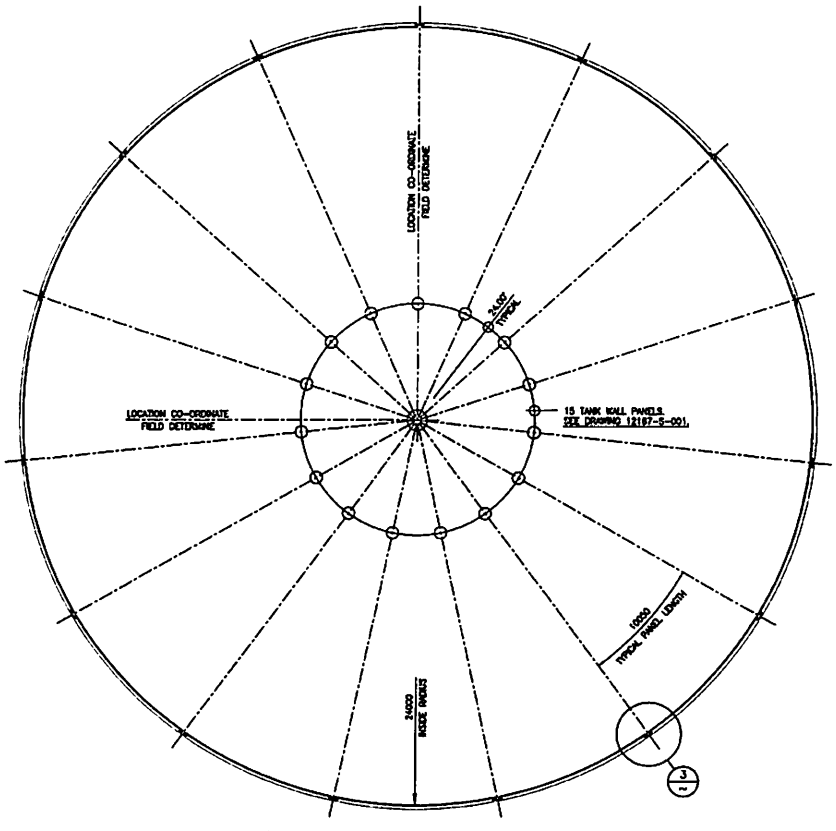
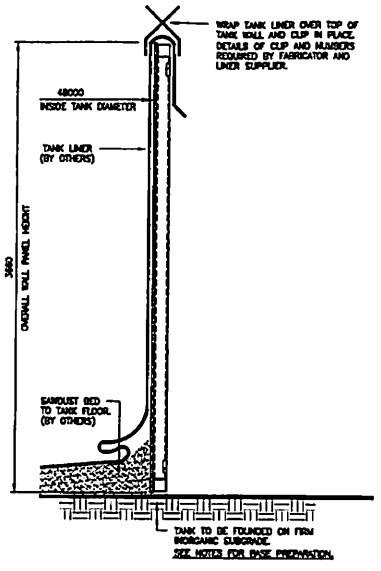
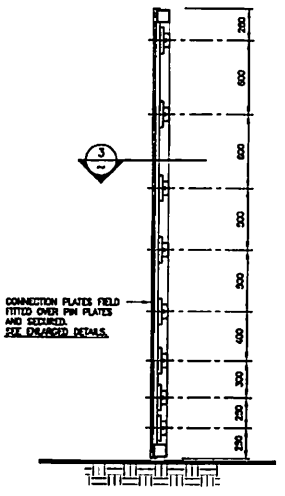


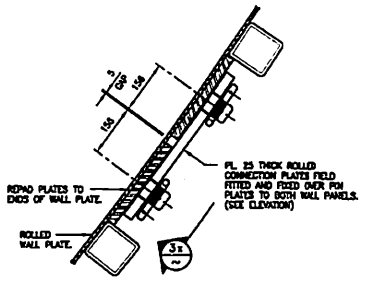
TANK LAYOUT PLAN (A)
SCALE 1 : 75



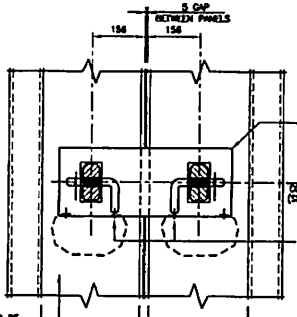
TYPICAL TANK WALL SECTION (1)
SCALE 1 : 20



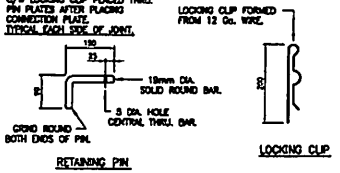
WALL SECTION AT PANEL JOINT (2)
SCALE 1 : 20



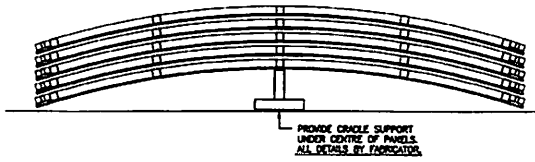
ENLARGED PLAN DETAIL (3)
NOT TO SCALE



ENLARGED ELEVATION (3x)
NOT TO SCALE



SUGGESTED PIN AND CUP DETAILS
SHOP TO CONFIRM ALL DETAILS



TRANSPORT AND STORAGE DETAILS
NOT TO SCALE

APEGGA PERMIT NO. 2042

NOTES :

1. CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR THE STABILITY OF THE STRUCTURE AND FOR THE SAFETY OF ALL PERSONNEL DURING ASSEMBLY AND DISASSEMBLY. ALL WORK SHALL BE IN STRICT ACCORDANCE WITH OCCUPATIONAL HEALTH AND SAFETY REGULATIONS.
2. THE CONTRACTOR SHALL ENSURE ALL THE PANELS ARE ADEQUATELY SUPPORTED OR BRACED UNTIL THE ENTIRE STRUCTURE IS ASSEMBLED.
3. ALL TOPSOIL, ORGANICS, SOFT OR WET SOILS, DEBRIS OR OTHER DELETERIOUS MATERIALS SHALL BE REMOVED FROM THE TANK SITE.
4. THE FINISHED GRADES ALONG THE PERIMETER OF THE TANK SHALL BE LEVEL AND TRUE TO PLANE. THE MAXIMUM ELEVATION DIFFERENCE ACROSS ANY TWO DIAMETRICAL POINTS SHALL BE LESS THAN 230mm.
5. THE MAXIMUM DEVIATION FROM PLANE OVER ANY 3.0 METERS OF CIRCUMFERENCE SHALL BE LESS THAN 5mm AND LESS THAN 12mm OVER ANY 10.0 METERS OF CIRCUMFERENCE.
6. THE AREA SURROUNDING THE TANKS SHALL BE GRADED TO DIRECT SURFACE WATER AWAY FROM THE TANK.
7. THE EDGE OF ANY (DOCUMENTED) SUMP SHALL BE A MINIMUM OF 800mm FROM THE EDGE OF THE TANK WALL.
8. THE PANELS SHALL BE ERECTED PLUMB. THE MAXIMUM OUT-OF-PLUMBNESS OF THE TOP OF THE PANEL RELATIVE TO THE BOTTOM SHALL BE LESS THAN 25mm.
9. THE MAXIMUM DEVIATION FROM THE THEORETICAL RADIUS SHALL BE LESS THAN 50mm AT ANY POINT ALONG THE TANK WALL.
10. THE LINER SHALL BE SECURELY FASTENED TO THE TOP OF EACH PANEL IN ACCORDANCE WITH THE LINER'S MANUFACTURER'S RECOMMENDATIONS. THE LINER SHALL BE INSTALLED WITH SUFFICIENT SLACK AT THE BASE OF THE PANEL TO PREVENT ANY TENSION IN THE LINER.
11. THE VERTICAL LIFTING BAR SHALL ONLY BE USED TO LIFT THE PANELS INTO THE VERTICAL POSITION. THE LIFT RIGGING MUST BE WITHIN 250mm OF THE TOP RAIL PRIOR TO LIFTING THE PANEL.

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	CHK'D	APP'D	CLIENT APP'D
12167-S-001	TANK WALL PANEL FRAMING LAYOUTS	A	ISSUED FOR REVIEW	14.12.10	RP	MH		
12167-S-002	TANK WALL PANEL FRAMING DETAILS	0	ISSUED FOR CONSTRUCTION	17.12.10	MH	MH		

FILE : 12167-E-001

ENGINEER AND PERMIT STAMPS

Designed :	Date :	Drawn :	Date :	Checked :	Date :
MH	06.12.10	RP	11.12.10	MH	14.12.10

Client : OPEN RANGE ENERGY CORP

Project : 48m dia. MODULAR WATER TANK

TANK INSTALLATION AND ASSEMBLY
LAYOUT PLAN, SECTIONS AND DETAILS

Job No.	Scale :	Dwg. No.	
12167	AS NOTED	12167-E-001	0

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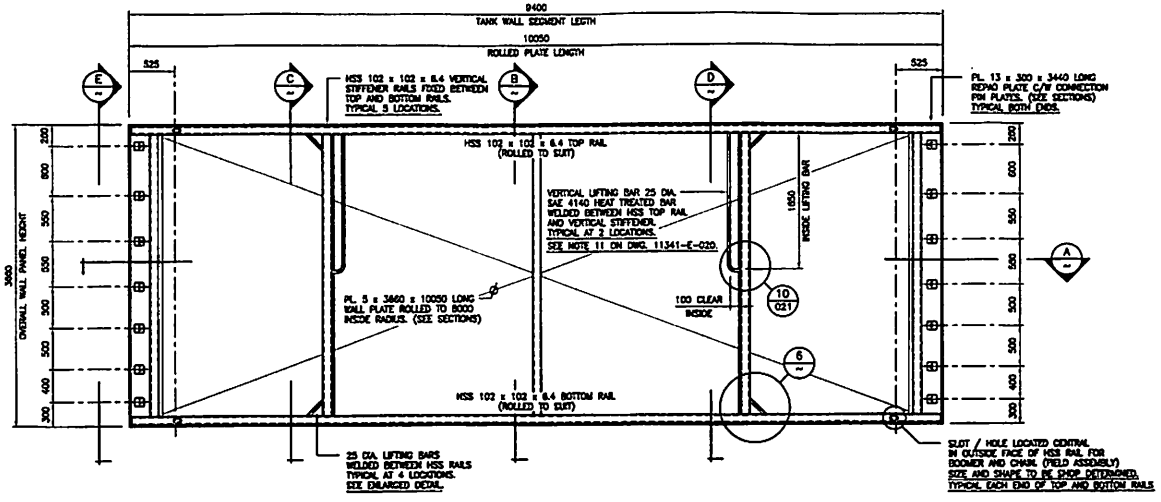
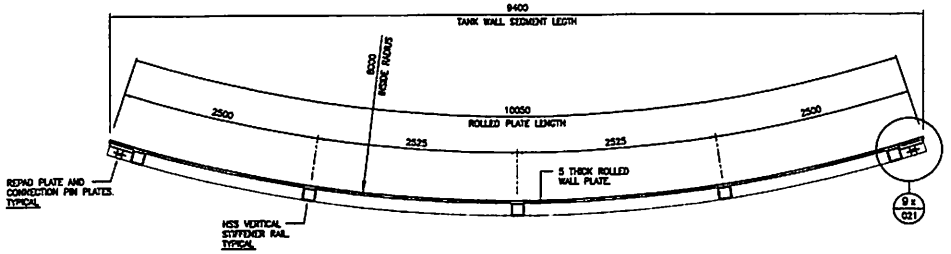
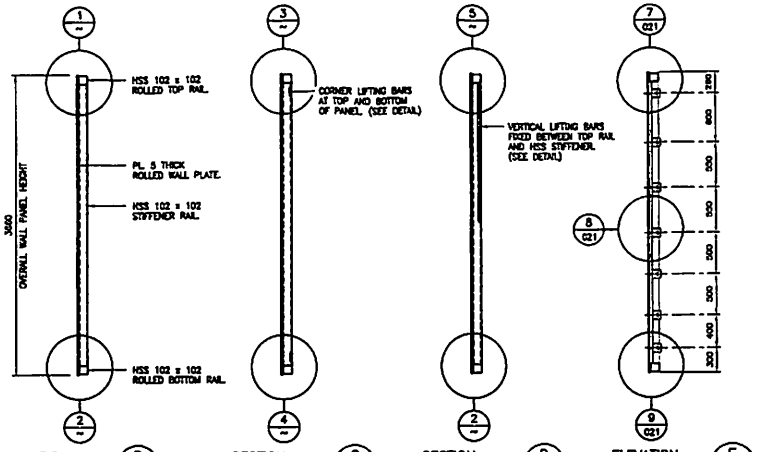


ELEVATION – SHOWING FRAMING TO OUTSIDE FACE OF WALL PANEL
SCALE 1 : 30

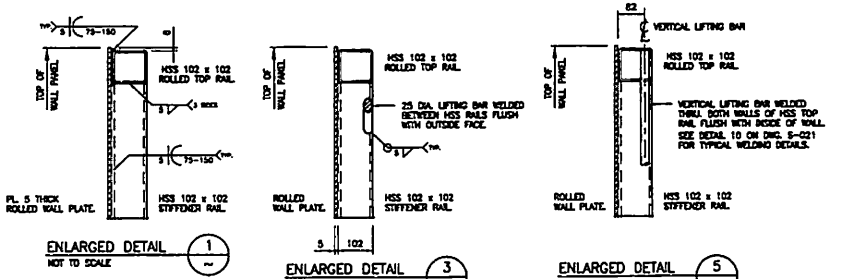
(x5 PANELS REQUIRED AS DRAWN)



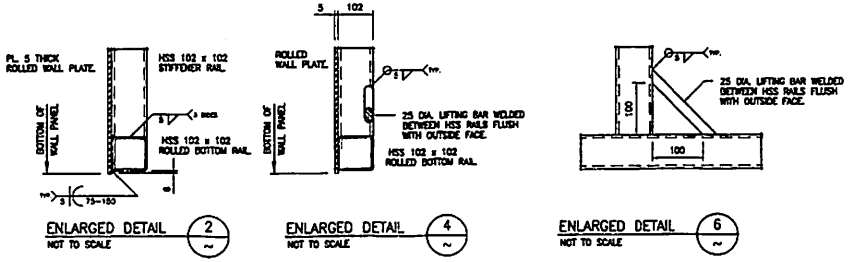
TYPICAL PLAN SECTION A
SCALE 1 : 30



SECTION B SCALE 1 : 30
SECTION C SCALE 1 : 30
SECTION D SCALE 1 : 30
ELEVATION E SCALE 1 : 30



ENLARGED DETAIL 1 NOT TO SCALE
ENLARGED DETAIL 3 NOT TO SCALE
ENLARGED DETAIL 5 NOT TO SCALE



ENLARGED DETAIL 2 NOT TO SCALE
ENLARGED DETAIL 4 NOT TO SCALE
ENLARGED DETAIL 6 NOT TO SCALE

GENERAL NOTES :

1. STRUCTURAL STEEL DESIGN, FABRICATION AND ERECTION SHALL COMPLY WITH THE LATEST EDITION OF :
   - CSA-S16-01 LIMIT STATES DESIGN OF STRUCTURAL STEEL
   - CISC HANDBOOK OF STEEL CONSTRUCTION
   - CSA W59 WELDED STEEL CONSTRUCTION
2. MATERIALS SHALL CONFORM TO THE FOLLOWING GRADES OF CSA G40.21 :
   - HOLLOW STRUCTURAL SECTIONS – 350W
   - W SHAPES – 350W
   - C AND L SHAPES – 300W
   - PLATE AND ALL OTHER SECTIONS – 300W (UNLESS NOTED OTHERWISE)
3. ALL WELDING SHALL BE IN ACCORDANCE WITH CSA W59-M "WELDED STEEL CONSTRUCTION (METAL ARC WELDING)".
4. FRAMING TO BE OF SOLID WELDED CONSTRUCTION (E-4900) COPE FRAMING MEMBERS INTO ONE ANOTHER.

PROFESSIONAL ENGINEER PROVINCE OF ALBERTA
June 2/10

APEGGA PERMIT NO. 2042

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	CHK'D	APP'D	CLIENT APP'D
11341-S-021	TANK WALL PANEL FRAMING DETAILS	A	ISSUED FOR REVIEW	02.06.10	RP	MH		
11341-E-020	TANK ASSEMBLY LAYOUT PLAN & SECTIONS	0	ISSUED FOR CONSTRUCTION	02.06.10	RP			

FILE : 11341-S-020

ENGINEER AND PERMIT STAMPS

Designed :	Date :	Drawn :	Date :	Checked :	Date :
JH	01.12.09	RP	01.06.010		02-06-10

Client : OPEN RANGE ENERGY CORP
Project : 16m dia. MODULAR WATER TANK
TYPICAL TANK WALL PANEL FRAMING PLAN, ELEVATION, SECTIONS & DETAILS

Job No.	Scale :	Dwg. No.	
11341	AS NOTED	11341-S-020	0

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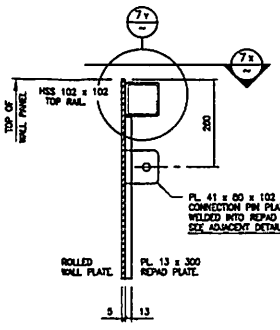
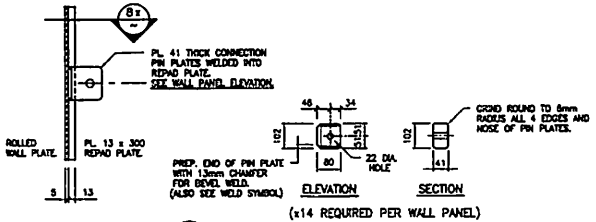
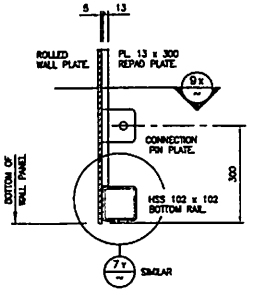


ENLARGED DETAIL 7 (7x) — NOT TO SCALE — 020

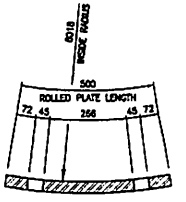


(x14 REQUIRED PER WALL PANEL)

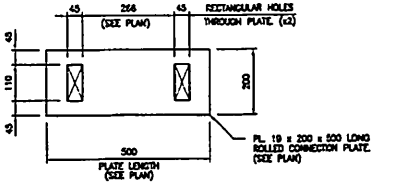
ENLARGED DETAIL 8 (8x) — NOT TO SCALE — 020



ENLARGED DETAIL 9 (9x) — NOT TO SCALE — 020



PLAN
(EXAGGERATED SCALE)

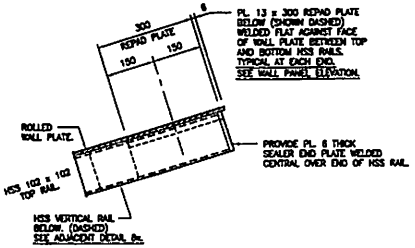


ELEVATION

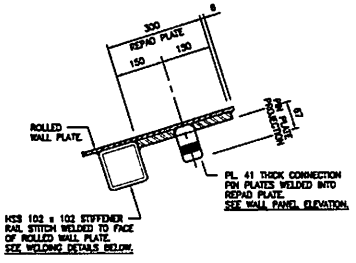
WALL PANEL CONNECTION PLATES

(x7 REQUIRED PER WALL PANEL)

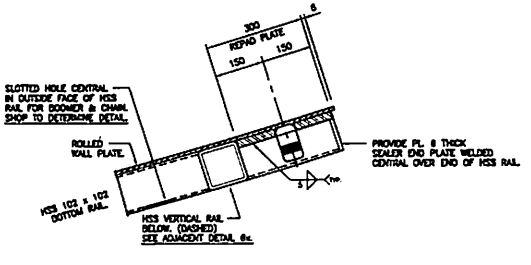
NOTE :
PAINT OUTSIDE FACE OF PLATE FOR IDENTIFICATION PURPOSES ONLY.



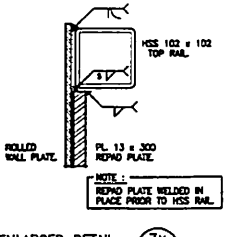
PLAN DETAIL 7x — NOT TO SCALE



PLAN DETAIL 8x — NOT TO SCALE

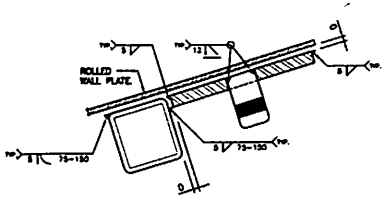


PLAN DETAIL 9x — NOT TO SCALE

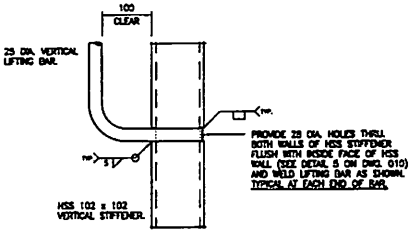


ENLARGED DETAIL 7Y — NOT TO SCALE

EXPLODED TO SHOW WELD DETAILS.



ENLARGED TYPICAL PLAN – EXPLODED TO SHOW WELD DETAILS.
NOT TO SCALE



ENLARGED DETAIL 10 — NOT TO SCALE — 020

APEGGA PERMIT NO. 2042

NOTE :
REFER TO DRAWING 11341-S-020 FOR ALL MATERIAL SPECIFICATIONS AND CONSTRUCTION NOTES.

