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Nevada Department of Transportation

Report No. 494-24-803

Development of Alternative Desert Tortoise Crossing Criteria and Designs

June 2026

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16. Abstract

The primary goal of this project is to improve desert tortoise connectivity and crossings by developing creative site-specific designs, including implementation-ready plans, specifications, and estimates for the retrofit of four culverts along SR160. The Desert Conservation Program (DCP) considers the selected culverts as grades 3 or 5 which characterizes the locations as either impassable or with conditions that are either difficult and/or hazardous for desert tortoise passage. The goals/deliverables for this Project are:

- Identify four culvert crossings along Nevada State Route 160 (SR160) to evaluate and retrofit into desert tortoise culvert crossings with minimal to low maintenance requirements
- Obtain topographical surveys to develop designs and plans
- Produce final report documents that provide details and a summary of the design efforts performed
- Provide implementation-ready construction plans, specifications, and cost estimates

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AtkinsRéalis

Final Design Report

Nevada Department of Transportation
June 2026
NDOT Agreement #: 494-24-803

DEVELOPMENT OF ALTERNATIVE DESERT TORTOISE CROSSING CRITERIA AND DESIGNS

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ACRONYMS & ABREVIATIONS

ACB	Cable-Reveted Articulated Concrete Block
BLM	Bureau of Land Management
CCRFCD	Clark County Regional Flood Control District
CMP	Corrugated Metal Pipe
DCP	Desert Conservation Program
DI	Drop Inlet
DT	Desert Tortoise
FHWA	Federal Highway Administration
NDOT	Nevada Department of Transportation
RCB	Reinforced Concrete Box Culvert
R/W	Right-of-Way
USFWS	United States Fish and Wildlife Service

1. Introduction

1.1 Project Description

The purpose of this report is to summarize the four (4) culvert sites that were previously selected by NDOT and AtkinsRéalis as the most optimal location for culvert evaluations. The technical objectives in PS 23-03-E2 and summarized in our proposal are included in **Section 1.1.2**. This report will also provide the Nevada Department of Transportation (NDOT) with the material research and evaluation data necessary to implement improvements at the selected sites as well as using the findings on future projects.

1.1.1 Project Location and General Information

The project is located on State Route 160 (SR160) between Pahrump and Las Vegas in Southern Nevada within NDOT's District 1. SR160 is a 4-lane divided highway and has been classified as an "Other Principal Arterial" by NDOT. SR160 connects Pahrump and Las Vegas and is located within Eastern Mojave Recovery Unit of the desert tortoise in Clark and Nye Counties. The habitat along SR160 is typical of Southern Nevada and consists of Mojave Desert scrub.

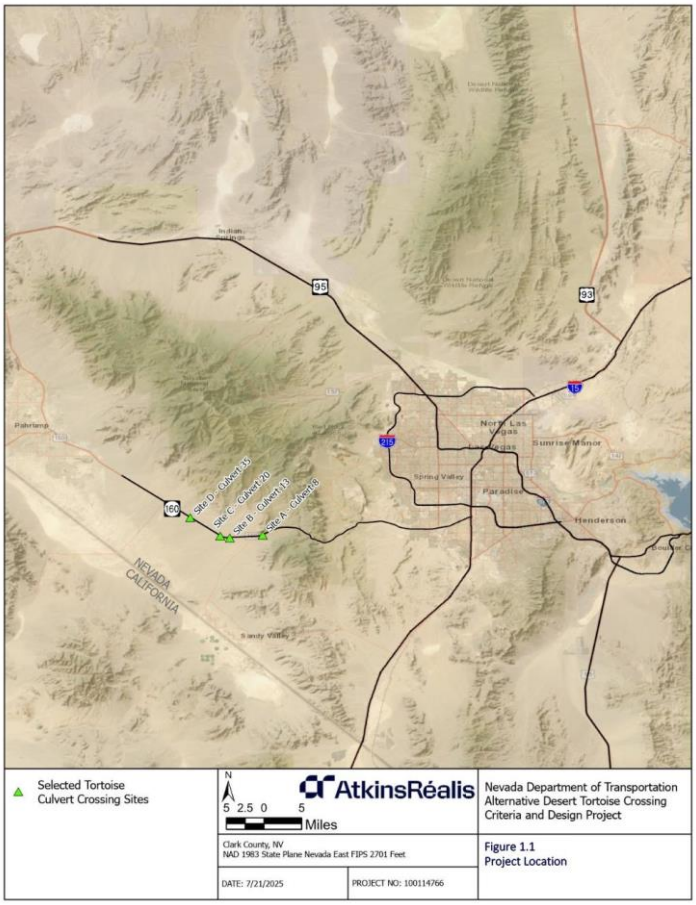


Figure 1.1 - Project Location

Like many roads in Nevada, the watersheds draining to SR160 are bisected alluvial fans. The geologic and hydrologic processes typical of alluvial fans result in high erosion potential, a lack of defined and/or stable channels with large deposits of boulders, gravels, and fine sediments also known as alluvium. These uncertainties present difficulties with safely and efficiently perpetuating off-site runoff under/across SR160. The drainage facilities crossing SR160 are highly variable and demonstrate instability due to runoff laden with heavy sediment and debris.

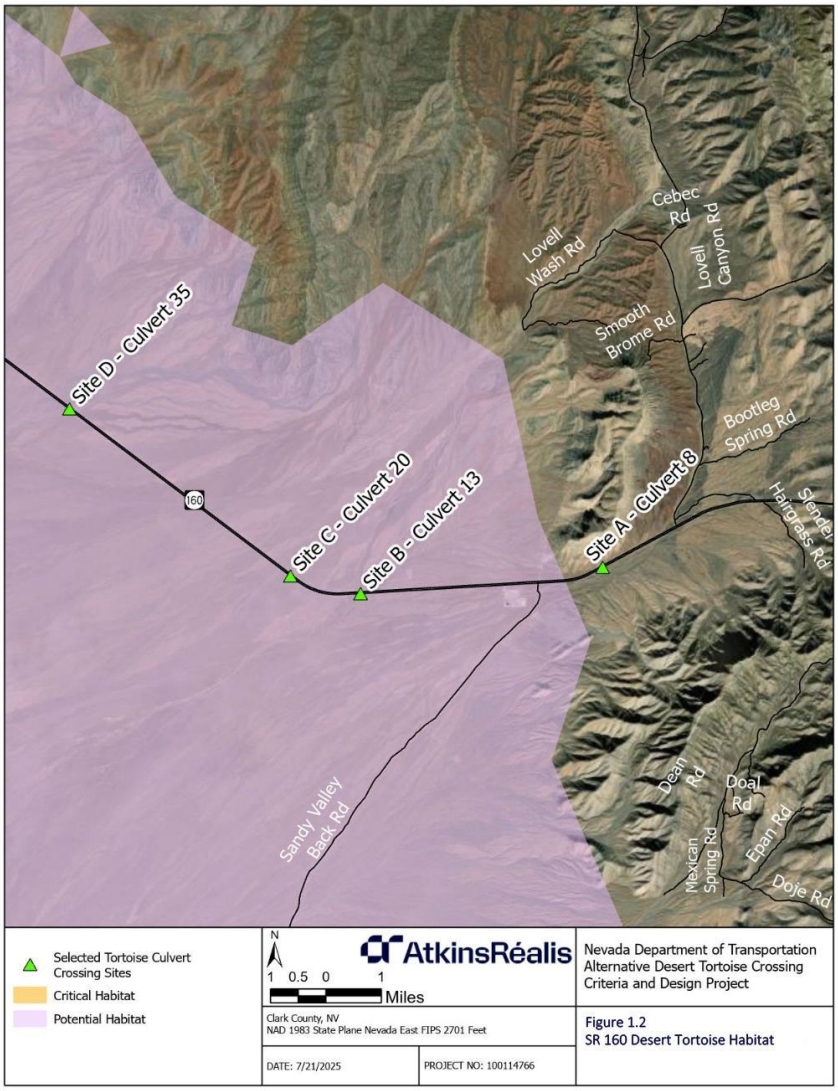


Figure 1.2 - Culvert Location and Habitat

1.1.2 Project Goals and Objectives

The primary goal of this project is to improve desert tortoise connectivity and crossings by developing creative site-specific designs, including implementation-ready plans, specifications, and estimates for the retrofit of four culverts along SR160. The DCP considers the selected culverts as grades 3 or 5 which characterizes the locations as either impassable or with conditions that are either difficult and/or hazardous for desert tortoise passage.

The goals/deliverables for this Project are:

- Identify four culvert crossings along Nevada State Route 160 (SR160) to evaluate and retrofit into desert tortoise culvert crossings with minimal to low maintenance requirements
- Obtain topographical surveys to develop designs and plans
- Produce final report documents that provide details and a summary of the design efforts performed
- Provide implementation-ready construction plans, specifications, and cost estimates

2. Selected Sites & Alternatives Considered

Existing culverts at four sites were selected to capture conditions that have presented difficulties for tortoise passage. Selected sites include a variety of culvert types, sizes and materials, and chosen locations that target improvements for culvert inlets and outlets. A summary of the selected sites is captured in the following table and sub-sections.

Site	Culvert No.	Mile Post	DCP Rating (2021) (inlet/ outlet)	Current Rating (2025)*	Size/ Materials	Design Location	Selection Notes
A	8	25.4	1/5	5	36” CMP	Inlet	The standard NDOT Type 8 DI structure on the culvert entrance prevents 2-way tortoise passage through the culvert.
B	13	29	1/5	5	Triple 12’x10’ RCB	Outlet	Channel erosion and scour at the downstream end of the culvert has resulted in the development of a head cut with a drop-off in excess of 18-inches.
C	20	30.3	1/4	3	36” CMP	Outlet	Riprap with large voids and steep slopes present dangerous terrain for desert tortoises trying to pass. Stilling basins at the outlet side can include both conditions if not constructed properly.
D	35	34.1	5/5	5	Dual 8’x6’ RCB	Inlet & Outlet	Storm-related repairs were recently made (2023) with large riprap installed at both the inlet and outlet of the culvert. The large riprap poses both an obstacle and an entrapment hazard.

Table 2.1 - Site Selection Summary

2.1 Site A – Culvert No. 8, MP 25.4


Figures 2.1 - Site A/Culvert 8 Photos—DI at Upstream End (Left) and Culvert Outfall (Right)

Site A/Culvert 8 consists of a 36-inch CMP with an NDOT Type 8 DI at the upstream end and a free outfall at the downstream end. While the free outfall does not inhibit tortoise passage, the vertical walls of the NDOT Type 8 DI completely block tortoise passage for this culvert. Therefore, the treatment in this project will focus on retrofitting the upstream portion of Site A/Culvert 8 while maintaining the existing condition at the downstream outlet.

2.1.1 Hydrologic and Hydraulic Information

The hydraulic information for Site A/Culvert 8 is presented in **Table 2.2** below. The NDOT Drainage Manual (2006) criteria for culvert design requires the culvert be sized so that the HW/D = 1.5 * culvert height. The "total discharge" value in **Table 2.2** below would represent the design flow.

Site	Culvert No.	Total Discharge (cfs)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
A	8	49.5	2.12	2.29	2.12	0.77	9.25	7.46

Table 2.2 - Site A/Culvert 8 Hydraulic Information

The existing Type 8 DI receives flow from the upstream watershed as well as potentially any excess flow from the adjacent upstream culvert crossing. A rational method analysis of the contributing watershed was completed and the Q_{25} was estimated at 40 cfs. The proposed channel upstream of the culvert extension was designed to convey this 40 cfs. The proposed channel may be slightly oversized but is acceptable when considering the uncertainty associated with alluvial fan watersheds.

2.1.2 Alternatives/Improvements Considered

There are limited options available at the upstream end of the culvert. It is necessary to continue to capture runoff from the roadside ditch with the existing DI while maintaining roadside safety for the traveling public.

The retrofit at this location targets the approximately 4' vertical concrete walls standard with the Type 8 DI. The retrofit will include the installation of a 36" CMP that penetrates the upstream-most wall of the Type 8 DI that extends upstream, to a point where a culvert end treatment will be installed consisting of either a headwall or metal end section. The area upstream of the proposed culvert's inlet end treatment will be graded with mild slopes and lining that accommodates desert tortoise passage.

For the upstream channel section, lining materials options acceptable to stakeholders[1] are:

1. Grouted riprap, or
2. Grout-filled fabric lining

With either of these options, fencing modifications are needed. See **Section 3.1** for specific recommendations.

2.2 Site B – Culvert No. 13, MP 29

Figures 2.2 - Site B/Culvert 13 Photos—Culvert Inlet (Left) and Culvert Outfall (Right)

Site B/Culvert 13 consists of a triple 12-ft by 10-ft RCB. While the upstream end of the culvert remains passable, the downstream outlet has experienced severe scour and erosion resulting in a 1.5-ft to 2-ft drop/head cut. The project will

[1] BLM, USFWS and NDOT District 1 Maintenance

focus on optimizing the downstream portion of Site B/Culvert 13 while preserving the existing condition at the upstream end.

2.2.1 Hydraulic Information

The hydraulic information for Culvert 13 is presented in **Table 2.3** .

Site	Culvert No.	Total Discharge (cfs)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
B	13	4850	4.1	8.26	5.27	3.38	25.56	23.88

Table 2.3 - Site B/Culvert 13 Hydraulic Information

2.2.2 Alternatives/Improvements Considered

For Site B/Culvert 13, the following options were considered:

1) Install riprap protection at the outfall. With higher flows and high velocities and the overall poor condition of previously constructed riprap, riprap has not performed well and is not an acceptable treatment at this outfall. Grouted riprap could be considered as a treatment option downstream of the RCB.

    a) New grouted riprap is a potential option however, it would be cost prohibitive due to the additional cost of the excavation, riprap/bedding and grout. Furthermore, this location presents an opportunity to use an alternative lining material and a new configuration that is more conducive to desert tortoise passage.

2) Streambed Level Energy Dissipator Structure

    a) The size and extent of the energy dissipator structure, extent of R/W required, and the overall cost; make this option less preferable.

3) Cable-reveted articulated concrete block (ACB), has been successfully used for water quality basin floor lining. The purpose for the floor lining was to provide a stable and easy-to-maintain surface to remove accumulated sediment, not to protect the basin floor from high outlet velocities.

4) Grout filled fabric lining in a configuration that provides a combination sloping and flat apron that addresses the current headcut and still provide stable desert tortoise passable slopes.

These four options all require fencing modifications. See **Section 3.2** for a specific recommendation.

2.3 Site C – Culvert No. 20, MP 30.3

Figures 2.3 - Site C/Culvert 20 Photos—Existing Riprap Basin at Culvert Outfall

Site C/Culvert 20 consists of a 36-inch CMP with an existing stilling basin at the outfall. The inlet condition is stable and doesn't pose as a barrier for desert tortoise passage. The outlet contains medium or approximately Class 300 riprap with side slopes as steep as 2:1. These conditions can create significant barriers and entrapment risks for the desert tortoise. Therefore, this project will focus on maintaining the configuration of stilling basin at the outfall of Site C/Culvert 20.

2.3.1 Hydraulic Information

The hydraulic information for Site C/Culvert 20 is presented in **Table 2.4**.

Site	Culvert No.	Total Discharge (cfs)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
C	20	31	1.99	1.9	1.9	1.52	7.76	3.39

Table 2.4 - Site C/Culvert 20 Hydraulic Information

2.3.2 Alternatives/Improvements Considered

For Site C/Culvert 20, the following options were considered:

1) Remove existing riprap and replace with an alternative lining material, or

2) Grout the full extent of existing riprap to treat all voids

3) For new stilling basin installations, either grouted riprap or an alternative lining material could be used

For all of these options, fencing modifications are needed. See **Section 3.3** for specific recommendation.

