Appendix H

Specifications

ECTION 02100
SITE PREPARATION

PART 1 - GENERAL

1.1 SUMMARY

A. Requirements of this Section shall consist of CONTRACTOR providing all required clearing, grubbing, and stripping related labor, materials, equipment, tools, and services for the WORK.

1.2 DEFINITIONS

A. Clearing: Clearing shall consist of removal of all vegetation and the satisfactory disposal of brush, rubbish, and any other vegetation.

B. Grubbing: Grubbing shall consist of the removal and disposal of roots, root mats, stumps, logs, peat, and other objectionable matter which could adversely affect the quality of the subgrade or borrow materials.

C. Topsoil: Topsoil is the upper soil horizon which is characterized by a significant organic content.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.1 AREAS TO BE CLEARED AND GRUBBED

A. Perform clearing and grubbing only in areas identified by the ENGINEER OR OWNER. Clear and grub all areas where WORK is to take place.

B. Clear and grub all borrow areas to the extent necessary to provide fill materials free of all objectionable matter described above.

C. Vegetation located outside the construction limits shall not be damaged.

3.2 DISPOSAL OF CLEARED AND GRUBBED MATERIALS

A. All brush, vegetation, rubbish, organic soils, and other debris from clearing and grubbing operations, including all debris remaining from previous clearing operations, shall be stockpiled separately at a location designated by the OWNER.

3.3 EXCAVATING, STOCKPILING, AND WASTING TOPSOIL

A. If present, excavate topsoil from areas designated for project grading or construction, as encountered. In addition, excavate topsoil from areas designated for use as waste locations for earth subsoil material.

B. Remove lumped soil, vegetative material, boulders, and rocks from the excavated topsoil to be stockpiled.

C. Stockpile, if available, sufficient topsoil material on-site for use as vegetative cover for future reclamation purposes. Protect stockpile from erosion and grade to prevent ponding of water. Organic soils shall be segregated from soil materials that may be suitable for other uses described in these SPECIFICATIONS and shown on the DRAWINGS.

D. Dispose of excess topsoil and waste topsoil not intended for reuse in a location selected by the OWNER. Disposal and handling of this material shall be performed following the requirements of the appropriate government agencies.

END OF SECTION 02100

SECTION 02200
EXCAVATION, BACKFILL AND COMPACTION

PART 1 - GENERAL

1.1 SUMMARY

A. The section describes the following:

1. All excavation required to reach planned grades and contours, install project components, and to construct temporary run-on and run-off conveyance systems.
2. Placement of various fill materials:
   a. Compacted embankment fill
   b. Drainage Aggregate (Drain Rock)
3. Material placement and compaction
4. Site grading
5. Foundation preparation
6. Construction of fills and backfills
7. Compaction requirements
8. Site grading

B. The WORK shall be done in accordance with the SPECIFICATIONS and as shown on the DRAWINGS.

C. The WORK includes furnishing all labor, tools, materials, equipment, and supervision necessary to construct the project as described in the contract documents.

1.2 TOLERANCES

A. All excavations shall be constructed within the tolerance as shown in these SPECIFICATIONS except where dimensions or grades are shown or specified as minimum or maximum in the DRAWINGS. All grading shall be performed to maintain slopes and drainages as shown in the DRAWINGS.

B. Excavate to within a horizontal and vertical tolerance of ± 0.1 -foot on all slopes flatter than 10% and within a vertical tolerance of ± 0.2 -foot on all slopes 10% or steeper unless otherwise approved by the ENGINEER or OWNER.

C. Place Drain Rock Aggregate within a vertical tolerance of ±0.1-ft, regardless of the steepness of the slope.

1.3 SUBSURFACE CONDITIONS

A. Subsurface investigations have been performed at the site by the ENGINEER. The results of the subsurface investigations can be provided to the CONTRACTOR at the CONTRACTOR'S request during the bidding interval.

B. The CONTRACTOR shall identify and locate utility lines, flow lines, wells, survey monuments, and other nearby structures prior to performing work. Utilities, flow lines, wells, survey monuments and other nearby structures shall be protected from damage during the WORK. Any damage to utility lines, flow lines, wells, survey monuments, and other nearby structures during the WORK shall be repaired by the CONTRACTOR at no additional cost to the OWNER. Costs associated with these repairs shall include the actual repair costs and all engineering costs required by the ENGINEER to coordinate and obtain regulatory approval of repairs, if required.

1.4 SUBMITTALS

A. Imported materials that may include Drain Rock Aggregate, Engineered Fill or others shall have material properties such as grain size distribution submitted to the OWNER or ENGINEER for material approval prior to delivery to the site.

1.5 REFERENCES

A. American Society for Testing and Materials (ASTM):

Where reference is made to one of the standards listed below, the revision in effect at the time of the bid shall apply.

1. ASTM D422 – Standard Test Method for Particle Size Analysis of Soils.

2. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3)).

3. ASTM D854 – Standard for Test Method for Specific Gravity of Soil Solids by Water Pycnometer.

4. ASTM D1140 – Standard Test Method for Amount of Material in Soils Finer than the Number 200 (75 micrometer) Sieve.

5. ASTM D1556 – Standard Test Method for Density and Limit Weight of Soil in Place by the Sand Cone Method.

6. ASTM D2216 – Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.

7. ASTM D2434 – Test Method for Permeability of Granular Soils

8. ASTM D2487 – Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).

9. ASTM D2488 – Standard Practice for Description and Identification of Soils (Visual Manual Procedure).

10. ASTM D2922 – Standard Test Method for Density of Soil and Soil Aggregate in Place by Nuclear Methods (Shallow Depth).

11. ASTM D2937 – Standard Test Method for Density of Soil in Place by Drive-Cylinder Method.

12. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

13. ASTM D4318 – Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils

14. ASTM D6913 – Test Method for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

15. ASTM D6938 – Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

B. Geotechnical Data Report for the proposed PLU NorthContainment Site.

1.6 QUALITY ASSURANCE

A. The CONTRACTOR will retain an independent testing laboratory approved by ENGINEER for testing during earthwork operations. The CONTRACTOR shall coordinate and schedule all tests as required by the Drawings and Specifications.

PART 2 - PRODUCTS

2.1 ENGINEERED FILL

A. Engineered Fill is defined as material obtained from excavations associated with the WORK or designated on-site borrow sources, approved by the ENGINEER, that meet the requirements of the SPECIFICATIONS.

B. Engineered Fill material shall be free of debris, organics, oversized material (clods or rocks greater than 1 inch in diameter), frozen material, ice, snow, deleterious, or other unsuitable materials.

C. The aggregate for the fill material should conform to the requirements as shown in Table 1 Grade 1. Each source must meet Table 1 requirements for liquid limit, plasticity index, and wet ball mill for Grade 1. Do not use additives such as, but not limited to lime, cement, or fly ash, to modify aggregate to meet requirement of Table 1. As per the geotechnical study, the on-site material meets these requirements and are suitable as Engineered Fill.

D. The CONTRACTOR will provide laboratory testing results to the OWNER for all fill material used in construction for verification of material compliance as required for the project.

E. Based on the results of the geotechnical investigation, native soils at the PLU NorthContainment site are suitable for use as “Engineered Fill” as described in this Section.

2.2 ENGINEERED FILL MATERIAL USED IN SUBGRADE PREPARATION

A. The upper six (6) inches of the pond bottom, interior embankment slopes, and sump shall be regular, smooth, and compacted; and shall be free of sharp changes in elevation, rocks larger than 1.0 inch, clods, organic debris, and standing water, other unsuitable objects, deleterious materials, or soft unsuitable areas. One hundred percent of the prepared subgrade soil material gradation shall pass a U.S. standard #4 sieve.

B. Engineered Fill material used for the prepared pond bottom shall meet the liner manufacturer's specifications for material suitable for liner placement.

2.3 DRAINAGE AGGREGATE (DRAIN ROCK)

A. Drainage Aggregate (Drain Rock) is defined as engineered fill material consisting of selected or processed granular material that meets the requirements of the SPECIFICATIONS and is in accordance with this section. Drain Rock shall be obtained from on-site approved stockpiles or outside sources approved by the ENGINEER or OWNER.

B. The Drain Rock shall be clean washed sand and gravel with the following gradation:

Gradation	
Sieve Size	**Percent by Weight**
1 ½ inch	100
1 inch	95-100
½ inch	25-60
No. 4	0-10
No. 8	0-5

Particles shall be rounded and free of sharp, angular edges that may damage the liner.

C. Drain Rock Aggregate shall be free of organic material, frozen material, ice, snow, or excess moisture.

D. Drain Rock Aggregate material must be hard, durable, and not subject to grain crushing. Individual rock fragments shall be dense, sound, and resistant to abrasion and shall be free from cracks, seams, and other defects that would tend to increase their destruction from water and frost actions. Drain Rock Aggregate shall be less than 5 percent carbonate.

E. Material shall be poorly-graded within the SPECIFICATION limits with a uniform grading of coarse to fine particles. No gap-graded material, as determined by the ENGINEER, shall be acceptable.

F. Verify that all necessary pre-construction submittals such as conformance testing of the Drain Rock Aggregate have been performed prior to placement or importing.

PART 3 - EXECUTION

3.1 PREPARATION, EXAMINATION, AND PROTECTION OF EARTHWORK

A. Provide construction staking and grade control. Establish and set required lines, levels, grade, contours, and datum by construction staking.

B. Provide for dust control in accordance with site requirements and OWNER'S direction.

C. Provide for dewatering as necessary for finish excavation and fill placement.

D. Locate, identify, and protect all utilities and existing structures from damage (including overhead and suspended utilities).

E. Protect temporary or permanent bench marks, survey stakes, settlement monuments, existing structures, fences and existing WORK from damage or displacement by construction equipment and vehicular traffic.

F. Coordinate traffic control, operations, and haul routes with the OWNER and LINER CONTRACTOR.

G. Note that topography shown on DRAWINGS may differ from topography at time of construction.

H. Protect the exposed surfaces of compacted lifts from drying and cracking due to excessive heat, or softening due to excessive moisture, until overlying fill material is placed and compacted.

I. Any earthen surface upon which the liner is installed shall be prepared and compacted in accordance with the project SPECIFICATIONS. The surface shall be smooth, firm, and unyielding. The top six-inches of fill beneath the surface shall be free of:

1. Vegetation/Roots/Sticks
2. Construction debris
3. Sharp, angular rocks
4. Rocks larger than 1 inch in diameter
5. Void spaces
6. Abrupt elevation changes
7. Standing water
8. Cracks larger than six millimeters in width
9. Any other foreign matter that could contact the liner

J. Immediately prior to liner deployment, LINER CONTRACTOR shall arrange for the subgrade to be final-graded by the EARTHWORK CONTRACTOR to fill in all voids or cracks, then smooth-rolled to provide the best practicable surface for the liner. At completion of this activity, no wheel ruts, footprints or other irregularities in the subgrade are permissible. Furthermore, all protrusions extending more than 0.5-inches from the surface shall be removed, crushed, or pushed into the surface with a smooth-drum roller compactor.

K. On a continuing basis, the OWNER's REPRESENTATIVE shall examine the subgrade for suitability before liner placement.

L. It shall be the CONTRACTOR'S responsibility to indicate to the OWNER or ENGINEER any change in the condition of the subgrade that could cause the subgrade to be non-compliance with any SPECIFICATION requirement. If the CONTRACTOR has not notified the OWNER or ENGINEER of changes that cause the subgrade to be non-compliant and installs the liner, then the CONTRACTOR has determined and assumes responsibility that the subgrade is acceptable for liner installation.

M. At the crest of the embankments, an anchor trench for the liner shall be constructed by the EARTHWORK CONTRACTOR as detailed on the DRAWINGS. Any deviation from the anchor trench details shown on the DRAWINGS requires review and approval by the ENGINEER. No loose soil shall be allowed at the bottom of the trench, and no sharp corners or protrusions shall exist anywhere within the trench.

N. Verify as applicable that all underlying components such as geomembrane and piping have been installed, tested, and accepted in accordance with the DRAWINGS and SPECIFICATIONS.

3.2 EXCAVATION

A. Excavate material shown on the DRAWINGS and as necessary to complete the WORK. Excavation carried below the grade lines shown on the drawings shall be repaired as specified by the OWNER unless previously approved by the OWNER. Correction of all over-excavated areas shall be at the CONTRACTOR's sole expense.

B. All necessary precautions shall be taken to preserve the material below and beyond the established lines of all excavation in the soundest possible condition. Any damage to the

WORK beyond the required excavation lines due to wetting, drying, or the CONTRACTOR'S operations shall be repaired at the CONTRACTOR'S sole expense.

C. Excavation, shaping, and any other work related to material removal, shall be carried out by the method(s) considered most suitable, provided it meets the design intent as determined by the ENGINEER.

D. Limits of excavation to accomplish the WORK safely shall be determined by the CONTRACTOR. Any minimum excavation limits shown on the DRAWINGS are for material identification only and do not necessarily represent safe limits. All excavations shall be free of overhangs, and the sidewalls shall be kept free of loose material. As a minimum, the CONTRACTOR shall slope, bench and shore all excavations as necessary to prevent any unsafe conditions as required by OSHA 29 CFR 1926.651 and 1926.652.

E. Accurate trimming of the slopes of excavations to be filled will not be required, but such excavations shall conform as closely as practical to the established lines and grades.

F. For pipe trench excavations, grade trench bottom to provide uniform bearing for the entire length of pipe to be installed. Fill in voids, gaps, low points ("dips" or "bellys") and bridging areas within trench bottom and along the entire length of pipe.

G. Subsoil not to be used in the construction of earth fills or reclamation shall be stockpiled in areas designated by OWNER and in accordance with applicable laws, rules, and regulations.

H. Permanently stockpiled earth material shall be graded to drain and blended seamlessly into the natural landscape.

I. Provide and operate equipment adequate to keep all excavations and trenches free of water.

J. Excavate unsuitable areas of the subgrade and replace with approved fill materials. Compact to density equal to requirements for subsequent fill material.

K. The subgrade of each pond shall be proof-rolled and compacted in place prior to fill placement or grading.

L. Grade top perimeter of excavation to prevent surface water from draining into excavation.

3.3 MISCELLANEOUS EXCAVATION

A. The CONTRACTOR shall perform all excavations necessary for the placing of seeding and plants, for constructing roadways, and any other miscellaneous earth excavation required under this Contract.

3.4 FILL PLACEMENT

A. General

1. Transport, process, place, spread, compact, and complete fill using the appropriate equipment to achieve lift thickness, design lines and grades and compaction specified in the DRAWINGS and SPECIFICATIONS.

2. To the extent practicable, fill shall be placed by routing the hauling and spreading units approximately parallel to the axis of the embankment.

3. Hauling equipment shall be routed in such a manner that they do not follow in the same paths but spread their traveled routes evenly over the surface of the fill.

4. Protect installed measurement instrumentation, structures, and utilities from damage.

5. Care shall be taken at all times to avoid segregation of material being placed, and all pockets of segregated or undesirable material shall be removed and replaced with material matching the surrounding material.

6. Each zone shall be constructed with materials meeting the specified requirements and shall be free from lenses, pockets, and layers of materials that are substantially different in gradation from surrounding material in the same zone.

7. No material shall be placed on material that is too soft, smooth, wet, or dry, or that has been damaged by drying, cracking, frost, runoff, or construction activities. Previously completed portions of the subgrade that are deemed unsuitable for construction shall be repaired until approved by the ENGINEER. **The top 8 inches of the foundation surface shall be scarified, moisture conditioned (as necessary), and compacted so fill material will bond firmly to surfaces of excavation.** Remove standing water prior to placement of all fill material.