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	Chk'D	APP'D	CLIENT APP'D
11341-S-020	TANK WALL PANEL FRAMING LAYOUTS	A	ISSUED FOR REVIEW	02.06.10	RP	MH		
		0	ISSUED FOR CONSTRUCTION	02.06.10	RP			

FILE : 11341-S-021

ENGINEER AND PERMIT STAMPS

Designed :	Date :	Drawn :	Date :	Checked :	Date :
JH	01.12.09	RP	02.06.10		02.06.10

Client : OPEN RANGE ENERGY CORP

Project : 16m dia. MODULAR WATER TANK

TYPICAL TANK WALL PANEL FRAMING SECTIONS AND DETAILS

Job No.	Scale :	Dwg. No.	
11341	AS NOTED	11341-S-021	0

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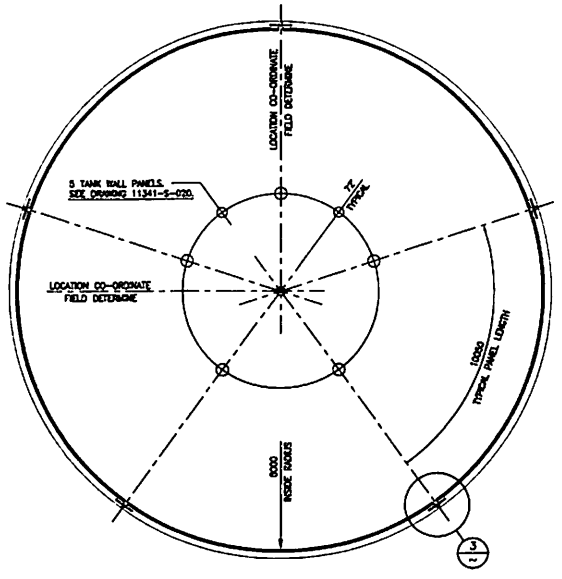
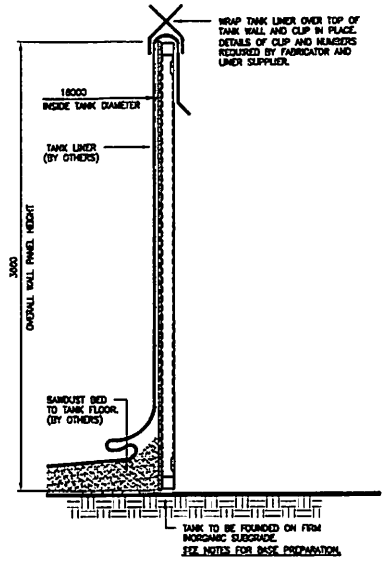
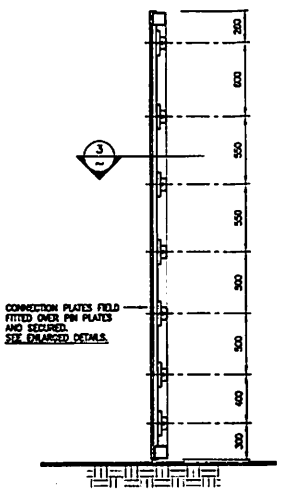


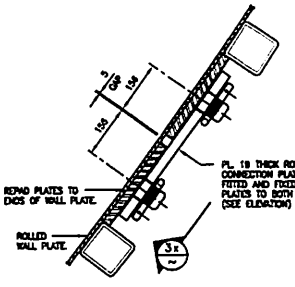
TANK LAYOUT PLAN (A)
SCALE 1 : 75



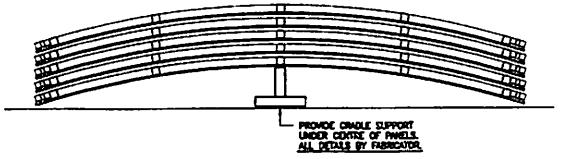
TYPICAL TANK WALL SECTION (1)
SCALE 1 : 20



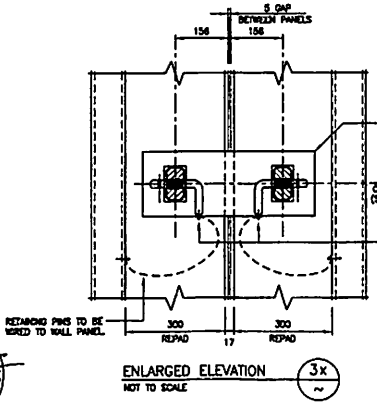
WALL SECTION AT PANEL JOINT (2)
SCALE 1 : 20



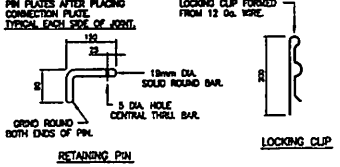
ENLARGED PLAN DETAIL (3)
NOT TO SCALE



TRANSPORT AND STORAGE DETAILS
NOT TO SCALE



ENLARGED ELEVATION (3x)
NOT TO SCALE



SUGGESTED PIN AND CLIP DETAILS
SHOP TO CONFIRM ALL DETAILS

NOTES :

1. CONTRACTOR SHALL BE FULLY RESPONSIBLE FOR THE STABILITY OF THE STRUCTURE AND FOR THE SAFETY OF ALL PERSONNEL DURING ASSEMBLY AND DISASSEMBLY. ALL WORK SHALL BE IN STRICT ACCORDANCE WITH OCCUPATIONAL HEALTH AND SAFETY REGULATIONS.
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6. THE AREA SURROUNDING THE TANKS SHALL BE GRADED TO DIRECT SURFACE WATER AWAY FROM THE TANK.
7. THE EDGE OF ANY (EXCAVATED) SUMP SHALL BE A MINIMUM OF 800mm FROM THE EDGE OF THE TANK WALL.
8. THE PANELS SHALL BE ERECTED PLUMB. THE MAXIMUM OUT-OF-PLUMBNESS OF THE TOP OF THE PANEL RELATIVE TO THE BOTTOM SHALL BE LESS THAN 25mm.
9. THE MAXIMUM DEVIATION FROM THE THEORETICAL RADIUS SHALL BE LESS THAN 50mm AT ANY POINT ALONG THE TANK WALL.
10. THE LINER SHALL BE SECURELY FASTENED TO THE TOP OF EACH PANEL IN ACCORDANCE WITH THE LINER'S MANUFACTURER'S RECOMMENDATIONS. THE LINER SHALL BE INSTALLED WITH SUFFICIENT SLACK AT THE BASE OF THE PANEL TO PREVENT ANY TENSION IN THE LINER.
11. THE VERTICAL LIFTING BAR SHALL ONLY BE USED TO LIFT THE PANELS INTO THE VERTICAL POSITION. THE LIFT RIGGING MUST BE WITHIN 250mm OF THE TOP RAIL PRIOR TO LIFTING THE PANEL.

APEGGA PERMIT NO. 2042

DWG. NO.	REFERENCE DRAWINGS	REV	REVISIONS	DATE	BY	CHK'D	APP'D	CLIENT APP'D
11341-S-020	TANK WALL PANEL FRAMING LAYOUTS	A	ISSUED FOR REVIEW	02.06.10	RP	MH		
11341-S-021	TANK WALL PANEL FRAMING DETAILS	0	ISSUED FOR CONSTRUCTION	02.06.10	RP	MH		

FILE : 11341-E-020

ENGINEER AND PERMIT STAMPS

Designed :	Date :	Drawn :	Date :	Checked :	Date :
JH	01.12.09	RP	01.06.10		02.06.10

Client : OPEN RANGE ENERGY CORP

Project : 16m dia. MODULAR WATER TANK

TANK INSTALLATION AND ASSEMBLY
LAYOUT PLAN, SECTIONS AND DETAILS

Job No.	Scale :	Dwg. No.	
11341	AS NOTED	11341-E-020	0

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Appendix B

Design/Construction Plan

General

In this plan, the portion of the Produced Water Re-use Rule that is addressed by certain text is underlined.

Examination of the engineering drawings in Appendix A, the SOP that is Appendix C, the text below and the history of solid performance of these ASTs demonstrates that Rockwater has designed and will construct the recycling containment to ensure the confinement of produced water, to prevent releases and to prevent overtopping due to wave action or rainfall. As the AST is only about 160 feet in diameter, wave action is not a meaningful consideration.

This design and construction plan has been large abstracted from Appendix C. However, this Design and Construction Plan provides additional protocols to cause the proposed recycling containments (ASTs) to conform to NMOCD Rules. Therefore, if a conflict exists between the SOP of Appendix C and this plan (Appendix B), Rockwater will adhere to the mandates of this plan.

The Rockwater ASTs are constructed of 12-foot high steel panels and are netted to prevent ingress of migratory birds. OCD has approved a variance under Rule 17 that eliminates the need for Rockwater to 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.

The customer of Rockwater (the operator) shall post an upright sign no less than 12 inches by 24 inches with lettering not less than two inches in height in conspicuous places surrounding the containment. The operator shall post the sign in a manner and location such that a person can easily read the legend. The sign shall provide the following infom1ation: the operator's name, the location of the site by quarter-quarter or unit letter, section, township and range, and emergency telephone numbers.

Rockwater 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.

Site Preparation

Foundation for AST

Preparation of the soils on site is required to form a dependable base for the AST. Preparation of the tank pad is the sole responsibility of Rockwater's AST customer (typically an oil and gas

operating company). In general, prior to constructing the containment foundation, the operator will strip and stockpile the topsoil for use as the final cover or fill at the time of closure.

The Rockwater Field Operations Manager will check the status of soil preparation during the pre-project meeting on site. Rockwater personnel will also check the soil preparation using a proof roll test immediately prior to the AST setup.

Rockwater's soil preparation requirements are as follows:

1. Rockwater recommends a minimum soil compaction of 95% compaction.
2. Rockwater recommends soil compaction testing to be conducted via
    a. Standard Proctor Test (American Society for Testing and Materials {ASTM} Standard D698) or Modified Proctor Test (ASTM Standard D1557).
    b. A proof roll test may be used if observed and documented by qualified Rockwater personnel. Attachment 3 of the SOP provides guidance on how to perform a proof roll test and how to interpret the results.
3. Grade AST footprint and 30 feet work area to 0.25 % or 3" feet drop per 100 feet, toward sump location.
4. Site should be graveled prior to tank installation, utilizing gravel size 2B or smaller. (3/4" road grade preferred, or coarse sand with minimum thickness of 4 inches). Do not use crushed rock as sharp edges could puncture the tank liner. After completion of these steps the tank setup can be approved.
5. If 2-3 foot high levees are used to contain the AST, the interior slope of the levee are 2H:1V and the exterior slope is 3H:1V.

Thus, the AST (recycling 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 will be placed under the liner where needed to reduce localized stress-strain or protuberances that otherwise may compromise the liner's integrity. If Rockwater constructs the containment in a levee, the inside grade is no steeper than two horizontal feet to one vertical foot (2H: 1 V) and the outside grade no steeper than three horizontal feet to one vertical foot (3H: IV). As the secondary liner covers the levee with the anchor trench outside of the containment, there is for inspection and maintenance of the anchor trench. If Rockwater elects to use a pre-fabricated containment structure, a variance request is included in the registration.

Tank Layout on Foundation

- Check proposed AST site to confirm a 30' clear work area around the perimeter of the tank is possible to provide access for equipment and laydown area for AST materials and erection equipment.
- Check that the minimum distances to existing wells, power lines, etc. are met.
- Regardless of manufacturer, the minimum footprint should be a circle of at least 24' greater than that the radius of the tank.
- Establish final location for the suction tube and stairs.
- For a pin tank, the pad should be graded and sloped 0.25% from high side of location to suction side of tank. This will allow for better drainage of tank.
- For a plate tank, the pad needs to be flat.

The transmittal letter identifies the type of foundation to be used for the proposed containment (e.g. sloped or flat) as well as some other features of the particular installation.

AST Tank Setup Preparation

Mark the Foundation for Setup

1. Determine center of tank and mark with paint, then bury preferred non-abrasive item (tennis ball, sand bag, water bottle, etc.) This will be used to find the center of tank after liners have been placed.
2. Measure distance from tank center to existing oil/gas wells to check that the tank meets the minimum distance for the operator
3. Measure and paint a line to mark the circumference of tank for panel placement.
4. Mark the circumference of the liner laid out flat to ensure the liner is properly placed.
5. Determine where tank suction is to be placed (the low side of pad).
   a. For pin tanks, dig 8' wide x 8' long x 16" deep sump hole for the suction manifold to set in and taper the edges so there are no sharp corners of the excavation. Remove any sharp stones
   b. If multiple suction manifolds are required, the sumps should have a minimum of 8' of separation. Attention! In cold weather conditions, the sumps should be dug out as late as possible and should never be left unattended overnight. Barricade any sump pit with appropriate cones or tape if left open when crew is not present or active in the area.
6. When installing certain ASTs, a "Y Trench" can be used both for wind stabilization and for draining the tank. The "Plate Tank Y-Trench Guidance Document" can be found in Attachment 5 of Appendix C (SOP).

The placement of sumps in the foundation and the AST design demonstrates that at a point of discharge into or suction from the recycling containment, the liner is protected from excessive hydrostatic force or mechanical damage and external discharge or suction lines shall not penetrate the liner.

Liner and Leak Detection Materials

The liner and geotextile specifications in Appendix A show that 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 45-mil LLDPE string reinforced (minimum). A variance may be requested to use a double-liner system that results in equivalent or better characteristics.

Secondary liners shall be 30-mil LLDPE string reinforced (minimum) 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.

Install Secondary Liner, Leak Detection System and Secondary Containment

All tanks holding produced water will have a primary (upper) liner and a secondary (lower) liner with a leak detection system appropriate to the site's conditions. The edges of all secondary liners shall be anchored in the bottom of a compacted earth-filled trench. The anchor trench shall be at least 18 inches deep.

The steps to install the secondary liner are:

1. The crew walks the entire tank base area to and pick up any sharp stones or other sharp debris that could damage the liner.
2. If necessary, lay out a geotextile to create a pad between the liner and the earth foundation. In some cases, the geotextile is "bundled" with the liner and will be rolled out together. After unrolling, pull the geotextile and liner to extend it fully using several crew members spaced along the edge.
3. Perform a visual inspection n of the liner – repair any defects as necessary.
4. Install a 40-mil LLDPE secondary liner per the manufacturer's specifications
    a. to extend over or on any earthen levees for secondary containment and then into the anchor trench (18-inches deep) or
    b. attach the secondary liner to pre-fabricated secondary containment in accordance with the manufacturer's specifications.
5. Within and extending several feet from the footprint of the AST, place 200-mil geogrid or 10-oz geotextile (see variance request if applicable) and secure to the secondary liner. This geotextile material is permeable and will act as the drainage layer between the primary liner system and the secondary liner. Any leakage from the AST will be obvious as the fluid moves from beneath the AST into the secondary containment.

Thus, the recycling containment will have a leak detection system between the upper and lower geomembrane liners that shall consist of 200-mil geonet (or a suitable material pursuant to a variance) to facilitate drainage. The leak detection system shall consist 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 presence of the secondary containment levee or pre-fabricated secondary containment meets the OCD Rule mandate that a recycling containment shall design the containment to prevent run-on of surface water. The containment shall be surrounded by a berm, ditch or other diversion to prevent run-on of surface water,

AST Tank Setup

Install Primary Liner

As with the secondary liner, Rockwater will minimize liner seams and orient them up and down, as much as possible, not across, a slope. Factory welded seams shall be used where possible. Rockwater will employ field seams in geosynthetic material that are thermally seamed. Prior to field seaming, Rockwater shall overlap liners four to six inches and minimize the number of field seams and corners and irregularly shaped areas. There shall be no horizontal seams within five feet of the AST bottom. Qualified personnel shall perform field welding and testing.

Installation set up consistent with the SOP (Appendix C) continues:

A. Place the two 30-mil LLDPE primary liner system aligned to the center of the tank and painted line for the tank walls. The preferred 30 feet area around tank allows the liner to be laid out flat so that fold back can be uniform.
B. Bundling of the liner with the drainage geotextile by the liner supplier is generally not used in New Mexico. If the liner is bundled with the geotextile, roll it out across the diameter of the tank over the geotextile material that extends beyond the AST diameter (described above). Be sure not to use padded vice grips to move liner unless located at edge of liner. Inspect liner and report any damage or bad seams, punctures due to handling, etc. to the Crew Leader
C. Secure liner from wind using sand bags, or if plate tank. If a "Y" trench is used, fill it with water
D. Fold the liner toward inside the painted tank edge line to allow stockpiling of sand and placement tank panel walls.
E. Stockpile sand just inside marked panel perimeter. Place enough sand at spaced locations around the circle to provide for sand approximately 12" deep at tank wall and a 1:1 slope into tank.

Tank Wall Erection

F. Stand the first tank panel in place and keep connected to the hoist mechanism until all the remaining panels have been connected. This will be done using a front-end loader equipped with an engineer-approved attachment specific for this task.
G. Monitor hoist and rigging mechanism of first panel closely to ensure it remains stable, especially during wind and while the other panels are attached.
H. Begin placing the remaining panels in place with the front-end loader and panel rigging frame
I. Personnel secured on man-lift then secure the panels in place with 4 pins each (for pin tanks) or (for plate tanks) with the connecting plates and lug busses, secured with chained cotter pins.
J. To protect the liner, distribute sand with shovels to form 1:1 sand bank against the inside bottom of each panel. Be sure the slope is uniform. Alternatively, roll up excess geo pad (geotextile) into minimum 6" diameter cylinders around the inside of the tank ring to help support the liner at the base of the tank wall as the tank is being filled.
K. Prior to lifting liner into place against inside panel, place metal covering plates over all panel gaps in plate type tank. For pin tanks, check that sand or rolled up geo pad is evenly placed at base of all walls.
L. Prior to covering sump with the geo pad or liner, confirm sump excavation has smooth sides and corners, and that no sharp stones are present.
M. When placing the final panel in the circle, attach this final panel only on left or right side but LEAVE OTHER PANEL SIDE OPEN at this time for access and egress points. (Must have an entry and exit point to the tank at all times.)

Liner Placement and Securing Top With Clips or Clamps

N. After 4 or 5 panels are set, and all liner protection as described above is in place, unfold the liner in sections, toward the base of each panel, making sure the sand or rolled up geo pad will provide padding at the base of the inside of each panel.

O. Crew of 2 inside the tank wall unfolds and pulls the liner toward each panel. Working in small liner sections, this inside crew works with a crew of 2 on a man lift located outside and above each tank panel to pull the liner edge up and over the top of each panel. The man lift crew lifts the liner edge using ropes attached (by the inside crew) to padded vice grips that grip the liner. The man lift crew lifts a small liner section to the top of the panel and folds it over the top of the panel, being sure there is enough slack in the liner inside the panel wall.

P. Once a section of liner is positioned properly (with liner slack inside the tank) and over the top of each panel wall, the man lift crew secures the top of the liner with clips (pin tanks) or clamps (plate tanks). NOTE: A minimum of 5 clips (pin tanks) or 5 clamps (plate tanks) or more are required at the top of each tank panel to secure the liner. Add additional clips and clamps as needed to secure liner.

Q. Both inside and man lift crews continue this process, working around the tank, one or two panels at a time, until the entire liner is in place. NOTE: The crew must allow sufficient slack in the liner at the wall to allow for liner movement during filling and draining.

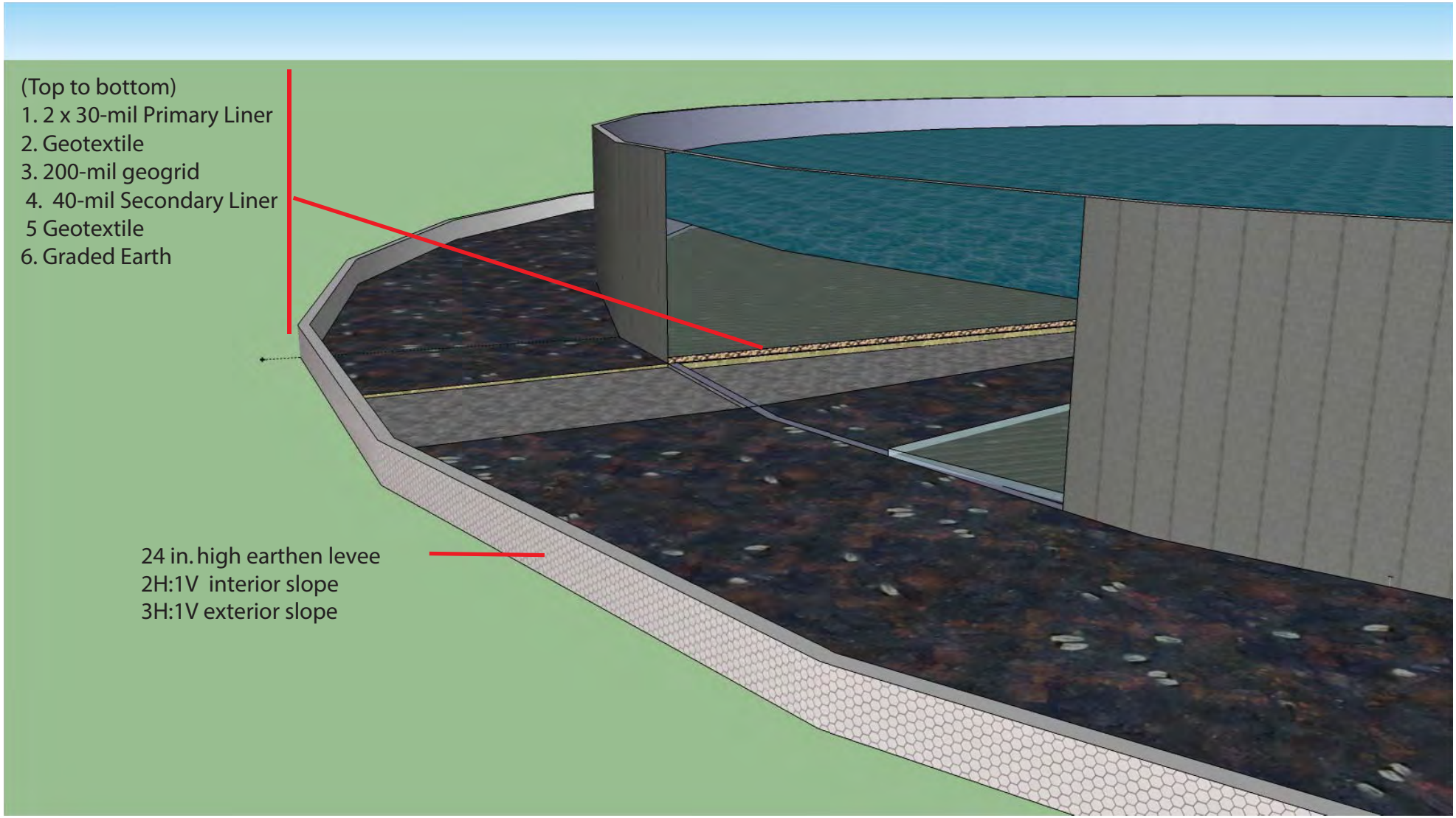
Stairs, Fill Tubes, and Suction Tubes

I. Install safety stair system, fill tubes, and suction tubes. Ensure that stair system and tubes are appropriately secured to the tank walls according to customer specifications.

II. Upon completion of the stair system installation, the stairs should be secured as per the operating company requirements. At a minimum, these requirements should include access chains with “Authorized Personnel Only” (or equivalent) signage at the bottom of the stairs outside the tank, water rescue equipment on the platform at the top of the stairs, and access chains with “Do Not Enter” signage at the top of the stairs that go inside the tank.