2.4 Site D – Culvert No. 35, MP 34.1

Figures 2.4 - Site D/Culvert 35 Photos—Culvert Inlet (Left) and Culvert Outfall (Right)

Site D/Culvert 35 consists of a double 8-ft by 6-ft RCB. The inlet and outlet of this culvert have large riprap with rock ranging in size from 1-ft to 5-ft. The large riprap has large voids that pose potential entrapment hazards for desert tortoises. Additionally, the inlet side has slopes that vary from 6:1 to 10:1. These slopes along with the large voids/riprap, makes it nearly impossible for desert tortoises to traverse these features and cross the culvert. Therefore, this project will focus on treating and optimizing the existing riprap at both the upstream and downstream ends of Site D/Culvert 35.

2.4.1 Hydraulic Information

The hydraulic information for Site D/Culvert 35 is presented in **Table 2.5.**

Site	Culvert No.	Total Discharge (cfs)	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
D	35	999	4.73	4.95	4.74	4.46	13.18	7.73

Table 2.5 - Site D/Culvert 35 Hydraulic Information

2.4.2 Alternatives/Improvements Considered

For Site D/Culvert 35, the following options were considered:

1. For the existing riprap upstream of the double 8’ X 6’ RCB, apply grout to the full extent of the existing riprap, and

2. For the existing riprap downstream of the 8’ X 6’ RCB, limit grouting of the existing riprap to only portions of the riprap and the sides to provide tortoise walkways that extends from the invert culvert outlet to the downstream extent of existing riprap. This would leave the flat portion of apron un-grouted to provide more energy dissipation.

    a. With a portion of un-grouted riprap remaining, it would be necessary to include a vertical barrier that prevents tortoises from falling into the un-grouted riprap. Vertical barrier would consist of double-faced guardrail with metal posts core/hammered or drilled and grouted into the existing rock/riprap.

    b. Or apply grout to the full extent of existing riprap at both the upstream and downstream ends of the double 8-ft by 6-ft RCB

These options all require fencing modifications. See **Section 3.4** for specific recommendations.

3. Recommended Alternatives

3.1 Site A – Culvert No. 8, MP 25.4

For Site A/Culvert 8, we are recommending that the existing culvert be modified by including a culvert extension from the existing Type 8 DI. The culvert extension will penetrate the upstream most wall of the DI and extend upstream a sufficient distance (± 28 feet) to provide the necessary cover over the culvert. It will be necessary to grade a new v-ditch. The stormwater runoff at this location is minor and presents a good opportunity to implement an alternative channel lining material. The grout filled fabric channel lining requires less excavation than standard riprap during installation and is being recommended for consideration at this location.

Existing tortoise fencing upstream and downstream of the culvert along the R/W will be removed to allow desert tortoise passage. New tortoise fencing will be installed to guide/route desert tortoises to the new culvert crossing location and the outlet. The fencing will be installed in a configuration to allow desert tortoises to reach the culverts, while preventing them from reaching the SR160 travel way. 12-foot metal gates have been included to provide maintenance access. See the plans in **Appendix D** for additional information and detail.

3.2 Site B – Culvert No. 13, MP 29

For Site B/Culvert 13, the option being advanced includes the sloping apron concept constructed with the grout filled fabric formed lining. The sloping apron will consist of the lining extending downward from the culvert invert at a 3:1 slope for a total distance of 18 feet, providing a gradual 6-foot elevation drop. The lining will then extend an additional 35 feet with no slope. Side slopes will be lined and will extend up at a maximum of a 3:1 slope until it matches the existing ground and will further extend until it matches the existing riprap. Once installed, the sloping apron will be backfilled with native material. This configuration provides protection for the culvert outfall and roadway by providing a lined protected area that can be scoured out. Even with scour, the lining maintains slopes that are compatible with desert tortoise passage. A dissipation pool will form during peak runoff and be refilled with sediment when the storm recedes. See the plans in **Appendix D** for additional information and detail.

Existing fencing on both the upstream and downstream sides of the culvert is installed and configured in a manner that allows desert tortoise to reach the culvert. Fencing already ties to existing headwalls or features that prevent desert

tortoise from reaching the SR160 travel way. New tortoise fencing is being proposed and included on the downstream side to accommodate fence removals necessary for the installation of the proposed outfall lining improvement and grading. There are already gates present that allow access for maintenance.

3.3 Site C – Culvert No. 20, MP 30.3

For Site C/Culvert No. 20, the large rocks and the associated large voids present barriers and/or voids may cause entrapment hazards. We are recommending the full extent of existing riprap be grouted to maintain the current stilling basin configuration. The stilling basin configuration is stable and is functioning. The addition of grout to the existing riprap will improve desert tortoise passage by minimizing void spaces while maintaining the stilling basin configuration and a stable culvert outfall. Based on much coordination and discussion, grout will be applied in a smooth finish application which allows for rock protrusions up to 3” above the new grout for a “Smooth Grouted Riprap”.

Existing tortoise fencing upstream and downstream of the culvert along the R/W will be removed allowing desert tortoise passage. New tortoise fencing will be installed to guide/route desert tortoises to the new culvert inlet location. The fencing will be installed in a configuration to allow tortoises to reach the cross culverts, while preventing them from reaching the SR160 travel way. 12-foot metal gates have been included to provide maintenance access. See the plans in **Appendix D** for additional information and detail.

3.4 Site D – Culvert No. 35, MP 34.1

Based on stakeholder feedback and current requirements from the USFWS, riprap needs to be void free to be accessible for desert tortoises. Whether grout is applied as fine finish or coarse finish, voids will be eliminated. In order to move forward with an option that is acceptable to all stakeholders, we are recommending grouting all of the existing riprap that could potentially present an obstacle or entrapment hazard.

For Site D/Culvert No. 35—OUTLET, grout will be applied to all riprap at the culvert outlet. A combination of smooth grouted riprap and coarse grouted riprap is being recommended. Smooth-grouted riprap will be provided at the outlet to provide a tortoise walkway from the side of the existing riprap to the culvert. The remainder of the riprap will have grout applied in a coarse-grouted finish with rocks protruding up 6 to 9 inches above the grout. The coarse grouted riprap will eliminate tortoise trapping voids yet will provide enough roughness to provide a similar dissipating function as intended with the original riprap installation. See the plans in Appendix D for additional information and details.

For Site D/Culvert No. 35—INLET, grout will be applied to all the riprap at the culvert inlet. A smooth-grouted riprap finish is recommended for all riprap. The finish provided by smooth-grouted riprap provides the greatest benefit for tortoise passage. The energy dissipating benefit provided by coarse-grouted riprap is not necessary at the inlet side. See the plans in **Appendix D** for additional information and detail.

Existing tortoise fencing upstream and downstream of the culvert along the R/W will be removed allowing desert tortoise passage. New tortoise fencing will be installed to guide/route desert tortoises to the new culvert inlet location. The fencing will be installed in a configuration to allow tortoises to reach the cross culverts, while preventing them from reaching the SR160 travel way. 12-foot metal gates have been included to provide maintenance access.

4. Stakeholder Feedback

Meetings were held with stakeholders including the USFWS, BLM, and NDOT District 1 Maintenance. In addition, a number of meetings were held with members of the project team to vet ideas and review alternative lining materials as well as to consider stakeholder input. Through these meetings, the discussion and feedback helped guide ideas, acceptable materials and alternative lining products that are presented herein.

4.1 USFWS and BLM Feedback

A meeting occurred with USFWS and BLM, and alternative materials and general concepts were presented for each of the culvert crossing sites. USFWS and BLM were generally supportive of what was presented. Some concerns noted and highlights include:

- Potential for UV degradation of the FlexMat plastic grid
- General overall durability and longevity concerns with the HydroTurf
- Toxicity concerns with all 3 of the alternative materials
- BLM was supportive of the barrier between the grouted and un-grouted/loose riprap concept presented for Site D. However, this is contrary to what is currently approved by USFWS. Voids in riprap will need to be addressed by filling all voids with grout.

4.2 NDOT Maintenance Feedback

The NDOT Maintenance team's participation was invaluable and provided candid input. The maintenance team has considerable experience maintaining this stretch of SR160 and are very experienced with the types of storms and debris that come with the storms. They said they generally have to remove large volumes of material and it takes large equipment to do it effectively and efficiently. They indicated the following:

- NDOT District 1 Maintenance are short staffed
- Available equipment generally includes large wheel loaders, large metal tracked excavators, and metal tracked dozers
- Equipment availability is limited and access to specialized equipment is extremely limited
- They don't have space to store replacement or extra lining materials

The alternative lining materials that had been researched and were being considered were presented to the maintenance team. This included FlexMat, HydroTurf, and HYDROTEX grout filled fabric formed lining. After reviewing and discussing the different options, they had very little confidence in FlexMat and HydoTurf being able to hold up to the runoff and the amount of rock and sediment being carried by the runoff. Furthermore, they didn't believe they could maintain it efficiently and effectively with the equipment that was readily available. They also voiced concerns with making repairs as the lining requires maintenance and repair. They didn't want to be required to stock material and

have specialized equipment and/or experience to be able to weld seams, etc. In general, the only alternative material they felt comfortable with is the grout-filled fabric formed lining material. This lining option, like other improvements including grouted riprap and tortoise fencing, will require regular inspection and future maintenance to ensure it continues performing as intended.

5. Design Guidance/Criteria

5.1 Project Planning/Scoping

Where transportation projects are being planned and are in desert tortoise habitat, an opportunity to improve desert tortoise crossings is available. Selection of locations to implement culvert inlet and outlet modifications to improve desert tortoise passage and connectivity needs to be reviewed at the project planning and scoping. A multi-discipline team consisting of members from NDOT Roadway, Hydraulics, and the Environmental Services Divisions will need to review the various factors including project limits, funding availability, available right-of-way, existing field conditions, safety, and constructability/maintenance considerations.

5.2 Existing Conditions & Selection Considerations

A project specific inventory of existing culvert crossings should be compiled to ascertain the existing culvert conditions and suitability for desert tortoise crossing. Factors discussed in **Section 5.1** will ultimately determine the overall project opportunity and scale of desert tortoise mitigation opportunities and improvements that can be included in a project. An accurate and comprehensive inventory will be critical in getting to an approved wildlife crossing scope.

As part of developing a project culvert inventory, culvert crossings should be identified as either a minor culvert or major culvert. Minor culverts are equivalent diameter is 48-inches or less. Major culverts are equivalent diameter greater than 48-inches. Minor culverts are located more frequently and convey lower flow rates, have lower flow depths and lower outlet velocities. These typically require less robust and more reasonable outlet protection. Major culverts are found less frequently and convey larger flows, higher flow depths, higher outlet velocities and generally require more substantial outlet protection.

Table 5.1 below summarizes a general rule-of-thumb criteria used by NDOT hydraulics in assessing outlet protection for design culvert outlet velocities. Per the NDOT Drainage Manual, judgment must be applied in all cases, considering site conditions (soils, slope, existing conditions velocity, existing conditions erosion, etc.), when evaluating the need for outlet protection. HEC-11 and HEC-14 are the design guidance referenced during design.

Outlet Velocity	Rule of Thumb Treatment
Velocity < 5fps	Little or No Outlet Treatment
5fps < Velocity < 10fps	Riprap Aprons
10fps < Velocity < 15fps	Grouted Riprap or Stilling Basin or Sloping Aprons
15fps < Velocity	Structural Energy Dissipator

Table 5.1 - Velocity Criteria Considerations

5.2.1 Desired Tortoise Crossing Spacing and Mitigation Selection

The recommended desert tortoise crossing spacing to help restore adult connectivity is approximately 2,200 feet between crossings (USFWS-2014). Culvert spacing for drainage purposes varies considerably with landform so relying on existing drainage culverts to meet the desired spacing may not be obtainable. Constructing new culverts to function as standalone desert tortoise crossing has been discussed but is generally cost prohibitive. In addition, desert tortoises have been found to travel in and utilize natural washes so installing new crossings doesn't guarantee their use by desert tortoises.

As funding is typically limited, mitigation for desert tortoise culvert crossings should focus on and prioritize treating minor culvert crossings over major culvert crossings if possible. This allows funding to go further and help mitigate as many culverts with desert tortoise obstructions/barriers as possible while attempting to achieve compliance with providing desert tortoise crossings at the desired 2,200 foot interval. Where identified by the team and prioritized during project scoping, major culvert crossings will be considered and included as agreed upon by the team.

5.2.2 Culvert Inlets and Outlets

5.2.2.1 Culvert Inlets

In general, culvert inlets do not experience the type of scour or erosion that results in conditions that prevent desert tortoise passage. Where existing conditions or existing improvements or features present barriers for desert tortoise passage, individual treatments and/or site-specific designs may be necessary. Existing conditions or improvements that present barriers for tortoises may include fencing, scour holes/vertical drops, steep grades, drop inlets, large riprap with voids, sediment deposition and others etc.

Culvert Inlet Mitigation Measures may include options like:

- DI replacement with culvert extensions and associated grading
- Desert tortoise compatible linings such as typical concrete lining, coarse- and/or smooth-grouted riprap, articulated concrete block lining, and grout filled fabric formed lining and others as approved by NDOT Hydraulics, Environmental Services, and Maintenance Divisions
- Fencing reconfigurations

Generally, these improvements are location and site specific and only general options are discussed here. Location specific details will need to be developed for each project on a case-by-case basis.

5.2.2.2 Culvert Outlets

Stormwater runoff velocities generally increase along the length of a culvert. The runoff concentrates as it enters the culvert. Culvert roughness is generally lower than the natural wash, therefore the “Mannings n” value is lower for culverts and higher in the surrounding natural wash. This results in an increase in velocity as the runoff exits the culvert and can result in hydraulic conditions that are conducive to scour and erosion.

Culverts and the receiving downstream natural wash should be evaluated using FHWA’s HY-8 Culvert Analysis Program and Hydraulic Toolbox Program. When the culvert outlet velocity exceeds 5 fps and/or the tailwater velocity or velocity in the existing wash, outlet protection is generally necessary but ultimately, engineering judgement is required.

HY-8 and Hydraulic Toolbox include the functionality to evaluate and estimate hydraulic parameters such as outlet and tailwater/natural channel velocities flow depth, estimate scour hole geometry as well as designing and sizing riprap protection. Other methodologies including those found in Clark County Regional Flood Control District's Hydrologic Criteria and Drainage Design Manual may be considered and utilized on a case-by-case basis.

5.2.3 Field Investigation—Culvert Outlet Conditions with Mitigation/Treatment Options

Existing conditions at a culvert outlet will need to be evaluated and documented, and ultimately used to determine possible mitigation options, pending identified project limitations and constraints. The options presented in **Table 5.2** take into consideration the type/size of existing culvert facility, current conditions including amount of current/existing scour, and will help identify and guide mitigation and/or treatment options.