8. To the extent practicable, fill materials shall be brought to the placement area at the recommended moisture content.

9. Moisture conditioning is the operation required to increase or decrease the moisture content of material to within the specified limits for proper material placement and compaction. If moisture conditioning is necessary, it may be carried out by whatever method CONTRACTOR deems suitable, provided it produces the moisture content specified in the SPECIFICATIONS.

3.5 TRENCH BACKFILL

A. Backfilling over pipes, culverts, and pipe boxes shall begin as soon as practicable after the pipe, culvert or box has been laid, jointed and inspected. All backfilling shall be performed expeditiously.

1. Sand bedding material shall be placed around the lower half of the pipe, culvert or box and thoroughly rodded and tamped to fill all voids and provide uniform support. Material shall be thoroughly compacted by machine tamping in 6-inch thick layers as required to provide 95% of the Modified Proctor maximum dry density per ASTM D1557.

2. Common fill shall be placed around the upper half of the pipe, culvert or box and to a minimum depth of 12-inches over the top of the pipe, culvert or box. Common Fill shall be thoroughly compacted by machine tamping in 6-inch thick layers as required to provide 95% of the Modified Proctor maximum dry density per ASTM D1557.

3. The remainder of the trench shall be backfilled with Common Fill in loose layers not to exceed 8-inches in thickness and thoroughly compacted by machine tamping as required to provide 95% of the Modified Proctor maximum dry density per ASTM D1557.

4. Backfilling under haunches shall be performed manually by tamping rods or similar hand equipment to eliminate voids underneath.

5. The minimum frequency of Moisture Content ASTM D3017 and In Place Density ASTM D2922 testing shall be 1 test per lift per 50 linear feet of trench for all material types.

3.6 ROAD SUBGRADE

A. The final 8-inch lift of road subgrades shall be compacted to 95% of the Modified Proctor maximum dry density per ASTM D1557. The minimum frequency of Moisture Content ASTM D3017 and In Place Density ASTM D2922 testing shall be 1 test per lift per 10,000 square feet or as directed by the ENGINEER.

3.7 MOISTURE CONTROL

A. Prior to and during all compacting operations, maintain moisture content within the limits recommended herein. Maintain uniform moisture content throughout the lift. To the extent practicable, add water to materials that are too dry at the site of excavation. Supplement, if necessary, by sprinkling and mixing water into the fill material prior to compaction. The moisture content shall be at or no more than 2 percent above the optimum moisture content in accordance with ASTM D2216.

B. Do not attempt to compact fill material containing excessive moisture. Aerate material by blading, disking, harrowing, or other methods, to dry the material to acceptable moisture content.

3.8 LIFT THICKNESS REQUIREMENTS

A. Berm Fill:

1. Placement lift thickness for Engineered Fill shall not exceed 6 inches prior to compaction with hand-operated compaction equipment and should not exceed 8 inches with heavy machine operated compaction equipment. It is the CONTACTOR's responsibility to ensure that the compaction achieved meets the specifications.
2. Fill placement for anchor trenches shall not exceed 6 inches in loose lift thickness for each lift.

B. Drain Rock Aggregate:

1. Drain Rock Aggregate shall be placed and spread in lifts not exceeding 8 inches in thickness.

3.9 COMPACTION AND MOISTURE CONTENT REQUIREMENTS

A. After material placement, spreading, and leveling to the appropriate lift thickness, all material shall be uniformly compacted in accordance with the requirements for each type of fill as indicated on the following table:

Table 2: Compaction and Moisture Content Requirements

Fill Material	Compaction Specifications	Moisture Content
Engineered Fill	95% of the Modified Proctor maximum dry density	±2% of Optimum
Drain Rock Aggregate	Place uniform thickness and tamp with dozer or loader bucket	No requirements

3.10 COMPACTION EQUIPMENT

A. Compaction equipment shall be maintained in good working condition at all times to ensure that the amount of compaction obtained is the maximum for the equipment.

B. Compactor:

1. The fill is required to be compacted with a heavy vibratory-optional roller and a maximum roller speed of approximately 2 mph.
2. The compactor shall be of self-propelled design to develop 10,000 pounds in weight per linear foot of width at rest on level ground or equivalent as approved by the ENGINEER.

C. Special Compactors:

1. Special compactors shall be used to compact materials that, in the opinion of the ENGINEER, cannot be compacted properly by the specified roller because of location or accessibility.
2. Special compaction measures shall be adopted, such as hand-held compactors, smooth drum rollers, or other methods approved by the ENGINEER, to compact fill material in trenches, around structures, around geomembrane, and in other confined areas that are not accessible to the Compactor. The final surface on which the geomembrane will be placed shall be compacted with a smooth drum roller.
3. Anchor trenches shall be compacted with a hand-operated compaction machine.

3.11 COMPACTION TESTING OF ENGINEERED FILL

Field compaction testing of each lift shall be performed a minimum of one test every 100 to 300 linear feet or 5000 square feet.

3.12 SITE GRADING

A. Perform all placement of fill to lines and grades as shown in the DRAWINGS and/or established by the ENGINEER, with proper allowance for surface treatments (topsoil placement, etc.) where specified or shown. Neatly blend all new grading into surrounding, existing terrain.

END OF SECTION 02200

SECTION 02776

HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE

PART 1 - GENERAL

1.1 SUMMARY

A. Furnish all labor, materials, equipment and incidentals required to install High Density Polyethylene (HDPE) geomembrane as shown on the Drawings and specified herein.

1.2 SUBMITTALS

A. The CONTRACTOR shall submit a Subgrade Acceptance Letter to the ENGINEER prior to installation of the geomembrane stating the subgrade is acceptable and does not void the warranty.

B. The CONTRACTOR shall submit the following product data to the ENGINEER:

1. Resin Data:

    a. Certification stating that the resin meets the SPECIFICATION requirements.

2. Geomembrane Roll:

    a. Statement certifying no recycled polymer and no more than 10% rework of the same type of material is added to the resin.

C. Pre-Construction Submittals: Submit the following within 10 days of Notice to Proceed. Pre-Construction materials shall be submitted to the OWNER and ENGINEER.

1. The MANUFACTURER'S Information
    a. The MANUFACTURER'S name and address and primary contact.
    b. The manufacturing plant name and address where the geomembrane for this project will be produced.
    c. The MANUFACTURER'S qualifications including:
        1) Evidence of production of at least 10 million square feet of geomembrane that meets the specifications.
        2) Certification that the MANUFACTURER has sufficient capacity to provide the required material in the given timeframe.
        3) A list of at least 10 projects for which geomembrane has been supplied by the MANUFACTURER, three of which shall have been for projects of similar size.
    d. Product name and the MANUFACTURER'S description of the proposed geomembrane and five (5) representative samples of the product proposed for use on this project.
    e. The MANUFACTURER'S material properties sheets (cut sheets) of proposed geosynthetic products meeting the requirements of the specification.

    f. The MANUFACTURER'S Quality Control (MQC) Plan, including examples of geomembrane certification documents, name and address of the quality control testing laboratory, quality control laboratory certification, examples of retesting notification, and documentation.

g. The MANUFACTURER'S written instructions for storing, handling, installing, seaming, protecting from hydration, and repairing the proposed geomembrane, including recommendations for handling equipment (model number and load capacity).
h. Samples product warranty.

2. CONTRACTOR'S Information:
   a. CONTRACTOR'S name and address and primary contact.
   b. CONTRACTOR'S qualifications including a list of at least three previous projects of similar size to this project, including project name, location, size and date of installation, and evidence of installing at least 1 million square feet of geomembrane.
   c. The Construction Quality Control (CQC) Plan, including examples of subgrade certification documents, daily record documents, methods for repairing geomembrane and subgrade and example documents to certify repairs, method for removing rejected materials, proposed staffing, and proposed equipment.
   d. Description of welding equipment, techniques, and material, including a list of proposed equipment.
   e. A complete set of forms to be used for record installation CQC data.
   f. Résumés of key installation personnel. The Installation Supervisor, Master Seamers, and QC Representative must be clearly identified.
   g. Workmanship warranty.

D. The CONTRACTOR shall furnish SHOP DRAWINGS to the OWNER and ENGINEER as follows:

1. Installation layout SHOP DRAWINGS.
   a. Must show proposed panel layout including field seams and details.
   b. Must show panel identification numbers.
   c. Installed square footage of the geomembrane.
   d. Must be approved prior to installing the geomembrane.
   e. Approved SHOP DRAWINGS will be for concept only and actual panel placement will be determined by site conditions.

E. CONTRACTOR'S geomembrane field installation quality assurance plan.

F. The CONTRACTOR will submit the following to the OWNER and ENGINEER upon completion of installation:

1. Certificate stating the geomembrane have been installed in accordance with the contract documents.
2. Material and installation warranties:
   a. Material shall be warranted against MANUFACTURER's defects for a period of five (5) years from the date of geomembrane installation.
   b. Installation shall be warranted against defects in workmanship for a period of one (1) year from the date of geomembrane completion.
3. As-built drawings showing actual geomembrane placement, seams, testing locations and results, and anchor trench details.

1.3 REFERENCES

Note: Where reference is made to one of the standards listed below, the revision in effect at the time of bid opening shall apply.

A. American Society for Testing and Materials (ASTM)

1. ASTM D792 – Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement

2. ASTM D1004 – Test Method for Initial Tear Resistance of Plastic Film and Sheeting

3. ASTM D1238 – Test Method for Melt Flow Rates of Thermoplastics by Extrusion Plastometer

4. ASTM D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics

5. ASTM D3895 – Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry

6. ASTM D4218 – Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique

7. ASTM D4716 - Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head

8. ASTM D4873 Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples

9. ASTM D4833 – Test Method for Index Puncture Resistance of Geomembranes and Related Products

10. ASTM D5035 - Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method)

11. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geomembrane

12. ASTM D5596 – Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geomembrane

13. ASTM D5641 – Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber

14. ASTM D5820 – Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes

15. ASTM D5885 - Standard Test Method for Oxidative Induction Time of Polyolefin Geomembrane by High-Pressure Differential Scanning Calorimetry

16. ASTM D5994 – Test Method for Measuring Core Thickness of Textured Geomembrane

17. ASTM D6364 - Standard Test Method for Determining Short-Term Compression Behavior of Geomembrane

18. ASTM D6392 – Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods

19. ASTM D6693 – Test Method for Determining Tensile Properties of Non-Reinforced Polyethylene and Non-Reinforced Flexible Polypropylene Geomembranes

20. ASTM D7179 - Standard Test Method for Determining Geomembrane Breaking Force

21. ASTM D7406 - Standard Test Method for Time-Dependent (Creep) Deformation Under Constant Pressure for Geosynthetic Drainage Products

22. ASTM D7466 – Standard Test Method for Measuring the Asperity Height of Textured Geomembrane

B. Geosynthetic Research Institute (GRI)

1. GRI-GM9 Cold Weather Seaming of Geomembranes.

2. GRI GM10 – Specification for the Stress Crack Resistance of Geomembrane Sheet.

3. GRI GM12 – Measurement of the Asperity Height of Textured Geomembranes Using a Depth Gage.

4. GRI GM13 – Test Properties, Testing Frequency for HDPE Smooth and Textured Geomembranes.

5. GRI GM14 **–** Test Frequencies for Destructive Seam Testing Selecting, Variable Intervals for Taking Geomembrane Destructive Samples Using the Method of Attributes.

6. GRI GM 19 – Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes.

1.4 DEFINITIONS

A. Lot – A quantity of resin (usually the capacity of one rail car) used in the manufacture of geomembrane. Finished roll will be identified by a roll number traceable to the resin lot used.

B. ENGINEER – Party, independent from manufacturer and CONTRACTOR, that is responsible for observing and documenting activities related to quality assurance during the lining system construction.

C. Geomembrane Manufacturer – The party responsible for manufacturing the geomembrane rolls.

D. Geosynthetic Quality Assurance Laboratory (testing laboratory) – Party, independent from the OWNER, manufacturer, and CONTRACTOR, responsible for conducting laboratory tests on samples of geomembrane obtained at the site or during manufacturing.

E. CONTRACTOR – Party responsible for field handling, transporting, storing, deploying, seaming and testing of the geomembrane seams.

F. Minimum Average Roll Value (MARV): Property value calculated as typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample taken during quality assurance testing will exceed value reported.

G. Panel – Unit area of a geomembrane that will be seamed in the field that is 10 square yards or larger.

H. Patch – Unit area of a geomembrane that will be seamed in the field that is less than 10 square yards.

I. Subgrade Surface – Soil layer surface which immediately underlies the geosynthetic material(s).

1.5 QUALIFICATIONS

A. MANUFACTURER

1. MANUFACTURER shall have manufactured a minimum of 10 million square feet of HDPE geomembrane material during the last year.
2. MANUFACTURER shall have manufactured a minimum of 10,000,000 square feet of polyethylene geomembrane material during the last year.
3. MANUFACTURER shall have a GAI-LAP Accredited Laboratory at the manufacturing facility.
4. MANUFACTURER shall have ISO 9001; 2008 certification.

B. CONTRACTOR

1. CONTRACTOR shall have installed a minimum of 10,000,000 square feet of geomembrane in the last 3 years.
2. CONTRACTOR shall have worked in a similar capacity on at least 3 projects similar in complexity to the project described in the contract documents, and within a total of at least 400,000 square feet of geomembrane installation on each project.
3. The Installation Supervisor shall have worked in a similar capacity on at least 3 projects similar in size and complexity to the project described in the Contract Documents in the last 5 years.

1.6 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Geomembrane labeling, shipment, and storage shall follow ASTM D4873. Product labels shall clearly show the manufacturer or supplier name, style name, and roll number.

B. Each geomembrane roll shall be wrapped with a material that will protect the geomembrane from damage due to shipment, water, sunlight, and contaminants.

C. The CONTRACTOR shall note any visible damage to roll materials on the Bill of Lading prior to unloading roll materials. Should any visible damage be noted, CONTRACTOR or ENGINEER shall notify the MANUFACTURER in writing immediately.

D. Labeling – Each roll of geomembrane delivered to the site shall be labeled by the manufacturer. The label will identify:

1. Manufacturer's name
2. Product identification
3. Thickness
4. Length
5. Width
6. Roll number
7. Date and time of production
8. Resin lot number

E. Delivery – Rolls of liner will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

F. Storage – The on-site storage location for geomembrane material, provided by the CONTRACTOR to protect the geomembrane from punctures, abrasions and excessive dirt and moisture, should have the following characteristics:

1. Level (no wooden pallets)
2. Smooth
3. Dry
4. Protected from theft and vandalism
5. Adjacent to the area being lined
6. Geomembrane shall not be stacked higher than three rolls

G. Handling – Materials are to be handled to prevent damage. The CONTRACTOR shall take any necessary precautions to prevent damage to underlying layers during placement of the geomembrane.

1.7 WARRANTY

A. Material shall be warranted, against manufacturer's defects for a period of five (5) years from the date of geomembrane installation.

B. Installation shall be warranted against defects in workmanship for a period of one year from the date of geomembrane completion.

PART 2 - PRODUCTS

2.1 HIGH DENSITY POLYETHYLENE (HDPE) GEOMEMBRANE

A. Material shall be **smooth (both sides) 40-mil black LLPDE** and **60-mil grey HDPE (textured on one side and smooth on other)** or equivalent HDPE geomembrane meeting the thickness, texture, and color requirements as shown on the DRAWINGS.

B. Geomembrane Rolls

1. Geomembrane rolls must not exceed a combined maximum total of 1 percent by weight of additives other than carbon black.
2. Geomembrane shall be free of holes, pinholes, bubbles, blisters, excessive contamination by foreign matter, and nicks and cuts on roll edges.