Final Steps, Filling, and Inspection

- Close final panel and secure with pins or plates as needed.
- Trim liner and allow approximately 3’ of liner to hang over edge of tank.
- Secure liner with sufficient clips or clamps and be sure ratchet straps are applied to all tanks.
- Place straps to secure the cut edge of liner on outside of tank.
- Inspect all connections and equipment, confirming at least 5 liner clips or clamps (or more as needed) are in place on top of each panel.
- Have a minimum of 8 inches of water put in the high side of the tank to check for leaks and to hold liner in place.
- Fill tank and monitor.
- If tank remains on site for any period longer than 7 days perform periodic inspections of the tank to ensure everything is in proper working order.
- Every time a tank is fully emptied and refilled, an inspection must be performed.
- Visibly inspect all tank panels and stairs for cracking, dents, burrs on the inside of the panels, chipping paint on welds or sharp edges on panels.
- Look for any cracked or broken valves, damage on pipes and tubes, missing D-Rings, damage to chains or ratchets, and bent clips.
- Pay close attention to hinge plates for chipping paint and cracking.
- Water must NEVER go below 24 inches at the LOWEST level in the tank. (Mark this on the liner as a caution).



Source: R.T. Hicks Consultants, Ltd

R.T. HICKS CONSULTANTS, LTD.
910 Rio Grande Blvd Suite F-142 Albuquerque, NM 87104
505.266.5004

Recycling Containment Materials Schematic

Devon Energy Production Company, LP
Hackberry Recycling Containment and Facility

Appendix B

March 2015

Appendix C
Rockwater SOP

STANDARD OPERATING PROCEDURES

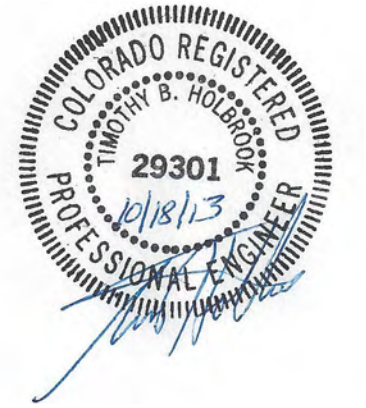
FOR ABOVE GROUND STORAGE TANKS

Rockwater Energy Solutions
Above Ground Storage Tank Division
131 ½ N. 35th Avenue
Greeley, Colorado 80634

CERTIFICATION

This Standard Operating Procedure for Above Ground Storage Tanks (ASTs) was developed based on a draft document provided to Industrial Facilities Engineering, Inc. (IFE) by Rockwater Energy Solutions, and edited for clarity by Industrial Facilities Engineering, Inc. (IFE). IFE observed Rockwater field procedures for erecting portable above ground storage tanks, received verbal input from Rockwater personnel, and documented those field procedures in this SOP. No engineering, safety, mechanical, or structural analysis was completed for this effort, only technical writing. IFE and IFE's personnel do not accept any responsibility for any structural, health, safety, or environmental aspects of the activities described herein.

This document is intended as guidance for installing AST Systems and is subject to review by Rockwater's Health, Safety, and Environmental (HSE), Rockwater legal representatives, and also subject to review by Rockwater's customer's health, safety, and environmental representatives. This document assumes that all Rockwater personnel on customer's sites will be advised of and follow the requirements of customer's HSE programs that apply to construction contractors on customer sites as required by OSHA regulations for process safety management (29 CFR 1910). Any conflicts between the procedures described herein and customer's OSHA requirements should be reported immediately to Rockwater HSE and customer HSE representatives and resolved prior to completing the procedures. IFE recommends reviewing and updating this SOP annually or when conditions warrant.



STANDARD OPERATING PROCEDURES FOR ABOVE GROUND STORAGE TANKS

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Section 1.0 Introduction and Summary

1.1 Introduction and Purpose

Rockwater Energy Solutions, Inc. (and all its affiliated and subsidiary companies, hereinafter collectively referred to as "Rockwater") is committed to providing its employees a safe working environment and avoiding injury to our contractors, customers, and neighbors. As part of our overall commitment to safety, Rockwater seeks to prevent acts or conditions that could result in injury and/or illness to any employee, customer, contractor, neighbor, and/or the environment.

In an effort to prevent potentially harmful acts or conditions, Rockwater has developed this ***Standard Operating Procedure*** (SOP) that focuses on above ground storage tank (AST) systems including planning, set up, operations, and take down. This SOP will discuss steps to be taken to promote a safe process, as well as a list of potential hazards that should be identified and remediated prior to beginning this procedure.

1.2 Background

AST is the industry term for an above ground storage tank. At Rockwater, AST's are used for a variety of field applications within the fluids management operations. AST's can be used in place of traditional tank farms and in-ground water impoundments, and are suitable for fresh water as well as production water. At Rockwater, AST's are available in several standard sizes, ranging from 4,500 barrel (bbl) capacity to 41,000 bbl capacities. Rockwater currently uses two basic styles of AST's. One is referred to as a "pin" tank that uses large diameter steel pins to attach tank plates together. The other type of AST is a "plate" tank. Steel panels of a plate tank are attached using steel plates.

1.3 Intended Use

This SOP will be a part of the training provided to all affected employees when they begin their employment with Rockwater and any time the plan is changed. This SOP will also be reviewed with an employee if his/her responsibilities change under the plan. A written copy of this plan will remain in the regional Safety Office, and will be available for employee review. The Vice-President of Health Safety and Environment, or his agents, may be contacted by any employee if he/she needs additional information about this SOP.

This SOP has been developed to assist affected employees with the operational steps that may be used to complete the task safely. It must be noted, however, that the experience and background of a trained water transfer employee is essential to the success of any project or task.

Nothing contained in this SOP is a substitute for each employee's individual judgment in any given situation. In the event that any employee believes that any task outlined in any SOP cannot be completed safely, then that employee should immediately halt the performance of such task and notify their direct supervisor.

This SOP may also be used to inform customers about Rockwater's typical equipment and procedures for setting up an AST system. This SOP will be reviewed and revised on an ongoing basis to keep pace with best oilfield practices and applicable OSHA regulations.

1.4 Customer Environmental Health and Safety Programs

This SOP recognizes that oil and gas operating companies have developed their own environmental, health, and safety (EHS) programs that contractors who work at customer's sites like Rockwater, must comply with. In addition to this SOP, Rockwater personnel will strictly observe the policies and procedures of each operating company.

1.5 Summary

This SOP is divided into four separate phases, each organized in chronological order. First is the planning phase that includes a customer-Rockwater meeting and close coordination to be sure Rockwater complies with all of customer's

environmental, health, and safety requirements and that the site is ready for the AST setup. This SOP then presents the specific tasks and safety requirements during the second phase - the AST setup phase. The third phase is the AST operation during which periodic checks of the tank are made per customer's requirements. The fourth phase addresses AST takedown during which all materials are removed from the site, and the site returned to customer specified conditions.

Section 2.0 Planning for AST Rig-Up

The planning phase for AST systems includes several important activities that can impact the safety and success of an AST project. Step by step procedures are presented below for each of the following activities during the planning phase of an AST project:

AST order information
Customer meeting
Pre-mobilization on-site meeting
Site soil preparation (by customer)
Notifications
Job Safety Analysis (JSA)
AST material deliveries

2.1 AST Order Information

Rockwater Account Manager will record general AST order information including the customer's site location information, general tank requirements (size, number, liner type, etc), desired schedule, customer's order reference number, and site specific customer contact information. The Account Manager provides this information, along with customer's contractual and safety requirements, to the appropriate personnel.

2.2 Customer Meeting

Prior to finalizing the delivery schedule, a meeting or conference call is held with Rockwater and customer representatives including the customer's purchase agent and the customer's environmental health and safety (EHS) representative. Rockwater is normally represented by the Account Manager, Operations Manager, and Field Operations Supervisor.

This meeting is best done in person, but must at least be covered in a phone call, followed up by a brief email confirming the AST order details, delivery schedule, and noting special conditions, safety requirements, etc.

The following key topics will typically be discussed.

Rockwater site specific staff/roles

Customer roles/responsibilities/contact information including customer's project manager, key on site staff, and EHS staff.

Review AST intended use and customer safety requirements.

Review AST scope of work, what is normally included, what is not.

Permitting for AST (as needed)

Site access and truck route requirements

Time line for AST to be operational

Confirm AST size(s) to be used

AST Layout: Attachment 1 of this SOP presents tank size, setback, and volume per inch data. It also includes an AST Layout Form that can be used during the customer meeting to sketch the location of an AST at a specific customer location. The Sketch should include the position of suction tube, Y trench (if needed), and setbacks to other tanks and existing site equipment. At the end of the meeting, a copy of the sketch should be provided to customer.

NOTE: It is preferable to maintain a 30' clear work area around the perimeter of the tank to provide access for equipment. For all Rockwater ASTs, the minimum footprint should be a circle with a radius of at least 24' greater that the radius of the tank.

Current site conditions, status/schedule for site preparation, and soil preparation requirements

Responsibility for filling the tank, to a minimum of 2 feet deep, immediately after it is set up to protect from wind.

Responsibility for AST inspections during AST operation, any time tank is fully emptied, and the frequency of inspections.

Conditions that could result in standby time charges or additional charges, and what prior customer approvals are required.

Responsibility for the used liner, residual solids left in the tank, and how the site is to be reclaimed.

Begin filling out AST's Pre-Project Evaluation/Checklist in AST Jobsite Workbook (Attachment 4 of this SOP)

Understand customer's OSHA Process Safety Management – Contractor safety and notification requirements for all activities on customer controlled sites.

Note any customer-specific or site-specific, personal protective equipment (PPE) or safety requirements for the AST site.

Notifications: Establish a list of notifications/communications that Rockwater will be responsible for and timing for each. Rockwater standard procedure is to notify owners of buried utilities in the AST site area using state-wide or Canadian Province "one-call" services at least one week in advance of AST setup. Identify any other notifications that Rockwater will need to make (e.g. Truck routes, neighbors, etc). Also identify customer's procedures for notifying the customer if conditions arise that could impact scope, schedule, cost) and get email addresses as needed.

Other Topics

Any additional site preparation to be completed by customer prior to setup
Underground material needs to be taken into account for site preparation.
Other Activities: Discuss AST site activities that will be ongoing during the AST set up. Rockwater personnel will be aware and courteous of simultaneous operations at all times.

Follow Up Email

After customer meeting, the Rockwater Account Manager will prepare a brief email to the customer and Rockwater representatives to confirm the AST order information, schedule, and site specific instructions from the customer, especially for tasks that are not included in the standard AST setup (per AST SOP) and customer specific, safety requirements.

2.3 Pre-Mobilization Onsite Meeting

Rockwater Field Operations Manager will hold a pre-mobilization meeting at the site of the AST project with customer representatives for the purpose of checking the site to confirm it is ready, or soon to be ready, for AST installation. During this meeting, the Field Operations Manager will complete will complete the AST Pre-Project Checklist (included in Attachment 4 of this SOP) and then send it to the Rockwater Account Manager. Based on the information in the checklist and other information, the Account Manager may send a brief follow up email to the customer and Rockwater management, if needed, to update previous site-specific instructions that the Account Manager issued as the follow up to the client meeting.

2.4 Site Soil Preparation

Preparation of the soils on site is required to form a dependable base for the AST. Preparation of the tank pad is the sole responsibility of Rockwater's AST customer (typically an oil and gas operating company). The Rockwater Field Operations Manager will check the status of soil preparation during the pre-project meeting on site. Rockwater personnel will also check the soil preparation using a proof roll test immediately prior to the AST setup.

Rockwater's soil preparation requirements are as follows:

Rockwater recommends a minimum soil compaction of 95% compaction. Soil testing results are normally shared with Rockwater. Due to different regions and environments; this may not always be possible. In order to meet industry standards, site preparation requirements must be deemed satisfactory by a Rockwater representative.

Rockwater recommends soil compaction testing to be conducted via Standard Proctor Test (American Society for Testing and Materials {ASTM} Standard D698) or Modified Proctor Test (ASTM Standard D1557).

Compaction test results must be provided to Rockwater prior to the commencement of AST construction.

A proof roll test may be used if observed and documented by qualified Rockwater personnel. Attachment 3 of this SOP provides guidance on how to perform a proof roll test and how to interpret the results.

Grade AST footprint and 30 ft work area to 0.25 % or 3" ft drop per 100 feet, toward sump location.

Site should be graveled prior to tank installation, utilizing gravel size 2B or smaller. (3/4" road grade preferred, or coarse sand with minimum thickness of 4 inches).

Do not use crushed rock as sharp edges could puncture the tank liner.

After completion of these steps the tank setup can be approved.

2.5 Notifications

Even though the customer or their subcontractor may have already called for utility locates for the soil preparation work, Rockwater Crew Leader must call the local or state underground utility location service again at least one week in advance before construction/digging begins. Rockwater Crew Leader should document the ticket or reference number provided by the one-call service on the Pre-Project Checklist in the AST Jobsite Workbook included in Attachment 4.

The following web site has contacts for all the states and provinces.
http://www.call811.com/state-specific.aspx. The website link below is provided for smart phones:

Call 811 in United States
For Canada
Alberta: 1-800-242-3447
British Columbia: 1-800-474-6886
Ontario: 1-800-400-2255
Quebec: 1-800663-9228
Saskatchewan: 1-866-828-4888

2.6 AST Material Deliveries

Once the delivery route and schedule are established and the pre-project onsite inspection is completed, the AST materials can be delivered. Notifications will be made as agreed to during the customer meeting. Rockwater delivery personnel unload all materials safely and taking care to avoid damage to liners, plates, and all other AST components. They will also stay out of the way of ongoing site activities, and notify Rockwater Crew Leader if site conditions are not suitable for delivery.

Section 3.0 AST Setup

The Crew Leader will fill out the "AST During Project Checklist" during set up of the AST system.

3.1 Job Safety Analysis (JSA)

A job safety analysis must be completed on site prior to beginning work. The JSA will be completed following Rockwater approved procedures. Customer's safety requirements will also be communicated during the JSA. All Rockwater personnel, 3rd party contractors, and customer representatives are expected to participate and sign the JSA forms when the JSA is completed. JSA forms are included in Attachment 2.

3.2 Check Soil Condition

Preparation of the tank pad is solely the responsibility of the customer (oil/gas operating company). However, weather and rain/snow events can change the soil conditions quickly. Therefore, Rockwater will check the soil compaction using field methods prior to setting up the AST using one or more of the following methods, depending upon site conditions immediately before liner and tank layout:

- Perform a proof roll test using the large loader with a bucket full of sand, driving slowly over the tank base area, focusing on the tank wall perimeter. Refer to Ohio Department of Transportation specifications for proof rolling at http://www.dot.state.oh.us/Divisions/ConstructionMgt/OnlineDocs/2009MOP/200 Earthwork/204/204 Subgrade Compaction and Proof Rolling.htm - Proof Rolling (bottom of page 4) for acceptable soil deflections or displacements. This specification is included in Attachment 3.

3.3 Tank Layout

- Check proposed AST site to confirm a 30' clear work area around the perimeter of the tank is possible to provide access for equipment and laydown area for AST materials and erection equipment.
- Check that the minimum distances to existing wells, power lines, etc. are met.
- Regardless of manufacturer, the minimum footprint should be a circle of at least 24' greater than that the radius of the tank.
- Establish final location for the suction tube and stairs.
- For a pin tank, the pad should be graded and sloped 0.25% from high side of location to suction side of tank. This will allow for better drainage of tank.
- For a plate tank, the pad needs to be flat.

3.4 Equipment (Rockwater provided)

All equipment is subject to daily inspection. (Check condition, rigging, oil, water, fuel and cleanliness.) Here is a list of the recommended equipment needed to set a tank. Actual equipment used will vary among regions and specific projects.

- Two 40' extending straight boom man-lifts.
- 16,000 lb capacity extending boom, rough terrain powered industrial truck (Tele-handler or equivalent) as needed.
- Tractor/loader/backhoe unit with minimum one ton lift capacity (Volvo 110 series, or equivalent) and a modified jig for setting walls (as needed).
- 40 ton crane for plate tank setups – large enough to complete the job at hand. In the event that a crane operator is needed, the operating company or Rockwater will contract with a third party for this service.
- Recommended equipment to remove scraps and miscellaneous material on site (trailer, dumpster, etc.)

- Optional excavator with thumb for plate tank setups.

3.5 Hand Tools Recommended

All hand tools are subject to daily inspection.

- Two 13’ ladders
- Four 4 lb. sledgehammers
- 100’ or 200’ tape measure
- 1 case of marking paint – minimum
- Set of wrenches ¼” – 1 ½”
- Set of sockets ¼” – 1 ½”
- Two 36” pry bars
- 8’ rock bar (digging bar)
- Five safety harnesses with retractable tethers (Rockwater owned)
- Five retractable lanyards
- 100’ of 3/8” rope
- Duct tape
- Covered hook bladed knife
- Three 40’ lifting straps (minimum of 5,000 lb capacity)
- Three 20’ 3/8” chains (must have visible certification tags)
- Two rolling head pry bars
- 150’ strap
- Two ½” impact guns
- Ten padded vise grips to pull liners
- Two sets of rigging chains
- Patch tape
- Rubbing alcohol
- Patch roller
- Leather gloves
- Wire brush or wheel with 4” angle grinder
- Generator
- Steel toed rubber boots
- Fire retardant clothing (FRs)

3.6 AST Tank Setup Steps

- There must be a Rockwater company representative on site the day prior to setup in order to approve everything for setup.

Tank Layout

- Determine center of tank and mark with paint, then bury preferred non-abrasive item (tennis ball, sand bag, water bottle, etc.) This will be used to find the center of tank after liners have been placed.
- Measure and double check minimum distance from tank center to existing wells meets the minimum distance
- Measure and paint a line to mark the circumference of tank for panel placement.
- Also mark the circumference of the liner laid out flat to ensure the liner is properly placed.

Suction Pit

- Determine where tank suction is to be placed (the low side of pad).

- For pin tanks, dig 8’ wide x 8’ long x 16” deep sump hole for the suction manifold to set in and taper the edges so there are no sharp corners of the excavation.
- Remove any sharp stones
  - If multiple suction manifolds are required, the sumps should have a minimum of 8’ of separation.

Attention!

In cold weather conditions, the sumps should be dug out as late as possible and should never be left unattended overnight.

Barricade any sump pit with appropriate cones or tape if left open when crew is not present or active in the area.

- When installing a plate tank, the “Y Trench” can be used both for wind stabilization and for draining the tank. The “Plate Tank Y-Trench Guidance Document” can be found in Attachment 5 of this SOP.

Geo Pad and Liner

- All tanks setups will require the use of a Rockwater approved underlayment and liner. Typically one 10 ounce, geo pad is laid out for added protection and one, 30 mil liner will be placed inside the tank.
- In the event that the tank will be holding produced or recycled water, an extra felt liner (geo pad) should be laid out prior to the AST setup.
- Check customer specifications and regulatory permit liner and containment requirements for ASTs that may hold flowback or produced water.
- The crew walks the entire tank base area to and pick up any sharp stones or other sharp debris that could damage the liner.
- Lay out the geo pad prior to the liner. In some cases, the geo pad is “bundled” with the liner and can be rolled out together. After unrolling, pull the geo pad to extend it fully using several crew members spaced along the edge.
- Perform a visual inspection of the liner – repair any defects as necessary.
- Place the liner and align to the center of the tank and painted line for the tank walls. The preferred 30 ft area around tank allows the liner to be laid out flat so that fold back can be uniform.
- Bundling of the liner with the geo pad by the liner supplier is preferred. If the liner is bundled with the geo pad, roll it out across the diameter of the tank, extending outside the painted perimeter wall line. Be sure not to use padded vice grips to move liner unless located at edge of liner. Inspect liner and report any damage or bad seams, punctures due to handling, etc. to the Crew Leader
- Secure liner from wind using sand bags, or if plate tank, use the “Y” trench by filling the trench with water
- Fold the liner toward inside the painted tank edge line to allow stockpiling of sand and placement tank panel walls.

Sand Against Inside Panel

Stockpile sand just inside marked panel perimeter. Place enough sand at spaced locations around the circle to provide for sand approximately 12” deep at tank wall and a 1:1 slope into tank.

Tank Wall Erection

- Ensure all tank parts and pieces are accounted for.
- Crew Leader will complete a visual inspection of each panel as it is prepared to be placed. Fill out Tank Panel Visual Inspection Check Sheet in Attachment 6, place in Jobsite Notebook.
- Stand the first tank panel in place and keep connected to the crane until all the remaining panels have been connected.
- Monitor crane and rigging of first panel closely to ensure it remains stable, especially during wind and while the other panels are attached.
- Begin placing the remaining panels in place with the front-end loader and panel rigging frame

- Personnel secured on man-lift then secure the panels in place with 4 pins each (for pin tanks) or (for plate tanks) with the connecting plates and lug busses, secured with chained cotter pins.
- To protect the liner, distribute sand with shovels to form 1:1 sand bank against the inside bottom of each panel. Be sure the slope is uniform. Alternatively, roll up excess geo pad into minimum 6" diameter cylinders around the inside of the tank ring to help support the liner at the base of the tank wall as the tank is being filled.
- Prior to lifting liner into place against inside panel, place metal covering plates over all panel gaps in plate type tank. For pin tanks, check that sand or rolled up geo pad is evenly placed at base of all walls.
- Prior to covering sump with the geo pad or liner, confirm sump excavation has smooth sides and corners, and that no sharp stones are present.
- When placing the final panel in the circle, attach this final panel only on left or right side but LEAVE OTHER PANEL SIDE OPEN at this time for access and egress points. *(Must have an entry and exit point to the tank at all times.)*

Liner Placement and Securing Top With Clips or Clamps

- After 4 or 5 panels are set, and all liner protection as described above is in place, unfold the liner in sections, toward the base of each panel, making sure the sand or rolled up geo pad will provide padding at the base of the inside of each panel.
- Crew of 2 inside the tank wall unfolds and pulls the liner toward each panel. Working in small liner sections, this inside crew works with a crew of 2 on a man lift located outside and above each tank panel to pull the liner edge up and over the top of each panel. The man lift crew lifts the liner edge using ropes attached (by the inside crew) to padded vice grips that grip the liner. The man lift crew lifts a small liner section to the top of the panel and folds it over the top of the panel, being sure there is enough slack in the liner inside the panel wall.
- Once a section of liner is positioned properly (with liner slack inside the tank) and over the top of each panel wall, the man lift crew secures the top of the liner with clips (pin tanks) or clamps (plate tanks). NOTE: A minimum of 5 clips (pin tanks) or 5 clamps (plate tanks) or more are required at the top of each tank panel to secure the liner. Add additional clips and clamps as needed to secure liner.
- Both inside and man lift crews continue this process, working around the tank, one or two panels at a time, until the entire liner is in place.
- NOTE: The crew must allow sufficient slack in the liner at the wall to allow for liner movement during filling and draining.