Culvert Outlet Condition/Treatment	**Outlet Velocity or Existing Scour/Degradation "D" = Scour Depth (FT)**	**Mitigation/Treatment Options**
MINOR CULVERT—No Outlet Treatment and/or Minimal Scour	No Scour or "D" < 6" in depth or sediment deposition/aggradation	Grade to drain to remove potential barriers
MINOR CULVERT—None or Class 150 or Smaller Riprap Protection	Min. scour w/ existing scour depths ~~ 0.5" < "D" < ~1'	Standard riprap apron w/ ~2-foot-wide smooth grouted desert tortoise walkways and coarse grouting of remaining riprap
MINOR or MAJOR CULVERT—Class 300 or Larger Riprap w/ riprap in stable/good condition and/or as per original installed condition	Voids creating DT Barriers **OR** Entrapment Hazard	Grout existing riprap to provide approx. 2-foot-wide smooth grouted desert tortoise walkway to culvert invert and coarse grouting of remaining riprap
MINOR or MAJOR CULVERT—Class 300 or Larger Riprap w/ riprap in poor condition or with missing or moving rock noted and/or scour/drops/barriers greater than 1-foot	"D" ~~ 1' < "D" < 2.5', **AND/OR** Drop offs and voids creating DT Barriers or Entrapment Hazards	Sloping Apron constructed of concrete lining, smooth grouted riprap or ACB/Fabric Formed Liner, **OR** Smooth grouted riprap stilling basin/plunge pool
MINOR or MAJOR CULVERT—Class 300 or Larger Riprap w/ riprap in poor condition or with missing or moving rock noted and/or scour/drops greater than 1-foot	"D" ~~> 2.5', **OR** Voids creating DT Barriers and/or Entrapment Hazards	Sloping Apron constructed of concrete lining, smooth grouted riprap or ACB/Cable Reveted Fabric Formed Liner, **OR** Smooth grouted riprap basin/plunge pool, **OR** At grade or sloping structural energy dissipator w/ blocks or chutes oriented in DT friendly configuration

Table 5.2 - Culvert Outlet Criteria For Providing Desert Tortoise Treatment

5.2.4 Proposed Standard Detail Considerations

In an effort to simplify and standardize the planning and design process, two standard details are being developed. The NDOT Hydraulics team was already developing a lined sloping apron concept. After considerable discussion it was determined that it had good potential and could be developed into a standard detail that could be applied across a variety of culvert types, sizes, and materials. A copy of the draft detail is included in **Appendix B**.

A second type of culvert energy dissipator that NDOT commonly uses in Nevada is a riprap basin per FHWA's HEC-14 culvert energy dissipator design guidance. This type of dissipator is based on armoring a pre-formed scour hole with riprap. Configuration and dimensions are determined by guidance in HEC-14 or by utilizing HY-8 culvert analysis application. Making the riprap compatible with desert tortoise passage requires the riprap be grouted to eliminate any large voids that could either trap or present an obstacle for tortoise passage. A detail previously used by NDOT was modified to incorporate the inclusion of grouting. The detail can be found in **Appendix. B**.

5.3 Right-of-Way (R/W) Fencing

Generally, the NDOT R/W limits are fenced. In most cases, the fencing is either Type A-3S or Type A-4S which consists of steel round and T-posts with 3 or 4 strand barb wire. In southern Nevada desert tortoise habitat, a concerted effort has been made by NDOT to add new fencing, upgrade existing or replace existing fencing to include desert tortoise mesh fencing. This has helped reduce desert tortoise mortality from desert tortoise reaching the travel way and being struck by vehicles. The fencing details can be found in the most current NDOT Standard Plans – For Road and Bridge Construction. See NDOT Standard Details numbers FC-1, FC-2, FC-4 and FC-5.

5.3.1 Tortoise Fencing

Where culverts will be used for desert tortoise passage, R/W fencing must be configured to allow desert tortoises to reach the culvert inlets/outlets. Sections from NDOT's tortoise fencing detail below depict the measures necessary to allow tortoise passage. The detail below, **Figure 5.1** provides general guidance for fencing installation around typical headwall and end sections. It doesn't show possible erosion treatments that may need to be considered.

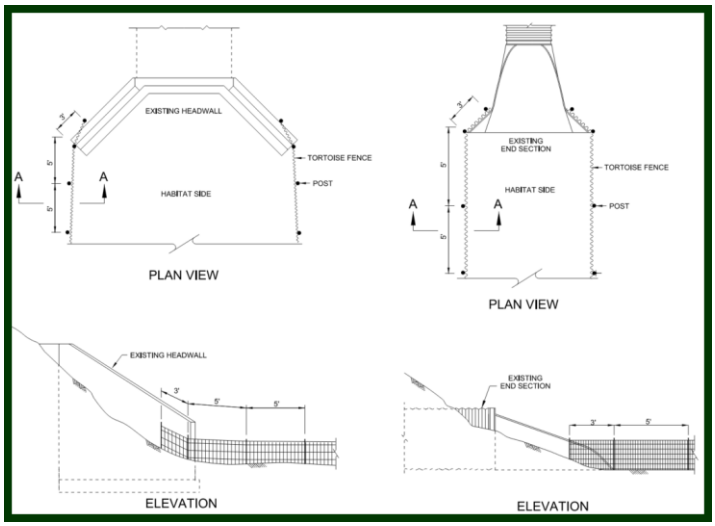


Figure 5.1 – Fencing with Culvert End Treatment (NDOT-2024)

Tortoise fencing installation at culvert inlets and outlets will also need to take into consideration site specific conditions like existing topography, minor drainage ways, and culvert outlet protection generally consisting of riprap etc. Where possible, fencing installation across flow paths should be avoided. The tortoise mesh fencing can collect debris from storm runoff, resulting in accumulation that can damage the fence and cause other erosion. This creates a condition where desert tortoise and other wildlife can cross the fence and possibly reach the travel way. It can also results in increased maintenance of the fencing. If possible, fencing should be laid out in a flared configuration to accommodate the riprap as well as to create a funneling effect. The funneling configuration has been found to aid desert tortoises in reaching culverts and crossing the R/W. The pictures in **Figures 5.2** show desert tortoise fencing installations at culverts with flares or funnels. The installations were completed on recent NDOT projects.

Figures 5.2 –Project Tortoise Fencing at Culverts (photos by NDOT)

5.3.2 R/W Fencing with Existing Tortoise Mesh

Where existing culvert outlets and inlets are being improved to accommodate tortoise passage, it will be necessary to install new tortoise fencing so it extends and connects to the existing culvert end treatment (headwall or end section) to create the funneling effect as described above. In most instances, mitigation will be limited to culvert outfalls, however, it may still be necessary to upgrade/modify the fencing between the R/W limits and the culvert inlet. In these situations, it will be necessary to call out for the removal of the existing fencing. Removal of the tortoise fence/mesh and 3-wire and/or 4-wire from active flow paths will reduce future maintenance of the fencing as it is prone to collecting debris and damning runoff.

If routine fence maintenance is necessary, it is generally carried out by District 1 maintenance forces. If the work will be completed with NDOT construction contract work, the removal of material from existing fencing and/or repair of fencing during contract work is generally accomplished and paid for with the “REPAIR FENCE” force account bid item. The force account bid item gives the Resident Engineer the flexibility to have the contractor perform the necessary fence maintenance.

6. Lining Materials Costs & Pros/Cons

The implementation of desert tortoise mitigation will take a significant investment and will result in increases in project costs. The information in this section will provide comparative installation costs along with pros and cons and will help with both project planning and implementation.

Acceptable drainage material lining options include grouted riprap lining (new installation), grouting of existing riprap, concrete lining, articulated concrete block (ACB) and grout filled fabric formed lining. Other or new lining material options can be considered and approved on a case-by-case basis with consideration and input from Hydraulics, Environmental Services and Maintenance Divisions.

6.1 Lining Costs

As opportunities to implement desert tortoise mitigation into either standalone projects or other NDOT project opportunities arise, the limiting factor will commonly be available funding. Being able to select the most appropriate and cost-effective treatment is critical. Estimated costs for acceptable lining materials are included below in **Tables 6.1 through 6.4**.

New Grouted Riprap Cost				
	Class 150 "B" = 12"	Class 300 "B" = 24"	Class 400 "B" = 36"	Class 550 "B" = 48"
Excavation	$ 42	$ 67	$ 96	$ 125
Riprap	$ 43	$ 87	$ 130	$ 173
Bedding	$ 27	$ 27	$ 33	$ 40
Grout	$ 47	$ 47	$ 70	$ 93
Geotextile	$ 5	$ 5	$ 5	$ 5
New Grouted Riprap--$$/SY	**$ 164**	**$ 233**	**$ 334**	**$ 436**

Table 6.1 - New Grouted Riprap

Grout Existing Riprap Cost ($$$ Values Pulled From Table 6.1)				
	Class 150 "B" = 12"	Class 300 "B" = 24"	Class 400 "B" = 36"	Class 550 "B" = 48"
Riprap Thickness "B" (FT)	1	2	3	4
Grouting Thickness (FT) @ 1/2 "B" or 1' min	1	1	1.5	2
Grout Volume (CUY) @ 40% Riprap Vol	0.13	0.13	0.20	0.27
Grout Existing Riprap--$$/SY	**$ 47**	**$ 47**	**$ 70**	**$ 93**

Table 6.2 - Grout Existing Riprap

Grout Filled Fabric Formed Liner (GFFL)		
	3" FFL	6" Cable FFL
Excavation	$ 6	$ 13
Material	$ 12	$ 23
Installation	$ 68	$ 102
Grout	$ 36	$ 72
Geotextile	$ 5	$ 5
GFFL--$$/SQYD	$ 127	$ 215
USE:	**$ 130**	**$ 220**

Table 6.3 - Grout Filled Fabric Formed Liner

Recent NDOT Articulated Concrete Block (ACB) Bid History					
Contract	Bid Info--Installed				
	Low	High	Mid	Avg.	Quantity (sqy)
3983	$ 250	$ 275		$ 263	548
3911	$ 175	$ 190		$ 190	404
3948	$ 170	$ 290	$ 230	$ 230	2289
			ACB $$/SY	$ 227.50	
			USE	**$ 228**	

Table 6.4 - Articulated Concrete Block Bid History

Comparing the above material costs, there is an opportunity to realize some savings by trying new lining materials. As with implementing any new material or item, there will be some growing pains. However there appears to be good opportunities for lifecycle cost savings.

6.2 Pros and Cons

Aside from costs, there are other items that should be considered when selecting lining material for desert tortoise culvert mitigation. Although not a comprehensive list, some of these items are covered below in **Table 6.5**. Other items not specifically listed in the table that will need to be considered include R/W compatibility and local availability/sourcing, to name a few.

Acceptable Desert Tortoise Lining Materials--Pros and Cons		
Lining Material	**Pros:**	**Cons:**
Grouted Riprap (New Installation)	Installation Familiarity Installation Flexibility, more forgiving More Roughness/Energy Dissipation, Higher Mannings "n" Values	Cost and Volume of Material Deep Installation Thicknesses Trucking of Large Volume of Material More Roughness/Energy Dissipation Higher Manning's "n" Values
Grouting Existing Riprap	Lower Cost Utilizes Existing Materials Lower Overall Impacts	Requires Existing Installation to be in Good Overall Condition More Roughness/Energy Dissipation Higher Manning's "n" Values
Grout Filled Fabric Formed Liner	Shallower Installation Depths Lower Overall Installation Cost	New product/less history Less Contractor Familiarity Less Installation Flexibility Less Forgiving No Bid History Less Roughness/Energy Dissipation, Moderate Manning's "n" Values
Articulated Concrete Block	Shallower Installation Depths Lower Overall Installation Cost	Newer product/less history Less Installation Flexibility Less Forgiving Limited Bid History Low Roughness/Energy Dissipation Lowest Manning's "n" Values

Table 6.5 - Pros and Cons

7. Summary

This report presents a summary of the efforts carried out over the past 15-months to select 4 sites suitable for desert tortoise passage that cover a variety of different obstacles and constraints. The report includes a summary of the site assessment and selection process, coordination with stakeholders including USFWS, BLM, District 1 Maintenance, alternative lining material research and review with stakeholders, site survey, design with the incorporation and compilation of research, construction challenges, fencing/access, cost considerations, and stakeholder input and feedback. The efforts, design, and documentation have been refined for incorporation in this final report and for ultimate design implementation.

8. References

NDOT, NDOT Drainage Manual, 2nd Edition (NDOT-DM), 2006.
NDOT, NDOT Standard Specifications for Road and Bridge Construction, 2014.
NDOT, NDOT Stormwater Quality Manuals Planning and Design Guide (NDOT-SWQM), 2023-revised.
NDOT, NDOT Standard Plans for Road and Bridge Construction, 2024.
FHWA, *HY-8,* Latest Version
FHWA, *Hydraulic Toolbox,* Latest Version
CCRFCD, Hydrologic Criteria and Drainage Design Manual, 1999
FHWA, HEC-14—Hydraulic Design of Energy Dissipators for Culverts and Channels, 3rd Edition—July 2006
FHWA, HEC-11—Design of Riprap Revetment, 3rd Edition-March 1989
USFWS, Passages for Connectivity of Mojave Desert Tortoise Populations Across Fenced Roads—March 2014

APPENDICES

Appendix A. Stakeholder Feedback

A.1 USFWS/BLM Feedback-meeting minutes

A.2 NDOT D1 Feedback-meeting minutes

A.3 NDOT Grouting Discussion-meeting minutes

AGENDA_MINUTES

P494-24-803: Development of Alternative Desert Tortoise Crossing and Design Criteria (100114766)

SUBJECT	MEETING PLACE	DATE AND TIME	MINUTES BY
Stakeholder Meeting	Virtual/Teams	29 September 2025 | 11:00	AtkinsRéalis

MEETING NO	ATTENDEES	REPRESENTING
1st Stakeholder	Kristi Holcomb	NDOT Environmental
	Eric Yount	NDOT Hydraulics
	Mitch Ison	NDOT Research
	Melissa DeMattei	NDOT Research
	Kerry Holcomb	USDI-USFWS
	Kelly Douglas	USDI-USFWS
	Evan Myers	USDI-BLM
	Keith Hidalgo	AtkinsRéalis
	Matt Nussbaumer	AtkinsRéalis

Item	Description	Responsible
1.	Introductions	Kristi/Keith

2.	Project History/Summary/Scope
	• Limits (Essentially Mountain Springs to Pahrump)
	• Previous NDOT Research/Studies
	  ○ NDOT Research Report No. 733-19-803 (heavy on literature research, light on design)
	• Project Scope/Goals
	  ○ Site selections 3-4 locations w/ various conditions that stays w/in right-of-way and can ultimately be maintained
	  ○ Consider alternative materials for large riprap
	  ○ Develop Design Criteria and Procedures
	  ○ Draft Standard Details
	  ○ Documentation-Final Report
		Matt N

3. Site/Location - Review Sites and Concepts Developed — Matt N

- Selected Sites are:
  - a combination of culvert inlets and outlets
  - propose alternatives to large riprap
  - Include updates to existing fencing and new fencing as necessary

- Site A
  - Inlet w/ structural barrier
  - EY/NDOT Hydraulics has concerns w/ long term stability/durabiity of HydroTurf. Not durable/flexible enough. Applies to Site B as well
  - Kerry/BLM was receptive of the con but was also concerned w/ longevity. Also concerned w/ toxicity to tortoises if they eat the turf.
  - How receptive to experimental type products. Mitch noted that this is a research project and not an implementation and that this was to be determined in the implementation phase
  - Matt/AR to follow up w/ any problems w/ existing installs and specific locations in Nevada. Kerry/USFWS, referenced and provided a link for an alternate product-TerraCrete by Terraforce.
  - In general, the FlexMat appeared acceptable if it could hold up to UV degradation.
- Site B
  - Outlet w/ erosion and headcut. EY/NDOT - material type and make sure to include perimeter type benching for anything w/ a plunge pool
    - Same concern w/ HydroTurf as @ Site A
- Site C
  - Outlet w/ typical riprap stilling basin. Ok with concept as long voids could be eliminated and safe passage of desert tortoises could be provided.
- Site D
  - Inlet and Outlet – existing large & expansive riprap
  - Kerry/BLM-an edge barrier would be beneficial maybe not the full 11" tall barrier rail
  - Follow up w/ Glen/NDOT ENV and/or Jim M/NDOT HYDR - on partially grouted riprap and previous discussion, for the Searchlight project that's currently under construction. Why they went away from partially grouting existing riprap and leaving more of the rock protruding up/above the new grout
  - Evan Meyer-Question backfill material for void, EY-backfill w/ native worked on aprons w/ flat slopes, but didn't work as well on steeper riprap aprons especially on inlet/US sides. Slope dependent.