3. Geomembrane material is to be supplied in roll form. Each roll is to be identified with labels indicating roll number, thickness, length, width, and manufacturer.
4. All liner sheets produced at the factory shall be inspected prior to shipment and be tested by an acceptable method of inspecting for pinholes. If pinholes are located, identified and indicated during manufacturing, these pinholes may be corrected during installation.

2.2 RESIN

1. Resin shall be first quality, compounded polyethylene resin.

2. Resin testing values and testing frequencies requirements are presented in Table 1 below. Natural resin (without carbon black) shall meet the following additional minimum requirements:

TABLE 1: RAW MATERIAL VALUES

Property	Test Method (1)	Testing Frequencies	Value
Density (g/cm3)	ASTM D 1505	Once Per Resin Lot	>0.94
Melt Flow Index (g/10 min)	ASTM D 1238	Once Per Resin Lot	$\leq$ 1.0

[1]Manufacturer may utilize test equipment and procedures that enable effective and economical confirmation that the product will conform to specifications based on the noted procedures. Some test procedures have been modified for application to geomembrane.

2.3 EQUIPMENT

A. Welding equipment and accessories shall meet the following requirements:

1. Gauges showing temperatures in apparatus (extrusion welder) or wedge (wedge welder) shall be present.
2. An adequate number of welding apparatus shall be available to avoid delaying WORK.
3. Power source must be capable of providing constant voltage under combined line load.

B. Extrudate Rod or Bead

1. Extrudate material shall be made from the same type of resin as the geomembrane.
2. Additives shall be thoroughly dispersed.
3. Materials shall be free of contamination by moisture or foreign matter.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Preparation of surfaces to be lined shall be completed by the EARTHWORK CONTRACTOR but the LINER CONTRACTOR will be responsible for inspecting the prepared surfaces to verify that the surfaces are acceptable for liner placement and free from any rocks, clods, sticks, surface irregularities or debris which could damage the liner. Acceptance of the subgrade shall be provided in a written submittal.

B. All geomembrane installation shall meet the manufacturer's recommendations for preparation, storage and placement or installation.

3.2 DEPLOYMENT

A. Assign each panel a simple and logical identifying code. The coding system shall be subject to approval and shall be determined at the WORK site.

B. Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.

C. The geomembrane installation shall meet the manufacturer's recommendations for preparation, storage and placement or installation.

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

1. Unroll geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage (spreader bar, protected equipment bucket).
2. The geomembrane roll shall be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the ENGINEER.
3. Use full length rolls or those with a significant length remaining at the top of the slope so that no roll end occurs on side slopes.
4. Place ballast (commonly sandbags) on geomembrane, which will not damage geomembrane, to prevent wind uplift.
5. Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage it. Smoking will not be permitted on the geomembrane.
6. Do not allow heavy vehicular traffic directly on geomembrane. Rubber-tired ATVs and trucks are acceptable if wheel contact is less than six (6) pounds per square inch.

E. Sufficient material (slack) shall be provided to allow for thermal expansion and contraction of the material. This practice will be used to prevent excessive tension (trampolines) from developing. This is particularly important in cold weather conditions.

F. Anchor trench compacting equipment shall not come into direct contact with the geomembrane.

3.3 FIELD SEAMING

A. Seams shall meet the following requirements:

1. To the maximum extent possible, orient seams parallel to line of slope, i.e., down and not across slope.
2. Minimize number of field seams in corners, odd-shaped geometric locations and outside corners.
3. Slope seams (panels) shall extend a minimum of five feet beyond the grade break into the flat area.
4. Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the ENGINEER and CONTRACTOR.
5. All seam overlaps shall be aligned consistent with the requirements of the welding equipment being used. Seams shall be made by lapping the uphill material over the downhill material with sufficient overlap. Extrusion seaming shall have a minimum overlap of six (6) inches. Wedge-welded seaming shall have a minimum overlap of six inches.
6. Seaming of the geomembrane at material temperatures below 32 degrees F and above 170 degrees F must be successfully demonstrated to the ENGINEER using prequalification test seams to demonstrate that the seams comply with these SPECIFICATIONS.

B. During Welding Operations

1. Provide at least one master seamer who shall provide direct supervision over other welders as necessary.

C. Extrusion Welding

1. Hot-air tack adjacent pieces together using procedures that do not damage the geomembrane.
2. Clean geomembrane surfaces by disc grinder or equivalent. Number 80-grit sandpaper shall be used.
3. Grinding shall not reduce the thickness of the geomembrane more than one mil.
4. Purge welding apparatus of heat-degraded extrudate before welding.
5. Extrusion welding shall be considered a secondary means of welding and shall be used for repairs unless otherwise approved by ENGINEER.

D. Hot Wedge Welding

1. Welding apparatus shall be a self-propelled device equipped with an electronic controller which displays applicable temperatures.
2. Clean seam area of dust, mud, moisture and debris immediately ahead of hot wedge welder.
3. Protect against moisture build-up between sheets.
4. Hot wedge welding shall be considered the primary method of welding and shall be used for panel seaming unless otherwise approved by ENGINEER.

E. Trial Welds

1. Perform trial welds on geomembrane samples to verify welding equipment is operating properly.
2. Make trial welds under the same surface and environmental conditions as the production welds, i.e., in contact with subgrade and similar ambient temperature.
3. A minimum of two trial welds shall be required per day, per welding apparatus, one made prior to the start of work and one completed at mid-shift. Additional trial welds will be required after repairs are made to the apparatus.
4. Cut six one-inch wide by six-inch long test strips from the trial weld.
5. Quantitatively test three specimens for peel adhesion, and then three specimens for shear strength.
6. Trial weld specimens shall pass when the results shown in Table 2 are achieved in both peel and shear test.

TABLE 2: MINIMUM WELD VALUES FOR HDPE GEOMEMBRANES

Property	Test Method	Minimum Value
Peel Strength (fusion), ppi	ASTM D 6392	98
Peel Strength (extrusion), ppi	ASTM D 6392	78
Shear Strength (fusion & ext.), ppi	ASTM D 6392	121

7. The break, when peel testing, occurs in the liner material itself, not through peel separation (Film Tear Bond (FTB) break).
8. The break is ductile.
9. A test will be considered a failure if one specimen on either peel or shear testing does not meet the requirements on Table 2 or does not achieve an FTB break.

10. Repeat the trial weld, in its entirety, when any of the trial weld samples fail in either peel or shear.
11. No welding equipment or welder shall be allowed to perform production welds until equipment and welders have successfully completed two additional trial welds.

F. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. The CONTRACTOR shall demonstrate that acceptable seaming can be performed by completing acceptable trial welds.

G. Defects and Repairs

1. Examine all seams and non-seam areas of the geomembrane for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter.
2. Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available.

3.4 FIELD QUALITY ASSURANCE

A. The manufacturer and CONTRACTOR shall participate in and conform to all terms and requirements of the OWNER'S quality assurance program. The CONTRACTOR shall be responsible for assuring this participation.

B. Quality assurance requirements are as specified in this section.

C. Field Testing

1. Non-destructive testing shall be carried out as the seaming progresses, not at completion of all field seaming. Each seam shall be non-destructive tested with either of the following tests.

a. Vacuum Testing

1) Shall be performed in all extrusion welds performed during installation and in accordance with ASTM D 5641.
2) The vacuum box assembly shall consist of the following:

a) Rigid housing;
b) Transparent viewing window;
c) Soft rubber gasket attached to bottom of housing;
d) Porthole or valve assembly;
e) Vacuum gauge; and
f) A vacuum pump capable of delivering a minimum of a 27psi vacuum.

3) When vacuum testing, the installer shall:

a) Carefully trim all overlapped material using an approved cutting instrument. The "pull-tear" method of overlap removal shall not be accepted;
b) Clean windows, gasket surfaces, and check for leaks;
c) Wet a strip of geomembrane approximately 1 foot by 2.5 feet (length of box) with soapy solution;
d) Place the vacuum box over the wetted area;
e) Ensure that a leak-tight seal is created;

f) Apply a minimum vacuum pressure of five psi;
g) For a period of not less than 15 seconds, examine the length of weld through the viewing window for the presence of soap bubbles;
h) If no bubbles appear after 15 seconds, move the box over the next adjoining area with a minimum three inches of overlap and repeat the process;
i) Areas where soap bubbles appear shall be marked, repaired, and re-tested;
j) All vacuum testing will be documented by the CONTRACTOR'S QC Technician and submitted to the ENGINEER at the end of each WORK shift. The liner shall be indelibly marked near the seam to indicate passing or failing test results accordingly.

b. Air Pressure Testing

1) Shall be performed in all hot wedge welds performed during installation and in accordance with ASTM D 5820
2) The equipment for pressure testing shall include the following:

a) Air pumps equipped with a pressure gauge capable of generating and sustaining a pressure of 30 pounds per square inch (psi); and
b) Sharp hollow needles or other pressure feed devices approved by the ENGINEER. The liner shall be indelibly marked near the tested area to indicate passing or failing test results accordingly.

3) To perform the air pressure test, the installer's QC Technician shall:

a) Pass air through the channel to guarantee a clear pathway;
b) Seal both ends of the seam to be tested;
c) Insert a needle or other approved pressure-feed device into the tunnel created by double hot wedge seaming;
d) Energize the air pump to 30 psi;
e) Close the valve while sustaining the air pressure and allow the air to reach ambient liner temperature;
f) Read the pressure gauge;
g) Sustain the test for a minimum of five (5) minutes and re-read the pressure gauge;
h) If the loss of pressure exceeds three psi after a two-minute period or does not stabilize, faulty areas shall be located and repaired. After testing, pressure-feed devices shall be removed and insertion points sealed; and
i) All pressure testing shall be documented by the CONTRACTOR'S QC Technician and submitted to the ENGINEER by the end of each WORK shift. The liner shall be indelibly marked near the seam to indicate passing or failing test results accordingly.

c. Alternative testing methods other than vacuum or pressure testing may be proposed by the CONTRACTOR and will be subject to the approval of the ENGINEER prior to their use.

d. At locations where seams cannot be non-destructively tested, the CONTRACTOR shall:

1) Cap-strip seams with the same geomembrane when possible; and
2) If the seam is accessible to testing equipment prior to final installation, non-destructively test the seam prior to final installation.

e. Seaming and cap-stripping operations will be observed by the ENGINEER for uniformity and completeness.

2. Destructive Testing (performed by the CONTRACTOR with observation from the ENGINEER)

a. Location and frequency of testing

1) Collect destructive test samples at a frequency of one per every 500 lineal feet of seam length per machine used.
2) Test locations will be determined after seaming.
3) Exercise method of attributes as described by GRI GM-14 to minimize test samples taken.

b. Sampling Procedures are performed as follows:

1) The CONTRACTOR shall cut samples at locations designated by the ENGINEER as seaming progresses in order to obtain field laboratory test results before the geomembrane is covered.
2) The ENGINEER will number each sample, and the location will be noted on the installation as-built.
3) Samples shall be 12 inches wide by 36 inches long with the seam centered lengthwise (length may vary to minimize cutting of the liner).
4) Cut 10 two-inch wide by six-inch long test strips from each end of the samples for field testing.
5) The remaining sample shall be distributed as follows:

a) One portion for CONTRACTOR, 12 by 12 inches
b) Additional samples may be archived if required by OWNER

6) The CONTRACTOR shall repair all holes in the geomembrane resulting from destructive sampling.
7) Repair and test the continuity of the repair in accordance with these SPECIFICATIONS.

c. Destructive testing procedures

1) Destructive testing shall be performed in accordance with ASTM D6392.
2) Quantitatively test five (5) specimens for peel adhesion, and then five (5) specimens for shear strength.
3) Destructive testing specimens shall pass when the results shown in Table 2 are achieved in both peel and shear test.
4) The break, when peel testing, shall occur in the liner material itself, not through peel separation (FTB).
5) The break is to be ductile.

6) A test will be considered a failure if one specimen on either peel or shear testing does not meet the requirements on Table 2 or does not achieve an FTB break.

3. Failed Seam Procedures

a. If the seam fails, the CONTRACTOR shall follow one of two options:

1) Reconstruct the seam between any two passed test locations.
2) Trace the weld to intermediate locations at least 10 feet minimum or where the seam ends in both directions from the location of the failed test. If necessary the failed seam shall be traced to previous days of seaming for the particular machine.
3) All tracing events shall be recorded by the ENGINEER.

b. An additional sample is required for the next seam welded using the same welding device regardless of the length of the next seam.
c. If the new sample passes, then the failed seam shall be reconstructed or capped between the test sample locations.
d. If any sample fails, the process shall be repeated to establish the zone in which the seam is to be reconstructed.

3.5 REPAIR PROCEDURES

A. Remove damaged geomembrane and replace with acceptable geomembrane materials if damage cannot be satisfactorily repaired.

B. Repair any portion of unsatisfactory geomembrane or seam area failing a destructive or non-destructive test.

C. Install additional liner anywhere excessive tension (trampolines) exists and to avoid excessive tension.

D. The CONTRACTOR shall be responsible for repair of defective areas.

E. Agreement upon the appropriate repair method shall be decided between the ENGINEER or OWNER and CONTRACTOR by using one of the following repair methods:

1. Patching – Used to repair large holes, tears, undispersed raw materials and contamination by foreign matter. Patch materials shall be of the same material type and thickness as the material being repaired. A patch shall be a minimum of 12 inches larger in all directions than the area requiring repair. All patches shall have rounded corners;
2. Abrading and Re-welding – Used to repair short section of a seam;
3. Spot Welding – Used to repair pinholes or other minor, localized flaws, or where geomembrane thickness has been reduced;
4. Capping – Used to repair long lengths of failed seams;
5. Flap Welding – Used to extrusion-weld the flap (excess outer portion) of a fusion weld in lieu of a full cap; or
6. Remove the unacceptable seam and replace with new material.

F. The following procedures shall be observed when a repair method is used:

1. All geomembrane surfaces shall be clean and dry at the time of repair;
2. Surfaces of the geomembrane which are to be repaired by extrusion welds shall be lightly abraded to assure cleanliness; and
3. Extend patches or caps at least six inches for extrusion welds and six inches for wedge welds beyond the edge of the defect, and around all corners of patch material.

G. Repair Verification

1. Number and log each patch repair (performed by the ENGINEER)
2. Non-destructively test each repair using methods described in this SPECIFICATION

3. Any rips, tears or damaged areas on the deployed geomembrane shall be removed and patched. The patch shall be secured to the original geomembrane by tying every 6 inches with the approved tying devices. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out, the two portions of the geomembrane shall be cut out, and the two portions of the geomembrane shall be joined in accordance with these SPECIFICATIONS.

3.6 DEPTH OR ELEVATION MARKINGS

A. Following completion of geomembrane install depth or elevation markings as shown on the DRAWINGS.

END OF SECTION 02776

SECTION 02273
NONWOVEN GEOTEXTILES

PART 1 - GENERAL

1.1 SUMMARY

A. The WORK described in this SPECIFICATION section includes the manufacture and installation of geotextile fabrics as stand-alone items only and not included as part of a composite drainage net.

1.2 SUBMITTALS

A. Product Data

1. The CONTRACTOR shall provide to the ENGINEER a certificate stating the name of the manufacturer, product name, style number, chemical composition of the filaments or yarns, and other pertinent information to fully describe the geotextile. The certification shall state that the furnished geotextile meets Minimum Average Roll Value (MARV) requirements of the SPECIFICATION as evaluated under the manufacturer's quality control program. The certification shall be attested to by a person having legal authority to bind the manufacturer.