Stairs, Fill Tubes, and Suction Tubes

- Install safety stair system, fill tubes, and suction tubes. Ensure that stair system and tubes are appropriately secured to the tank walls according to customer specifications.
- Upon completion of the stair system installation, the stairs should be secured as per the operating company requirements. At a minimum, these requirements should include access chains with "Authorized Personnel Only" (or equivalent) signage at the bottom of the stairs outside the tank, water rescue equipment on the platform at the top of the stairs, and access chains with "Do Not Enter" signage at the top of the stairs that go inside the tank.

Final Steps, Filling, and Inspection

- Close final panel and secure with pins or plates as needed.
- Trim liner and allow approximately 3' of liner to hang over edge of tank.
- Secure liner with sufficient clips or clamps and be sure ratchet straps are applied to all tanks. Place straps to secure the cut edge of liner on outside of tank.

- Inspect all connections and equipment, confirming at least 5 liner clips or clamps (or more as needed) are in place on top of each panel.
- Have a minimum of 8 inches of water put in the high side of the tank to check for leaks and to hold liner in place.
- Fill tank and monitor.
  - If tank remains on site for any period longer than 7 days perform periodic inspections of the tank to ensure everything is in proper working order.
  - Every time a tank is fully emptied and refilled, an inspection must be performed.
  - Visibly inspect all tank panels and stairs for cracking, dents, burrs on the inside of the panels, chipping paint on welds or sharp edges on panels.
  - Look for any cracked or broken valves, damage on pipes and tubes, missing D-Rings, damage to chains or ratchets, and bent clips.
  - Pay close attention to hinge plates for chipping paint and cracking.
  - Water must NEVER go below 24 inches at the LOWEST level in the tank. (Mark this on the liner as a caution).

Crew Leader will complete the Post Project Checklist (included in Attachment 4 of this SOP) and assemble all required jobsite forms into the Jobsite Notebook. Also document crew hours and expenses to Rockwater Field Operations Manager.

Section 4.0 AST Operation

4.1 Inspections and Monitoring

AST Operation Phase includes periodic AST monitoring, leak detection, and identifying potential hazards that may have developed, change in site conditions or if the contents of the tank change from the initial use. Periodic visual inspection of each individual tank panel is also completed. Inspections are recommended whenever the tank is emptied and prior to refilling.

Attachment 4 of this SOP contains a form titled AST Visual Inspection Checklist that is filled out during periodic inspections. The form provides a list of observations that will enable early detection of uneven tank panel settlement, soil settlement, liner damage, insufficient liner slack, or leaks. Any AST issues are quickly reported to the Rockwater Crew Leader.

Attachment 6 to this SOP is a form used to inspect individual tank panels and connections titled Tank Panel Visual Inspection Check Sheet. Each individual tank panel has a unique identifying number that is used on the sheet. Each panel is checked to identify any abnormal wear or damage. Any tank panel issues are quickly reported to the Rockwater Crew Leader.

If the tank is drained, it should be secured from wind impacts and the liner inspected and re-positioned (to provide sufficient slack during filling) prior to refilling. Specifically, it may be necessary to rearrange the liner folds at the walls prior to refilling if the wind has shifted the liner folds when the tank was empty.

If the contents of the tank have changed from the contents originally planned for the tank, report this change to the Rockwater Crew Leader as soon as possible.

CAUTION – If conditions are observed that could indicate an imminent tank failure, clear the area immediately, advise others in the vicinity to do so also and contact the customer to drain the tank, and the Field Operations Supervisor to advise of the situation.

4.2 Initial Leak Detection and Liner Repair

In the event of a leak in the tank due to a hole in the liner, the following steps should be followed.

- If there is a question that it is in fact a leak from the AST, a pH balance test may need to be performed on both the water in the tank and on the ground.
- If the leak is found to be coming from the tank, narrow down from which panel the leak is originating.
- Use a strap or rope to mark the point where the water is coming out of the tank.
- Determine if the water is coming out high or low on the tank.
- Locate the puncture or hole in the liner.
- Empty the tank to the point of damage in liner if necessary.
- Clean area of liner that needs to be repaired.
- Cut out piece of material (patch or tape) to overlay liner.
- Either weld the patch to the injured area in the liner or stick the tape (2 types – dry or underwater) over the leak.
- Make sure puncture is completely covered.
- Monitor as needed.

Section 5.0 AST Breakdown

The AST breakdown follows the reverse order of the setup steps presented in Section 3.0 above. The sump or "Y" trench will be filled in with soils or fill approved by the customer and compacted with a loader to the surrounding grade.

The customer is normally responsible for draining and disposing of all liquids and residual solids that have accumulated in the tank. Rockwater Field Operations Supervisor is responsible for following the customer's requirements for proper off site management or recycling of the liner and geo pad materials, and for returning the site to the customer per the customer's site specific requirements.

Rockwater will complete an AST Visual Inspection Checklist to document the condition of each panel. A completed checklist is then placed into the Jobsite Notebook. If panel or fastener damage is observed, provide a copy of the inspection to Rockwater General Manager.

ATTACHMENTS TO AST SOP

ATTACHMENT 1 - Tank Size, Setback, BBL/inch Data and Layout Form

ATTACHMENT 2 - Job Safety Analysis Form

ATTACHMENT 3 – Proof Roll Testing Guidance

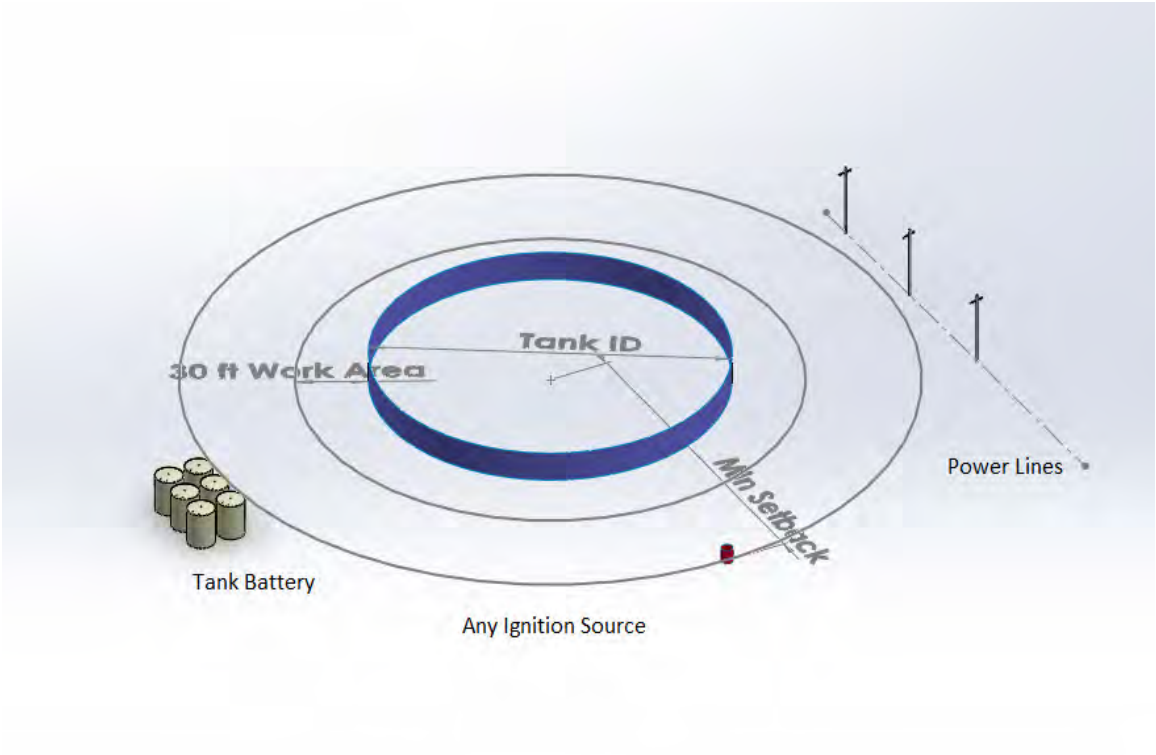
ATTACHMENT 4 - RCK AST Jobsite Workbook Forms

ATTACHMENT 5 –"Y" Trench Guidance

ATTACHMENT 6 - Tank Panel Visual Inspection Check Sheets

ATTACHMENT 1 - Tank Size/Layout Table, Graphic, BBL/Inch, and Layout

Tank	Panels	Inside Dia (ft)	Layout Radius	Minimum Setback from Well to Tank Center (Tank radius + 75 ft + 5 ft)	Capacity (Bbl)	bbl/Inch
PIN 40,000	24	153	76’ 6”	156’ 6”	40,000	279.4
PIN 24,000	20	119.5	59’ 9”	139’ 9”	24,000	166.5
PIN 9,600	12	76.7	38’ 4”	118’ 4”	9,600	68.6
PLATE Atlantis	15	157.5	78’ 9”	158’ 9”	41,000	287.4
PLATE Odyssey	12	126	63’	143’	26,500	185.2
PLATE Poseidon	10	105	52’ 6”	132’ 6”	18,000	128
PLATE Triton	7	73.5	36’ 9”	116’ 9”	9,000	62.9
PLATE Neptune	5	52.5	26’ 3”	106’ 3”	4,500	32.1



AST LAYOUT FORM

CUSTOMER: _____PAD: _____
LOCATION: _____

TANK FROM: _____FRAC'D DATE: _____ SET DATE: _____
DRECTIONS: _____

ADDITIONAL COMMENTS: _____

PREPARED BY: _____ APPROX. SCALE: _____ NORTH ARROW: ____

ATTACHMENT 2 - Job Safety Analysis Form

TO BE COMPLETED PRIOR TO STARTING JOB
ROCKWATER ENERGY SOLUTIONS JOB SAFETY ANALYSIS

Company: _____
Project #: _____
Project Description: _____

9-1-1 Address: _____
Well #: _____
County/State: _____
Date: _____

Safety Equipment Required To Do This Job											
Hard Hat	☐	4-Gas Monitors	☐	Metacarpal Gloves	☐	Safety Glasses	☐	Lockout/Tagout	☐	Metatarsal	
Fire Extinguisher	☐	Back Support Belt	☐	Confined Space Permit	☐	Work Permit Req'd	☐	Hearing Protection	☐	Boots	☐
Face Shield/Goggles	☐	Safety Harness/Anti-Fall Device	☐	Proper Clothing	☐	Ground Cable	☐	Wheel Chock	☐		

Pre-Job Hazard Assessment											
Lifting	**Y**	**N**	Housing of Tools/Material	☐	☐	Electrical Hazards	☐	☐	Twisting Motion	☐	☐
Manual Lifting (body position)	☐	☐	Secure Footing	☐	☐	Welding/Flame Cutting	☐	☐	Walking	☐	☐
Mechanical Lifting Equipment	☐	☐	**Hazards**			Mechanical equipment	☐	☐	Swinging	☐	☐
Awkward Body Position	☐	☐	Proper tool/matl placement	☐	☐	**Environmental**			Straining	☐	☐
Slip/Trip Potential	☐	☐	Hot/Cold Surface or Material	☐	☐	Pollution (Personal Exposure)	☐	☐	Stretching	☐	☐
Lifting with Other Employees	☐	☐	Inadequate Lighting	☐	☐	**Constant Body Position/Movement**			Reaching	☐	☐
Proper Rigging Practices	☐	☐	Fall Protection/Anchor Points	☐	☐	Climbing	☐	☐	Over Extending	☐	☐
Access/Exit	☐	☐	Pinch Points	☐	☐	Pulling, Pushing	☐	☐	Jumping	☐	☐
Scaffold (Properly Inspected)	☐	☐	Trenching/Excavation	☐	☐	Bending - If 'Y', Identify:	☐	☐	Crawling	☐	☐
Ladder	☐	☐	Hand & Finger Hazards	☐	☐						

Environmental Conditions

Conditions						Temperature		Winds		Mud		Hazwoper		
Day	☐	Drizzle	☐	Ice	☐	32 or less	☐	15 or less	☐	Dried	☐	Reviewed	☐	☐
Night	☐	Humid	☐	Dust	☐	32 to 80	☐	15 to 40	☐	Moderate	☐	MSDS Needed	☐	☐
Clear	☐	Rain	☐	Lighting	☐	80 or More	☐	40 or More	☐	Deep	☐		☐	☐
Fog	☐	Snow	☐	Other	☐									

Sequence of Basic Job Steps	Potential At-Risk Behaviors or Other Hazards	Action Taken to Eliminate or Reduce Potential Hazards

Signatures:

Supervisor: _____ **Crew:** _____

_____

Crew: _____ _____

_____ _____

_____ _____

Must be turned into HSE daily.

ROCKWATER Energy Solutions | **Job Safety Analysis Process Worksheet REV. B** | **"LIVE INCIDENT FREE EVERY DAY"**

Permit To Work #: _____

Permit Approver: _____

Work Team Leader: _____

Work Group / Company: _____

Work Location: _____

Date:_____ Start Time:_____ Planned End Time:_____

Description of Work Activity: _____

_____

Emergency Response Initial Contacts:

Client Representative: _____

1. Radio Channel: _____

2. Phone: _____

WPD Supervisor: _____

1. Radio Channel: _____

2. Phone: _____

Greeley Branch Safety on-call (970) 219-4264 Other Emergencies: 911

Emergency Response Actions:

- Evacuate Area (get to safe zone)
- Notify Operations (and Leads)
- Secure Area
- (Don't allow entry unless it's authorized responders)

Field Staging Areas:

Primary _____

Secondary _____

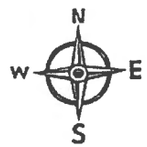
Complete Sign-up Sheet Daily

JSA filled out by whom: _____

By Signing Below I have read, fully understood and have had the opportunity to make suggestions or add aditional hazards. I will follow this process.

Printed Name	Signature	In	Out

Diagram of work location(s) with site muster areas noted **(If multiple locations are applicable, please used 2nd JSA form):**



Current Weather Conditions: _____ Wind Direction: _____

ROCKWATER Energy Solutions

Job Safety Analysis Process Worksheet REV. B

"LIVE INCIDENT FREE EVERY DAY"

Jobs Steps/Procedures List all the steps and tasks associated with doing this job.	Potential Hazards or Incidents List the potential hazards associated with the steps or tasks to do this job.	Safe Procedures/Behaviors List the Safeguards/behaviors used to protect all affected individuals from these hazards.	JSA Corrections, Changes, and Notes List any changes, corrections, notes, or review comments associated with this JSA and job.

Job Preparation:
- ☐ Get duties assigned.
- ☐ Get Proper Tools and Equipment.
  - ☐ Including PPE
- ☐ Go to Work Location.
  - ☐ Driving
- ☐ Review Plan and Hazard Analysis.
- ☐ Complete JSA.
- ☐ Do job walk around.
- ☐ Prepare Tools and Equipment.

Doing the Job:

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Finishing the Job:
- ☐ If work isn't complete ensure everything is secure.
- ☐ If work is complete make sure everything is correct.
- ☐ Pick up tools and equipment.
- ☐ Housekeeping completed.
- ☐ Complete Paperwork.
- ☐ Leave Work Location.

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Mentor: ____________________

Check boxes below that apply for this task

- ☐ Did you get all the material you needed for the job?
- ☐ Did all the hand tools and equipment get inspected?
- ☐ Is this JSA filled out, read by each crew member and signed?
- ☐ Has everyone inspected and wearing all their PPE properly?
- ☐ Does everyone understand that they will give their full attention to this task?
- ☐ Does the crew need hearing protection?
- ☐ Does everyone understand all the instruction(s) and duties given for this task?
- ☐ Has the crew been ask if there are any missing steps, hazards, mitigation on the JSA?
- ☐ Does everyone on the crew understand it is everyone's responsibility to stop activity where a hazard is detected or identified?
- ☐ Have I met greeted and shared JSA's with other contractors in my work vicinity?
- ☐ Are all barriers in place before starting work and left in place if the work is incomplete?
- ☐ Is everyone trained on tools and equipment being used for this task?
- ☐ Does everyone on this crew understand procedures used for this task?
- ☐ Is a hot work permit required?
- ☐ Is a confine space permit required?
- ☐ Did Fire Extinguishers get inspected from truck, pump, air compressor and are set out away from pump/compressor during operation?

Signature of person(s) checking boxes:

Print Name: ____________________

Signature:

ATTACHMENT 3 – Proof Roll Testing Guidance

204 Subgrade Compaction and Proof Rolling

Importance

Over 25 million dollars of extra work was used to stabilize soft subgrades during the construction seasons of 2000 and 2001. This extra work has been minimized in recent years because of the construction and design criteria created since that time.

This section will help the project construct stable subgrades for pavement construction. Proper subgrade treatment ensures a constructible pavement, enhances pavement performance over its life, and ensures that the pavement design intent is carried through in the construction phase. This section is based on research performed by the Department from the 1960's through today. This section should not be used as the ultimate answer to solve all subgrade problems.

This section is detailed in such a manner so that construction personnel can easily apply information from the field and subsurface investigation to provide reasonable adjustments to the plan subgrade treatment.

Specification and Plan Requirements

Item 204 requires the top 12 inches of the subgrade to be compacted. Item 204 requires the subgrade to be proof rolled. If subgrade stabilization or undercutting is designed for the entire project, then proof rolling is only used to verify the undercut replacement material stability. If special subgrade treatment is provided in the plans at spot locations, proof rolling is specified to identify these areas and then performed afterwards to verify the undercut stability.

Proof rolling deflections and soil conditions that are observed during construction determine if the plan subgrade treatment must be adjusted. Adjustment of subgrade treatment to fit field conditions is essential and is the responsibility of the Project Engineer.

Subgrade Correction Prior to Proof Rolling

The Engineer must observe the effect of heavy equipment operating on the subgrade during rough grading. When rutting and deflection under heavy equipment indicates soft subgrade, the Engineer should authorize the correction. See "Elasticity and Deformation of Soils" in section 203.02 Materials of this manual.

Do not delay the correction until it can be checked by proof rolling. Investigate the extent of the problem by using the "Investigation" section of this Item. Be aware that the condition can be improved by time, drainage, and hauling as detailed in the section "Draining and Hauling" of this item.

If needed, make the correction by excavating and disposing of soft soil, and replacing it with suitable material as detailed in the section "Undercut Depth and Stabilization Determination" of this item.

Drainage and Hauling

Excess water in fine-grained soil is the principal cause of unstable soil conditions. The Engineer has a responsibility to ensure adequate drainage during construction. If the investigation indicates the need for underdrains or the cleaning of the existing underdrain outlets, then the Engineer must order the work as soon as possible.

Some examples of these conditions are as follows:

1. Existing underdrains with clogged outlets on rehabilitation projects.

2. Free water in the subgrade.
3. Saturated soils of moderately high permeability, such as sandy silt and silty clay of low plasticity.
4. Ground water seepage through layers of permeable soil.
5. Water seeping in the test pits.
6. Water seeping from higher elevations in cut locations.
7. Water flowing on the top of the rock or shale in subgrade undercuts.

Note: It is difficult to remove water from hard clay soils with PI's greater than 20 with construction underdrains.

Subgrade stability can be significantly improved by cleaning out the existing underdrain outlets on rehabilitation projects and by adding construction underdrains on new or rehabilitation projects. Once the underdrain systems are in place and functioning, the drainage system can reduce the subgrade soil moisture content from 3 percent over optimum moisture to the optimum moisture content in 6 to 8 weeks. Moisture contents that exceed 3 percent over optimum must be dealt with by other means.

For rehabilitation projects, the Contractor should be instructed to unclog the underdrain outlets immediately. Try to perform this work in the time frame listed above. If the project consists of several phases, instruct the Contractor to perform the outlet cleaning for the entire project at the same time.

For new or rehabilitation projects, subgrade stability can be achieved by constructing the plan or construction underdrains as soon as the water problem is found. On new construction projects a longer period of time can be allowed for the underdrain system to work. Opportune times for this work are at the beginning of construction and before winter shut down.

The plan underdrains should be placed only when they will not be contaminated by further construction. If contamination is a concern then sacrificial or construction underdrains should be used on the project.

Item 605 in the C&MS details the construction underdrain construction. Construction underdrains are usually placed in the centerline of the roadway. They may also be placed in the ditch line if the water is coming in from a cut section at a higher elevation. The porous backfill is extended to the subgrade elevation. The outlets for the construction underdrain are the same pipe material and backfill as regular underdrains. The underdrains can be outlet to any convenient location such as catch basins, manholes, pipe, or ditches. The project should not be concerned with the contamination in the upper portion of the underdrain backfill. Construction underdrains are sacrificial underdrains that will continue to work throughout the life of the contract, and afterwards even though the upper portion is contaminated.

In Figure 204.A, the subgrade is saturated and the soil acts like a waterbed when the subgrade is Proof Rolled or hauled on. However, once the underdrains are in place and the soil is loaded, as shown in Figure 204.B, then the water has a place to go. As the soil is loaded or hauled on, the water is squeezed out and the subgrade conditions will improve.

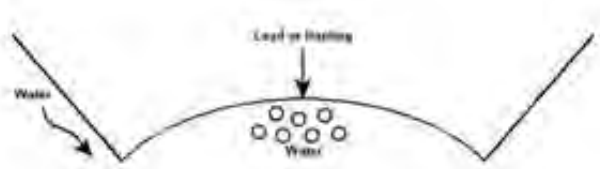


Figure 204.A – Water in the Subgrade without Drainage

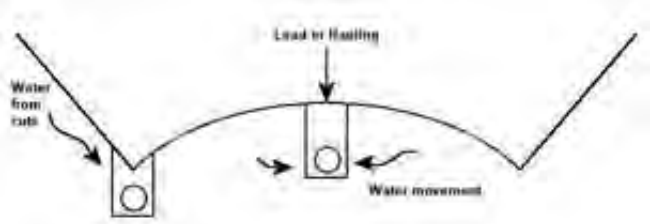


Figure 204.B – Water in the Subgrade with Drainage

By placing the drainage system prior to loading or hauling on the subgrade, the water is given a location to escape the subgrade system. If the drainage system is not in place before hauling or loading, the subgrade will rut or crack, and have a detrimental effect on the subgrade and not improve with loading.

Drainage and hauling can work together to correct soft subgrades under the above given guidelines.

Figure 204.C "Shale and Rock Undercuts" came from Figure 1009-10 in Location & Design Manual – Volume 2, *Drainage Design*. The

specification requirements are detailed in 204.05. Shale and rock are cut 24 inches (610 mm) below the bottom of the pavement. This ensures that the pavement gets uniform support and good drainage. In addition, soft rock or shale can deteriorate due to the accumulation of water under the pavement.