4.	Next Steps • Incorporate comments and concerns from this meeting for formal submittal	Matt/All
5.	Miscellaneous	All

Date Assigned	Due Date	Action	Notes
9/29/2025	10/10/2025	Matt/AR to Inquire about toxicity of HydroTurf artificial grass blades as well as material in the fabric forms (Synthetex)	Desert tortoises eat pretty much anything
9/29/2025	10/10/2025	Matt/AR to request from vendor reps specific installation locations in both northern and southern Nevada for possible site visits	
9/29/2025	10/17/2025	Matt/AR to obtain the following from HydroTurf: • Lab testing report for longevity and UV stability • Durability w/ sedimentation laden runoff	
9/29/2025	10/17/2025	Matt/AR to follow up w/ JimM or GlenC regarding previous riprap grouting discussions on the US95 project that is currently in construction.	

AGENDA

P494-24-803: Development of Alternative Desert Tortoise Crossing and Design Criteria (100114766)

SUBJECT	MEETING PLACE	DATE AND TIME	MINUTES BY
Maintenance Meeting	Virtual/Teams	22 October 2025 | 8:00am	AtkinsRéalis

MEETING NO	ATTENDEES	REPRESENTING
1st Maintenance	Kristi Holcomb	NDOT Environmental
	Glen Church	NDOT Environmental
	Eric Yount	NDOT Hydraulics
	Derek Ridenoure	NDOT Hydraulics
	Mitch Ison	NDOT Research
	Melissa DeMattei	NDOT Research
	Chris Rickerson	NDOT D1 Maintenance
	Neal Nelson	NDOT D1 Maintenance
	John Herman	NDOT D1 Maintenance
	Nanette Grahm	NDOT D1 Maintenance
	Keith Hidalgo	AtkinsRéalis
	Matt Nussbaumer	AtkinsRéalis

Item	Description	Responsible
1.	Introductions	Kristi/Keith

2.	Project History/Summary/Scope/Schedule
	• Limits (Essentially Mountain Springs to Pahrump)
	• Previous NDOT Research/Studies
	  ○ NDOT Research Report No. 733-19-803 (heavy on literature research, light on design)
	• Project Scope/Goals
	  ○ Site selections 4 locations w/ various conditions that stays w/in right-of-way and can ultimately be maintained
	  ○ Consider alternative lining materials for large riprap
	  ○ Develop Design Guidance and Procedures
	  ○ Draft Standard Details
	  ○ Documentation-Final Report
		Matt N

3. Alternative Materials for large riprap — Matt N

- Articulated Concrete Blocks (ACB) – not new but Eric pointed out that prior use/history has been limited to WQ basin floors
- Concrete lining – not new
- HydroTurf – new
- FlexMat – new
- Grout filled fabric cable reveted formed lining– new

Initial NDOT D1 Maintenance Input:

- They inquired about installing dedicated culverts to accommodate desert tortoise passage. They were advised the following:
  - The spacing requirements would make new standalone desert tortoise culverts cost prohibitive
  - Would require fencing off existing culverts and the fencing and the crossings would still require maintenance
  - Was cost prohibitive due to required spacing
- With HydroTurf and/or FlexMat, D1 Maintenance saw the following issues:
  - the shear volume of material these locations produce, they need to use heavy iron tracked equipment (wheel loader, excavators & dozers) to push and remove material just to get vactor trucks in place to clear culvert and clean the culverts. Were not convinced the material would hold up and didn't support the use.
  - Also saw issues with timing of getting replacement material to make repairs and the specialty aspect of making the repairs would make it difficult complete and/or require a separate repair contract
- They found the grout filled formed liming generally acceptable. They felt it was durable enough to support and hold up to maintenance activities without requiring special equipment.
- With grouted riprap they are still able to get equipment across it to remove/clear debris and ultimately clean culverts

4. Site/Location - Review Sites and Concepts Developed — Matt N/Derek

- The Project Selected Sites are:
  - a combination of culvert inlets and outlets
  - propose alternatives to large riprap
  - Will need to Include updates to existing fencing and new fencing as necessary
  -
- Site A
  - Inlet w/ structural barrier
    - D1 Maintenance concerned w/ maintainability of FlexMat. Remaining options that they felt were conducive to maintenance included grouted riprap, regular ACB or grout the filled fabric form lining
- Site B
  - Outlet w/ erosion and headcut
    - Either ACB or the more durable cable reveted grout filled fabric forms were the only acceptable alternatives to large riprap
- Site C
  - Outlet w/ typical riprap stilling basin
    - D1 Maintenance had little confidence that they could effectively maintain FlexMat or HydroTurf w/ their readily available equipment and not damage the lining material.
- Site D
  - Inlet and Outlet – large & expansive riprap w/ the upstream riprap area fully grouted and the downstream riprap grouted on the sides w/ a steel barrier similar to guardrail separating grouted and un-grouted riprap. The grouted side areas would provide a safe path for tortoises with the steel barrier would prevent the tortoises from trying to traverse the un-grouted riprap
    - D1 Maintenance felt the steel barrier would most likely not hold up to the runoff and large amounts of sediment/debris and debris. In addition, they felt the steel barrier would make it more difficult to access & maintain. They were generally not supportive
- NDOT Hydraulics General Alternatives
  - FlexMat in lieu of riprap
    - D1 Maintenance was concerned w/ maintainability of FlexMat and or HydroTurf as previously discussed
  - Sloping concrete apron
    - D1 Maintenance found this option acceptable

	Further discussed that acceptable lining materials for the sloping aprons could include concrete, standard ACB, grouted riprap and/or the grout filled fabric lining	
5.	Next Steps • Incorporate maintenance concerns and recommendations from this meeting for a formal submittal	Matt/All
6.	Miscellaneous	All

Date Assigned	Due Date	Action	Notes

AGENDA-NOTES

NDOT Tortoise Crossings Research Project

SUBJECT	MEETING PLACE	DATE AND TIME	MINUTES BY
Technical Discussion – Grouted Riprap	Virtual/Teams	24 Feb. 2026, 2:00 pm PT	Matt N./Keith

PRESENT	REPRESENTING
Kristi Holcomb	NDOT
Eric Yount	NDOT
Mitch Ison	NDOT
Glen Church	NDOT
Melissa DeMattei	NDOT
Derek Ridenoure	NDOT
Tom Young	NDOT
Keith Hidalgo	AtkinsRéalis
Matt Nussbaumer	AtkinsRéalis

Agenda for Meeting

1. Grouted riprap discussion with USFWS/BLM
    - Recap?? Focus was on coyote
    - Smooth grouting (less roughness) no more than 3" of rock protruding above the grout

      --versus --
    - Coarse grouting (more roughness)—EY good w/ grouting the upper 1/3 to 1/2 of riprap thickness with 1' min on smaller riprap (Class 150 and Class 300) and leaving 6" to 9" of rock protruding above the grout
    - Consider a smooth sidewalk down the middle—will push problem to the end of the center sidewalk
    - Or consider adding random boulder that are grouted into existing riprap. This would have maintenance implications and would make it more difficult to maintain.
2. Grout Specifications
    - NDOTs Class B, non-excavatable slurry cement concrete compressive strength approx. 200-1000psi has been performing

- Has there been any performance issues? EY concerned w/ long term durability. Nothing specific so far
- Most other entities have grout specification w/ comp. strength > or equal to 2000psi
- If a change is needed, how to implement the change??? No preference but was ok with something similar to Clark County's

3. Fencing concerns w/ recent contracts
   - Crossing minor vs. major washes
   - Should avoid tortoise mesh fence crossings of washes if at all possible
   - Alt. alignments and routing of fence—
     - route to culvert headwall and/or end section to avoid wash conflicts
     - Will need to add gates. 1-min and 2 maybe on more major facilities

~~3.~~4. Any others items
   - ~~None~~

Action Items

Item	Description and Action	Deadline	Responsible
1.			
2.			
3.			

Item	Description and Action	Deadline	Responsible
4.			
5.			
6.			
7.			

Appendix B. Draft Proposed Standard Details

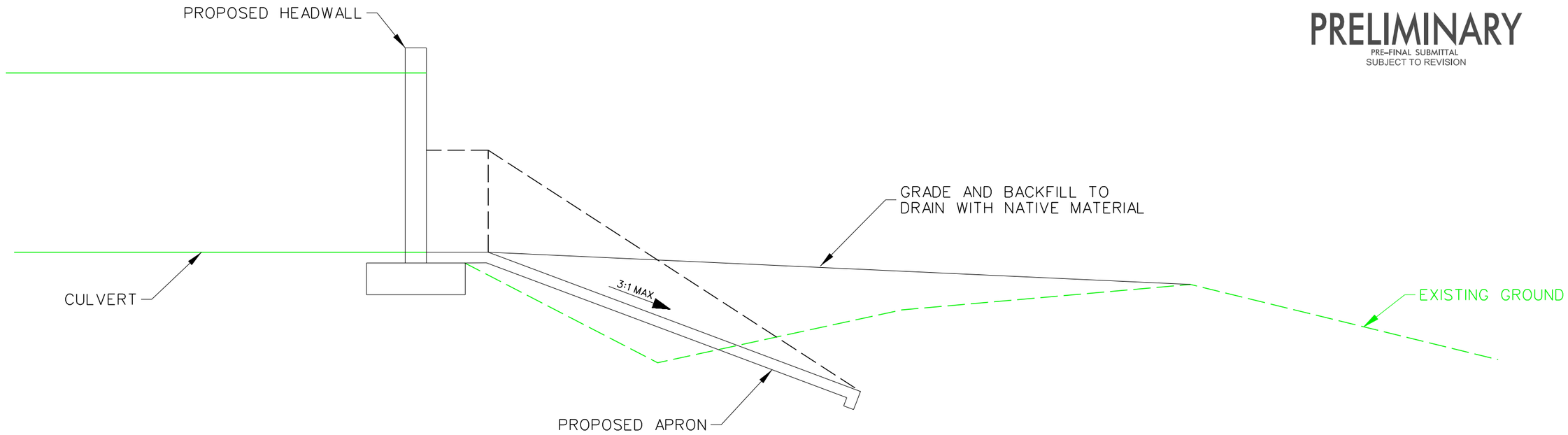
B.1 Sloping Lined Apron

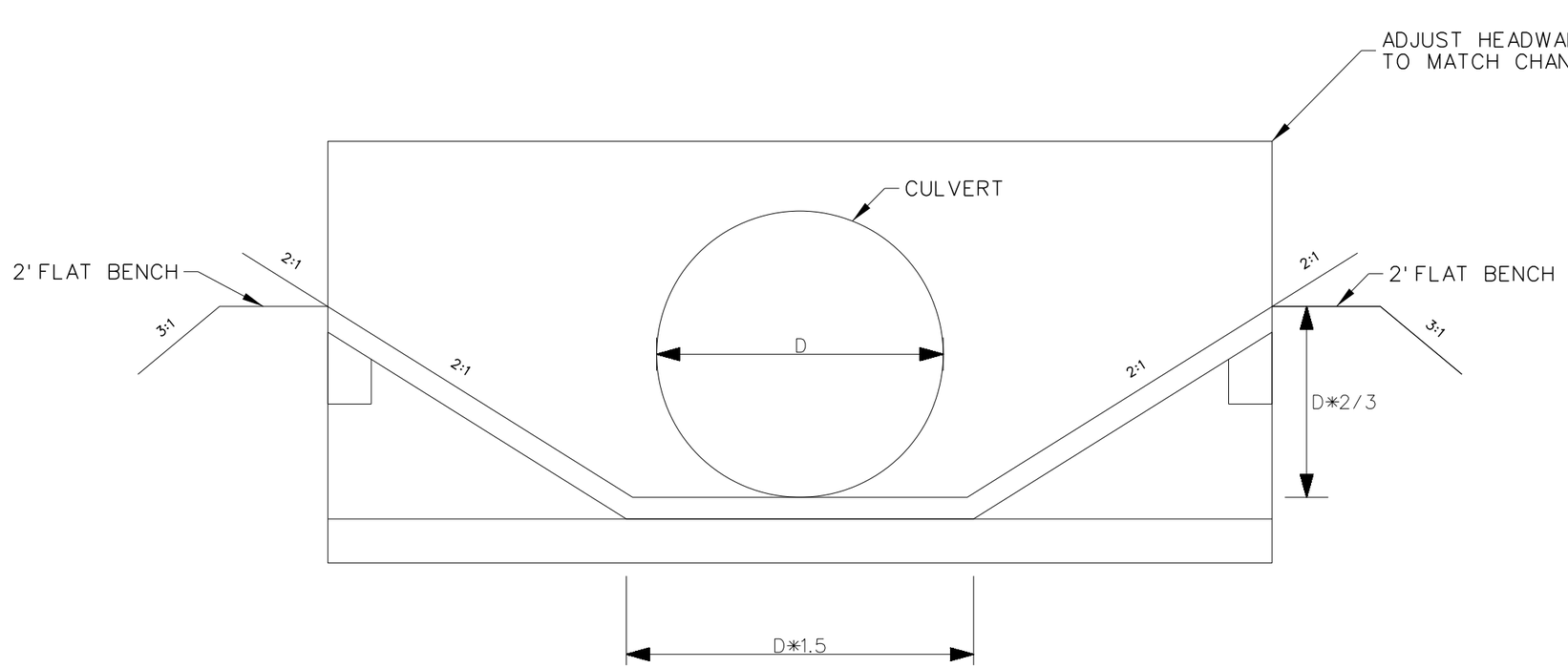
B.2 Grouted Riprap Basin

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	

PRELIMINARY

PRE-FINAL SUBMITTAL
SUBJECT TO REVISION





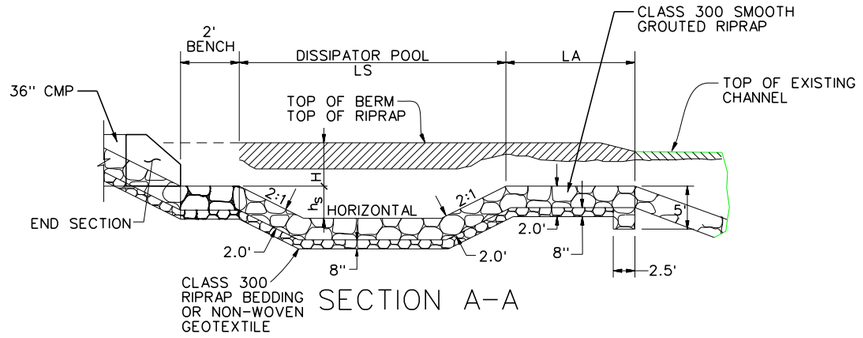
STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

DRAINAGE DETAILS

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	

PRELIMINARY

PRE-FINAL SUBMITTAL
SUBJECT TO REVISION



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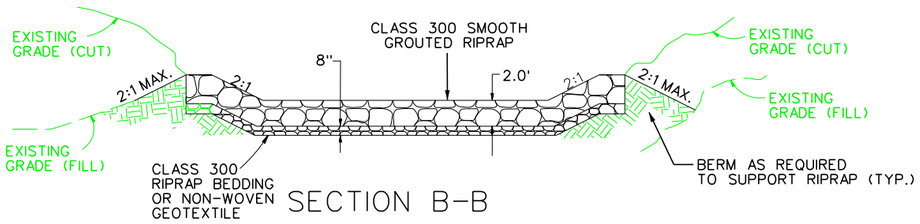