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):
1. ASTM D4354 – Practice for Sampling of Geomembrane for Testing
2. ASTM D4355 – Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus)
3. ASTM D4533 – Test Method for Index Trapezoid Tearing Strength of Geotextiles
4. ASTM D4632 – Test Method for Grab Breaking Load and Elongation of Geotextiles
5. ASTM D4751 – Test Method for Determining Apparent Opening Size of a Geotextile
6. ASTM D4833 – Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products
7. ASTM D4873 – Guide for Identification, Storage, and Handling of Geotextiles
8. ASTM D4491 - Standard Test Methods for Water Permeability of Geotextiles by Permittivity
9. ASTM D5261 - Standard Test Method for Measuring Mass per Unit Area of Geotextiles

B. American Association for Laboratory Accreditation (A2LA)

C. Geosynthetic Accreditation Institute (GAI) – Laboratory Accreditation Program (LAP)

D. National Transportation Product Evaluation Program (NTPEP)

1.4 DEFINITIONS

A. Minimum Average Roll Value (MARV): Property value calculated as typical minus two standard deviations. Statistically, it yields a 97.7% degree of confidence that any sample taken during quality assurance testing will exceed value reported.

1.5 QUALIFICATIONS

MANUFACTURER shall have manufactured a minimum of 10,000,000 square feet of geotextile material during the last year.

1.6 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Geotextiles labeling, shipment, and storage shall follow ASTM D4873. Product labels shall clearly show the manufacturer or supplier name, style name, and roll number.

B. Each geotextile roll shall be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight, and contaminants.

C. During storage, geotextile rolls shall be elevated off the ground and adequately covered to protect them from the following: site construction damage, precipitation, extended ultraviolet radiation including sunlight, chemicals that are strong acids or strong bases, flames (including welding sparks), excess temperatures, and any other environmental conditions that may damage the physical properties of the geotextile.

PART 2 - PRODUCTS

2.1 GEOTEXTILE

A. The geotextile shall be Nonwoven Geotextile or equivalent. The geotextile shall be manufactured with fibers consisting of long-chain synthetic polymers composed of at least 95% by weight of polyfins or polyesters. They shall form a stable network such that the filaments or yarns retain their dimensional stability relative to each other, including selvages.

B. Woven slit film geotextiles (i.e., geotextiles made from yarns of a flat, tape-like character) shall not be allowed.

C. The geotextile shall meet the requirements of Table 1. All numeric values in Table 1 except Apparent Opening Size (AOS) represent MARV in the weakest principal direction. Values for AOS represent maximum average roll values.

TABLE 1: 8 OZ GEOTEXTILE REQUIREMENTS

Property	Test Method	Units	Value
Mass per unit Area	ASTM D5261	oz/yd^2	8
Grab Tensile Strength	ASTM D4632	lbs	205
Grab Tensile Elongation	ASTM D4632	%	50
Trapezoid Tear Strength	ASTM D4533	lbs	85
CBR Puncture Strength	ASTM D4833	lbs	535
Permittivity	ASTM D4491	sec^{-1}	1.3
Apparent Opening Size	ASTM D4751	U.S. Sieve	80
Water Flow Rate	ASTM D4491	gpm/ft^2	90
UV Resistance[1]	ASTM D4355	%	70

[1]After 500 hrs

2.2 QUALITY CONTROL

A. Manufacturing Quality Control: Testing shall be performed at a laboratory accredited by GAI-LAP and A2LA for tests required for the geotextile, at a frequency meeting or exceeding ASTM D4354.

B. Geotextile properties, other than sewn seam strength, burst strength, and ultraviolet stability shall be tested by NTPEP to verify conformance with this SPECIFICATION.

C. Sewn seam strength shall be verified based on testing of either conformance samples obtained using Procedure A of ASTM D4354, or based on manufacturer's certifications and testing of quality assurance samples obtained using Procedure B of ASTM D4354. A lot size for conformance or quality assurance sampling shall be considered to be the shipment quantity of the given product or a truckload of the given product, whichever is smaller.

D. Ultraviolet stability shall be verified by an independent laboratory on the geotextile or a geotextile of similar construction and yarn type.

PART 3 - EXECUTION

3.1 PREPARATION

A. Grading shall be done in such a way so as to prevent large voids from occurring along the geotextile contact. The graded surface shall be smooth and free of debris.

3.2 INSTALLATION

A. The geotextile installation shall meet the manufacturer's recommendations for preparation, storage and placement or installation.

B. The geotextile shall be placed loosely with no wrinkles or folds, and with no void spaces between the geotextile and the ground surface. Successive sheets of geotextiles shall be overlapped a minimum of 12 inches, with the upstream sheet overlapping the downstream sheet.

C. Should the geotextile be damaged during installation or drainage aggregate placement, a geotextile patch shall be placed over the damaged area extending beyond the damaged area a distance of 12 inches, or the specified seam overlap, whichever is greater.

END OF SECTION 02273

SECTION 02240
COMPOSITE DRAINAGE NET

PART 1 - GENERAL

1.1 SUMMARY

A. This section covers the technical requirements for the manufacturing and installation of the Composite Drainage Net (CDN). All materials must meet or exceed the requirements of this SPECIFICATION, and all work will be performed in accordance with the procedures provided in these project SPECIFICATIONS unless approved by the ENGINEER.

1.2 REFERENCES

A. American Society for Testing and Materials (ASTM)
   1. ASTM D1505 - Standard Test Method for Density of Plastics by the Density-Gradient Technique
   2. ASTM D1603 - Standard Test Method for Carbon Black in Olefin Plastics
   3. ASTM D4218 - Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique
   4. ASTM D4354 - Practice for Sampling of Geomembrane for Testing
   5. ASTM D4716 - Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
   6. ASTM D4833 - Standard Test Method for Index Puncture Resistance of Geotextiles, Geomembranes and Related Products
   7. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geomembrane
   8. ASTM D7179 - Standard Test Method for Determining Geomembrane Breaking Force

B. Geosynthetic Research Institute (GRI)

   1. GRI GC7 – Determination of Adhesion and Bond Strength of Geocomposites
   2. GRI GC8 – Determination of the Allowable Flow Rate of a Drainage Geocomposite

C. Relevant publications from the Environmental Protection Agency (EPA):

   1. Daniel, D.E. and R.M. Koerner, (1993), Technical Guidance Document: Quality Assurance and Quality Control for Waste Containment Facilities, EPA/600/R-93/182.

1.3 DEFINITIONS

A. Geomembrane Manufacturer (MANUFACTURER) - The party responsible for manufacturing the CDN rolls.

B. Lot - A quantity of resin (usually the capacity of one rail car) used to manufacture polyethylene geomembrane rolls. The finished rolls will be identified by a roll number traceable to the resin lot.

1.4 QUALIFICATIONS

A. MANUFACTURER

MANUFACTURER shall have manufactured a minimum of 1 million square feet of CDN material during the last year.

B. CONTRACTOR

a. CONTRACTOR shall have installed a minimum of 3,000,000 square feet of CDN in the last 3 years.
b. CONTRACTOR shall have worked in a similar capacity on at least 5 projects similar in complexity to the project described in the contract documents, and within a total of at least 3,000,000 square feet of CDN installation on each project.
c. The Installation Supervisor shall have worked in a similar capacity on at least 5 projects similar in size and complexity to the project described in the Contract Documents in the last 5 years.

1.5 MATERIAL LABELING, DELIVERY, STORAGE, AND HANDLING

A. Labeling - Each roll delivered to the site shall be wrapped and labeled by the MANUFACTURER. The label will identify:

1. manufacturer's name
2. product identification
3. length
4. width
5. roll number

B. Delivery - Rolls will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Storage - The on-site storage location provided by the CONTRACTOR to protect the CDN from abrasions, excessive dirt and moisture shall have the following characteristics:

1. level (no wooden pallets)
2. smooth
3. dry
4. protected from theft and vandalism
5. adjacent to the area being lined

D. Handling

1. The CONTRACTOR shall handle all rolls in such a manner to ensure they are not damaged in any way.
2. The CONTRACTOR shall take any necessary precautions to prevent damage to underlying layers during placement of the drainage material.

1.6 WARRANTY

A. The Manufacturer shall warrant that the CDN shall be of merchantable quality (as defined by the Uniform Commercial Code). The Manufacturer shall guarantee that the CDN furnished is suitable for the purpose intended and free from defects of material and workmanship. In the event, the CDN fails to perform as specified the Manufacturer shall promptly replace defective materials without any costs to the OWNER.

B. Installation shall be warranted against defects in installation and in workmanship for a period of 2-years commencing with the date of final acceptance. The guarantee shall include the services of qualified service technicians and all materials required for the repairs at no expense to the OWNER.

PART 2 - PRODUCTS

2.1 COMPOSITE DRAINAGE NET (CDN)

A. A CDN shall be manufactured by extruding two crossing strands to form a bi-planar drainage net structure.

B. The CDN materials shall be used as shown on the DRAWINGS. Each type of CDN specified shall have properties that meet or exceed the values listed in the following tables below.

TABLE 1: 200-MIL CDN PROPERTIES

Property	Test Method	Frequency	Value
Geomembrane (prior to lamination)			
Geomembrane Core	ASTM D 5199	1/50,000 ft^2	200
Transmissivity[1], gal/min/ft	ASTM D 4716	1/540,000 ft^2	9.6
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94
Creep Reduction Factor	ASTM D 7406/7361	Per formulation	Maximum of 1.2 at 15,000 lb/ft^2
Tensile Strength (MD), lb/in	ASTM D 5035/7179	1/50,000 ft^2	45
Carbon Black Content, %	ASTM D 1603[2]/4218	1/50,000 ft^2	2.0

[1]Gradient of 0.1, normal load of 25,000 lb/ft^2, water at 70° F, between steel plates for 15 minutes.
[2]Modified.

C. Resin

1. Resin shall be new first quality, compounded polyethylene resin.

2. Resin testing values and testing frequencies requirements are presented in Table 2 below. Natural resin (without carbon black) shall meet the following additional minimum requirements:

TABLE 2: RAW MATERIAL PROPERTIES

Property	Test Method[(1)]	Value
Density (g/cm^3)	ASTM D 1505	>0.94
Melt Flow Index (g/10 min)	ASTM D 1238	< 1.0

[1]Manufacturer may utilize test equipment and procedures that enable effective and economical confirmation that the product will conform to specifications based on the noted procedures. Some test procedures have been modified for application to geomembrane.

2.2 MANUFACTURING QUALITY CONTROL

1. The CDN shall be manufactured in accordance with the Manufacturer's Quality Control Plan submitted to and approved by the ENGINEER.
2. The CDN shall be tested according to the test methods and frequencies listed on Tables 1 which has been prepared based on product data sheets.

PART 3 - EXECUTION

3.1 FAMILIARIZATION

A. Inspection

1. Prior to implementing any of the work in the Section to be lined, the CONTRACTOR shall carefully inspect the installed work of all other Sections and verify that all work is complete to the point where the installation of the Section may properly commence without adverse impact.

2. If the CONTRACTOR has any concerns regarding the installed work of other Sections, the CONTRACTOR shall notify the ENGINEER.

3.2 MATERIAL PLACEMENT AND INSTALLATION

A. The CDN installation shall meet the manufacturer's recommendations for preparation, storage and placement or installation.

B. The CDN roll should be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the ENGINEER.

C. Use full length rolls or those with a significant length remaining at the top of the slope so that no roll end occurs on side slopes.

D. In the presence of wind, all geomembrane, including the CDN, shall be weighted down with ballast (i.e. sandbags or approved equal)

E. Ballast shall be used during placement and remain until replaced with cover material or liquids.

F. The CDN shall be properly anchored to resist sliding. Anchor trench compacting equipment shall not come into direct contact with the CDN.

G. The drainage rock material shall be placed on the CDN in a manner that does not permit vehicular traffic directly on the CDN, and prevents damage to the CDN. No equipment shall be driven upon the CDN layer or geomembrane.

3.3 SEAMS AND OVERLAPS

A. Each component of the CDN will be secured or seamed to the like component at overlaps.

B. CDN Components

1. Butt seams should be shingled down in the direction of the slope, with the CDN portion of the top overlapping the CDN portion of the bottom CDN a minimum of 24 inches across the roll width and as recommended by the manufacturer. The overlaps shall be joined by tying the CDN structure with cable ties. These ties shall be spaced every 12 inches along the roll width.

2. Adjacent edge seams across the roll length should be shingled down in the direction of the slope, with the CDN portion of the top overlapping the CDN portion of the bottom CDN a minimum of 6 inches across the roll length. The overlaps shall be joined by tying the CDN structure with cable ties. These ties shall be spaced every 5 feet minimum along the roll width.

3.4 REPAIR

A. Prior to covering the deployed CDN, each roll shall be inspected for damage resulting from construction

B. Any rips, tears or damaged areas on the deployed CDN shall be removed and patched. The patch shall be secured to the original CDN by tying every 6 inches with the approved tying devices. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out and the two portions of the CDN shall be cut out and the two portions of the CDN shall be joined in accordance with Subsection 3.03 of this part.

END OF SECTION 02240

SECTION 02623
HIGH DENSITY POLYETHYLENE (HPDE) PIPE

PART 1 - GENERAL

1.1 SUMMARY

A. The WORK of this SPECIFICATION section shall consist of furnishing and installing the leakage collection and conveyance piping and appurtenances associated with the sump and collection trench as shown on the DRAWINGS.

B. The CONTRACTOR shall furnish all labor, materials, tools, equipment, and services for construction of the polyethylene piping and appurtenances.

C. Although such WORK may not be specifically indicated, CONTRACTOR shall furnish and install all supplementary or miscellaneous items, appurtenances, and devices incidental to or necessary for a fully functional installation.

1.2 PIPEWORK AND APPURTENANCES

A. All drainage, collection and conveyance pipework shall be carefully fabricated and placed as shown on the DRAWINGS and approved by the OWNER.

B. All pipe invert elevations and gradients shall be accurately set. CONTRACTOR shall adequately anchor or ballast the pipe to prevent movement during construction.

1.3 WARRANTY

A. The pipe manufacturer shall provide a warranty against manufacturing defects of material and workmanship for a period of 10 years after the final acceptance of the project by the OWNER. The manufacturer shall replace, at no additional cost to the OWNER, any defective pipe material within the warranty period.

1.4 REFERENCES

A. Provide IPS size HDPE pipe in accordance with the following standards and all other mandatory ASTM requirements detailed therein.

1. American Society for Testing and Materials (ASTM) most current versions and other applicable standards.
    a. ASTM D3350 – Standard Specification for Polyethylene Plastics Pipe and Fittings Materials
    b. ASTM F714 – Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter

1.5 SUBMITTALS

A. The CONTRACTOR shall submit the following:

1. Shop drawings of HDPE pipe, fittings, and manner of securing; a list of materials to be furnished; and the name of the pipe manufacturer;
2. Product data sheets showing compliance with the product requirements of this Section
3. Certifications of welder's qualifications for HDPE pipe fusion required for the project.

B. Submit manufacturer's installation instructions and maintain a copy on-site for reference during construction.

1.6 PIPE WELDERS QUALIFICATIONS

A. All operators conducting fusion welding activities must be certified by the manufacturer as technically qualified and properly experienced for fusion welding of HDPE pipe.

B. Submit names of certified operators in accordance with this Section.

PART 2 - PRODUCTS

2.1 HDPE PIPE

A. HDPE pipe and fittings shall be high-density, high molecular weight polyethylene pipe PE4710.

B. High density polyethylene (HDPE) resin: compounded and manufactured specifically for producing HDPE pipe.

C. Pipe: Manufactured in accordance with ASTM D3350 and ASTM F714.

D. Dimension Ratio (DR): As required by the DRAWINGS.

E. HDPE pipes shall be supplied in standard laying lengths not exceeding 40 feet.

F. HDPE pipes and fittings shall be homogeneous throughout and free of visible cracks, holes (other than manufactured perforations per design), foreign inclusions, or other deleterious effects, and shall be uniform in color, density, melt index, and other physical properties.