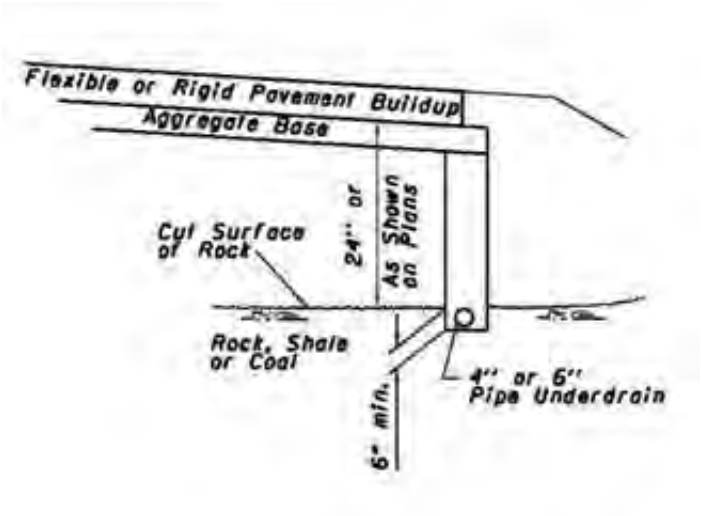


Figure 204.C – Shale and Rock Undercuts

The underdrains in these rock and shale cuts should extend at least 6 inches (150 mm) into the existing rock or shale formation. If the underdrains are too high, the water will accumulate at the rock and soil interface and cause subgrade instability.

Construction or rock underdrains can be placed in the ditches and other strategic locations in cut sections to minimize water coming under the pavement. Water under the pavement without drainage causes the subgrade to act like a waterbed. With drainage, the conditions improve and become more stable.

When to Proof Roll

For areas where subgrade appears to be stable without undercutting, proof roll after the top 12 inches (305 mm) of the subgrade meets the compaction requirements and after the subgrade has been brought to approximate shape within 0.1 to 0.2 feet (30 to 60 mm) required by plan lines.

For areas that are obviously unstable and require undercutting, do not proof roll unnecessarily to demonstrate that subgrade correction is required.

The proof rolling should be done immediately after the subgrade compaction operation, when the moisture content of the subgrade soil is near the optimum moisture content or at the moisture content that achieved compaction. This minimizes the subgrade becoming too wet or too dry for an effective proof rolling evaluation. If the subgrade is too wet, the material will displace and rut. If the subgrade is too dry, a hard surface crust may carry the proof roller over an undesirable soft wet underlying material without rutting or deflection, and the soft subgrade may not be detected.

Proof rolling may be done either before or after pipe underdrains are installed. If done after underdrains are installed, rolling should not be done directly over the underdrains. In C&MS 204.06, proof rolling must be performed at least 1.5 feet (0.5 m) away from the underdrains because of the potential damage to the underdrains.

Proof Rolling

CA-EW-2 “Proof Rolling Documentation Form” is used to document the proof rolling operation. It is imperative that the stations, deflections, weight of the proof roller, and comments are well documented. Digital photographs of subgrade distress are highly recommended.

The primary purposes of proof rolling are to locate soft areas, check the subgrade compaction, to carry out the intent of the design, and to provide uniform support for the pavement structure. Soft subgrade areas that are located will be corrected so that the subgrade density can be maintained throughout the construction. If done correctly, the pavement design intent will be carried through the construction process.

One trip with a proof roller is adequate to achieve satisfactory proof rolling results.

An over loaded proof roller for a soil type may cause satisfactory subgrade to become unstable during proof rolling. Conversely, soft areas will not be found if the proof roller is too light for the soil type.

Selection of Proof Roller Weights and Tire Pressure

In view of the many variations which must be expected in Ohio soil and moisture conditions, the Engineer is given authority to vary the weight and tire pressure of the proof roller to fit the conditions. The weights and tire pressures for the different soils are detailed in C&MS 204.06.

It is imperative that the project chooses the correct load for the type of soil on the project. These loads and tire pressures are soil type sensitive when evaluating the subgrade. For A-3, A-4, A-6, and A-7 soils, use a 35 ton (32 metric ton) roller with a tire pressure of 120 psi (820 kPa). This load and tire pressure is used on most projects because these are the most common soils found in the State of Ohio.

For granular soils, and soil, rock and granular mixtures, use a 50 ton (46 metric ton) roller with 150 psi (1030 kPa) tire pressure.

The goal of proof rolling is to maximize the load to locate soft subgrade. These soft soils could be 3 to 5 feet (1 to 2 m) deep. In rare cases, the soft soil may be deeper than 5 feet (2 m).

Close inspection throughout proof rolling is necessary to observe the rolling effects and to mark soft subgrade locations for correction or investigation. Inadequate stability is indicated by deflection, cracking, or rutting of the surface of the subgrade.

Failure Criteria

The failure criteria is used in this section to determine the locations from which to perform a detailed analysis. This detailed analysis consists of methods discussed later in this section such as rut depth, soil borings and test pits. If the subgrade deflects beyond the failure limits given in this section and the soil borings and test pits determine that the subgrade does not need to be undercut then the subgrade should be considered satisfactory. One additional area to evaluate is the moisture content of the soil. Some soils are more prone to rut at moisture contents greater than 3 percent below the optimum moisture content. In fill locations, the moisture content can be reduced to minimize this problem. If all of the above criteria are met then there is no reason the subgrade should not perform as anticipated. If there is any debate between the Department and the Contractor, especially if a warranty is involved, then further nondestructive or destructive testing can be used to resolve the issue.

The failure criteria for new construction and reconstruction projects are different because of the following reasons:

New construction projects

1. Longer construction time frames allow the subgrade to stabilize.
2. Haul roads to minimize the loading of the subgrade can be established for new construction projects.
3. Drainage and maintenance of these projects are much easier.
4. Even when rutting does appear during proof rolling, the material may be re-graded, hauled on, and re-compacted to meet the specifications.

Rehabilitation projects

1. The soil conditions under pavements are highly variable.
2. Water accumulates under the pavement because of the freeze thaw and wet dry cycles, high existing ditches and underdrain outlet clogging.
3. Construction time frames are limited.
4. Space limits the ability to dry the material in place.
5. Once the pavement is removed, all the drainage is toward the subgrade. This compounds an already poor drainage situation.
6. Alternate haul routes are limited or not available on rehabilitation projects.

The Criteria

In all situations, the maximum allowable rutting or elastic movement of the subgrade is the amount that allows the subgrade soil to maintain the specified density throughout the construction process. For example, if subgrade density can be maintained with 6-inch ruts, then this would be the allowable maximum.

The Contractor must be afforded reasonable use of the subgrade for hauling and for constructing the base material. If subgrade density cannot be maintained through reasonable use of the subgrade, then the allowable proof rolling rutting is too much. If the project conditions allows, areas other than the subgrade should be used as haul roads. For a Contractor ‘to bid’ to haul loaded trucks or scrappers endlessly across the subgrade throughout the life of the project is going above and beyond the reasonability test. At a minimum, the Contractor should be allowed the use of the subgrade to place the base material with vehicles of legal weight.

The following criteria have worked in the vast majority of the projects.

For new construction projects, permanent rutting in excess of 1 inch (25 mm) should be considered failure. In addition, elastic (rebound)

movement or rutting in excess of 1 inch (25 mm) with substantial cracking or substantial lateral movement should be considered failure. Rutting and cracking greater than detailed above is considered “pronounced elasticity.”

Elastic, rebound, or rolling movement is always associated with excess water in the subgrade system.

For reconstruction projects, permanent rutting greater than ½ inch (13 mm) should be considered failure. In addition, elastic (rebound) movement or rutting in excess of ½ inch (13 mm) with substantial cracking or substantial lateral movement should be considered failure. Rutting and cracking greater than detailed above is considered “pronounced elasticity.”

When deflections are greater than these criteria, there is no assurance that overlying pavement construction will not damage the subgrade compaction. Although subgrade density and stability can be maintained during the proof rolling, the repetitive loading, hauling of materials, and base and pavement construction can destroy the subgrade compaction.

See Figures 204.D, 204.E and 204.F.

In Figure 204.D, the soil has been compacted in the top foot of the subgrade and the conditions are good for the top 3 feet (1.0 m). However, there is a soft layer at a lower elevation. The soft layer has no detrimental effect on the subgrade density during the subgrade compaction.

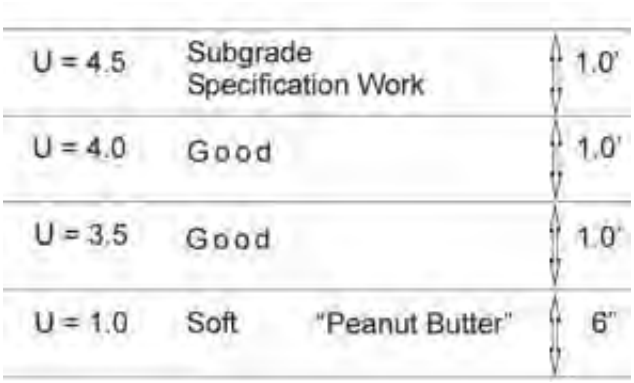


Figure 204.D - Stage 1 Compaction of Subgrade

In Figure 204.E the proof roller deflects because of the soft soils. The subgrade density may or may not be affected by the proof rolling. The loss of subgrade density is proportional to the amount of rutting or elasticity during proof rolling and subsequent construction operations. The severity of the overall subgrade condition can be measured by the amount of the deflection and elasticity on the surface.

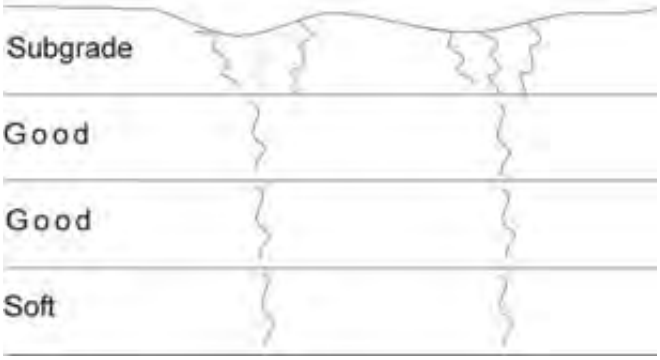


Figure 204.E - Stage 2 Proof Rolling

In Figure 204.F, when the deflections exceed the failure criteria, the proof rolling, repetitive loading, and pavement construction can destroy the top layers of the subgrade.

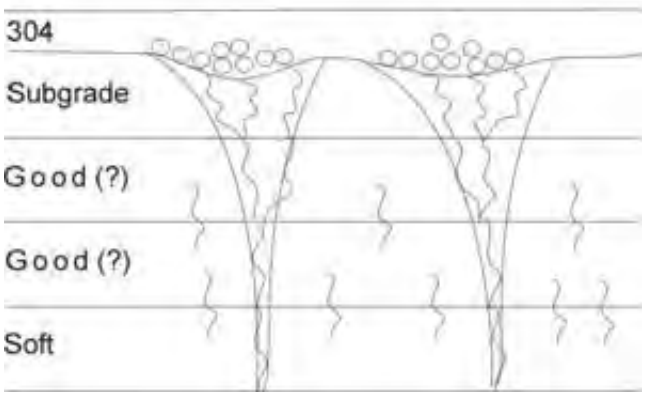


Figure 204.F - Stage 3 Hauling, Grading, and Placing 304

In actual field conditions, this soft layer can be just a few inches thick and at any elevation from the top 1 foot (0.3 m) to as deep as 5 feet (2 m). In addition, it may be an indication of an overall soil condition that is just over optimum for the entire 5-foot (2 m) depth of the subgrade. The field excavation is used to identify the layer or layers causing the surface distress is detailed in the section "Investigation" of this Item. Therefore, it is imperative that these conditions are correctly identified.

As shown in Figure 204.H "Subgrade Treatment Chart" subgrade constructability is suspect at curve locations to the left of the triangles. Further details are given in the section "Undercut Depth and Stabilization Determination" in this Item.

Crusting is a condition when the subgrade surface appears to be dry and there is substantial cracking on the surface with or without rutting. This indicates a need for further investigation and usually indicates soft or wet underlying soil with the top foot or so of the subgrade being very dry.

Variations in the Proof Rolling Results

The project should not be concerned with occasional or nominal deflections in excess of the above failure criteria. If the density is checked and the investigation shows that good soil extends throughout the top 5 feet of the subgrade, then the design intent will be fulfilled and the project can be constructed. All soils will occasionally deflect under these loads.

The pavement design is based on an average CBR. The CBR value was directly correlated to soil density many years ago. By using the average CBR (Density) value, the pavement design accounts for a 30 percent, or one standard deviation variation, in the subgrade strength from the design CBR; 15 percent is expected to exceed this value and 15 percent is expected to be less than this value. Therefore, some variation in the subgrade condition is already accounted for in the pavement design.

Another consideration is the fact that these proof rolling loads and tire pressures are about 10 times the final in-place stresses once the pavement is constructed. The proof rolling tire pressures are between 120 to 150 psi (820 to 1030 kPa) and the stresses once the pavement is constructed are about 8 psi (55 kPa) for a thin asphalt pavement and 4 psi (27 kPa) for a thick concrete pavement. Therefore, these loads are the largest loads that the subgrade will encounter.

If the project can be constructed while maintaining subgrade density, then the subgrade design intent will be fulfilled.

The project should not be concerned with the "Pavement Warranty" issues that Contractors often bring up. If the project follows theses guidelines and properly documents the subgrade work, Central Office can defend the warranty issue.

Once failure is established based on the proof rolling results, then the responsibility for the correction of the failure should be determined.

Responsibility for the Soft or Failed Subgrade

If soft or failed subgrade locations are found, take compaction tests to determine if the specifications are met in the top 12" (300 mm). The Engineer should instruct the Contractor to correct any deficiencies found in these locations.

The Department is responsible when the soft or failed subgrade is encountered in:

1. Cuts.
2. On rehabilitation projects.
3. In shallow fill locations where the soft material is found under the contract fill.
4. When the soft material is found at lower elevations than the project contract work.

Subgrade stability may not be possible by compacting the upper 12 inches (0.3 m) because of conditions at these lower elevations.

It is the Contractor's responsibility to correct all failed or soft locations in fills. If the Contractor built the fill correctly, the proof rolling will do nothing but verify specification work. If the fill fails then the proof rolling will determine the location of the deficient specification work.

If the Contractor fails to maintain the subgrade, then the Engineer should instruct the Contractor to repair the failed areas. See C&MS 203.04.A for the Contractor's responsibility to drain and maintain the subgrade.

Investigation

Investigate the causes of failed locations quickly to expedite the corrective treatment. Three pieces of information are needed to make the most economical subgrade treatment:

1. Rut Depth
2. Soil Boring Information
3. Test Pit Data

At this point the rut depth has already been determined.

Soil Boring Information

For rehabilitation projects or cut sections, the soil borings can be examined to determine an estimated undercut depth or stabilization methods.

Evaluate standard penetration test (SPT) results from soil borings in the failed subgrade locations. The standard penetration test (SPT) is an indicator of the soil consistency or strength, and measures the number of blows per foot (N) required to drive the soil sampler through the soil. The soil data on the boring logs are presented as the number of blows required to drive each 6-inch (150 mm) increment. The first 6 inches (150 mm) of the run is ignored because the sampler may not be seated in the borehole or may be driven through cuttings. For example, standard penetration data shown as 1/2/3 has an N value of 5 blows per foot.

When investigating the need for undercutting or stabilization in failed locations, look at the borings in those locations in the upper 5 feet (1.5 m) of the subgrade. At each location, pick the lowest N value when multiple N values are taken in the top 5 feet (1.5 m) of subgrade.

Average the N value along the failed locations. This value provides one part of the information needed to determine the undercut depth or stabilization methods.

Test Pits

Once the soil borings have been evaluated, construct test pits by excavating 3 to 5 feet (0.6 to 1.5 meter) into the subgrade using the Contractor's excavation equipment. Excavate at least two test pits that represent the failed area. Use judgment for long areas; usually about two to four test pits per mile is sufficient. Construct the test pits across the width of the subgrade in the failed locations. Pick locations with the highest deflections to evaluate the most severe locations.

Warning: These trenches may collapse on the construction personnel. The Department offers an 8 Hour Construction Safety Class to evaluate the trench collapse risk. In addition, there is a trench safety class offered by the Bureau of Workers Compensation, Division of Safety and Hygiene. These classes are given statewide all year around. (614-466-5563)

An examination of the soil and moisture conditions in these test pits provides valuable information to make the appropriate correction. Once the pits are excavated, the Engineer must examine the trench sidewalls and the bottom of the cut.

Record the test pit information on CA-EW-3, "Subgrade Test Pit Investigation" form shown in Figure 204.G. The soil conditions vary with depth and must be quantified. By examining the sidewalls, the Engineer can determine the soil type, layer thickness, soil condition, and soil strength by using a hand penetrometer.

CA-EW-3 Subgrade Test Pit Investigation

Subgrade Elevation:	Date:
Station:	Evaluation Stations:
Rut Depth:	Tire Pressure:

Unconfined Compressive (ton/SF) From Penetrometer		Soil Layer
U1		Layer Type:
U2		Layer Thickness:
U3		Soil Condition:
Uavg		Comments:
U1		Layer Type:
U2		Layer Thickness:
U3		Soil Condition:
Uavg		Comments:
U1		Layer Type:
U2		Layer Thickness:
U3		Soil Condition:
Uavg		Comments:
U1		Layer Type:
U2		Layer Thickness:
U3		Soil Condition:
Uavg		Comments:
U1		Layer Type:
U2		Layer Thickness:
U3		Soil Condition:
Uavg		Comments:
Soil Type (see section 203.02): Clay, Silt, Sand Gravel, Sandstone, Shale, Rock, Combination		
Soil Condition: Wet, Dry, Organic, Roots, Water seepage, Soup, Jell-O, Hard or Soft Peanut Butter		
Critical Later/ Design layer = U:		
Inspector Signature:		

Figure 204.G – Form CA-EW-3 Subgrade Test Pit Investigation

The Engineer must field classify the soil. See 203.02 Materials, "Identifying Soil and Granular Materials in the Field" for help in the classification.

Added soil conditions are described on the bottom of the test pit form. These conditions are stated in commonly-known consistencies, so that the non-geotechnical reader can relate to the soil conditions. They are listed on the bottom of the form. No explanation is needed for these terms.

Hand Penetrometer Readings

A hand penetrometer can be used to further classify the soil and to estimate its strength. A hand penetrometer can be obtained from a test lab supply company for less than $100. Hand penetrometers can be obtained from the following companies:

Gilson	Model # HM-500	Phone 800-444-1508
ELE	Model # E129-3729	Phone 724-864-3364
Humboldt	Model H-4200	Phone 800-444-7220

The exact instructions come with the hand penetrometer. In summary:

1. Push the hand penetrometer slowly into the soil at right angles.
2. Record the reading when the hand penetrometer penetrates the soil to the ¼-inch groove mark.
3. Record the readings to the nearest 0.25 tons per square foot (tsf).
4. Take at least three different readings in each soil layer.

Use CA-EW-3 “Subgrade Test Pit Investigation” form to record the readings. Average the readings once three readings are taken for the soil layer. Also evaluate the bottom of the test pit; this is extremely valuable information. Once the averages are determined, record the lowest average unconfined reading on the bottom of the form. This would be the most critical soil layer.

Average the unconfined readings (U) of all the test pits in the failed locations. Use this number to further evaluate the undercut depth or stabilization methods.

Consider the following when evaluating the sidewalls of a trench:

1. Different layers of a natural formation or cut are more noticeable than fill materials.
2. High unconfined numbers may be obtained with high deflections or rolling at the surface. This is an indication of soft soil at a lower elevation than 5 feet (2 m) or a subgrade soil that is just too wet.

Undercut Depth and Stabilization Determination

Once the proof rolling rut depth (in inches), soil boring information (N), and unconfined data from the test pits (U) are obtained, use the “Subgrade Treatment Chart” in Figure 204.H to determine the undercut depth requirements. The input values (rut depth, N and U) are on the horizontal axis. The two curves denote the type of project under construction. The left vertical scale shows the undercut depth in feet of granular material. The right vertical scale shows the stabilization depth required in inches of lime or cement.

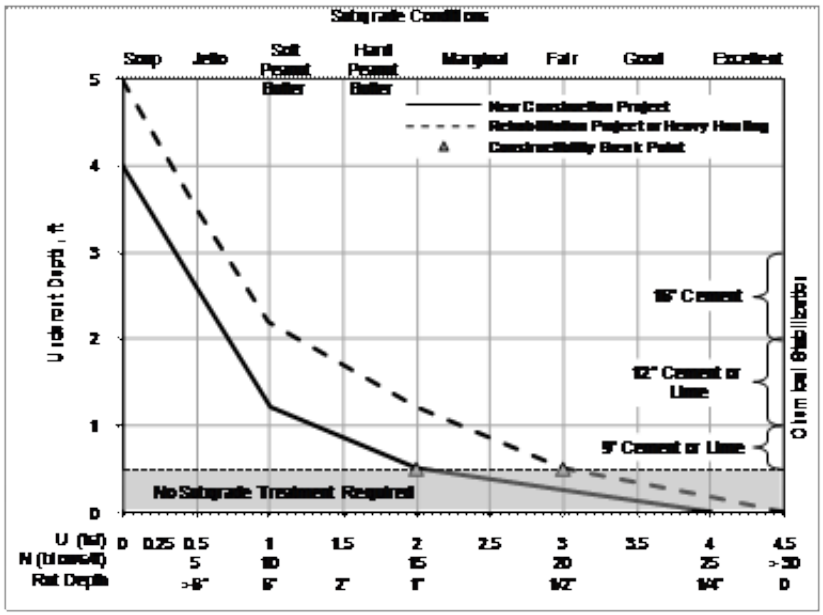


Figure 204.H - Subgrade Treatment Chart

The horizontal dashed line at about ½ foot indicates that treatment is not required for results below this line. The top portion of Figure 204.H details the general subgrade condition.

Figure 204.H takes into account the standard deviation of test results, anticipated truck loading, and type of project under construction.

Use the rut depth, N values, and unconfined strengths (U) from a hand penetrometer to draw a vertical line to the curve for the type of project under construction. At that intersection draw a horizontal line to the left and right. This determines the granular undercut depth or stabilization needs.

The undercut chart gives the required stabilization method to obtain stability when the undercut or stabilization is completed.

It would be rare to see a perfect alignment in the results from all three inputs. In some cases, one or two of these inputs may not be available. In other cases, some judgment is needed to redesign the most economical undercut that will work. In order of hierarchy, use the test pit data, then the N values, and then the rut depth. The rut depth is the least reliable indicator of undercut need because it cannot determine which soil layer is causing the deflection.

There will be cases where the N values and unconfined values are all high but the subgrade is rolling and cracking, and rut depth is greater than allowable. In this case use the rut depth as a guide to redesign the undercut. See the last example in the example section.