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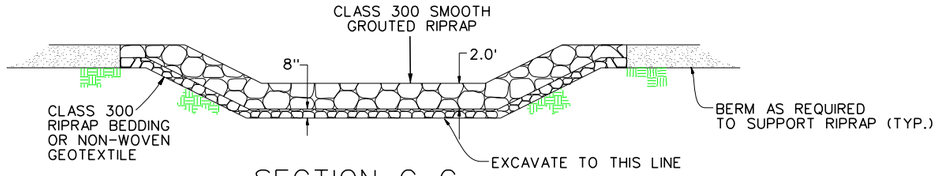

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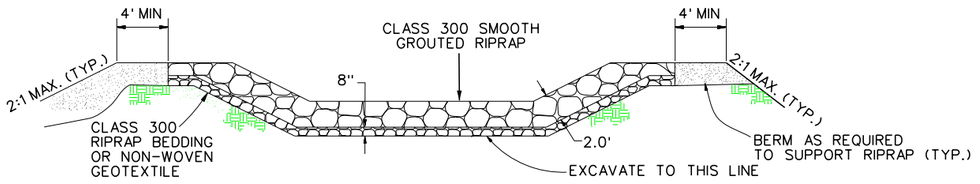

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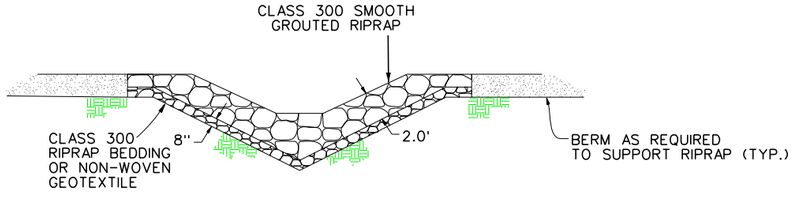

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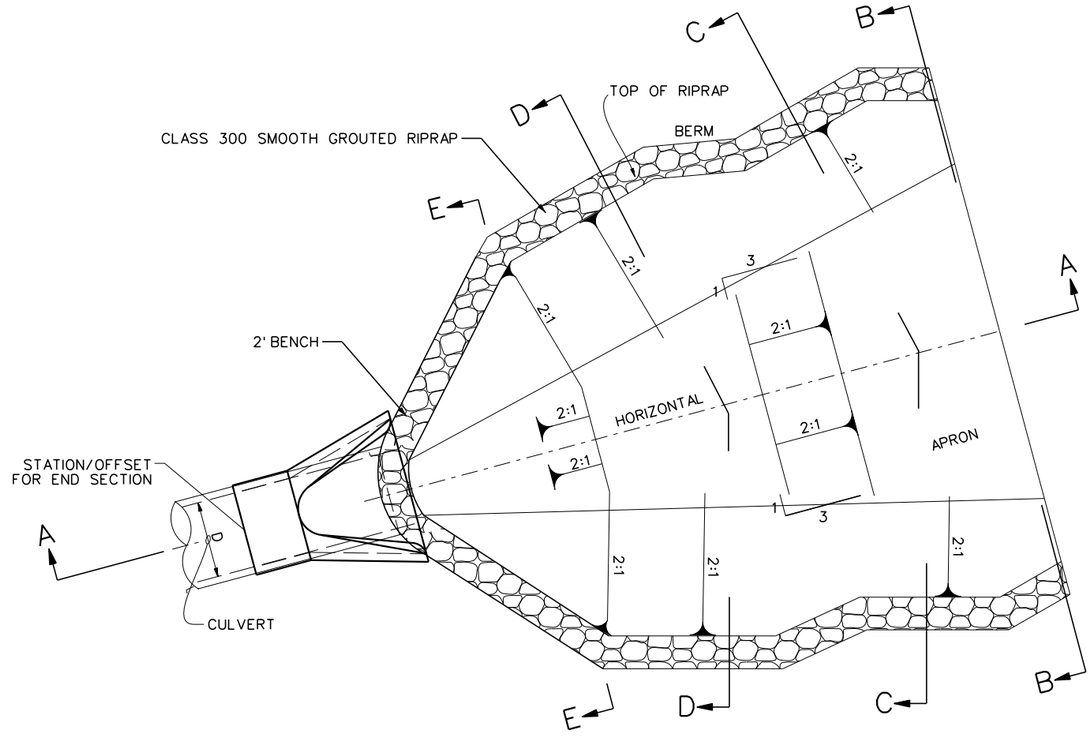


RIPRAP STILLING BASIN-PLAN

NOTES:

1. BASIN SIDE SLOPES ARE 2:1 (V:H).
2. AT END OF BASIN, SIDE SLOPES WILL TRANSITION TO EXISTING GRADING IN EITHER A CUT OR FILL.
3. ALIGN ℄ OF RIPRAP STILLING BASIN WITH ℄ OF CULVERT.

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

RIPRAP STILLING BASIN

Appendix C. Alternative Lining Materials

C.1 FlexMat

C.2 HydroTurf

C.3 Grout Filled Fabric Formed Lining

Flexamat®
PERMANENT EROSION CONTROL

PERMANENT EROSION CONTROL SOLUTIONS

Flexamat® - Permanent Solution for a Wide Range of Applications Including:

- AIRPORTS
- DOT ROADSIDE
- DRIVABLE SURFACES
- ENERGY SECTOR
- INLETS/OUTLETS
- LANDFILL/MINE RECLAMATION
- SHORELINE
- STREAM AND RIVERBANK

PERMANENT EROSION CONTROL SOLUTIONS

Erosion Prevention and Protection

OUR COMPANY

Motz Enterprises, Inc. is the manufacturer of **Flexamat®**. The company has been in business for over 30 years and is headquartered in Cincinnati, Ohio.

Flexamat is sold throughout the United States and Canada with material available locally in most areas.

We take pride in our performance and specifying the right product for the right application. **Flexamat** is an effective, long term solution. We look forward to working with you.

Flexamat®

Learn More About How Flexamat® Is The Best Permanent Erosion Solution!

About Flexamat®

Permanent Erosion Control

Flexamat is a permanent erosion control mat utilized for stabilizing slopes, channels, low water crossings, inlet/outlet protection, and shorelines. Tied Concrete Block Mat is a generic term for **Flexamat** It consists of concrete blocks (6.5˝ x 6.5˝ with a 2.25˝ profile) locked together and embedded into a high strength geogrid. There is 1.5˝ spacing between the blocks that gives the mat flexibility and allows for optional vegetation growth. The mat is packaged in rolls, making transporting and installing **Flexamat** efficient. It is manufactured with various underlayments, determined by onsite conditions.

Vegetated Solution

Flexamat offers permanent, hard armor protection, with a natural vegetation. **Flexamat** may be mowed over with commercial mowing equipment or left to grow wild. Besides grass, there are many other types of native plant species that can be planted to grow within the mat. For example, Willow stakes and other native plugs can be planted within **Flexamat**.

Work With Nature, Not Against

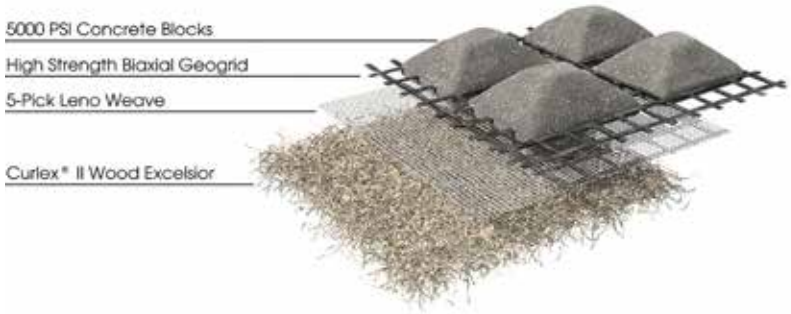
Incorporating perennial vegetation into storm water treatment plans will encourage the benefits of phytoremediation which is the direct use of living green plants for the removal, degradation or containments of contaminants. The establishment of perennial vegetation increases infiltration of storm water runoff into the soil, increased removal of pollutants found in road and parking lots runoff (oils & grease, metals, break dust salt, garbage, nutrients) through filtration and phytoremediation. The perennial vegetation also reduces or eliminates the thermal impacts to storm water runoff by shading the concrete blocks from sunlight and aiding in infiltration and filtering of the runoff, unlike rip rap or other hard armor alternatives.

Benefits of Flexamat®

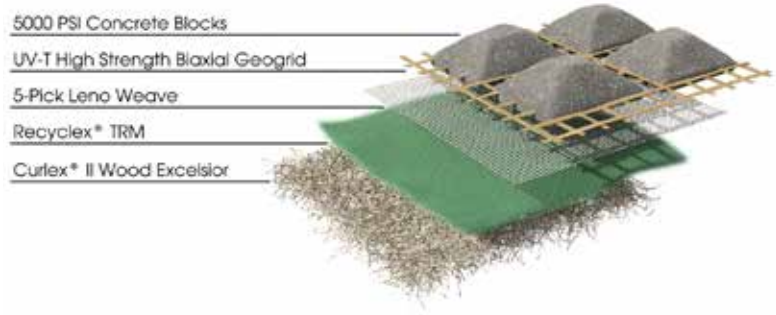
- HIGH PERFORMANCE
- EASY MAINTENANCE
- FAST INSTALLATION
- SIMPLE INSTALLATION
- AESTHETICALLY PLEASING
- IMPROVES SAFETY
- ENVIRONMENTALLY FRIENDLY
- REDUCES CONSTRUCTION COSTS
- DISCOURAGES GRAFFITI
- IMPROVES WATER QUALITY
- LOW-IMPACT DEVELOPMENT (LID)

Flexamat® *Products*

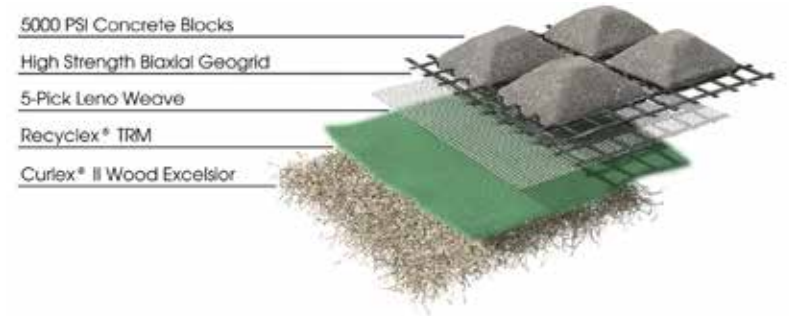
Flexamat Standard



Flexamat Plus UV-T

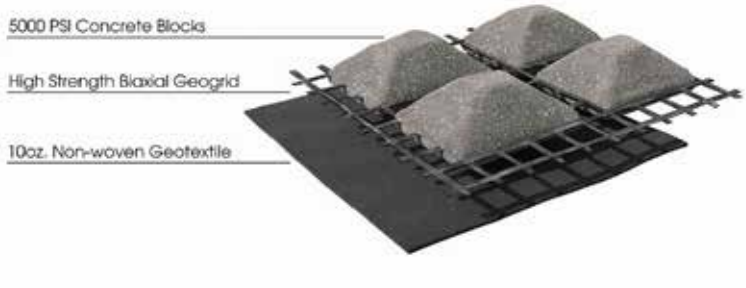


Flexamat Plus

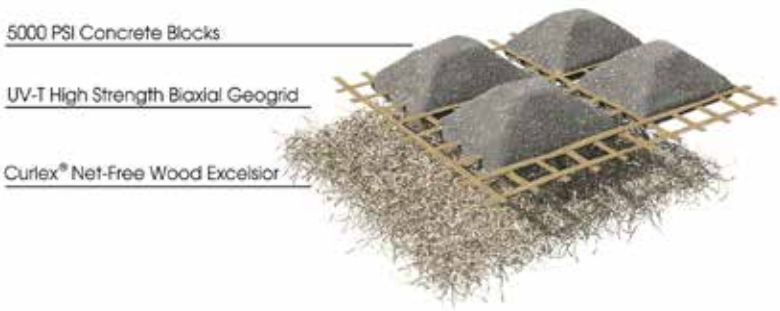


Flexamat 10NW UV-T

Flexamat 10NW



Flexamat NF UV-T



Flexamat® *Properties*

GENERAL COMPOSITION OF MATERIALS

Blocks	5000 PSI, Wet-cast Portland Cement
Interlocking Biaxial Geogrid	**Fornit 30/30** Polypropylene Geogrid with 2,055 lb/ft biaxial strength **UV-T Polypropylene** Geogrid with 2,055 lb/ft biaxial strength
Underlayment Options	**Standard** - Curlex® II ECB & Leno Weave **Plus** - Recyclex® TRM-V, Curlex® II ECB & Leno Weave **Fabric** - 10 oz Non-Woven Geotextile *More options available upon request, including Net Free underlayment.

MANUFACTURING VALUES

Flexamat® Properties	Values
Roll Widths	4’ 5.5’ 8’ 10’ 12’ 16’ 15.5’ with geogrid and underlayment extensions (for areas wider than 16’)
Roll Lengths	30’ 40’ 50’ / Custom
Material Weight	10 lbs./sf
Block Size	6.5” x 6.5” x 2.25”
Percentage Open Area (POA)	30% min.