G. Fitting at the toe of the slope for the leachate detection sump (LDS) pipe shall consist of a fabricated bend constructed of the same material as the pipe.

PART 3 - EXECUTION

3.1 GENERAL

A. Coordinate details of the prefabricated pipe penetration through the primary liner with the liner manufacturer and CONTRACTOR.

3.2 HANDLING AND PLACEMENT

A. HDPE pipe and fittings shall be installed as indicated on the DRAWINGS.

B. The CONTRACTOR shall exercise care when transporting, handling and placing pipe and fittings, such that they will not be cut, kinked, twisted, or otherwise damaged.

C. The CONTRACTOR shall comply with the pipe manufacturer's recommendations for handling, storage, and installation of all polyethylene pipe and fittings.

D. Ropes, fabric, or rubber-protected slings and/or straps shall be used when handling pipe. Chains, cables or hooks shall not be used as a means of handling pipe.

E. Pipe or fittings shall not be dropped or dragged over sharp objects.

F. The maximum allowable depth of cuts, gouges, or scratches on the exterior surface of pipe or fittings is 10% of the wall thickness. The interior of the pipe and fittings shall be free of cuts, gouges, and scratches. CONTRACTOR shall be required to remove and replace damaged pipe, at no additional cost to the OWNER.

G. Whenever pipe laying is not actively in progress, the open ends of pipes that have been placed shall be closed using watertight plugs.

3.3 INSTALLATION

A. Pipe shall be laid on geotextile within pond leak collection system as shown on the DRAWINGS.

B. All polyethylene pipe and fittings shall be installed in accordance with this SPECIFICATION and in conformance with the pipe manufacturer's written instructions.

C. The CONTRACTOR shall carefully examine all pipe and fittings for cracks, damage, or defects before installation.

D. The interiors of all pipes and fittings shall be inspected, and foreign materials shall be completely removed from the pipe and fitting interiors before they are moved into their final positions.

E. Do not damage underlying WORK, soil layers or geosynthetic installations during pipe installation operations. Repair all damaged WORK.

3.4 JOINTS AND CONNECTIONS

A. Fusion joining equipment shall be as supplied by, leased from, or approved by the pipe manufacturer.

B. Joining techniques and operating procedures shall carefully follow written instructions provided by the pipe manufacturer and the joint equipment supplier. A copy of such instructions, including heating time, cooling time, fusion temperature, and fusion pressure for each size of pipe shall be present at any location in which butt-fusion is being carried out.

3.5 PERFORATIONS

A. Perforations as shown on the DRAWINGS may be manufactured or field constructed with approval from the ENGINEER or OWNER.

END OF SECTION 02623

Appendix I

Geotechnical Report

Geotechnical Data Report

Proposed Water Impoundments – North PLU Site
Loving, Eddy County, New Mexico

July 17, 2017

Terracon Project No. A4175030 – Task 2

Prepared for:

CDM Smith

Houston, Texas

Prepared by:

Terracon Consultants, Inc.

Midland, Texas

terracon.com

Terracon

Environmental ■ Facilities ■ Geotechnical ■ Materials

July 17, 2017

Terracon

CDM Smith
11490 Westheimer Road, Suite 700
Houston, Texas 77077

Attn: Mr. Jason A. Vickery, P.E.
Senior Project Manager
P: 713.252.5488
M: 713.423.7314
E: vickeryja@cdmsmith.com

Re: Geotechnical Data Report
Proposed Water Impoundments Facility – North PLU Site
Rawhide Road and New Mexico Highway 128 (NM-128)
Loving, Eddy County, New Mexico
Terracon Project Number: A4175030 – Task 2

Dear Mr. Vickery:

Terracon Consultants, Inc. (Terracon) has completed the geotechnical engineering services for the above referenced project. This study was performed in general accordance with our proposal PA4175030, dated May 4, 2017 and agreement between Terracon and CDM Smith, dated May 15, 2017. This report presents the findings of subsurface exploration and provides geotechnical engineering data for this project.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.
Texas Registration #3272

Jitendra "JT" Thakur, Ph.D., P.E. (Texas)
Geotechnical Department Manager

J. Dan Cosper, P.E.
Senior Associate

Enclosures
Copies Submitted: Addressee: (1) Electronic

TABLE OF CONTENTS

GEOTECHNICAL DATA REPORT
PROPOSED WATER IMPOUNDMENTS FACILITY – NORTH PLU SITE
LOVING, EDDY COUNTY, NEW MEXICO

Terracon Project No. A4175030 – Task 2

July 17, 2017

1.0 INTRODUCTION

A Water Impoundments Facility will be constructed at North PLU Site that is located about 7.9 miles south of the intersection of Rawhide Road and NM-128 in Eddy County, NM. Our scope of services included drilling and sampling two (2) borings to depths of approximately 75 feet below existing ground surface (bgs), laboratory testing, field testing, and boring log preparation. The purpose of these services is to provide information and geotechnical data relative to:

- subsurface material conditions
- seismic site classification
- groundwater conditions

2.0 PROJECT INFORMATION

2.1 Project Description

Item	Description
Proposed Construction	Two water impoundments with a common berm will be constructed at the North PLU Site. The combined storage capacity and bottom width of these impoundments will be about 572 KBBL and 250 feet, respectively. The side slope and depth of each impoundment will be 3H:1V and 18 feet without free board (20 feet with freeboard), respectively.

2.2 Site Location and Description

Item	Description
Location	The North PLU Site is located about 7.9 miles south of the intersection of Rawhide Road and NM-128 in Loving, Eddy County, NM. The GPS coordinates of approximate center of the project site are 32.246667°N, 103.916641°W.
Existing improvements	None
Current ground cover	Exposed soil with shrubs and native grasses

Item	Description
Existing topography	The project site appears to be relatively level; however, the surrounding area slopes gently downwards from the northeast towards the southwest based on a USGS quadrangle map shown on Exhibit A-1 of this report.

Should any of the above information or assumptions be inconsistent with the planned construction, please let us know so that we may make any necessary modifications to this report.

3.0 SUBSURFACE CONDITIONS

3.1 Typical Profile

Conditions encountered at the boring locations are indicated on the boring logs. Stratification boundaries on the boring logs represent the approximate locations of changes in soil types; in-situ, the transition between materials may be gradual. Details for the boring locations can be found on the boring logs in Appendix A of this report. Based on the results of the borings, subsurface conditions at the project site can be generalized as follows:

Description	Approximate Depth to Bottom of Stratum (feet)	Material Encountered	Relative Density/ Consistency
Stratum I	6 to 8	Poorly Graded Sand with Silt; brown to reddish-brown	Very loose to Medium Dense[2]
Stratum II	15 to 25	Silty Sand; reddish-brown to tan and white	Medium Dense to Very Dense[3]
Stratum III	31 to 41	Poorly Graded Sand[1]/Sandy Silt; reddish-brown to tan	Dense/Hard[4]
Stratum IV	52 to 75[1]	Silty Sand or Poorly Graded Sand with Silt; reddish-brown to tan	Very Dense[5]
Stratum V	75[1]	Silty Clayey Sand with Gravel; reddish-brown	Very Dense[6]

[1]Borings were terminated within this stratum at the planned termination depth of approximately 75 feet bgs.

[2]Very loose to medium dense soils with standard penetration resistances (N-values) of 2 blows per foot (bpf) to 19 bpf were encountered in this stratum.

[3]Medium dense to very dense soils with N-values of 14 bpf to more than 100 bpf were encountered in this stratum.

[4]Dense or hard soils with N-values of 43 bpf to more than 100 bpf were encountered in this stratum.

[5]Very dense soils with N-values of 70 bpf to more than 100 bpf were encountered in this stratum.

[6]Very dense soils with N-values of more than 100 bpf were encountered in this stratum.

3.2 Groundwater

The borings were advanced in the dry using continuous flight auger drilling techniques that allow short-term groundwater observations to be made while drilling. Groundwater seepage was not observed during or at the completion of drilling.

These groundwater observations provide an indication of the groundwater conditions present at the time the borings were drilled. Groundwater conditions may be different at the time of construction because of seasonal variations in rainfall, runoff, irrigation, and other conditions not apparent at the time of drilling.

4.0 SEISMIC CONSIDERATIONS

Code Used	Site Classification
2012 International Building Code (IBC)[1]	C[2]

[1]In general accordance with the 2012 International Building Code, Section 1613.3.2

[2]The 2012 International Building Code (IBC) requires a site soil profile determination extending a depth of 100 feet for seismic site classification. The current scope requested does not include the required 100 foot soil profile determination. The borings were extended to maximum depths of approximately 75 feet bgs and this seismic site class definition considers that hard or very dense soils are below the maximum depth of the subsurface exploration. Additional exploration to deeper depths would be required to confirm the conditions below the current depth of exploration. Alternatively, a geophysical exploration could be utilized in order to attempt to justify a higher seismic site class.

5.0 GENERAL COMMENTS

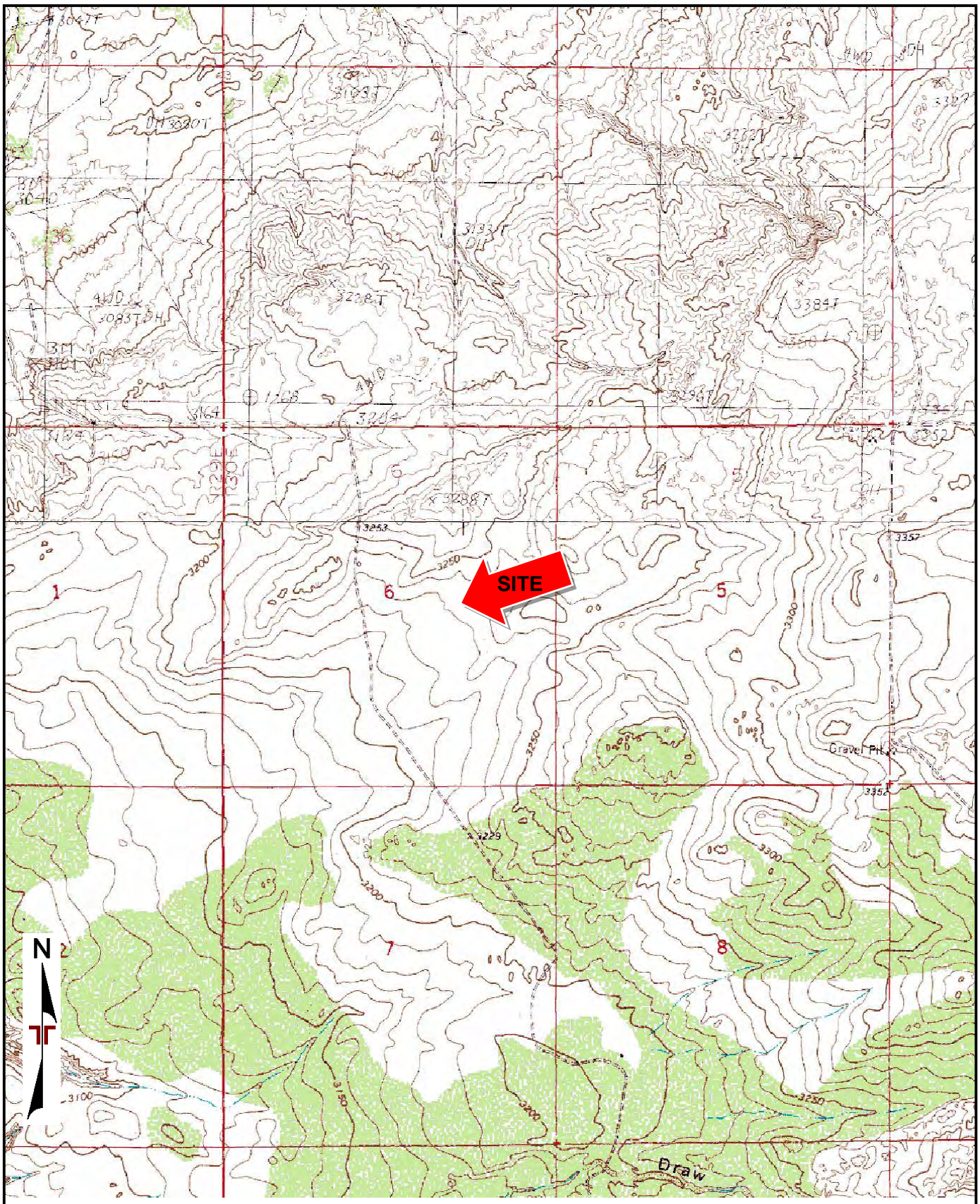
The data presented in this report are based upon the information obtained from the borings performed at the indicated locations and from other information discussed in this report. This report does not reflect variations that may occur across the site or due to the modifying effects of weather. The nature and extent of such variations may not become evident until during or after construction. If significant variations become apparent, it will be necessary to reevaluate the suitability of the site conditions for the proposed project.

The scope of services for this project does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

This report has been prepared for the exclusive use of our client for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranties, express or implied, are intended or made. Site safety, excavation support, and dewatering requirements are the responsibility of others. In the event that

changes in the nature, design, or location of the project as outlined in this report are planned, the data contained in this report shall not be considered valid unless Terracon reviews the changes and either verifies or modifies the data of this report in writing.

APPENDIX A
FIELD EXPLORATION



TOPOGRAPHIC MAP IMAGE COURTESY OF THE U.S. GEOLOGICAL SURVEY
QUADRANGLES INCLUDE: REMUDA BASIN, NM (1/1/1985) and PIERCE CANYON, NM (1/1/1968).