There is an example in Figure 204.I.

Given: 5 mile long Rehabilitation Project
Average N value was 12
U= 1.4 tsf
Average Rut Depth was 2-4 inches.

Answer: Use an undercut depth of 2.0 feet (0.6m) or stabilize with 12-16 inches of cement or lime. Since this is a long project, give serious consideration to the stabilization method. It will be more cost effective.

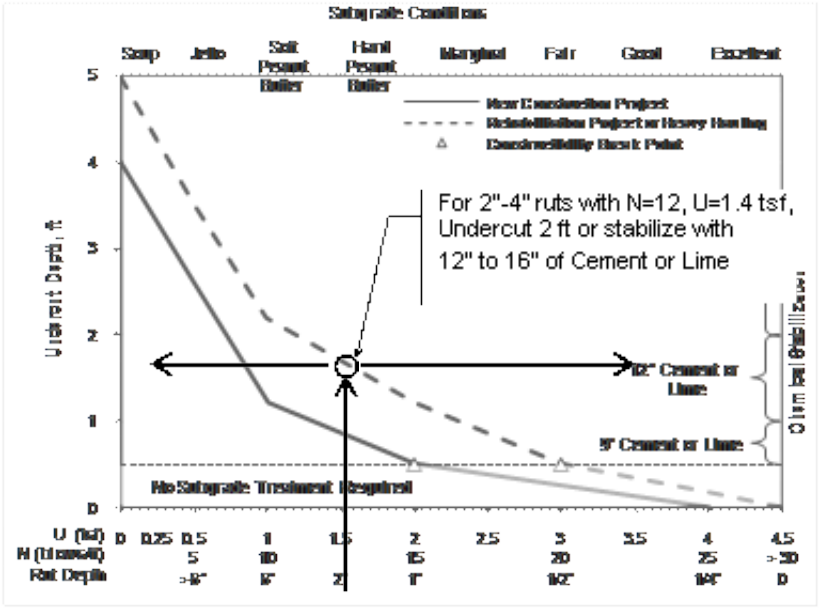


Figure 204.I - Example using the Subgrade Treatment Chart

After making the undercut, this depth may need to be adjusted to meet the actual conditions. See the section, "Implementation during Construction" of this manual.

General Rules

On new construction projects, if all of the soft material can be removed and the bottom of the test pits or cuts are stable, then soil may be used as replacement material. For reconstruction projects, soil is usually not available in large quantities and the bottoms of the cuts are highly variable. Therefore, soil undercuts are less effective solutions on reconstruction projects.

If the bottom of the test pit is unstable, when conditions are highly variable, or for rehabilitation projects then use granular material, rock, geotextile, or lime or cement stabilization, rather than soil.

Undercuts should be used in small locations or in areas where spot locations are identified. Consider cement or lime stabilization for long areas greater than one mile.

Only the most unusual cases require removal to depths greater than 3 feet (1 meter). Seventy five to ninety percent of subgrade problems can be solved with a one-foot treatment of granular material and geotextile or stabilization with lime or cement. Use stabilization methods for projects with long areas to stabilize or when the undercut depth is greater than 1.0 foot.

If a project or section of a project undercut locations are more than 30% of the total area, undercut or stabilize the entire area. If you do not undercut the entire area, these locations will grow and the construction will be inefficient as the construction proceeds. The Department pays a higher cost at a reduced final quality by undercutting a high percentage of the subgrade throughout the project. ODOT would not repair a bridge deck or pavement with this high a percentage of repairs.

Stabilization methods speed construction because of the ability to work immediately after a rain. Estimates indicate that the construction production is increased by at least 50 percent by using stabilization methods.

Examples

The following table shows some example solutions. The types of material refer to 703.16.C and Item 206.

Given	Solution
Rehabilitation Project with Silty A-4a material with N=15 or U=2.0 tsf Rut Depth>1"	1.5 feet of Granular Material Type B, C or D with geotextile or 12 inches of stabilization with cement
Rehabilitation Project with Deep, weak, and wet A-4 with N = 12 or U=1.4 tsf Rut Depth = 2"	2.0 feet of Granular Material Type B, C, or D, with geotextile or 12-16 inches of stabilization with cement
New Construction, Deep, weak & wet A-4, A-6 or A-7-6 combination with N = 10 or U=1.0tsf. Rut Depth = 4"	1.5 feet of Granular Material Type B C or D with geotextile or 12 inches of stabilization with lime or cement. (Check the PI of the soils. Use the stabilization type according to the PI's of the soil.)
New Construction Jell-O like consistency soil with N = 5 or U=0.5 tsf. Rut depth > 6"	2.5 feet of Granular Material Type B, C, or D, with geotextile or 16 inches of stabilization with cement. (Check the PI of the soil.)
Any Project with soup like consistency soil with N = 2 or U=0.25 tsf Rut Depth = Buried equipment	5 feet of Granular Material Type B, C, or D, with geotextile. (May need two layers of geotextile, Use type D Granular Material if available)
Reconstruction Project Sandy, A-4a, A-6a soil, PI < 20, N = 8 or U=1.0 tsf Rut Depth = 6". (Long Project)	Cement Stabilized Subgrade 16" deep at 6%
New construction A-7-6 clay soil, PI > 20 N = 11 or U=1.2 tsf Rut Depth =3". (Long Project)	Lime Stabilized Subgrade 12" deep at 5%
Reconstruction Project A-6a silty clay PI < 20, N=30 and U>4.5 tsf Rut depth > 2" and rolling The key here is the rolling. Probably caused by high moisture content of the soil at a depth. If the subgrade is rolling with one pass of a proof roller then the subgrade condition can rapidly deteriorate during construction.	16" of Cement at 6% or 2.5 foot undercut with Granular Material Type B, C, or D, with two layers of geotextile. Use Type D material if available.

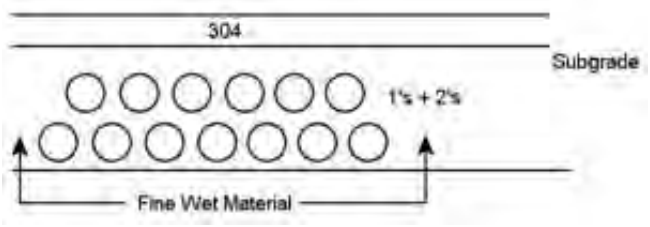
Type of Undercut Materials

Use Granular Material Types B, C, D, E, and F. They are cheaper than 304.

Type B is a well-graded aggregate with the gradations of Items 304, 411, or 617. Type C has a top size of 3 inches and type D has a top size of 8 inches. Both C and D are well-graded materials. The larger top size material will bridge the soft material better that the smaller size material.

Use Granular Material Type E when water levels are high or cannot be drained. The Type E materials are very porous. Always choke the Granular Material Type E with Granular Material Type B or geotextile fabric.

There is a potential for piping of soil into the Granular Material Type E as shown in Figure 204.J. In the upper detail, when the open material is placed on soft fine graded soil, the soil pipes into the open graded material during construction or by loading. In the lower detail, the geotextile fabric blocks the material from entering the open graded material. Geogrids will not work for this application.



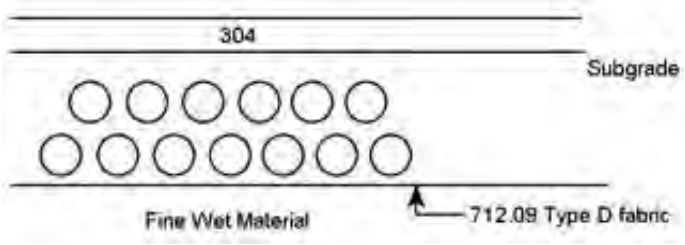


Figure 204.J - Soil Piping in Open Material

Underdrains cannot be placed through Granular Material Types D, E, or F or geotextile fabric. Use Granular Material Type B in the locations of the underdrains. Always drain the undercut to an underdrain, catch basin, or pipe.

Always use 712.09 Geotextile Fabric Type D. The cost is around $1.00 per square yard. In the case of deeper undercuts, multiple layers can be used at a 12-inch vertical spacing if needed.

Cement and Lime Stabilization of the Subgrade

Item 206 Chemically Stabilized Subgrade can be used to treat unstable subgrades. Lime or Cement can be used to stabilize the subgrade.

Lime is used for A-6b (silty/clay) or A-7-6 (clay) soils which have a plasticity index of 20 or greater. Use 5 percent lime by dry weight of the soil assuming a dry weight of 110 pounds per cubic foot.

Cement can be used to treat unstable subgrades consisting of A-3 (fine sand, coarse and fine sand), A-2-4 through 7 (gravels), A-4a (sand silt), A-6a (silt and clay), A-6b (silty clay), or A-7-6 (clay) which have a plasticity index less than 20. Use 6 percent cement by dry weight of the soil assuming a dry weight of 110 pounds per cubic foot.

See Item 206 Chemically Stabilized Subgrade of this manual.

Implementation during Construction

Once they type of stabilization treatment has been chosen, constant monitoring of the construction is required to adjust the treatment to meet the field conditions. Soil conditions always vary; they vary the most on rehabilitation projects or in cuts.

If the undercut option is chosen, the project should monitor the bottom of the cut and evaluate the condition. Take hand penetrometer readings at the bottom of the cuts and compare them to the initial test pit or soil boring information. If the condition changes from the earlier evaluation of the test pits or the soil borings, then adjustments to the undercut depth are required.

In addition, for undercuts that are two feet deep or greater, give consideration to placing multiple layers of geotextile fabric. The need for additional layers of geotextile can be determined by placing about ½ of the undercut depth. Load the undercut with a fully loaded truck. If the area is unstable, then place another layer of geotextile and continue to fill the undercut.

Once the undercut or stabilization is complete, proof roll the area to ensure that the final subgrade meets the rut depth and density requirements as detailed earlier in section “Failure Criteria”.

Constant vigilance is needed in order to make the most economical correction. It is easy to over-excavate unnecessarily and waste money. It is more difficult to make the right economical choice to stabilize the subgrade and to meet the design and construction needs.

Documentation Requirements - 204 Subgrade Compaction and Proof Rolling

1. Materials.
2. Compaction according to S-1015.
3. Lift thickness and roller passes.
4. Equipment used.
5. Type of soils.
6. Verify square yardage.
7. Verify subgrade line and grade.
8. Proof Roll and make corrections.
9. Subgrade Test Pit Investigations.
10. Undercut measurements.
11. Document on CA-EW-1,CA-EW-2,CA-EW-3, CA-EW-8, CA-EW-12 and CA-D-3. Do not duplicate the information on all forms

ATTACHMENT 4 - RCK AST Jobsite Workbook Forms

TAB 3 - Required AST Checklists/Forms

Complete the following checklist/forms and file them in this section of the AST Jobsite Notebook:

- **AST Pre-Project Checklist**
- **AST During-Project Checklist**
- **Tank Panel Visual Inspection Checklist (Attachment 6 of the AST SOP)**
- **AST Post-Project Checklist**
- **AST Visual Inspection Checklist (use for Periodic Monitoring)**

AST Pre-Project Checklist

Customer Company Name_____Pad/Location _____

Customer Field Rep Name/Phone/Email_____

Customer's Soil Preparation Contact Name/Phone/Email_____

Customer's Water Contact Name/Phone/Email_____

Rockwater Job Reference No. _____Rck Field Ops Mngr._____Date of pre-op visit_____

Proposed Start date:_____ Proposed End Date:_____

Approved trucking route obtained?_____ Planned Tank Contents: _____

Site Preparation/Status

Ground is level, proper grade stone is spread evenly: _____
Proper Compaction Test completed on tank pad: Y/N____ Compaction % Std. Proctor _____
Results provided?_____ (attach to this notebook)
Soil Test Data Reviewed by: _____
Proof Roll Test Observed by: _____ Date _____
Estimated Grade % _____
General description/evaluation of tank pad, downstream from tank pad:_____
Who providing lift equipment? Rck Ops_____ or 3rd Party Contr ____, Contr Name _____
Is 3rd party contractor safety program approved by RCK and customer?_____

AST Tank Information

Pin_____ Plate_____
Tank Capacity Needed, Number of Tanks: 4.5K__ 9K __ 10K__ 18K__ 26.5K__ 40K__ 41K__ Custom__

Sump/Stairs/Fill Tubes/Suction Tubes Locations Shown on Sketch Attached dated _____
Netting Required? _____ "Y" Trench Required? _____

Requested Liner Material: _____Liner Thickness: _____
Requested Geo Pad Material: _____Geo Pad Thickness:_____
Will double Geotextile liner be needed under the tank?_____ Double Liner Required? _____
Tank level monitoring system needed?_____
Additional Items needed for water suction or Discharge: (each tank comes with 1-Stair system, 2-Suction tubes, and 2-6" Discharge tubes): _____

Safety

- Utility Notification Ticket Number _____ Date Called In_____By _____
- AST Crews finished customer (contractual) and Rockwater Operations training?_____
- JSA Completed on Rockwater approved form?
- Subcontractors approved per Rockwater subcontractor management program?_____
- Subcontractor employees received required client training?_____
- Required lift and other equipment on site? _____
- Crane or large front end loader lifting capacity_____ Weight of Liner Bundle_____

AST During Project Checklist

Customer Name_____Pad/Location _____Tank ID No. or Stair Number(s)_____

Customer Field Rep Name/Phone/Email_____

Customer's Soil Preparation Contact Name/Phone/Email_____

Customer's Water Contact Name/Phone/Email_____

Rockwater Job Reference No. _____Rck Crew Leader_____ Cell Phone _____

AST Rig-Up Start date:_____ Proposed AST Project End Date:_____

Tank Panel Visual Inspection Checklist completed and attached? _____ Tank Contents: _____

All Panels are compatible (all have the same ID number)_____

AST Pre-Project Form Completed? _____ If not, date completed _____

Date of AST layout sketch, prepared during Pre-Project Site visit that you will be using: _____

Distance from tank center to closest structure:_____ Distance from tank side to nearest structure:_____

Utility locate ticket No. _____ Date called in _____

General description/evaluation of tank pad preparation _____

Tank Panel Visual Inspection Checklist completed and attached? _____ (date)_____

Safety:

Weather conditions onsite during operations:
JSA Completed_____ (time/date) SOP's Followed____ Roped off work area and sump?____
Inspection of hinge and pin system completed during the installation of each panel____
Slings/rigging and lift equipment inspected by _____
Fall protection being used when hanging the liner____ Tag line used during the movement of panels____
BBS Cards completed during this project?____ Hazard Signs Installed____ Cotter Pins in every connection___
All crew and subcontractors within our work area are properly trained and know stop work policy?____

Liner Manufacturer: _____Liner Serial Number: _____

Geo Pad Manufacturer: _____ Geo Pad Serial Number: _____

Job Box on site (Job box ID)_____GEO needed between the panels or under the tank?_____
Patches made on liner? _____ Sketch of location(s) attached? _____
Field tickets signed by customer representative and Rck Ops as needed? _____RCK Branding installed?_____
Customer contact notified that AST ready for water? (Who/Date/time)_____
Water placed into tank to minimum water level (Date/Time) _____

Comments about the overall Rig up Process (Faulty equipment, issues, concerns, improvement areas, etc.):

Completed walk around/visual inspection of the tank/connections and AST Visual Inspection Checklist? ____

AST Post-Project Checklist

Customer Company Name_____Pad/Location _____

Customer Field Rep Name/Phone/Email_____

Customer's Water Contact Name/Phone/Email_____

Rockwater Job Reference No. _____Rck Crew Leader_____ Cell Phone _____

Actual Start date:_____ Actual End Date:_____

Tank ID /Stair Number(s)_____

Were any additional Items requested during the project and provided for water suction or discharge? _____
(each tank comes with 1-Stair system, 2-Suction tubes, 2-6" Discharge tubes).
List any additional items:

Inspection of hinge and pin system completed by (name)_____(Date/Time)_____

Tank Panel Visual Inspection Checklist completed and attached? _____ (date)_____

Were there any damage to the equipment or panels?___ If yes, panel numbers:_____

Jobsite Notebook Documents (check when completed and in Jobsite Notebook):

Completed, dated, signed JSAs: _____Tank Panel Visual Inspection Check Sheet: _____

Pre-Project Checklist: _____During Project Checklist: _____Post Project Checklist: _____

Liner and Geo Pad serial numbers on During Project Checklist? _____

Soil test data in Jobsite Notebook?_____

BBS Cards completed during this project_____

Walk around check for leaks or any abnormal conditions? (Date/Time)_____

Crew Leader (signed)_____(Date/Time)_____

AST Visual Inspection Checklist

Customer Company Name_____Pad/Location _____Date of Inspection_____

Customer Field Rep Name/Phone/Email_____

Customer's Water Contact Name/Phone/Email_____

Rockwater Job Reference No. _____Rck Crew Leader_____ Cell Phone _____

Tank ID /Stair Number(s)_____ Tank Contents: _____

Tank Panel Visual Inspection Checklist completed and attached? _____ (date)_____

- CAUTION – If conditions are observed that could indicate an imminent tank failure, remove yourself and from the area immediately, advise others in the vicinity to do so also, and contact the customer to drain the tank, and the Field Operations Manager to advise of the situation.
-
- **Periodic Inspection Tasks:**
-
- Observe soil at base of all panels all around the tank to find any wet or moist areas that may indicate a leak
-
- Check for any uneven gaps between the panel edges from top of panel to bottom of panel. Uneven gaps between panels should be reported immediately, and noted on a sketch with the panel numbers involved and email or fax to the Field Operations Manager immediately
-
- Check that no panel bottom has sunk below the soil surface at any location. Tank panel settlement should be reported immediately, and noted on a sketch with the panel numbers involved and email or fax to the Field Operations Manager immediately. NOTE: Panel settlement should not be confused with soil pushed up against the panel bottom. If it is not clear from observing, call the Field Operations Manager.
- Check that the soil around the tank panels and within 10 feet of the tank panel is firm and has not been eroded by stormwater or leaking water
-
- Observe a vehicle driving near the perimeter of the tank to see if any soil settlement has occurred, note the location on a sketch
- Check contents of tank, advise Field Operations Manager if different than original order (see AST Pre-Project Checklist)
- Any running water on the ground in the vicinity of the tank is suspect and must be traced to its source using a pH test or other means. Take photographs of any running water if safe to do so.
- Check all liner clip (pin tanks) or clamps (plate tanks) are securing liner
- If tank is at low level check that sufficient liner slack is present against panel wall.
- Check all pins and plates, and cotter pins are in place
- Note any rust or corrosion of panels, stairs, or fill/suction tubes
- Note any damage to fill/suction tubes
- Note any liner visible liner damage, or damage to fill or suction tubes

---

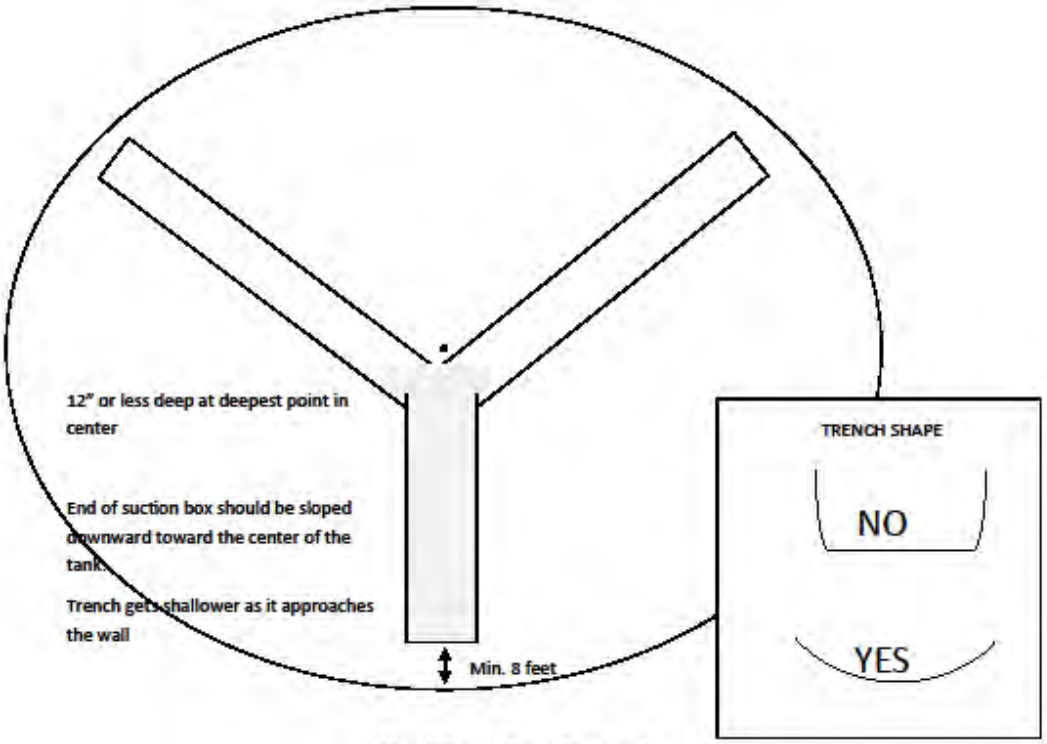
Customer contact notified of to drain tank? (Date/time)_____

Field Operations Manager notified of any issues (name/date/time) _____

Inspection Completed by:

(Printed name)_____(signed) _____ (date)_____

ATTACHMENT 5 – "Y" Trench Guidance Document



Guidelines for a Y-trench

Tank Center should NOT be located in the trench, but behind it and between the branches of the "y".

Depth is NOT to exceed 18 inches—12" depth recommended. (In some states a ground disturbance or pit permit is required if you disturb the ground deeper than that.) If you require more trench to accommodate more water for weighting down the liner, make it wider.

Trench should be deepest in the main channel and slope up to surface level as it approaches its end 3 feet from the line for the tank wall. Done properly—your suction should never float!

Side channels do not need to be as deep but should still slope from wall to center to feed water to suction channel.

The sides of the trenches should be sloped in (not an abrupt dropoff) See example above right.

Suction trench should begin a minimum of 8 feet from where the wall will be located.