PERFORMANCE

Test	Tested Value	Bed Slope	Soil Classification	Limiting Value
ASTM 6460	Shear Stress	30%	Sandy Loam (USDA)	24+PSF
ASTM 6460	Velocity	20%	Loam (USDA)	30+ ft/sec

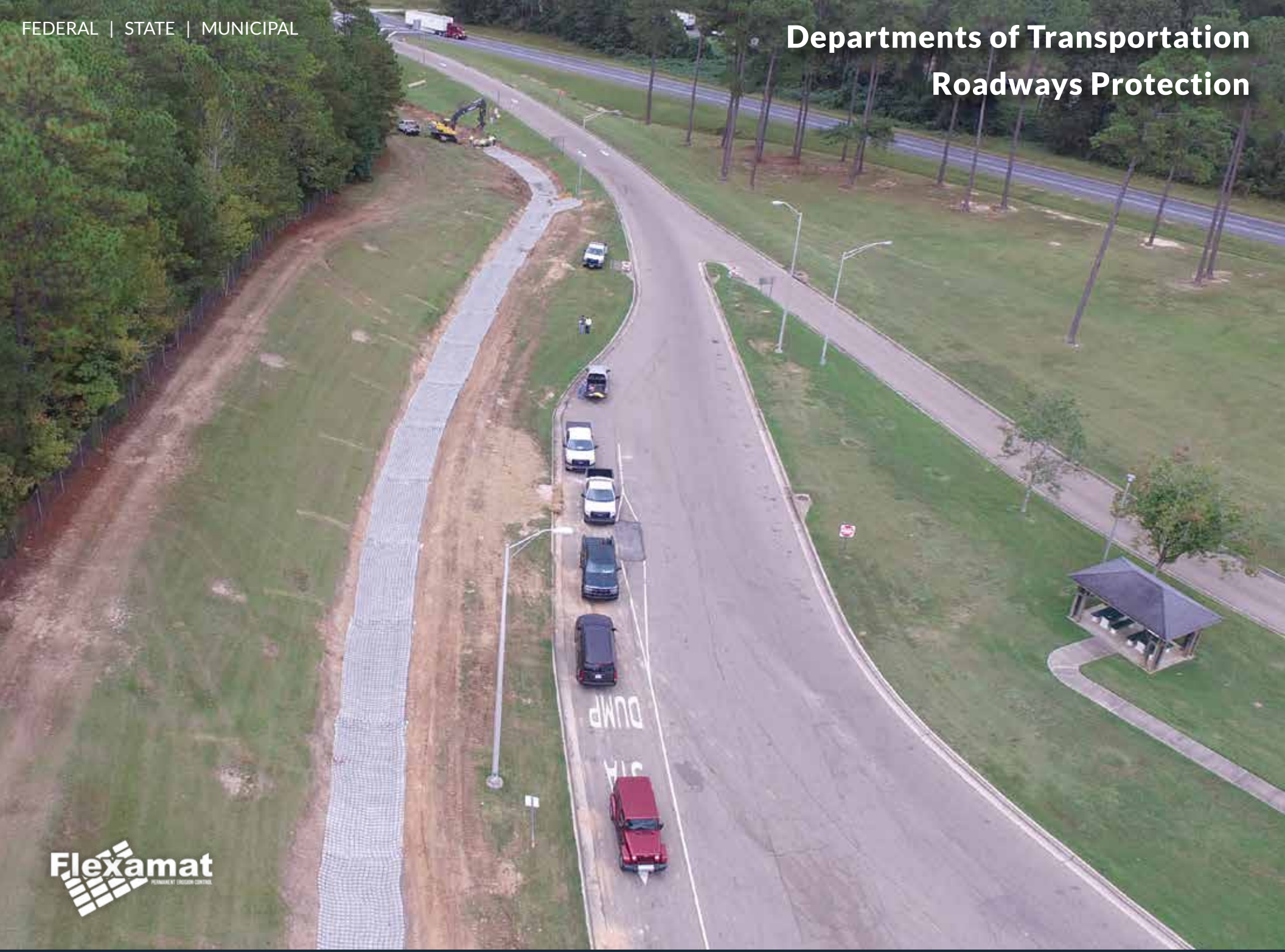
Departments of Transportation
Roadways Protection

Departments of Transportation
Roadways Protection

Three months after installation

One year after installation

Departments of Transportation
Roadways Protection



Flexamat

Departments of Transportation
Roadways Protection

One year after installation.

Inlet & Outlet Erosion Protection

Failing riprap

Outlet armored with Flexamat®, 3 years later

Armored drain

Eroded outlet

Repaired outlet

Landfill Erosion Protection


60’ wide letdown just installed


60’ wide letdown 4 years after installation

Energy Erosion Protection

Exposed high pressure gas pipeline

Energy Erosion Protection

Flood Control

One year after installation

Flood Control

Canals

Three months after installation

Percussion Anchors

Gas powered driver installation

Loading anchor with Jack Jaw®

Installed anchors


Elite Airways
Flexamat

Airports

Shoreline Erosion Protection

Shoreline Erosion Protection

Creek Erosion Protection

Streambank Protection

Fully vegetated Flexamat® with native littorals thriving

Drivable Surfaces Erosion Protection

Boat ramp

Gravel infill for residential driveway

Access road

Schools Erosion Protection


NEEDLER'S MILL


NEEDLER'S MILL

Up to 4800 square feet of material can ship on one truckload

Flexamat
PERMANENT EROSION CONTROL

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phone: 513-772-6689

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A Revolutionary Technology for PERMANENT EROSION CONTROL ARMORING

HydroTurf®

Advanced Revetment Technology

SUPERIOR ARMORING TECHNOLOGY

HydroTurf® is an innovative revetment technology that is an economical and sustainable solution for hydraulic applications that require hard armor. HydroTurf was specifically engineered as a high performing revetment with reduced construction and long-term maintenance costs. It can perhaps best be described as an impermeable fiber-reinforced concrete liner. It combines engineered synthetic turf with a high friction geomembrane that are locked into place with a specially designed HydroBinder® high-strength infill.

HydroTurf offers the best of both worlds—the environmental and aesthetic benefits of vegetation as well as the performance and maintenance benefits of hard armor. By offering superior erosion control, pointedly less turbidity, and significantly less maintenance, HydroTurf eliminates the headaches of traditional vegetative erosion control systems. HydroTurf's low carbon footprint makes it one the most sustainable hard or soft revetment solutions available.

ADVANTAGES COMPARED TO OTHER REVETMENT SOLUTIONS

Excellent Hydraulic Performance

HydroTurf has undergone extensive, full-scale hydraulic performance testing by independent third party laboratories. Flow velocities of 40 fps and hydraulic jump testing performed with no instability or subgrade erosion. HydroTurf provides predictable hydraulic performance.

50+ Year Functional Longevity

A functional longevity of 50+ years is engineered into the HydroTurf system when properly maintained and has been demonstrated through accelerated independent third party laboratory weathering testing.

Less Costly Construction

HydroTurf is significantly less costly than hard armor revetment systems (i.e. concrete, rock riprap, and articulated concrete block). Installed cost for HydroTurf is typically up to 50% less than that for traditional hard armor systems.

Rapid, Low Impact Construction

Construction of the HydroTurf system is rapid, low impact, and scalable. Only small, light-weight construction equipment is needed for installation. On large projects, one (1) construction crew is able to install approximately 1 acre per day. Additional crews can be added to increase this rate.

Significant Long Term Maintenance Cost Savings

Vegetation management and erosion control are significant maintenance costs for other armoring products (i.e., concrete, rock riprap, pipe, articulated concrete block (ACB), and Anchored Turf Reinforcement Mat (TRM) products). Maintenance costs for these products may be as high as $1,500/acre/year. HydroTurf requires minimal maintenance and will drastically lower long-term maintenance budgets.

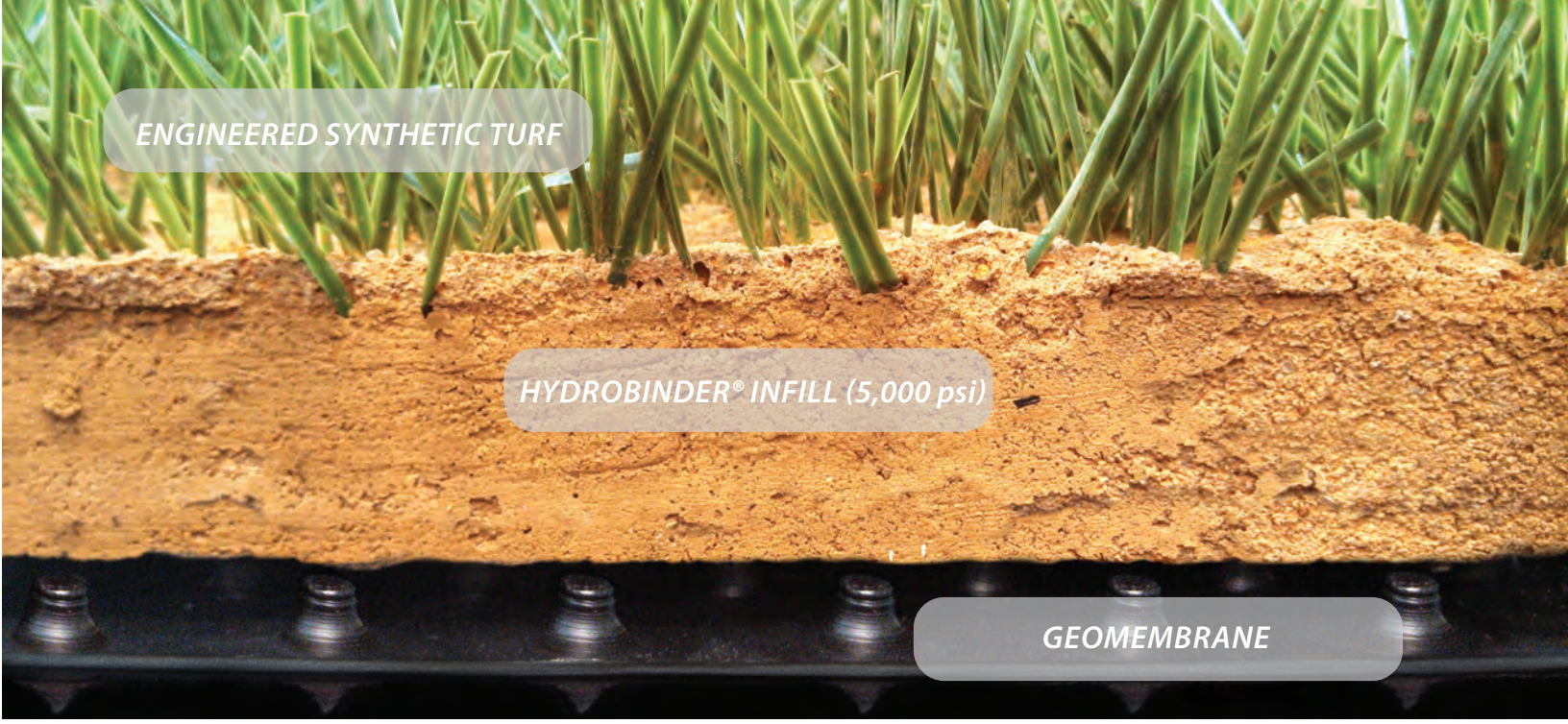
Reduction in Carbon Footprint

HydroTurf has a lower carbon footprint (75-85% reduction) than that of other traditional hardened revetment solutions.

Aesthetics

HydroTurf looks and feels like natural vegetation.

HydroTurf® protects against 40 ft/s flow velocity with no instability or damage.



CHANNEL AND STREAMBANK STABILIZATION

HYDROTURF® APPLICATIONS

Channel and Streambank Stabilization

Hydraulic forces from storm water runoff can cause significant erosion and scour of channels and streambanks. The HydroTurf® revetment technology is designed to resist erosive forces under high velocity conditions, even on steep grade applications.

Dam Overtopping

In high velocity applications of dam spillways and embankments, HydroTurf has been shown to protect against overtopping depths of 5.5 feet and the resulting flow velocity of 40 ft/s. It also protects the subgrade from erosion during severe hydraulic jump conditions. HydroTurf is recognized by Dam Safety agencies, including FEMA, as a solution for overtoping protection.

Shoreline and Bank Protection

HydroTurf's 5,000-PSI proprietary fiber-reinforced infill with the integrated polyethylene (PE) geomembrane provides a hard armor revetment against wave attack and fluctuating water levels. It offers exceptional performance at a lower cost than traditional alternatives.

Levees

The HydroTurf engineered revetment solution armors levees for protection against the extreme hydraulic conditions of storm surges, wave overtopping, and river flooding. It exceeded the USACE hydraulic performance specifications for levee wave overtopping protection.

Outfall Structures

Outfall structures need to protect watercourses, channels, swales, basins, and other storm water features against erosion. HydroTurf provides an excellent solution for the concentrated and high velocity storm water flows exiting outfall culverts.

Slope Protection

Erosion control on slopes can be challenging, especially when vegetation is difficult to establish. HydroTurf® is the solution for these slopes by providing an armoring that looks and feels like natural turf.

Landfill Storm Water Management System

Created specifically for downchutes, bench drains, and perimeter channels on and around landfills, HydroTurf provides superior hydraulic performance capable of handling large flows on steep gradients resulting in very high velocities.

Golf

Used by top golf courses throughout the world, HydroTurf is the ideal solution for courses where natural vegetation takes a beating and is difficult to establish and maintain. These high-traffic and erosion-prone areas include: cart paths, maintenance paths, lake and pond shorelines, drainage channels and outfall protection.

Roof Ballast

HydroTurf is the perfect roof ballast solution for protected membrane roofs. It has been shown to resist uplift at wind speeds over 150 mph. Also, it provides excellent resistance to physical and environmental damage.

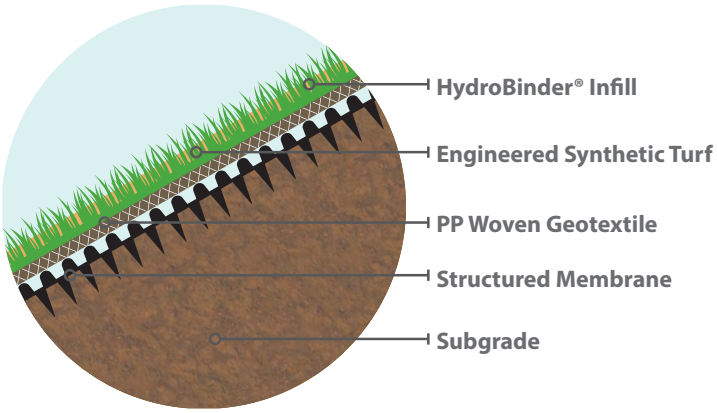
Roadside Shoulders, Medians and Landscaping

HydroTurf provides a total roadside management system that eliminates erosion, does away with vegetation management, institutes easy long-term maintenance, and has beautiful aesthetics.

TECHNOLOGY CONFIGURATION TYPES

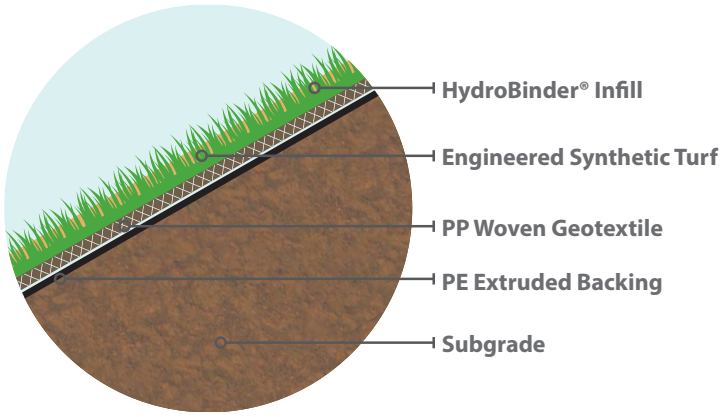
HydroTurf® CS

HydroTurf CS is typically used for high velocity conditions and for protection of critical structures.



HydroTurf® Z

HydroTurf Z is ideal for less critical applications involving lower velocities and flow conditions.



HydroTurf has been extensively tested in laboratories and project applications for extreme performance and real-world durability. From extensive 5.5-ft overtopping flows to simulated 500 year hurricanes, HydroTurf has established a new standard in the most comprehensive array of testing in the industry.