Project Manager: JT	Project No. A4175030	Terracon 10400 State Highway 191 Midland, TX 79707-1497	SITE LOCATION PLAN	Exhibit
Drawn by: JT	Scale: 1"=2,000'		Proposed Water Impoundments – North PLU **Rawhide Road and NM-128** **Loving, Eddy County, NM**	A-1
Checked by: JS	File Name: SLP/EP			
Approved by: JS	Date: 7/13/2017			

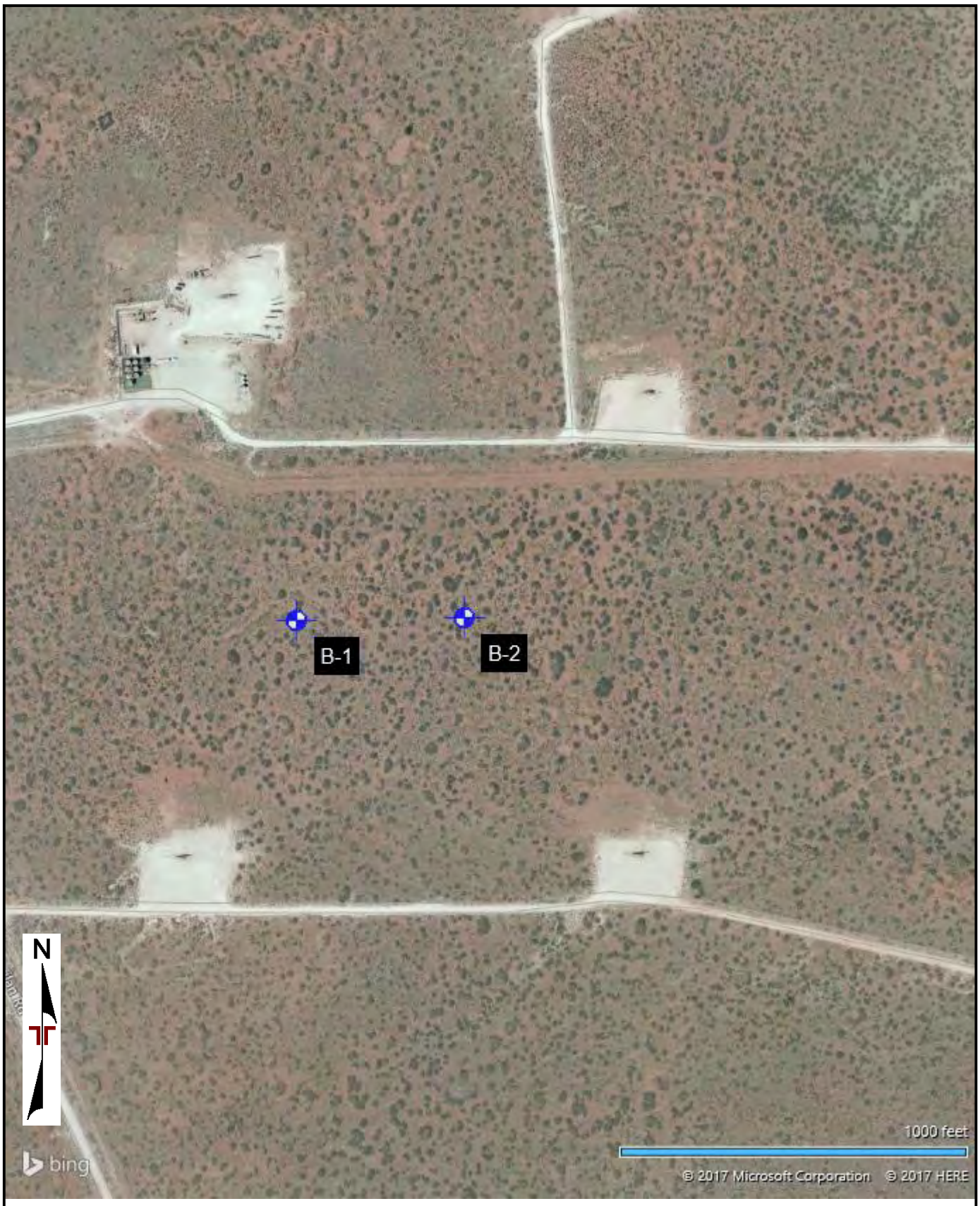


DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

AERIAL PHOTOGRAPHY PROVIDED BY MICROSOFT BING MAPS

Project Manager:	JT
Drawn by:	JT
Checked by:	JS
Approved by:	JS

Project No.	A4175030
Scale:	AS SHOWN
File Name:	SLP/EP
Date:	7/13/2017

Terracon
10400 State Highway 191
Midland, TX 79707-1497

EXPLORATION PLAN

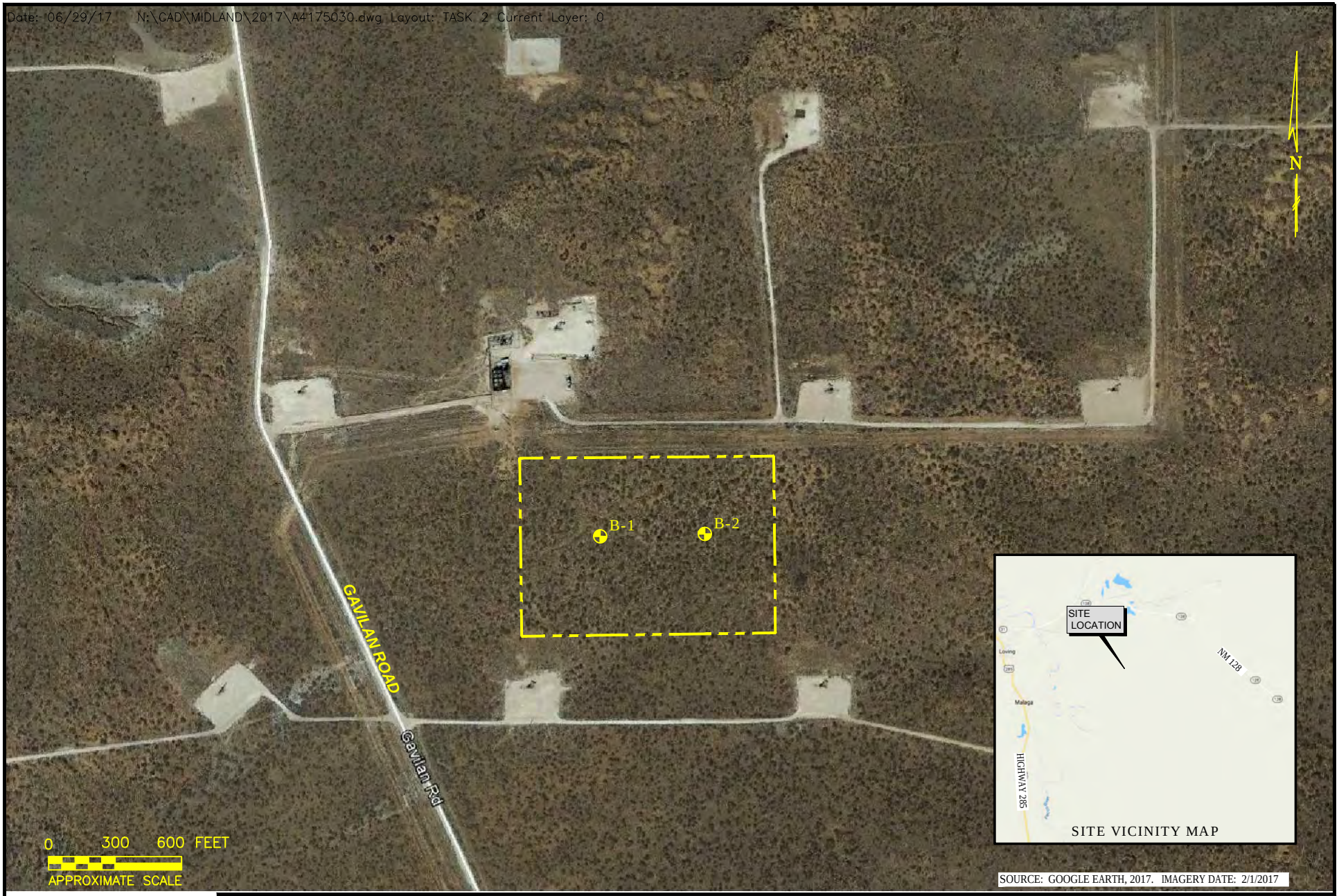
Proposed Water Impoundments – North PLU

Rawhide Road and NM-128
Loving, Eddy County, NM

Exhibit

A-2

Date: 06/29/17 N:\CAD\MIDLAND\2017\A4175030.dwg Layout: TASK 2 Current Layer: 0



SOURCE: GOOGLE EARTH, 2017. IMAGERY DATE: 2/1/2017

THIS DRAWING SHOULD NOT BE USED SEPARATELY FROM ORIGINAL REPORT.

NOTE: ALL BORING LOCATIONS ARE APPROXIMATE.

Project Mngr:	JT
Drawn By:	CDD
Checked By:	JT
Approved By:	JS

Project No.	A4175030-2
Scale:	AS SHOWN
Date:	06/29/17

Terracon
Consulting Engineers and Scientists
(Registration No.: F-3272)
10400 STATE HIGHWAY 191 MIDLAND, TX 79707
PH. (432-296-4142) FAX. (432-684-9608)

BORING LOCATION PLAN

PROPOSED WATER IMPOUNDMENTS - NORTH PLU SITE
RAWHIDE ROAD AND NM-128
LOVING, EDDY COUNTY, NEW MEXICO

EXHIBIT

A-3

Field Exploration Description

Subsurface conditions were explored by drilling two (2) borings at the approximate locations indicated on the Exploration Plan and Boring Location Plan presented on Exhibits A-2 and A-3 in this appendix. The field exploration was performed on June 20, 2017. The test locations were established in the field by a representative of CDM Smith and verified by a representative of Terracon by measuring from available reference features and using a handheld GPS device. The boring locations should be considered accurate only to the degree implied by the methods employed to determine them.

The borings were performed using a truck-mounted drill rig, utilizing continuous flight auger drilling techniques. Samples of the soils encountered in the borings were obtained using split-spoon sampling procedures in accordance with standard penetration tests, utilizing an automatic hammer. The samples were tagged for identification, sealed to reduce moisture loss, and taken to the laboratory for further examination, testing, and classification. Following the completion of drilling, the borings were backfilled with soil cuttings.

A CME automatic SPT hammer was used to advance the split-barrel sampler in the borings performed on this site. A greater efficiency is typically achieved with the automatic hammer compared to the conventional safety hammer operated with a cathead and rope. Published correlations between the SPT values and soil properties are based on the lower efficiency cathead and rope method. This higher efficiency affects the standard penetration resistance blow count (N) value by increasing the penetration per hammer blow over what would be obtained using the cathead and rope method. The effect of the automatic hammer's efficiency has been considered in the interpretation and analysis of the subsurface information for this report.

Field logs of the borings were prepared by a representative of Terracon. The logs included visual classifications of the materials encountered as well as interpretation of the subsurface conditions between samples. The boring logs included with this report represent the engineer’s interpretation of the field logs and include modifications based on laboratory evaluation of the samples. The boring logs are presented on Exhibits A-5 and A-6 in this appendix. General notes to log terms and symbols and other supporting documentation are included in Appendix C.

BORING LOG NO. B-1

PROJECT: Proposed Water Impoundments - North PLU Site

CLIENT: CDM Smith
Houston, Texas

SITE: South of Rawhide Road and NM-128
Loving, Eddy County, NM

Vickery, Jason A.

LOCATION See Exhibit A-4

Latitude: 32.246736° Longitude: -103.917558°

Approximate Surface Elev: 3235 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	DESCRIPTION
0	3235+/-	**POORLY GRADED SAND WITH SILT (SP-SM)**, brown to reddish-brown, very loose -loose at 2' -medium dense below 4'
8.0	3227+/-	**SILTY SAND (SM)**, reddish-brown to tan, very dense -dense below 13'
25.0	3210+/-	**POORLY GRADED SAND (SP)**, reddish-brown to tan, dense
41.0	3194+/-	**POORLY GRADED SAND WITH SILT, locally called "CALICHE" (SP-SM)**, reddish-brown, very dense
75.0	3160+/-	***Boring Terminated at 75 Feet***

DEPTH (Ft.)	SAMPLE TYPE	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
0					
5		1-1-1 N=2	1	NP	6
		1-1-3 N=4			
		6-9-10 N=19		NP	15
10		8-10-8 N=18	5	NP	16
		12-39-50 N=89			
15		13-17-22 N=39			
		11-17-30 N=47			
20					
25		10-20-27 N=47			
		13-19-24 N=43			
30					
35		9-18-25 N=43	1	NP	5
		14-17-30 N=47			
40					
45		25-40-50/5"			
		18-24-30 N=54			
50					
55		12-24-33 N=57			
		17-26-34 N=60			
60					
65		20-37-50/5"	1	NP	8
		32-50			
70					
75		50/5"			

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with soil cuttings

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations Obtained from Google Earth

Notes:
NP = Non-Plastic

WATER LEVEL OBSERVATIONS

No Groundwater Encountered During Drilling

Dry At Completion

Terracon
10400 State Highway 191
Midland, TX

Boring Started: 6/20/2017 Boring Completed: 6/20/2017

Drill Rig: CME 55 Driller: Leo

Project No.: A4175030 - Task 2 Exhibit: A-5

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL A4175030 TASK 2 PROPOSED WATER IM.GPJ TERRACON_DATATEMPLATE.GDT 7/14/17

BORING LOG NO. B-2

PROJECT: Proposed Water Impoundments - North PLU Site

CLIENT: CDM Smith Houston, Texas

SITE: South of Rawhide Road and NM-128 Loving, Eddy County, NM

Vickery, Jason A.

LOCATION See Exhibit A-4

Latitude: 32.246757° Longitude: -103.915989°

Approximate Surface Elev: 3243 (Ft.) +/-

DEPTH	ELEVATION (Ft.)	Description	DEPTH (Ft.)	FIELD TEST RESULTS	WATER CONTENT (%)	ATTERBERG LIMITS LL-PL-PI	PERCENT FINES
		POORLY GRADED SAND WITH SILT (SP-SM), brown to reddish-brown, very loose		1-1-1			
		-loose below 2'		N=2	2	NP	9
				1-2-4			
6.0	3237+/-		5	N=6			
		SILTY SAND (SM), reddish-brown to tan and white, medium dense		1-3-5	4	NP	14
		-very dense material, locally called "caliche" below 8'		N=8		NP	14
			10	6-7-7			
				N=14			
				9-40-50/5"			
15.0	3228+/-		15	18-33-28			
		SANDY SILT, locally called "CALICHE" (ML), reddish tan, hard		N=61			
			20	15-34-50			
				N=84			
			25	19-43-50/4"	5	20-17-3	50
31.0	3212+/-		30	28-36-48			
		SILTY SAND, locally called "CALICHE" (SP), reddish-brown to tan, very dense		N=84			
			35	18-31-39			
				N=70			
			40	19-38-44			
				N=82			
			45	21-34-37			
				N=71			
52.0	3191+/-		50	25-41-50	5	NP	34
		SILTY CLAYEY SAND WITH GRAVEL, locally called "CALICHE", reddish-brown, very dense		N=91			
			55	21-50/5"			
			60	34-50/5"			
			65	50/4"			
			70	50/5"	4	21-16-5	33
75.0	3168+/-		75	39-50/5"			
		Boring Terminated at 75 Feet					

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Continuous Flight Auger

Abandonment Method:
Boring backfilled with soil cuttings

See Exhibit A-3 for description of field procedures.
See Appendix B for description of laboratory procedures and additional data (if any).
See Appendix C for explanation of symbols and abbreviations.
Elevations Obtained from Google Earth

Notes:
NP = Non-Plastic

WATER LEVEL OBSERVATIONS

No Groundwater Encountered During Drilling

Dry At Completion

Terracon
10400 State Highway 191
Midland, TX

Boring Started: 6/20/2017 Boring Completed: 6/20/2017

Drill Rig: CME 55 Driller: Leo

Project No.: A4175030 - Task 2 Exhibit: A-6

THIS BORING LOG IS NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GEO SMART LOG-NO WELL A4175030 TASK 2 PROPOSED WATER IM.GPJ TERRACON_DATATEMPLATE.GDT 7/14/17

APPENDIX B
LABORATORY TESTING

Laboratory Testing

The boring logs and samples were reviewed by a geotechnical engineer who selected soil samples for testing. Tests were performed by technicians working under the direction of the engineer. A brief description of the tests performed follows.