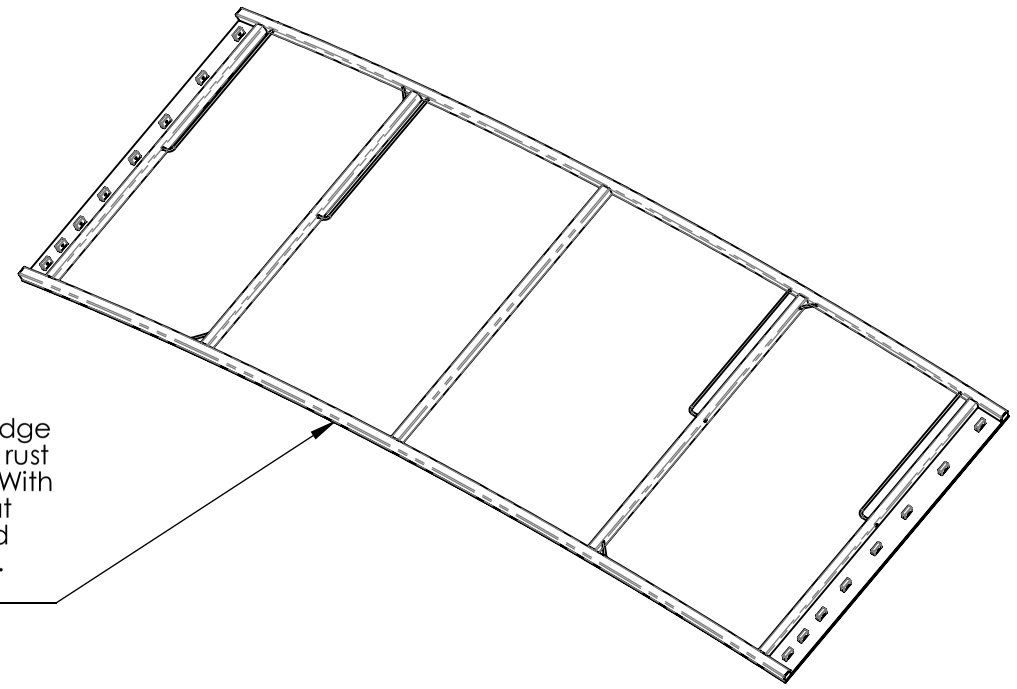
ATTACHMENT 6

Tank Panel Visual Inspection Check Sheets

Poseidon Panel Visual Inspection Check Sheet - Page 1 of 2

Tank Number	Panel No	Location	Date

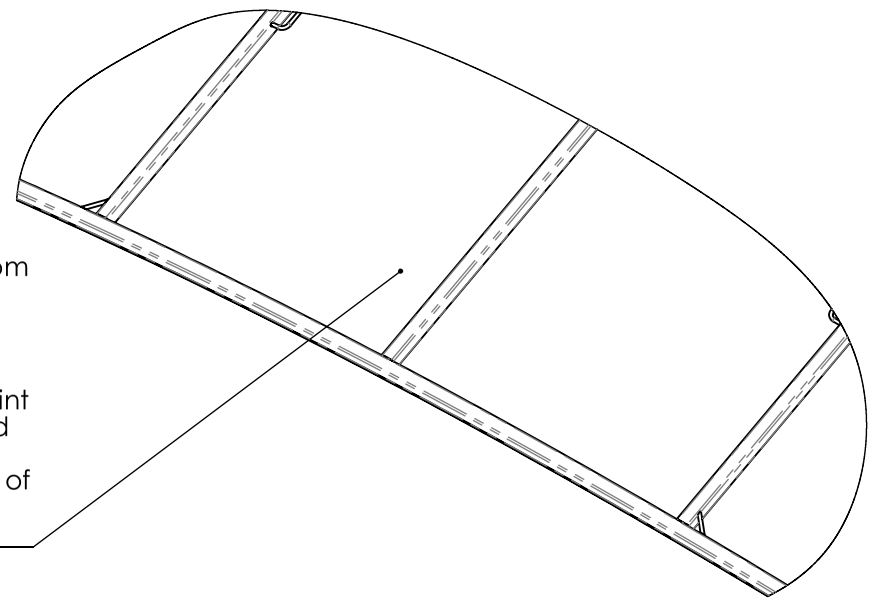
Step 1



Check the bottom edge of the tank panel for rust or damaged paint. With wire brush check that paint is not loose and easy to be removed.

Inspected By	Pass or Fail	Comment

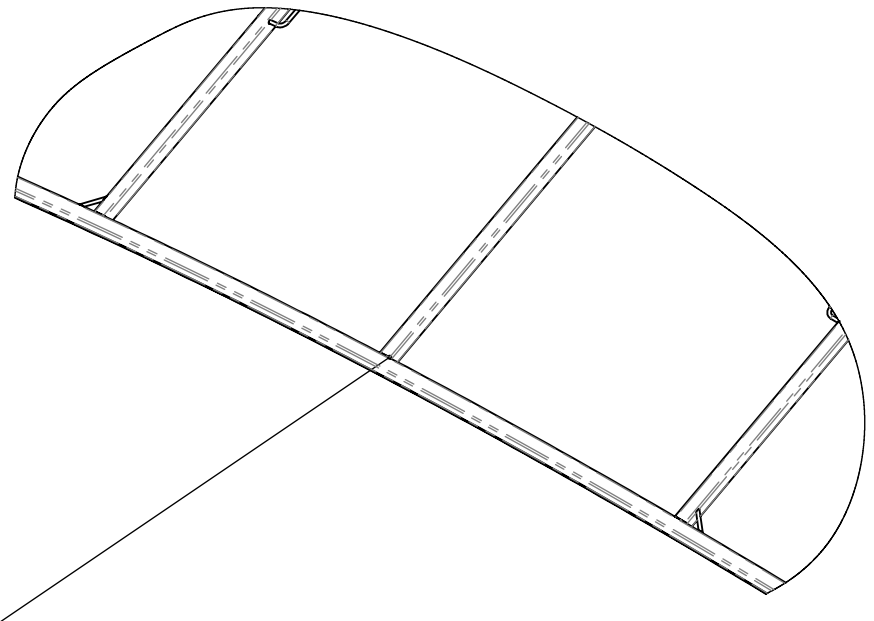
Step 2



Check the lower bottom (both inside and outside) area shown carefully for cracked welds or signs that the metal has yielded. Paint that is missing, cracked or has a crinkle appearance are signs of metal yield.

Inspected By	Pass or Fail	Comment

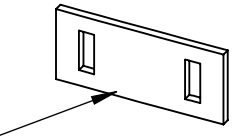
Step 3



Check the outer surface of the tubes near the weld in the lower bottom area shown carefully for signs that the metal has cracked or yielded. Paint that is missing, cracked or has a crinkle appearance are signs of metal yield. Any rust could be a sign of the start of a crack

Inspected By	Pass or Fail	Comment

Step 4



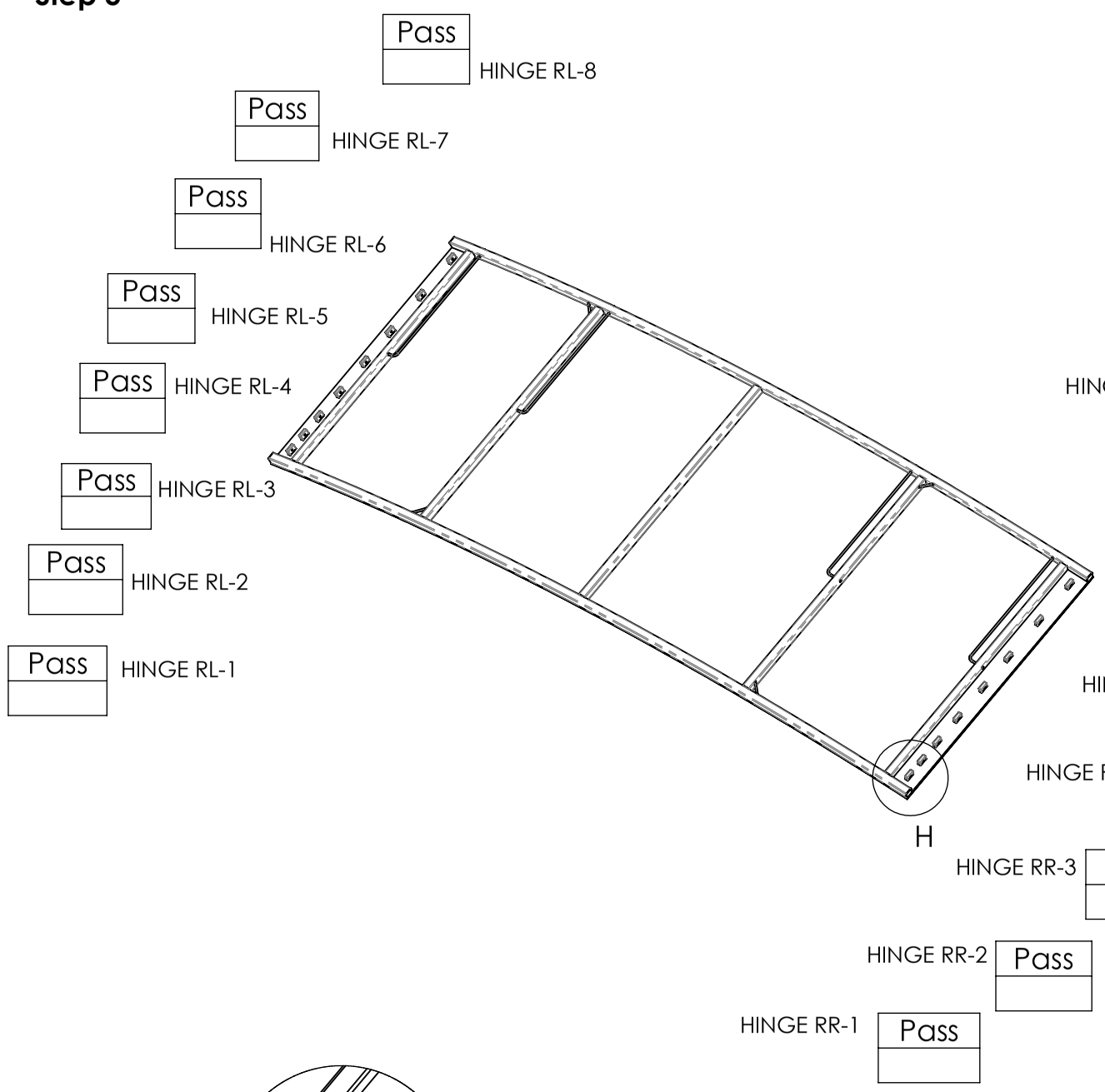
Check connection plates for bends, wear spot, rust. Check that the slots are not deformed.

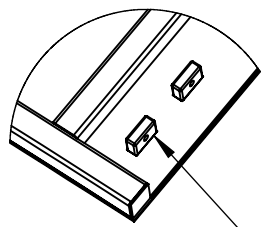
Inspected By	No of Plates that Pass	No of Plates that Fail
Comment		

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	As Released	06/27/13	

Poseidon Panel Visual Inspection Check Sheet - Page 2 of 2

Step 5



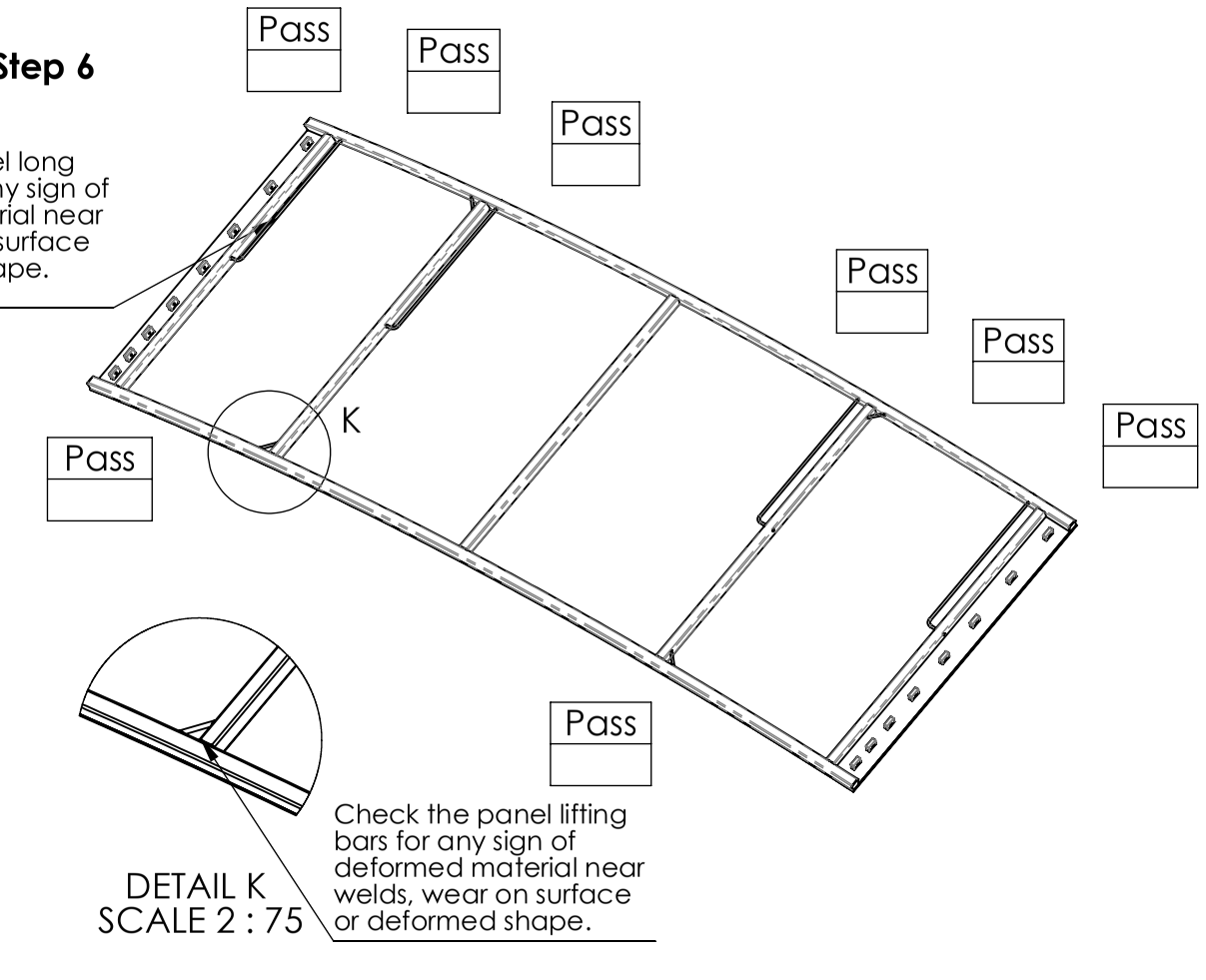


DETAIL H
SCALE 1 : 25

Check the hinge plates for any signs of metal yield near the welds to the repad plate. Initial each box next to hinge.

Step 6

Check the panel long lifting bars for any sign of deformed material near welds, wear on surface or deformed shape.

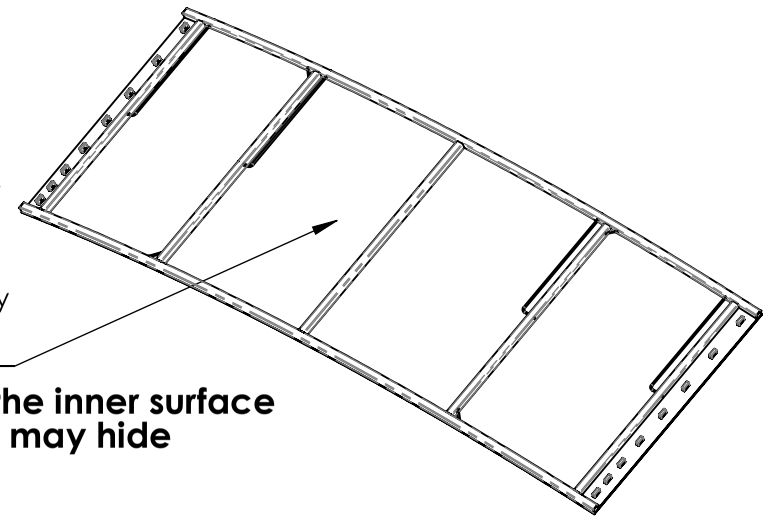


DETAIL K
SCALE 2 : 75

Check the panel lifting bars for any sign of deformed material near welds, wear on surface or deformed shape.

Step 7

Visually inspect all other areas and welds for anything that looks out of place and note on the inspection sheet any repairs or modifications recommended.



Visually inspect the inner surface Foam on outside may hide problems

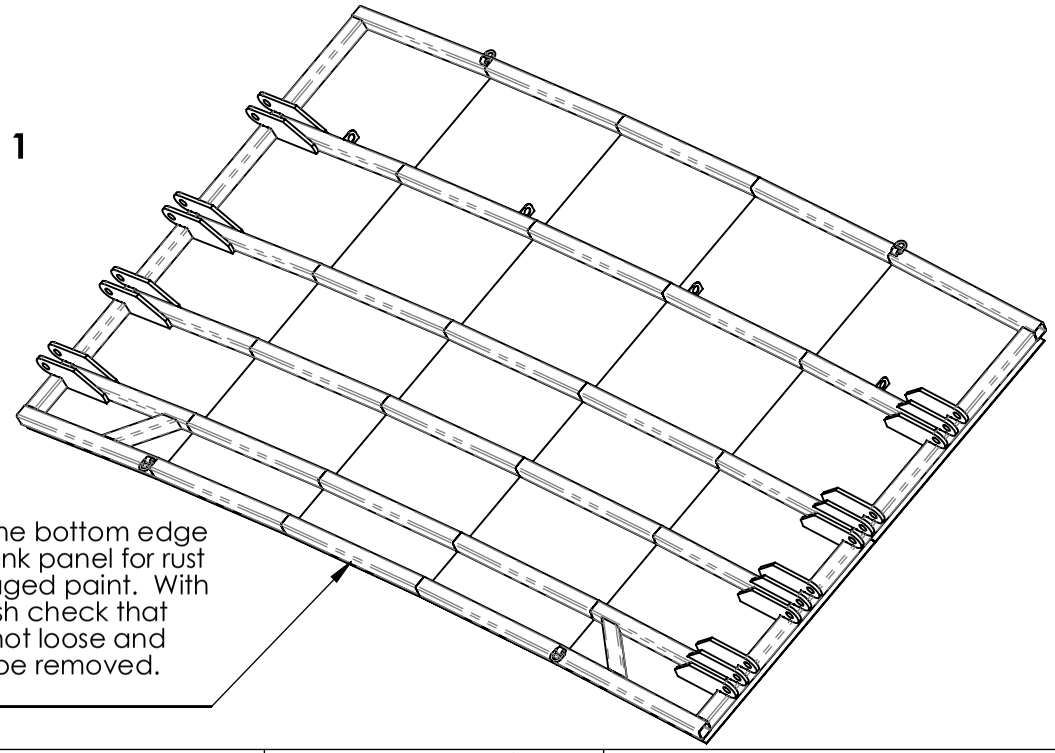
Inspected By	Pass or Fail	Comments

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	As Released	06/27/13	

MWS Tank Panel Visual Inspection Check Sheet - Page 1 of 2

Tank Number	Panel No	Location	Date

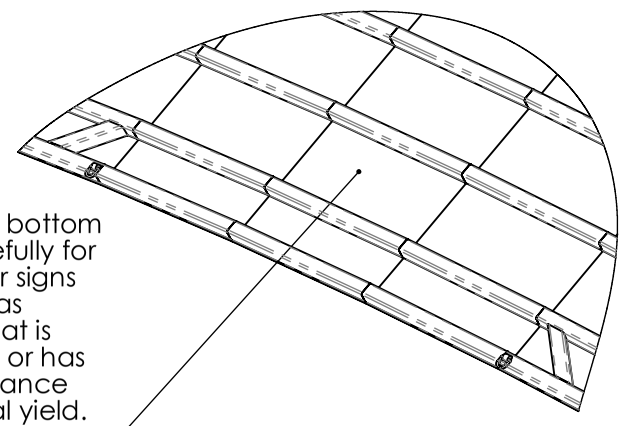
Step 1



Check the bottom edge of the tank panel for rust or damaged paint. With wire brush check that paint is not loose and easy to be removed.

Inspected By	Pass or Fail	Comment

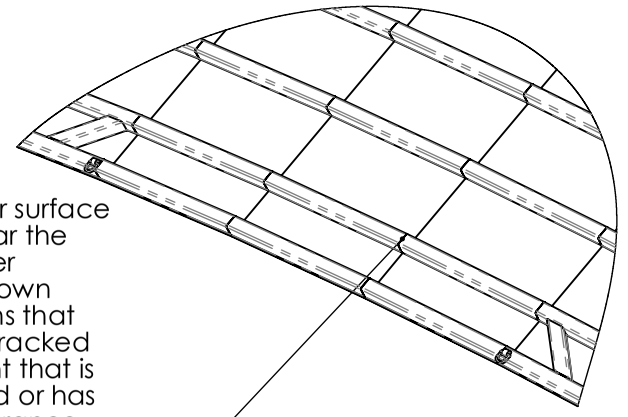
Step 2



Check the lower bottom area shown carefully for cracked welds or signs that the metal has yielded. Paint that is missing, cracked or has a crinkle appearance are signs of metal yield.

Inspected By	Pass or Fail	Comment

Step 3

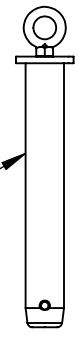


Check the outer surface of the tubes near the weld in the lower bottom area shown carefully for signs that the metal has cracked or yielded. Paint that is missing, cracked or has a crinkle appearance are signs of metal yield. Any rust could be a sign of the start of a crack

Inspected By	Pass or Fail	Comment

Step 4

Check connection pins for bends, wear spot, rust. Check that the top cap weld is not cracked or missing.