Full-Scale Hydraulic Testing:

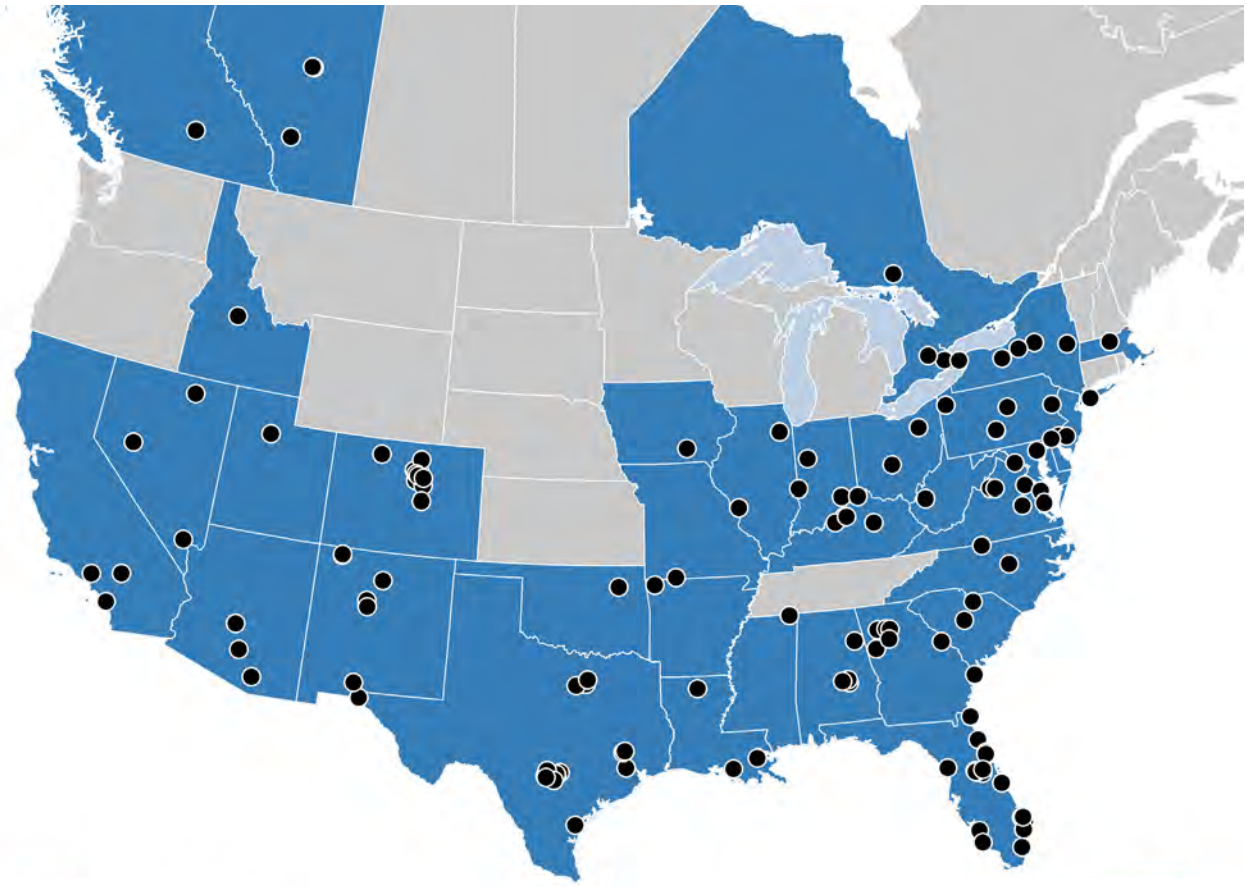
- Wave Overtopping for Levee Landward-Side Slope Protection
- Steady State Overtopping
- Hydraulic Jump
- Simulated Heavy Debris Loads
- Intentionally Damaged Conditions

Other Testing & Evaluations:

- Aerodynamic Wind Tunnel
- Flammability
- Freeze-Thaw Durability
- Weathering and Functional Longevity
- Vehicle Loading
- Carbon Footprint

FULL SCALE WAVE OVERTOPPING FLUME TEST

OVER 6,000,000 SF INSTALLED ACROSS NORTH AMERICA



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WG Watershed Geo® Unearthing Solutions

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Synthetex®
Reinforcing infrastructure for good.™

HYDROTEX®

Fabric Formwork customized to provide superior and affordable cast-in-place erosion control and scour protection

our process:

TOGETHER

We understand that firms charged with scour protection, erosion control, and infrastructure reinforcement projects need more than a product solution, and even more than a business partner.

You want a company who becomes your team member, who is also focused on the success of your project, and your business. Meet your new team member ... Synthetex®.

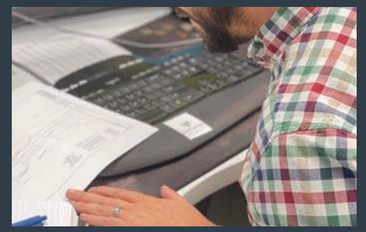
CUSTOM DESIGN FOR PROJECT SUCCESS

Our HYDROTEX® fabric formworks are designed with the concrete thickness required and the site specific considerations necessary for a successful installation, including hydraulic factors, vessel factors, slope, topography, obstructions, and the need to articulate or allow for vegetation.

SINGLE SOURCE VALUE

Since we are both the product designer and manufacturer, we are able to offer our customers a highly valuable solution at an affordable price, which includes, for first-time customers, up to 4 weeks of on-site training and technical support to ensure a successful installation.

PROJECT ANALYSIS



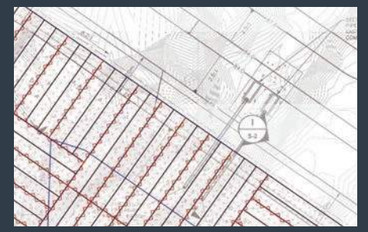
Unsure which product best solves the challenges of your project? We provide unbiased evaluations of your project specifications to determine the best solution ... even if it's not one of ours.

SOLUTION DESIGN

$$\Delta D = 0.035 \frac{\Phi}{\Psi} \frac{K_T K_h}{K_s} \frac{u_{cr}^2}{2g}$$

Our sales, engineering and manufacturing team members work closely with you to design the solution, product, mattress thickness and attributes required to meet your project's specifications.

PROPOSAL PROCESS



Our quotes are thorough and detailed, providing a solid case for solution design and cost savings. We can also assist with determining total installation costs and presenting the proposed solution to your key stakeholders.

MANUFACTURING

Once your product design is approved, our engineering team prepares shop drawings for every panel included in your project.

INSTALLATION SUPPORT

We understand that the key to a sucessful installation is proper instruction and technical support at the job site. No matter where your project takes us, we will be there to train your installation team and provide troubleshooting as needed.

What Is
FABRIC FORMWORK?

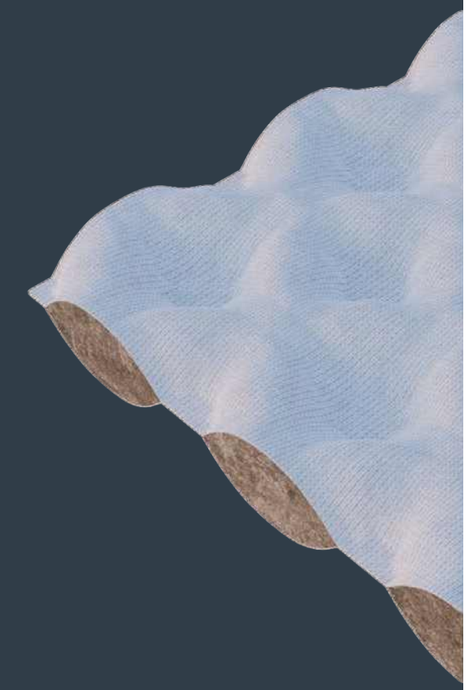
Fabric formwork is a method of concrete molding and installation invented in the 1970s, consisting of two layers of geosynthetic fabric that is pumped with fine aggregate concrete at the project site.

WHY CHOOSE HYDROTEX?

HYDROTEX® fabric formwork products have the strength of traditional rock an pre-cast concrete options, while also providing an easier, safer, more customized and more affordable installation.

- Inherent strength due to being a method of concrete casting
- Can be designed to articulate
- Can be designed with permeablility to relieve hydrostatic pressure
- Can be designed with cutouts to custom fit any environment
- Can be designed with internal cables for reinforcement
- Can be designed to allow for vegetation growth
- Can be installed in cold conditions
- Can be pumped with concrete underwater
- Zipped panel connections create a solid structure
- The light weight of fabric and cast in place design saves on shipping costs
- Less required labor, less time, and no heavy equipment

	Geocells	Rip Rap	Prefabricated Concrete Blocks	Gabions	HYDROTEX
Ease of Install	✗	✓	✗	✗	✓
Low Shipping Costs	✓	✗	✗	✗	✓
No Heavy Equipment	✓	✗	✗	✓	✓
Easy Site Access	✓	✗	✗	✓	✓



FILTER POINT

The HYDROTEX® fabric formwork system designed to enable permeability for hydrostatic pressure relief.

HYDROTEX Filter Point is a fabric formwork that consists of a double-layer woven fabric joined together by spaced, interwoven filter points to form a concrete lining with a deeply cobbled surface appearance. The filter points form water permeable drains and attachment points for the control of the concrete lining thickness.

AVAILABLE THICKNESSES, INCH (MM)

2.2 (55)	3 (75)	4 (100)	6 (150)	8 (200)	10 (250)	12 (300)

FEATURES

PERMEABLE - RIGID - CUSTOMIZABLE

APPLICATIONS

Canal Lining
Channel Lining
Culvert / Outfall Protection
Ditch Lining
Downchute Protection
Embankment Protection
Liner Protection
Pipeline Protection

INDUSTRIES

Landfills
Mining
Municipal Water and Wastewater
Rivers and Canals
Roads, Highways, and Airports

ARTICULATING BLOCK

The HYDROTEX® fabric formwork system designed to enable articulation.

HYDROTEX Articulating Block is a fabric formwork that consists of a series of compartments (blocks) linked by an interwoven perimeter of fabric and internal revetment cables. Ducts interconnect the compartments, and high strength revetment cables are installed between and through the compartments and ducts. The cables remain embedded in the mattress to facilitate articulation along the lines of the interwoven fabric perimeters.

AVAILABLE THICKNESSES, INCH (MM)

3 (75)	4 (100)	6 (150)	8 (200)	10 (250)	12 (300)	14 (350)	16 (400)	18 (460)	20 (510)	22 (560)	24 (610)

FEATURES

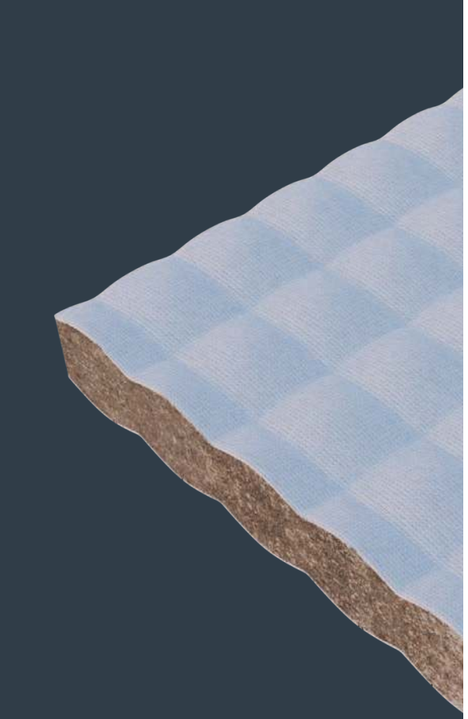
PERMEABLE - FLEXIBLE - CUSTOMIZABLE

APPLICATIONS

Bridge Abutment Protection
Bridge Pier Scour Protection
Canal Lining
Channel Lining
Embankment Protection
Pipeline Cover
Shoreline Revetment

INDUSTRIES

Bridges and Piers
Landfills
Locks and Dams
Marine and Coastal
Ports and Harbors

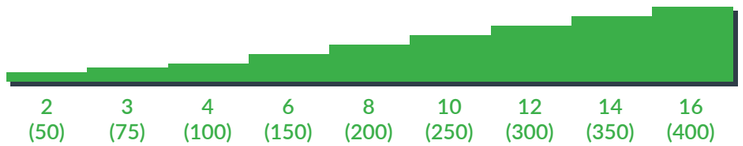


UNIFORM SECTION

The HYDROTEX® fabric formwork system designed to mimic smooth, poured concrete.

HYDROTEX Uniform Section is a fabric formwork with a relatively uniform (constant) cross section thickness and a brick pattern surface. Uniform Section has a relatively low coefficient of hydraulic friction (Manning's n value) to maintain optimum water velocities. Due to the impermeable aspect of concrete, this product is well suited for a wide array of lining and scour protection applications.

AVAILABLE THICKNESSES, INCH (MM)



FEATURES

IMPERMEABLE - RIGID - CUSTOMIZABLE

APPLICATIONS

Canal Lining
Coal Ash [CCR] Liner Protection
Cooling Channels and Ponds
Culvert / Outfall Protection
Embankment Protection
Liner Protection
Pipeline Protection

INDUSTRIES

Environmental and Containment
Municipal Water and Wastewater
Ports and Harbors
Rivers and Canals
Sediment Remediation

ENVIROMAT®

The HYDROTEX® fabric formwork system designed to enable vegetation.

HYDROTEX Enviromat is a fabric formwork that consists of concrete-filled elements and unfilled areas that allow vegetation. Once the concrete sets, the unfilled interwoven areas (approximately 20% of the total area of the lining) can be opened, filled with topsoil, and seeded. The Enviromat products are many times used in conjunction with a turf reinforcement mat (TRM).

AVAILABLE THICKNESSES, INCH (MM)

FEATURES

ALLOWS VEGETATION - PERMEABLE - CUSTOMIZABLE

APPLICATIONS

Canal Lining
Channel Lining
Collection Channels
Embankment Protection

INDUSTRIES

Mining
Rivers and Canals
Roads, Highways, and Airports

ENVIROMAT FX®

The HYDROTEX® fabric formwork system designed to enable maximum vegetation.

Designed to be either cast-in-place or precast and then hoisted-in-place, Enviromat FX is a fabric formwork with unwoven filtration/vegetation perimeters around each block. Once the concrete sets, the unfilled fabric areas (nominally 30% of the total area of the lining) are used to establish vegetation as well as facilitate articulation, lifting, and placing.

AVAILABLE THICKNESSES, INCH (MM)

1 (25)

FEATURES

ALLOWS VEGETATION - PERMEABLE - CUSTOMIZABLE

APPLICATIONS

Canal Lining

Culvert / Outfall Protection

Ditch Lining

Embankment Protection

INDUSTRIES

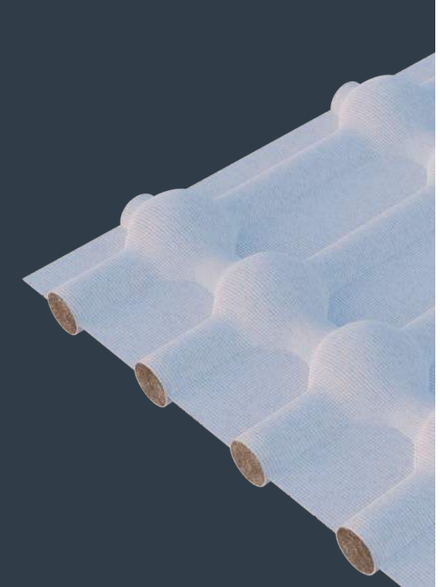
Landfills

Marine and Coastal

Mining

Rivers and Canals

Roads, Highways, and Airports



FILTERBAND®

The HYDROTEX® fabric formwork system designed to enable maximum permeability for hydrostatic pressure relief.

HYDROTEX Filter Band is a fabric formwork that consists of a double-layer woven fabric joined together by spaced, interwoven filter bands, creating permeable drains for water to filter through. With alternating concrete tubes, Filter Band has a deeply textured surface appearance and achieves greater reduction of flow velocity and wave run-up due to a higher Manning's n value.