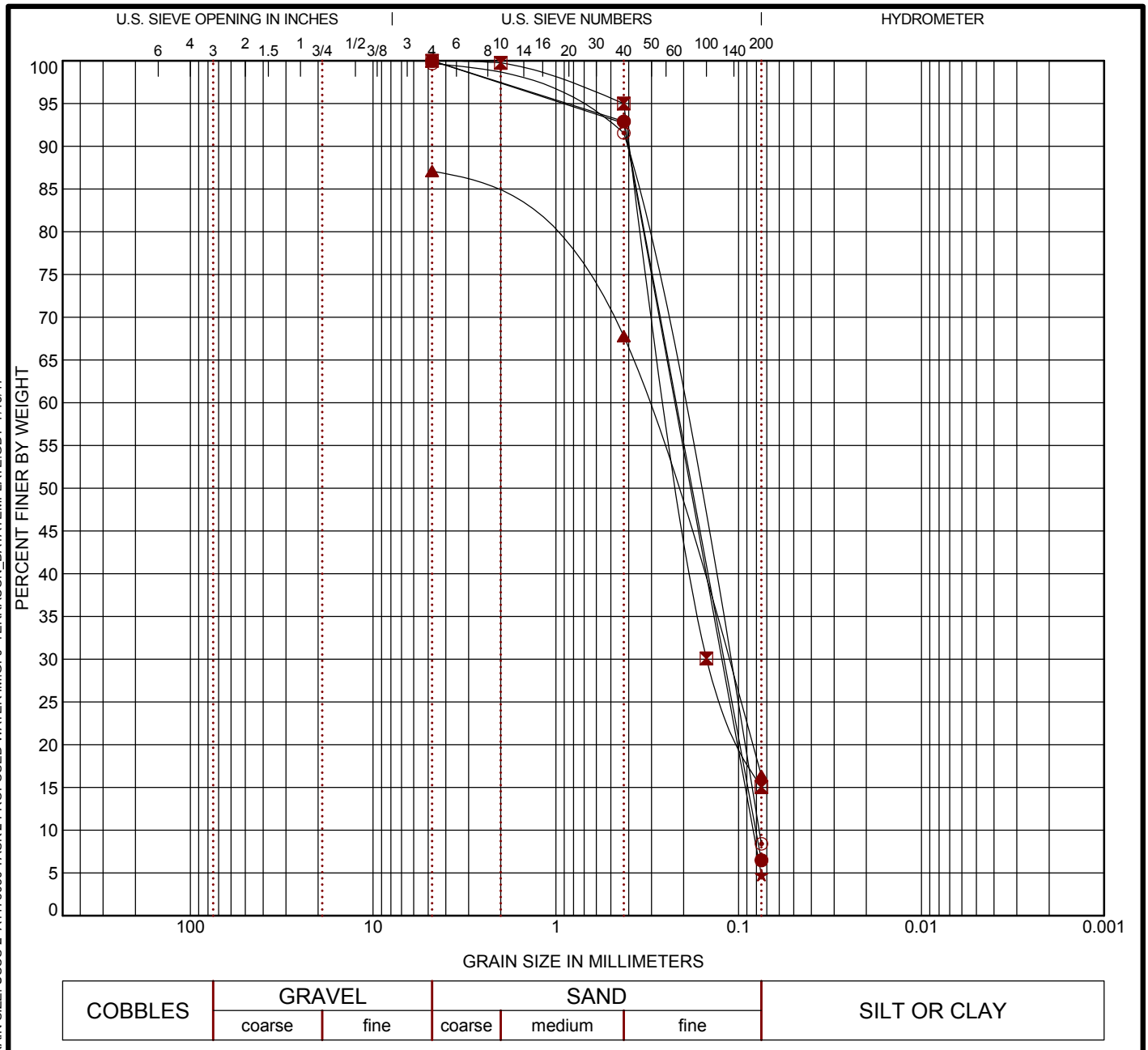
Particle size analysis (ASTM D422), liquid and plastic limit tests (ASTM D4318), and moisture content tests (ASTM D2216) were made to aid in classifying the soils in accordance with the Unified Soil Classification System (USCS). The USCS is summarized on Exhibit C-2 in Appendix C. The results of the laboratory tests are presented on the boring logs in Appendix A. The grain size distribution results are also shown on exhibits B-2 through B-4 of this appendix.

Modified Proctor tests (ASTM D1557) were performed on a bulk soil samples collected from depths of 8 to 10 feet bgs of borings B-1 and B-2. The modified Proctor test results are included on Exhibits B-5 and B-6 in this appendix.

Procedural standards noted above are for reference to methodology in general. In some cases variations to methods are applied as a result of local practice or professional judgment.

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
B-1	0 - 1.5	POORLY GRADED SAND with SILT (SP-SM)		NP	NP	NP	0.82	2.73
B-1	8	SILTY SAND (SM)		NP	NP	NP		
B-1	8.5 - 10	SILTY SAND (SM)		NP	NP	NP		
B-1	33.5 - 35	POORLY GRADED SAND (SP)		NP	NP	NP	0.82	2.68
B-1	63.5 - 64.9	POORLY GRADED SAND with SILT (SP-SM)		NP	NP	NP	0.81	2.84

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
B-1	0 - 1.5	4.75	0.22	0.12	0.08	0.0	93.5		6.5	
B-1	8	4.75	0.242	0.149		0.0	85.0		15.0	
B-1	8.5 - 10	4.75	0.327	0.119		0.0	70.7		16.4	
B-1	33.5 - 35	4.75	0.223	0.123	0.083	0.0	95.3		4.7	
B-1	63.5 - 64.9	4.75	0.22	0.118	0.078	0.0	91.3		8.4	

PROJECT: Proposed Water Impoundments - North PLU Site

SITE: South of Rawhide Road and NM-128 Loving, Eddy County, NM

Terracon
10400 State Highway 191
Midland, TX

PROJECT NUMBER: A4175030 - Task 2

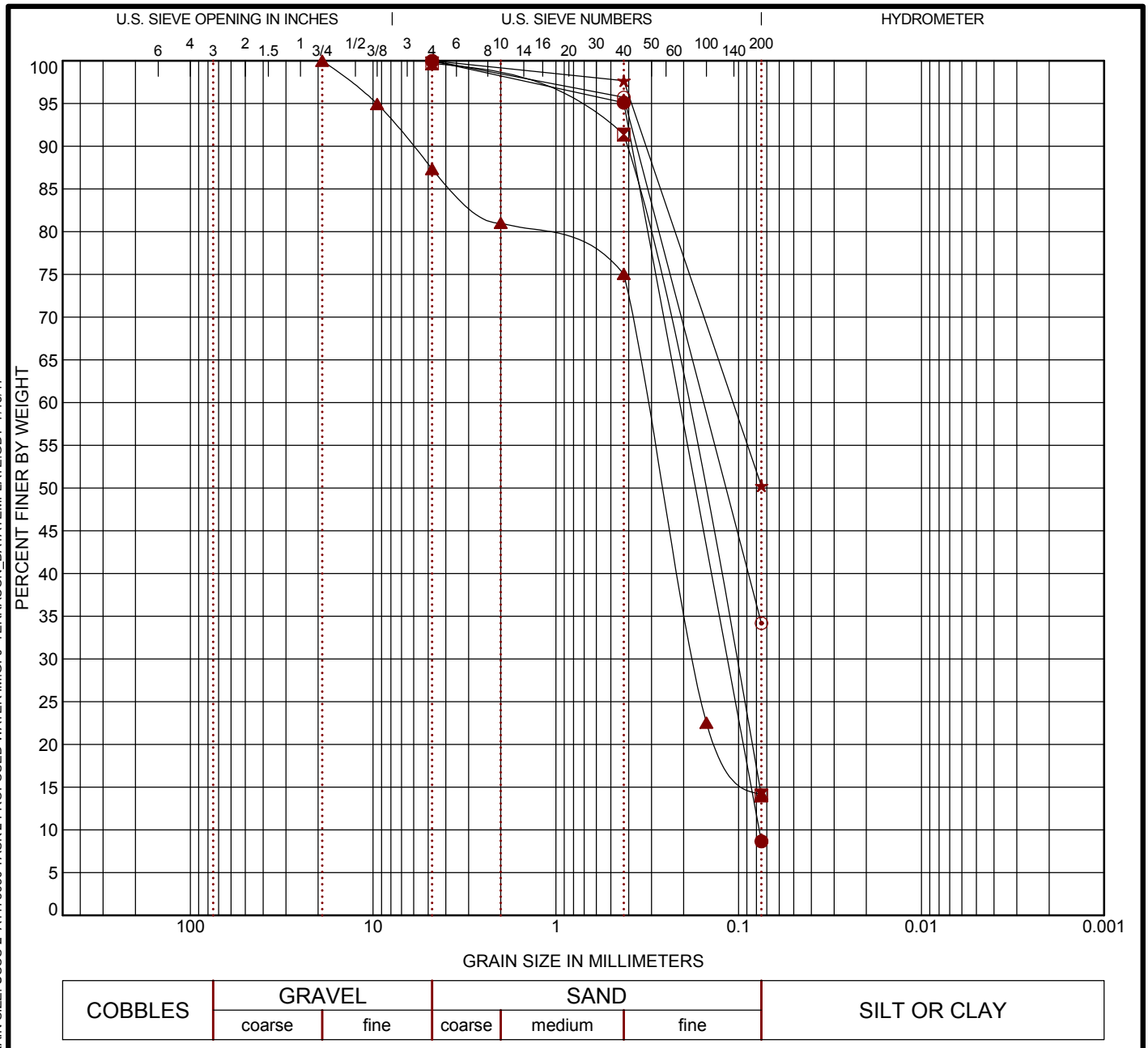
CLIENT: CDM Smith
Houston, Texas

EXHIBIT: B-2

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 A4175030 TASK 2 PROPOSED WATER IM.GPJ TERRACON_DATATEMPLATE.GDT 7/13/17

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
B-2	2 - 3.5	POORLY GRADED SAND with SILT (SP-SM)		NP	NP	NP	0.82	2.73
B-2	6 - 7.5	SILTY SAND (SM)		NP	NP	NP		
B-2	8	SILTY SAND (SM)		NP	NP	NP		
B-2	23.5 - 24.8	SANDY SILT (ML)		20	17	3		
B-2	48.5 - 50	SILTY SAND (SM)		15	15	NP		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
B-2	2 - 3.5	4.75	0.21	0.115	0.077	0.0	91.3		8.7	
B-2	6 - 7.5	4.75	0.21	0.107		0.0	85.7		14.0	
B-2	8	19	0.315	0.174		12.7	73.2		14.2	
B-2	23.5 - 24.8	4.75	0.107			0.0	49.7		50.3	
B-2	48.5 - 50	4.75	0.155			0.0	65.8		34.2	

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PROJECT NUMBER: A4175030 - Task 2

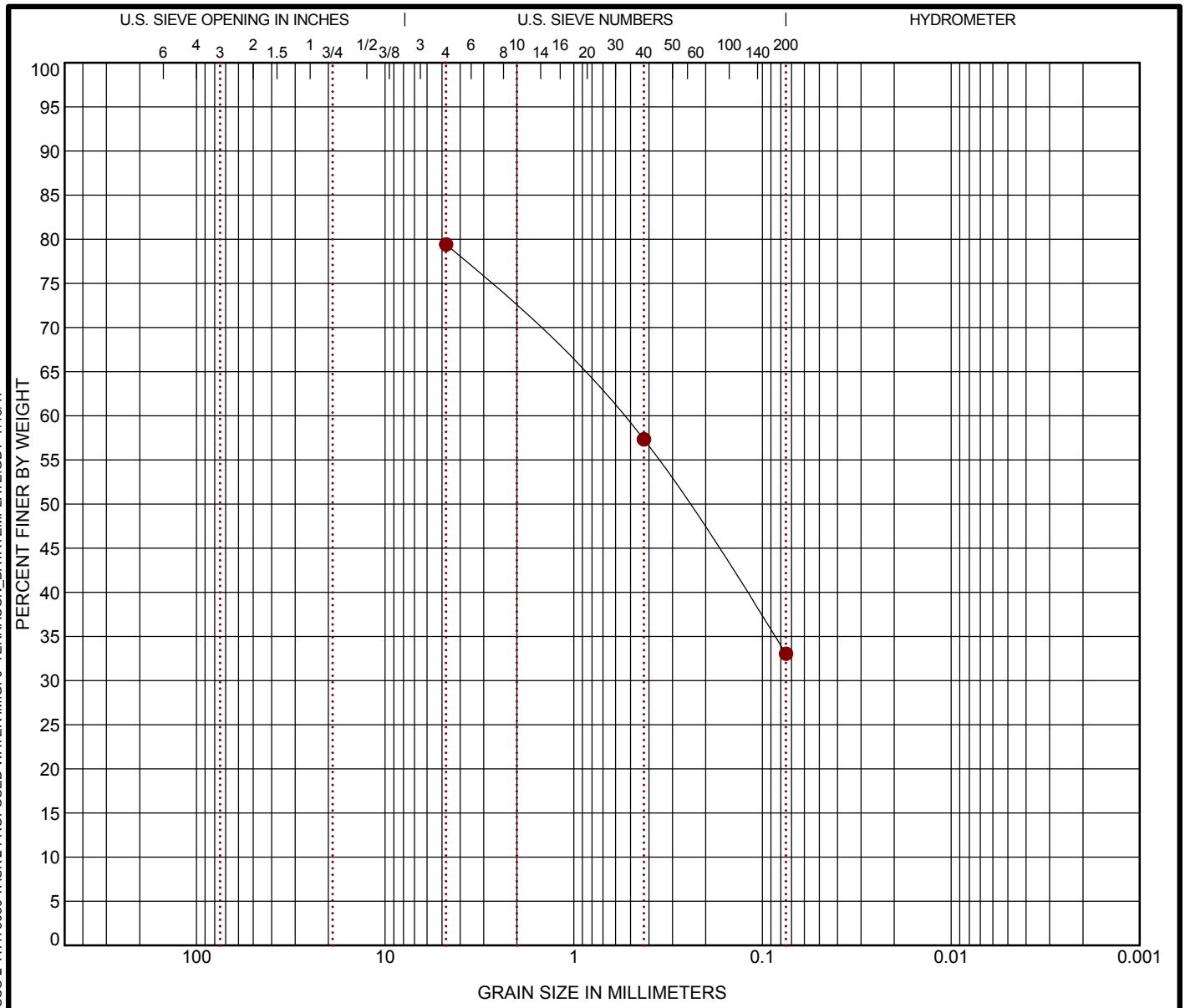
CLIENT: CDM Smith
Houston, Texas

EXHIBIT: B-3

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 A4175030 TASK 2 PROPOSED WATER IM.GPJ TERRACON_DATATEMPLATE.GDT 7/13/17

GRAIN SIZE DISTRIBUTION

ASTM D422 / ASTM C136



Boring ID	Depth	USCS Classification	WC (%)	LL	PL	PI	Cc	Cu
B-2	68.5 - 68.9	SILTY, CLAYEY SAND with GRAVEL (SC-SM)		21	16	5		

Boring ID	Depth	D_{100}	D_{60}	D_{30}	D_{10}	%Gravel	%Sand	%Silt	%Fines	%Clay
B-2	68.5 - 68.9	4.75	0.569			0.0	46.4		33.0	

PROJECT: Proposed Water Impoundments - North PLU Site

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10400 State Highway 191
Midland, TX