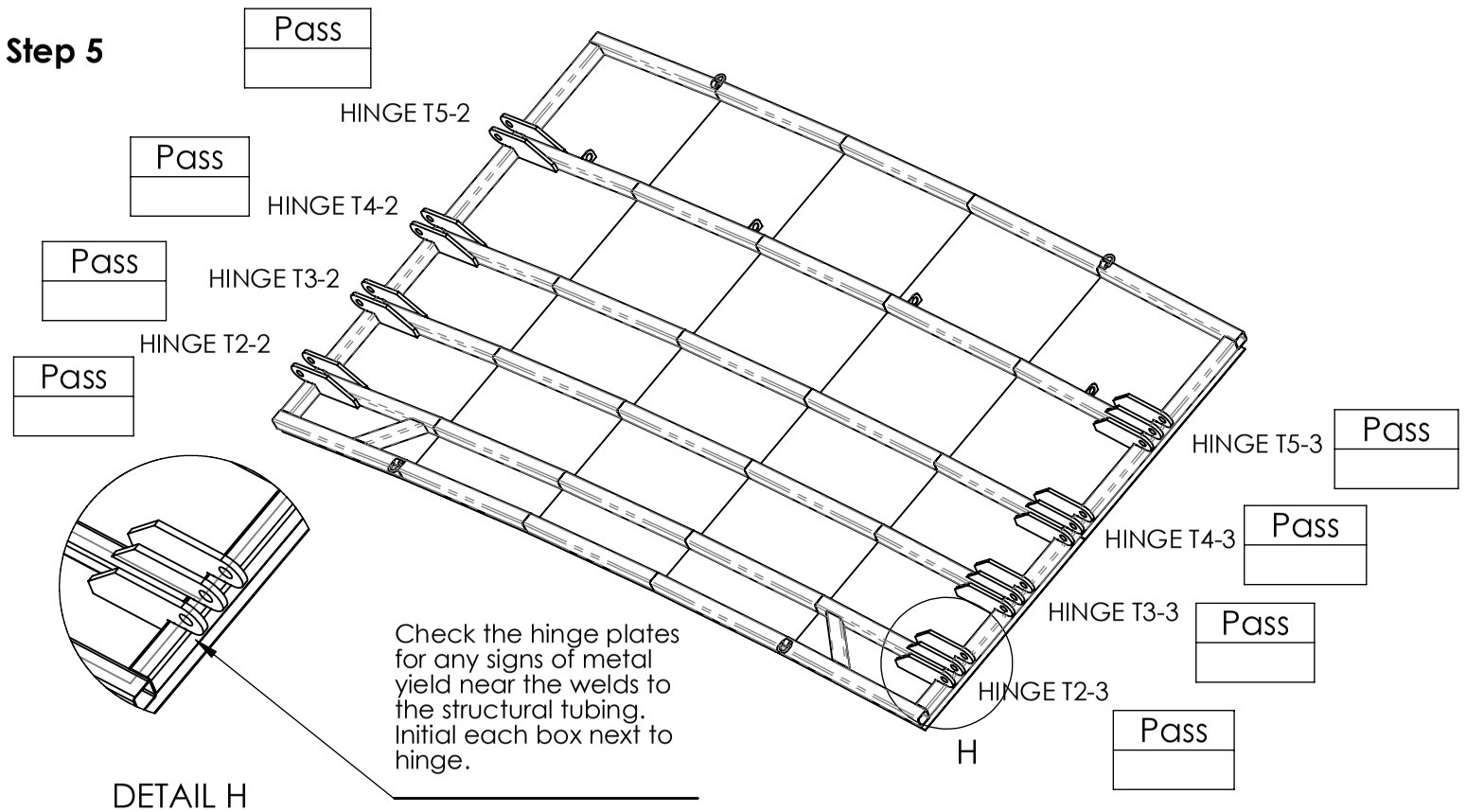
Inspected By	No of Pins that Pass	No of Pins that Fail
Comment		

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	As Released	03/06/13	

MWS Tank Panel Visual Inspection Check Sheet - Page 2 of 2

Step 5

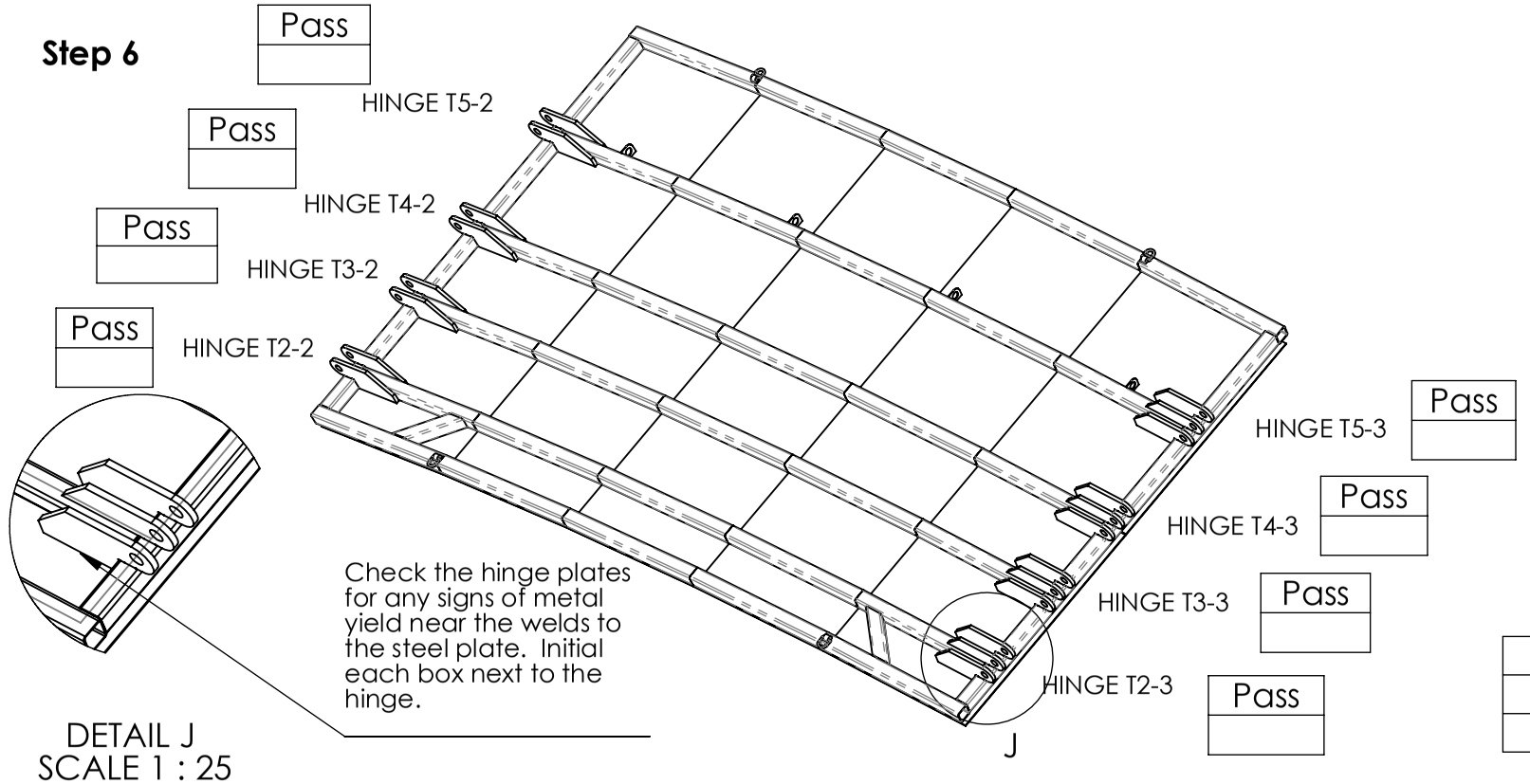
Pass



DETAIL H
SCALE 1 : 25

Step 6

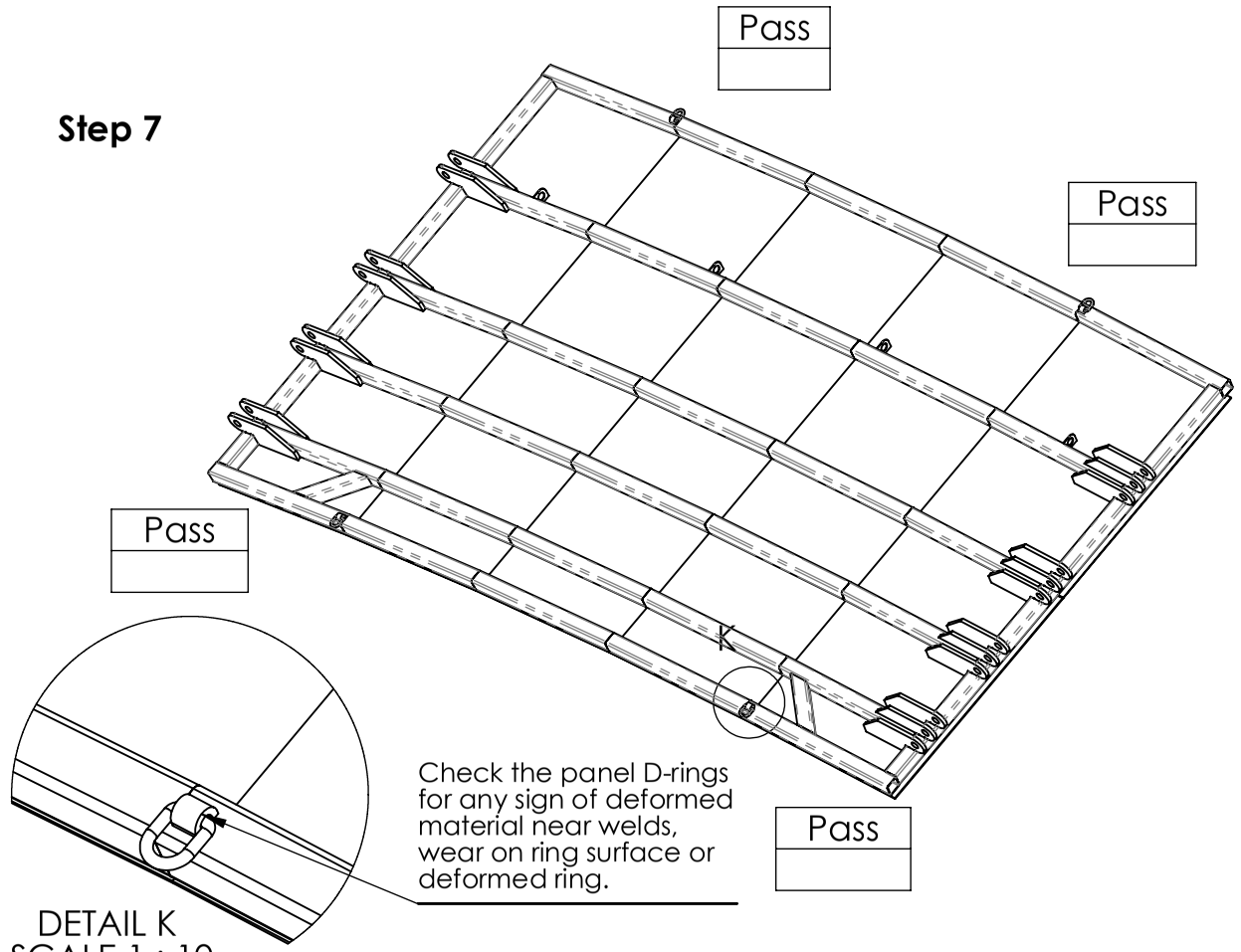
Pass



DETAIL J
SCALE 1 : 25

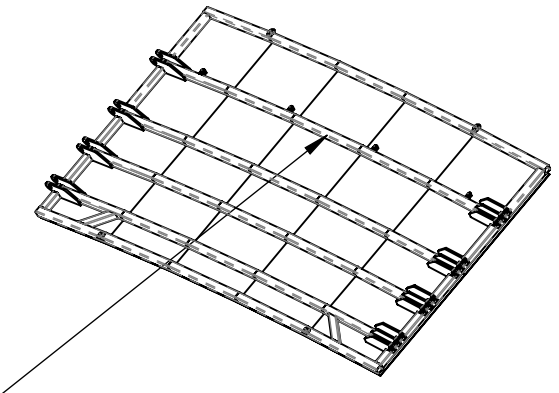
Step 7

Pass



DETAIL K
SCALE 1 : 10

Step 8



Visually inspect all other areas and welds for anything that looks out of place and note on the inspection sheet any repairs or modifications recommended.

Inspected By	Pass or Fail	Comments

REVISIONS			
REV.	DESCRIPTION	DATE	APPROVED
A	As Released	03/06/13	

Appendix D

Operating and Maintenance Plan

General Specifications

In this plan, the portion of the Produce Water Re-use Rule that is addressed by certain text is underlined. This operations and maintenance plan has been large abstracted from Appendix C. However, this plan provides additional protocols to cause the proposed recycling containments (ASTs) to conform to NMOCD Rules. Therefore, if a conflict exists between the SOP of Appendix C and this plan (Appendix D), Rockwater will adhere to the mandates of this plan. The operator will maintain and operate the recycling containments and facility in accordance with the following plan to contain liquids and maintain the integrity of the liner to prevent contamination of fresh water and protect public health and the environment.

- The operator will use the treated produced water in the containments for drilling, completion (stimulation), producing or processing oil or gas or both. If other uses are planned, the operator will notify the OCD though the submission of a modified C-147.
- For all exploration and production operations that use produced water, the operator will conduct these activities in a manner consistent with hydrogen sulfide gas provisions in 19.15.11 NMAC or NORM provisions in 19.15.35 NMAC, as applicable.
- The operator will address all releases from the recycling and re-use of produced water in accordance with 19.15.29 NMAC.
- The operator will not discharge into or store any hazardous waste in the recycling containments but they may hold fluids such was freshwater, brackish water, recycled and treated water, water generated by oil or gas processing facilities, or other waters that are gathered for well drilling or completion. The recycling facility will not be used for the disposal of produced water. The operator will maintain the containments free of miscellaneous solid waste or debris.
- The operator will verify that no oil is on the surface of the contained fluid. If oil is observed, the oil shall be removed using an absorbent boom or other device and properly disposed at an approved facility. An absorbent boom or other device will be maintained on site.
- The operator will install and use a header and diverter described in the design/construction plan in order to prevent damage to the liner by erosion, fluid jets or impact from installation and removal of hoses or pipes during injection or withdrawal of liquids.
- Pursuant to an approved variance, the operator will maintain at least 2-feet of freeboard in each AST containment. For other containments, the operator will maintain at least 3-feet of freeboard. Under extenuating circumstances, which will be noted on the inspection log as described below, the operator may temporarily exceed the freeboard mandate.
- If the liner develops a leak or if any penetration of the liner occurs above the liquid's surface, then the operator will repair the damage or initiate replacement of the liner

within 48 hours of discovery or will seek a variance from the division district office within this time period.

- If visible inspection suggests that the liner developed a leak or if any penetration of the liner occurs below the liquid's surface, then the operator will remove all liquid above the damage or leak line within 48 hours of discovery. The operator will also notify the district division office within this same 48 hours of the discovery and repair the damage or replace the liner.
- In the event of a leak due to a hole in the liner, the following steps will be followed:
    1. If the source of the fluid is uncertain, comparative field tests may need to be performed on both the water in the containment and that which may have been released (e.g. pH, conductance, and chloride).
    2. If the fluid is found to be coming from the containment, determine the location from which the leak is originating.
    3. Mark the point where the water is coming out of the tank.
    4. Locate the puncture or hole in the liner.
    5. Empty the containment to the point of damage in liner.
    6. Clean area of liner that needs to be repaired.
    7. Cut out piece of material (patch or tape) to overlay liner.
    8. Either weld the patch to the injured area in the liner or apply tape over the rupture.
    9. Make sure rupture is completely covered.
    10. Monitor as needed.
- The operator will inspect and remove, as necessary, surface water run-on accumulated in the secondary containment.

Monitoring, Inspections, and Reporting

The containment will contain enough produced water to prevent any shifting of the liner. Weekly inspections shall occur when there is 1-foot depth or more of produced water in the containment. Monthly inspections shall occur when there is less than 1-foot depth of produced water in the containment, as well as when the ASTs are emptied and prior to refilling. An inspection log will be maintained by the operator and will be made available to the division upon request. Inspection may include: freeboard monitoring, leak detection, identifying potential hazards that may have developed, change in site conditions or if the contents of the containment change from the initial use. The last pages of Appendix D contain the "Inspection Form" to be filled out during these routine inspections.

Attachment 4 of Appendix C contains the "AST Visual Inspection Checklist" form to be filled out by Rockwater during periodic inspections. The form provides a list of observations that will enable early detection of uneven tank panel settlement, soil settlement, liner damage, insufficient liner slack, or leaks.

The form "Tank Panel Visual Inspection Check Sheet" included in attachment 6 of Appendix C will be used by Rockwater to inspect individual containment panels and connections titled. Each individual tank panel has a unique identifying number that is used on the sheet. Each panel is checked to identify any abnormal wear or damage.

Monitoring and Inspection Checklist (routine weekly or monthly inspections):

- Visually inspect the liner. If a liner's integrity is compromised, or if any penetration of the liner occurs above or below the water surface, then the operator will notify the appropriate Division district office within 48 hours (phone or email).
- Inspect the system for injection or withdrawal of liquids from the ASTs and document that the design prevents damage to the liner by erosion, fluid jets or impact from installation and removal of hoses or pipes is working appropriately.
- Inspect the water surface for visible oil.
- Measure the freeboard.
- Inspect the secondary containment berm around the ASTs to check for erosion and collection of surface water run-on.
- If H_2S is a documented potential issue with the containment, measure H_2S concentrations on the down-wind side of the facility when produced water is present.
- Inspect the secondary containment for evidence of damage and monitor for leakage.
- Inspect the netting for damage or failure. If netting is jeopardized, repair of the netting shall occur within 48 hours.
- At least monthly, inspect netting for dead wildlife, including migratory birds. Operator shall report the discovery of a dead animal to the appropriate wildlife agency and to the district within 30 days of discovery. Further prevention measures may be required.

If observed conditions indicate a potential tank failure is imminent, the vicinity will be immediately cleared and the AST will be drained.

Recycling Facility

Form C-147 confirms financial assurance of the recycling facility. The operator of the facility is listed on form C-147.

- If the facility shares the same setting in regard to siting criteria, surface ownership, and location of the containments, registration will be submitted for both the containments and facility using one form C-147.
- The recycling facility serves many wells located on the same lease as the facility or on nearby leases.
- The operator of the facility will submit monthly reports to the division district detailing 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 and its disposition using form C-148.
- The facility operator will keep accurate records that identify the sources and disposition of all recycled water. These records shall be made available to the division by request.

Cessation of Operations

If less than 20% of the total fluid capacity is utilized every six months, beginning from the first withdraw, operation of the facility has ceased and the division district office will be notified. The division district may grant an extension not to exceed six months to determine the cessation of operations. The operator will remove all free fluids from the containments within 60 days from the date of operations cessation. An extension may be requested to allow no more than two months for the removal of fluid.

The breakdown of the containments follows the reverse order of the setup steps presented in Section 3.0 of the SOP (Appendix C).

The operator will remove all fluids from the recycling facility within 60 days of cessation of operations. An extension not be exceed 2 months may be granted by the district division for the removal of fluids from the facility.

Inspection Form

Date: _____

Hackberry Recycling Containments and Facility

(weekly inspection when fluids are present, monthly otherwise)

Tank ID: _____

Fluid Level: _____ Tank contents: _____

Inspection Task	Results		Remarks, Observations, and/or Remedial Actions
Visible Oil on Surface	☐ None Observed	☐ Yes, Describe Action	
	An absorbent boom or similar device is located on site to remove visible oil from surface.		
At least 2 ft of freeboard	☐ Yes	☐ No, Measure Freeboard	
Evidence of surface water run-on	☐ None Observed	☐ Yes, Describe	
	Check for excessive erosion of perimeter berms.		
Birds or wildlife in net or screen	☐ None Observed	☐ Yes, Describe	
	Within 30 days of discovery, report dead birds or wildlife to the appropriate agency (USFWS, NMDGF) and to NMOCD District II.		
Damage to netting or screen	☐ None Observed	☐ Yes, Describe	
Rupture of Liner	☐ None Observed	☐ Yes, Describe	
	If rupture is above fluid level, repair within 48 hours. If below fluid level, remove fluid above within 48 hours, notify NMOCD District II, and repair.		
Clips or clamps properly securing liner	☐ Yes	☐ No, Describe	
If low level, enough liner slack on panel wall	☐ Yes	☐ No, Describe	
Uneven gaps between panels	☐ None Observed	☐ Yes, Describe	
Signs of tank settlement	☐ None Observed	☐ Yes, Describe	

Erosion of soil surrounding tank (10 ft radius)	☐ None Observed	☐ Yes, Describe	
Running water on the ground	☐ None Observed	☐ Yes, Describe	
Unusual ponding of fluid inside berm	☐ None Observed	☐ Yes, Describe	
	Field test (pH, Cl-, conductance, etc.) ponded fluid and compare to fluid in tank. If tank is determined as the source, locate and repair rupture within 48 hours. Notify NMOCD District II and repair.		
Rust or corrosion on panels, stairs, or hardware	☐ None Observed	☐ Yes, Describe	
Damage to any hardware	☐ None Observed	☐ Yes, Describe	

Additional Observations or Actions: _____

Inspected by: _____

Appendix E
Closure Plan

Closure Plan

The containments are expected to contain a small volume of solids, the majority of which will be windblown sand and dust with some mineral precipitates from the water.

The operator will notify the division district (phone or email) before initiating closure of the containments and/or facility.

Excavation and Removal Closure Plan – Protocols and Procedures

1. Residual fluids in the containments will be sent to disposal at a division-approved facility.

2. The operator will remove all solid contents and transfer those materials to the following division-approved facility:
   Disposal Facility Name: R360 Permit Number NM 01-0006

3. If possible, geomembrane textiles and liners that exhibit good integrity may be recycled for use as an underliner of tank batteries or other use as approved by OCD via a variance request.

4. Disassemble the recycling containment infrastructure according to manufacturer's recommendations

5. After the disassemble of the containments and removal of the contents and liners, soils beneath the tanks will be tested as follows
   a. Collect a five-point (minimum) composite from beneath the liner to include any obviously stained or wet soils, or any other evidence of impact from the containments for laboratory analyses for the constituents listed in Table I of 19.15.34.14 NMAC.
   b. If any concentration is higher than the parameters listed in Table I, additional delineation may be required and closure activities will not proceed without Division approval.

   If all constituents' concentrations are less than or equal to the parameters listed in Table I, then the operator will backfill the facility as necessary using non-waste containing, uncontaminated, earthen material and proceed to reclaim the surface to pre-existing conditions.

Closure Documentation

Within 60 days of closure completion, the operator will submit a closure report (Form C-147) to the District Division, with necessary attachments to document all closure activities are complete, including sampling results and details regarding backfilling and capping as necessary.

In the closure report, the operator will 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 the closure plan.

Reclamation and Re-vegetation

The operator will reclaim the surface to safe and stable pre-existing conditions that blends with the surrounding undisturbed area. "Pre-existing conditions" may include a caliche well pad that existed prior to the construction of the recycling containment and that supports active oil and gas operations.

Areas not reclaimed as described herein due to their use in production or drilling operations will be stabilized and maintained to minimize dust and erosion.

For all areas disturbed by the closure process that will not be used for production operations or future drilling, the operator will

1. Replace topsoils and subsoils to their original relative positions
2. Grade so as to achieve erosion control, long-term stability and preservation of surface water flow patterns
3. Reseed in the first favorable growing season following closure

Federal, state trust land, or tribal lands may impose alternate reclamation and re-vegetation obligations that provide equal or better protection of fresh water, human health, and the environment. Re-vegetation and reclamation plans imposed by the surface owner will be outlined in communications with the OCD.

The operator will notify the division when the site meets the surface owner's requirements or exhibits a uniform vegetative cover 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.

The operator will notify the Division when reclamation and re-vegetation is complete.