PROJECT NUMBER: A4175030 - Task 2

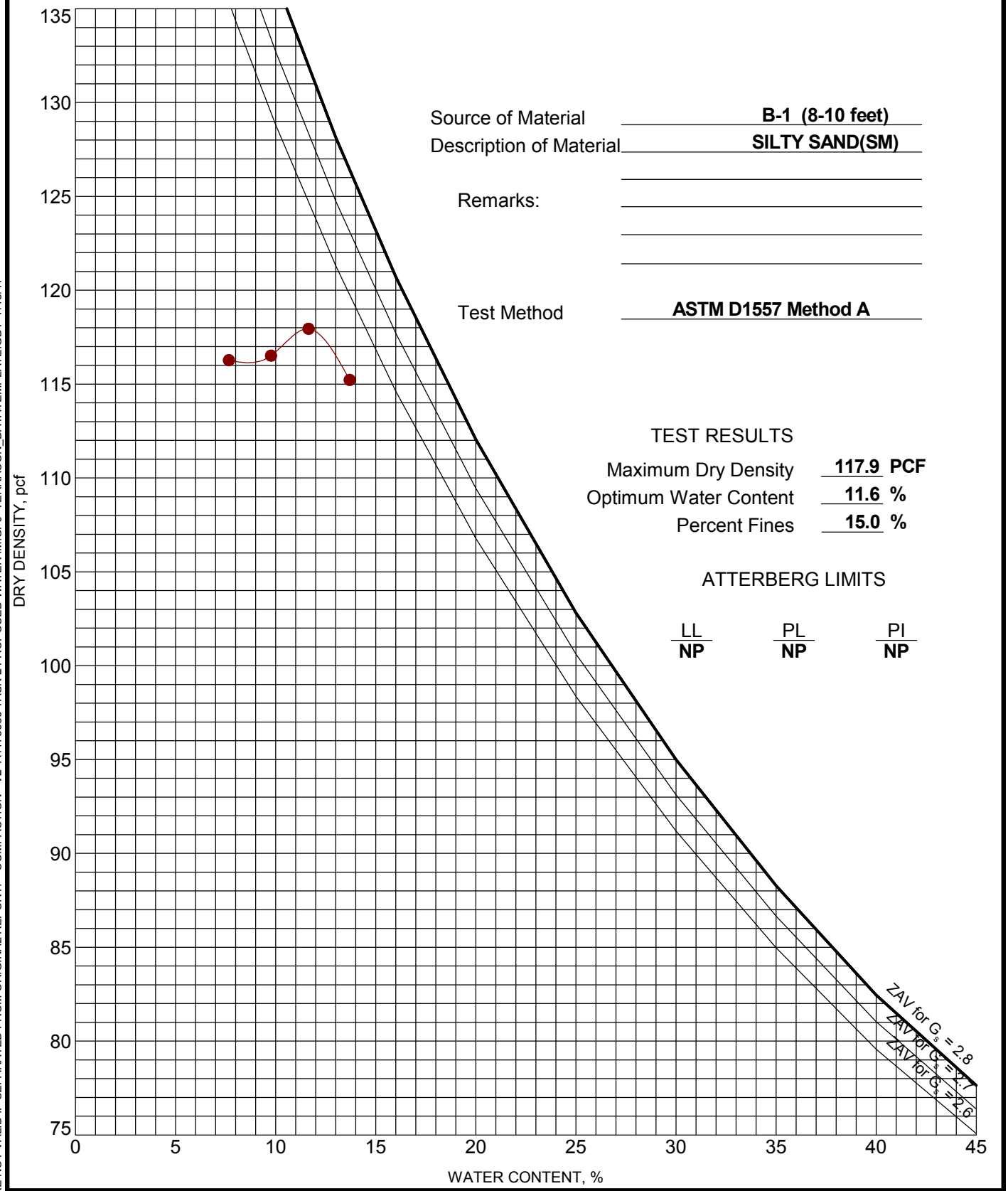
CLIENT: CDM Smith
Houston, Texas

EXHIBIT: B-4

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. GRAIN SIZE: USCS-2 A4175030 TASK 2 PROPOSED WATER IM.GPJ TERRACON_DATATEMPLATE.GDT 7/13/17

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **B-1 (8-10 feet)**

Description of Material: **SILTY SAND(SM)**

Remarks:

Test Method: **ASTM D1557 Method A**

TEST RESULTS

Maximum Dry Density	**117.9**	**PCF**
Optimum Water Content	**11.6**	**%**
Percent Fines	**15.0**	**%**

ATTERBERG LIMITS

LL	PL	PI
NP	**NP**	**NP**

PROJECT: Proposed Water Impoundments - North PLU Site

SITE: South of Rawhide Road and NM-128 Loving, Eddy County, NM

Terracon
10400 State Highway 191
Midland, TX

PROJECT NUMBER: A4175030 - Task 2

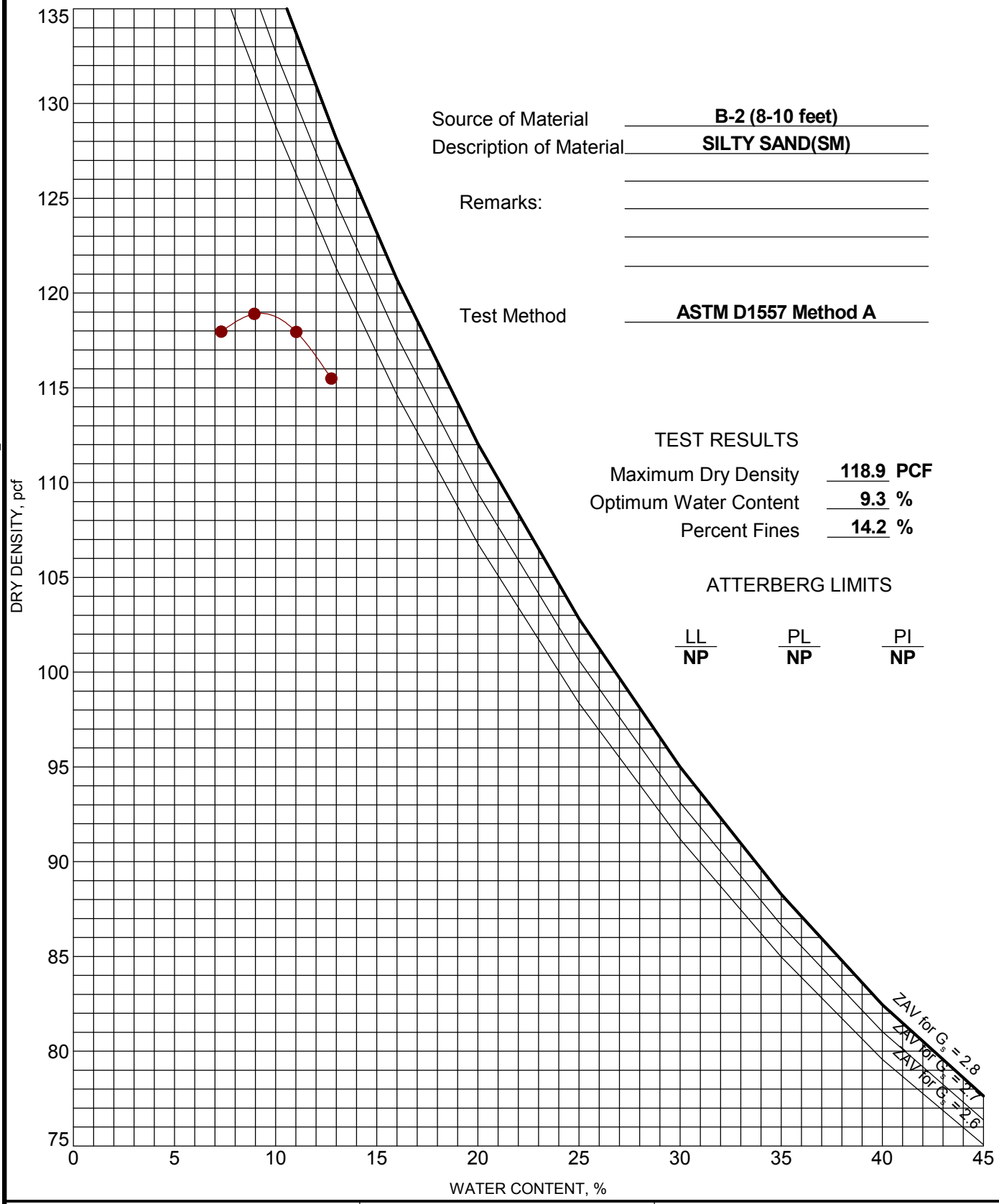
CLIENT: CDM Smith
Houston, Texas

EXHIBIT: B-5

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 A4175030 TASK 2 PROPOSED WATER IM.GPJ TERRACON_DATATEMPLATE.GDT 7/13/17

MOISTURE-DENSITY RELATIONSHIP

ASTM D698/D1557



Source of Material: **B-2 (8-10 feet)**

Description of Material: **SILTY SAND(SM)**

Remarks:

Test Method: **ASTM D1557 Method A**

TEST RESULTS

Maximum Dry Density	**118.9**	**PCF**
Optimum Water Content	**9.3**	**%**
Percent Fines	**14.2**	**%**

ATTERBERG LIMITS

LL	PL	PI
NP	**NP**	**NP**

PROJECT: Proposed Water Impoundments - North PLU Site

SITE: South of Rawhide Road and NM-128 Loving, Eddy County, NM

Terracon
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Midland, TX

PROJECT NUMBER: A4175030 - Task 2

CLIENT: CDM Smith
Houston, Texas

EXHIBIT: B-6

LABORATORY TESTS ARE NOT VALID IF SEPARATED FROM ORIGINAL REPORT. COMPACTION - V2 A4175030 TASK 2 PROPOSED WATER IM.GPJ TERRACON_DATATEMPLATE.GDT 7/13/17

APPENDIX C
SUPPORTING DOCUMENTS

GENERAL NOTES

DESCRIPTION OF SYMBOLS AND ABBREVIATIONS

SAMPLING

Split Spoon

WATER LEVEL

Water Initially Encountered

Water Level After a Specified Period of Time

Water Level After a Specified Period of Time

Water levels indicated on the soil boring logs are the levels measured in the borehole at the times indicated. Groundwater level variations will occur over time. In low permeability soils, accurate determination of groundwater levels is not possible with short term water level observations.

FIELD TESTS

N	**Standard Penetration Test Resistance (Blows/Ft.)**
(TC)	**TxDOT Cone Penetration Test (blows per Foot)**
(HP)	**Hand Penetrometer**
(T)	**Torvane**
(DCP)	**Dynamic Cone Penetrometer**
(PID)	**Photo-Ionization Detector**
(OVA)	**Organic Vapor Analyzer**

DESCRIPTIVE SOIL CLASSIFICATION

Soil classification is based on the Unified Soil Classification System. Coarse Grained Soils have more than 50% of their dry weight retained on a #200 sieve; their principal descriptors are: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are principally described as clays if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse-grained soils are defined on the basis of their in-place relative density and fine-grained soils on the basis of their consistency.

LOCATION AND ELEVATION NOTES

Unless otherwise noted, Latitude and Longitude are approximately determined using a hand-held GPS device. The accuracy of such devices is variable. Surface elevation data annotated with +/- indicates that no actual topographical survey was conducted to confirm the surface elevation. Instead, the surface elevation was approximately determined from topographic maps of the area.

STRENGTH TERMS

RELATIVE DENSITY OF COARSE-GRAINED SOILS (More than 50% retained on No. 200 sieve.) Density determined by Standard Penetration Resistance		**CONSISTENCY OF FINE-GRAINED SOILS** (50% or more passing the No. 200 sieve.) Consistency determined by laboratory shear strength testing, field visual-manual procedures or standard penetration resistance		
Descriptive Term (Density)	**Standard Penetration or N-Value Blows/Ft.**	**Descriptive Term (Consistency)**	**Unconfined Compressive Strength Qu, (psf)**	**Standard Penetration or N-Value Blows/Ft.**
Very Loose	0 - 3	Very Soft	less than 500	0 - 1
Loose	4 - 9	Soft	500 to 1,000	2 - 4
Medium Dense	10 - 29	Medium Stiff	1,000 to 2,000	4 - 8
Dense	30 - 50	Stiff	2,000 to 4,000	8 - 15
Very Dense	> 50	Very Stiff	4,000 to 8,000	15 - 30
		Hard	> 8,000	> 30

RELATIVE PROPORTIONS OF SAND AND GRAVEL

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 15
With	15 - 29
Modifier	> 30

GRAIN SIZE TERMINOLOGY

Major Component of Sample	Particle Size
Boulders	Over 12 in. (300 mm)
Cobbles	12 in. to 3 in. (300mm to 75mm)
Gravel	3 in. to #4 sieve (75mm to 4.75 mm)
Sand	#4 to #200 sieve (4.75mm to 0.075mm
Silt or Clay	Passing #200 sieve (0.075mm)

RELATIVE PROPORTIONS OF FINES

Descriptive Term(s) of other constituents	Percent of Dry Weight
Trace	< 5
With	5 - 12
Modifier	> 12

PLASTICITY DESCRIPTION

Term	Plasticity Index
Non-plastic	0
Low	1 - 10
Medium	11 - 30
High	> 30

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Exhibit: C-1

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]					Soil Classification	
					Group Symbol	Group Name [B]
Coarse Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu ≥ 4 and 1 ≤ Cc ≤ 3 [E]		GW	Well-graded gravel [F]
			Cu < 4 and/or 1 > Cc > 3 [E]		GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH		GM	Silty gravel [F,G,H]
			Fines classify as CL or CH		GC	Clayey gravel [F,G,H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu ≥ 6 and 1 ≤ Cc ≤ 3 [E]		SW	Well-graded sand [I]
			Cu < 6 and/or 1 > Cc > 3 [E]		SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH		SM	Silty sand [G,H,I]
			Fines classify as CL or CH		SC	Clayey sand [G,H,I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots on or above "A" line [J]		CL	Lean clay [K,L,M]
			PI < 4 or plots below "A" line [J]		ML	Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OL	Organic clay [K,L,M,N]
			Liquid limit - not dried			Organic silt [K,L,M,O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line		CH	Fat clay [K,L,M]
			PI plots below "A" line		MH	Elastic Silt [K,L,M]
		Organic:	Liquid limit - oven dried	< 0.75	OH	Organic clay [K,L,M,P]
			Liquid limit - not dried			Organic silt [K,L,M,Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor				PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.

[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \dfrac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15% sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

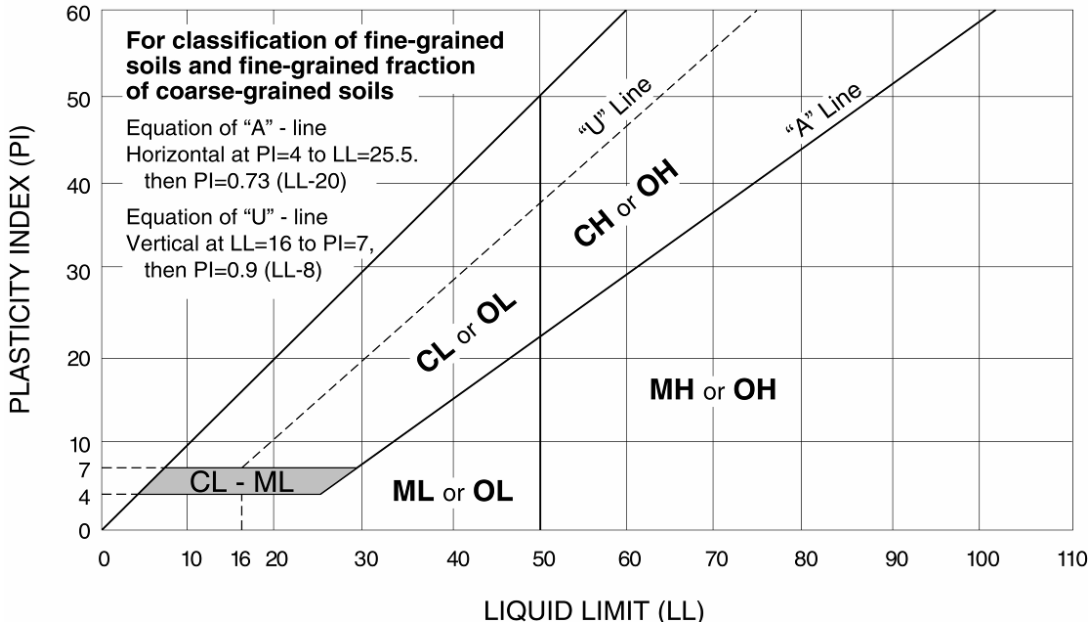

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Exhibit C-2