AVAILABLE THICKNESSES, INCH (MM)

4 (100)

FEATURES

PERMEABLE - RIGID - CUSTOMIZABLE

APPLICATIONS

Canal Lining

Channel Lining

Culvert / Outfall Protection

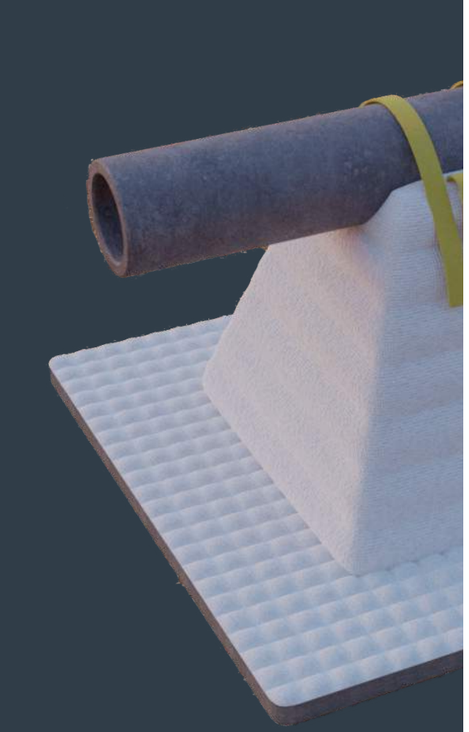
Embankment Protection

INDUSTRIES

Mining

Rivers and Canals

Roads, Highways, and Airports



HYDROCAST® ARMOR UNITS

The HYDROTEX® fabric formwork system designed to create large, custom support structures on land or subsea.

HYDROCAST Armor Units consist of woven fabric sewn together to form custom shapes such as cubes, rectangles, or geometries that incorporate curves. When filled with fine aggregate concrete, they form a fabric-formed 3-D concrete shape with custom dimensions and volume. Self-sealing filling valves, suitable for use with an injection pipe at the end of a pump hose, are installed at predetermined locations. Custom features — such as internal steel cables, straps, or cam-lock filling ports — may be added.

AVAILABLE THICKNESSES, INCH (MM)

Custom Manufactured

FEATURES

100% CUSTOM

APPLICATIONS

Pipe Plugs

Scour Aprons

Shoreline Revetment

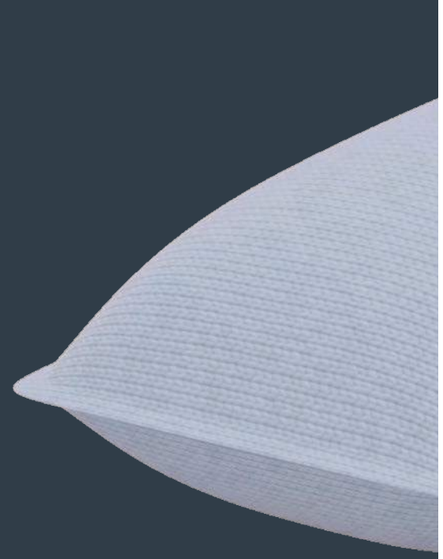
Tunnel Closures

INDUSTRIES

Bridges and Piers

Locks and Dams

Marine and Coastal



GROUT BAGS

The HYDROTEX® fabric formwork system designed to mimic sandbags but with superior strength.

HYDROTEX Grout Bags consist of specially woven, double-layer synthetic forms pumped with fine aggregate concrete to create a grout bag of personalized thickness, weight, and configuration. Additional items such as tie-down straps, cut-outs around obstructions, and reinforcing cables can be incorporated into a grout bag.

AVAILABLE THICKNESSES, INCH (MM)

Custom Manufactured

FEATURES

100% CUSTOM

APPLICATIONS

Bridge Pier Scour Protection and Remediation

Channel Lining

Culvert / Outfall Protection

Embankment Protection

Prop / Thruster Scour Protection

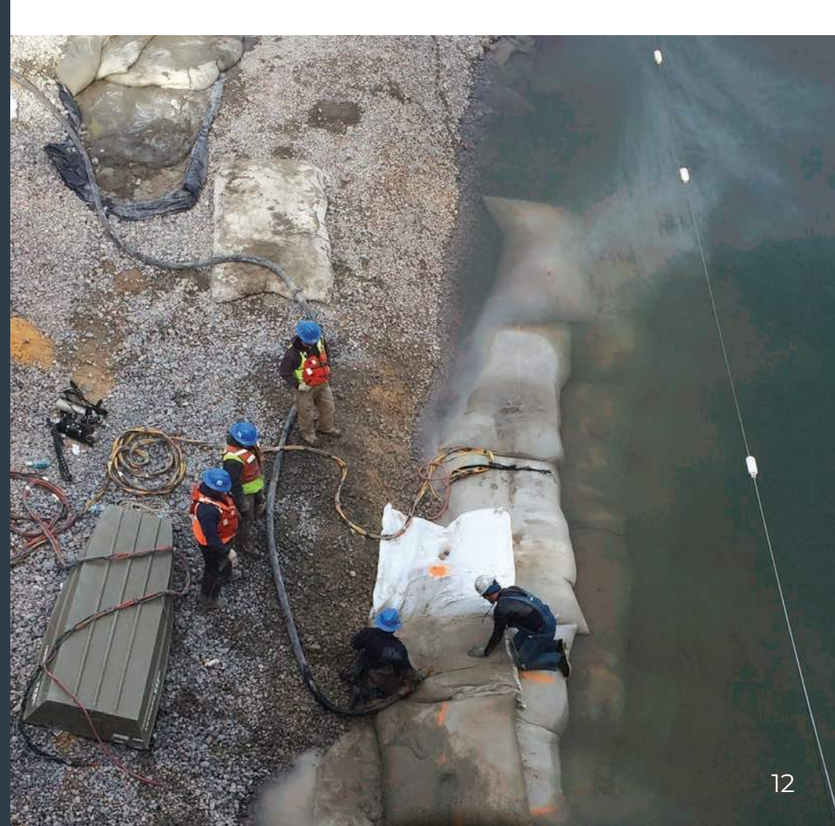
Scour Aprons

INDUSTRIES

Bridges and Piers

Locks and Dams

Marine and Coastal



PIPE WRAPS

The HYDROTEX® fabric formwork system designed to custom fit, wrap and protect oil & gas pipelines.

Synthetex's high-strength HYDROTEX pipe wraps are available in lengths and diameters designed to armor your above ground, underground, and subsea pipes with custom solutions and not restricted to the standard diameters. Fabric formed pipe wraps are a proven economical solution for pipe armoring and reinforcement.

AVAILABLE THICKNESSES, INCH (MM)

Custom Manufactured

FEATURES

100% CUSTOM

APPLICATIONS

Overland Gas and Oil Pipelines

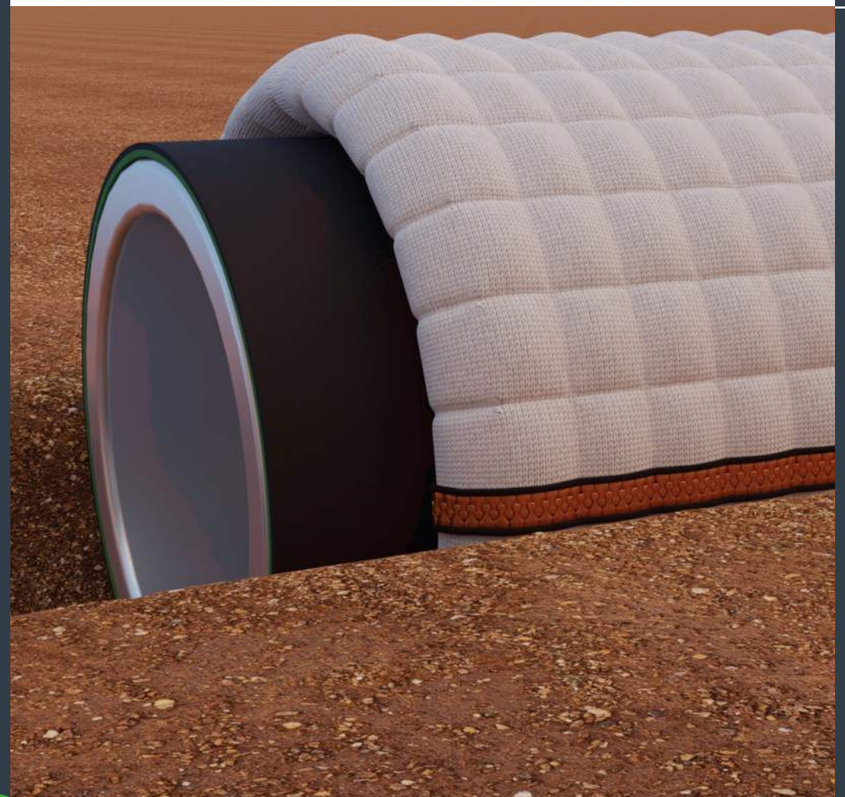
Subsea Gas and Oil Pipelines

Subterranian Gas and Oil Pipelines

INDUSTRIES

Oil and Gas

Municipal Utilities



PILE JACKETS

The HYDROTEX® fabric formwork system designed to custom fit, wrap and protect bridge or port piles.

Synthetex's high-strength HYDROTEX pile jacket systems are available in lengths and diameters designed to armor your steel, concrete or timber piles with custom solutions and not restricted to the standard diameters. Fabric formed pile jackets are a proven economical solution for pile repair and protection.

AVAILABLE THICKNESSES, INCH (MM)

Custom Manufactured

FEATURES

100% CUSTOM

APPLICATIONS

Bridge Pier Protection

INDUSTRIES

Bridges and Piers

Locks and Dams

Marine and Coastal

Filter Point

SIZE	Average Thickness		Mass Per Unit Area		Concrete Coverage		Filter Point Spacing	
	in	mm	lb/ft²	kg/m²	ft²/yd³	m²/m³	in	mm
FP220	2.2	55	25	120	136	16.6	5	125
FP300	3	75	34	165	100	12.1	6.5	165
FP400	4	100	45	220	75	9.1	8	200
FP600	6	150	68	330	50	6.1	10	255
FP800	8	200	90	440	38	4.6	12	305
FP1000	10	250	113	550	30	3.6	14	355
FP1200	12	300	135	660	25	3.0	16	405

Articulating Block

SIZE	Average Thickness		Mass Per Unit Area		Concrete Coverage	
	in	mm	lb/ft²	kg/m²	ft²/yd³	m²/m³
AB300	3	75	34	165	100	12.1
AB400	4	100	45	220	75	9.1
AB600	6	150	68	330	50	6.1
AB800	8	200	90	440	38	4.6
AB1000	10	250	113	550	30	3.6
AB1200	12	300	135	660	25	3.0
AB1400	14	350	158	770	22	2.6
AB1600	16	400	180	880	19	2.4

Uniform Section

SIZE	Average Thickness		Mass Per Unit Area		Concrete Coverage	
	in	mm	lb/ft²	kg/m²	ft²/yd³	m²/m³
US200	2	50	22	107	150	18.2
US300	3	75	34	165	100	12.1
US400	4	100	45	220	75	9.1
US600	6	150	68	330	50	6.1
US800	8	200	90	440	38	4.6
US1000	10	250	113	550	30	3.6
US1200	12	300	135	660	25	3.0
US1400	14	350	158	770	22	2.6
US1600	16	400	180	880	19	2.4

Filter Band®

SIZE	Average Thickness		Mass Per Unit Area		Concrete Coverage		Filter Point Spacing	
	in	mm	lb/ft²	kg/m²	ft²/yd³	m²/m³	in	mm
FB400	4	100	45	200	75	9.1	8	200

Enviromat®

SIZE	Average Thickness		Mass Per Unit Area		Concrete Coverage		open vegetated area
	in	mm	lb/ft²	kg/m²	ft²/yd³	m²/m³	%
EM250	2.5	65	28	138	120	14.6	20
EM400	4	100	45	220	75	9.1	20

Enviromat FX®

SIZE	Average Thickness		Mass Per Unit Area		Concrete Coverage		open vegetated area
	in	mm	lb/ft²	kg/m²	ft²/yd³	m²/m³	%
FX100	1	25	11	53.7	290	35.2	30

Fine Aggregate Concrete Mix Design

MATERIAL	Mix Proportions		After Placement Mix Proportions	
	lb/yd³	kg/m³	lb/yd³	kg/m³
CEMENT	750 - 850	445 - 505	805 - 915	475 - 540
SAND	2120 - 2030	1255 - 1205	2290 - 2190	1355 - 1295
WATER	540 - 555	320 - 325	460 - 470	270-275
AIR	As Required		As Required	

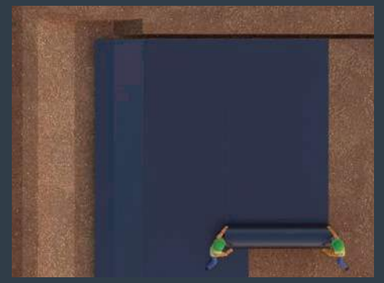
Water reducers and other admixtures may be required.
All dimensions and values in table are nominal.

INSTALLATION PROCESS

Zipped connections ensure the creation of a monolithic structure

SITE PREPARED

The site is first graded, staked, and trenched in preparation for HYDROTEX® fabric framework installation.



NON-WOVEN GEOTEXTILE INSTALLED

Depending on application, a nonwoven geotextile may be installed for soil retention.

HYDROTEX ROLLED OUT

HYDROTEX panels are rolled out and zipped together, forming a monolithic formwork.

HYDROTEX FILLED

Using predesigned filling points, the HYDROTEX fabric formwork is filled with fine aggregate concrete.

SITE INSPECTED

During and after pumping, the formwork is inspected to ensure even filling and structural integrity.

REQUIRED SUPPLIES

The following supplies are reccomended for effective installation of HYDROTEX fabric framework.

DITCH WITCH

DIGGER

CONCRETE PUMP WITH HOPPER

READY-MIX TRUCK

FLEXIBLE CONCRETE PUMP HOSE

FLOW CONE TO TEST GROUT

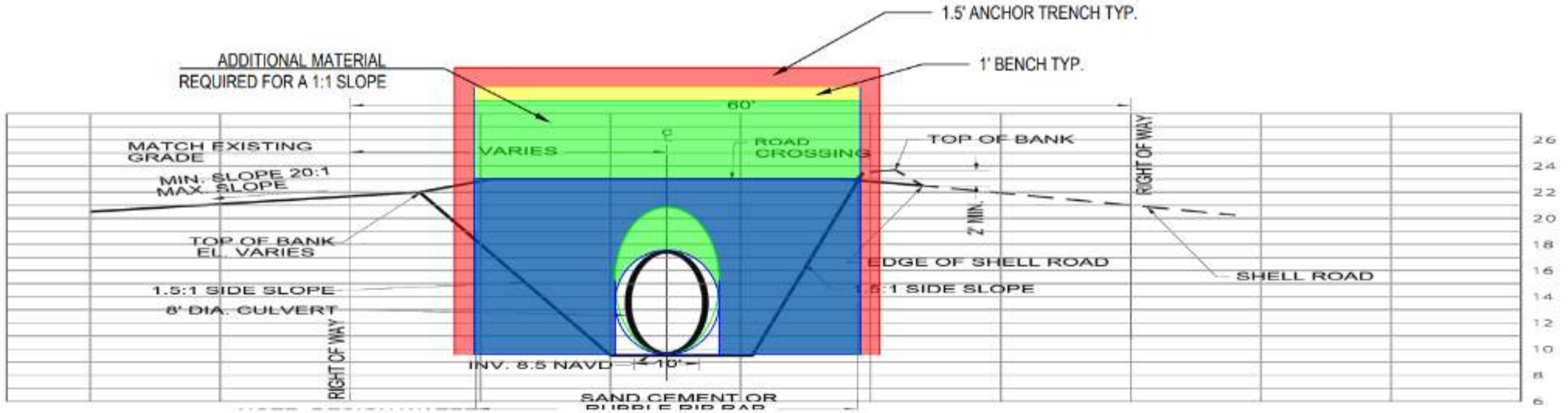
INSTALLATION HANDBOOK

LET'S REINFORCE INFRASTRUCTURE FOR THE GOOD OF YOUR NEXT PROJECT.

5550 Triangle Parkway, Ste 220
Peachtree Corners, Georgia
30092 USA

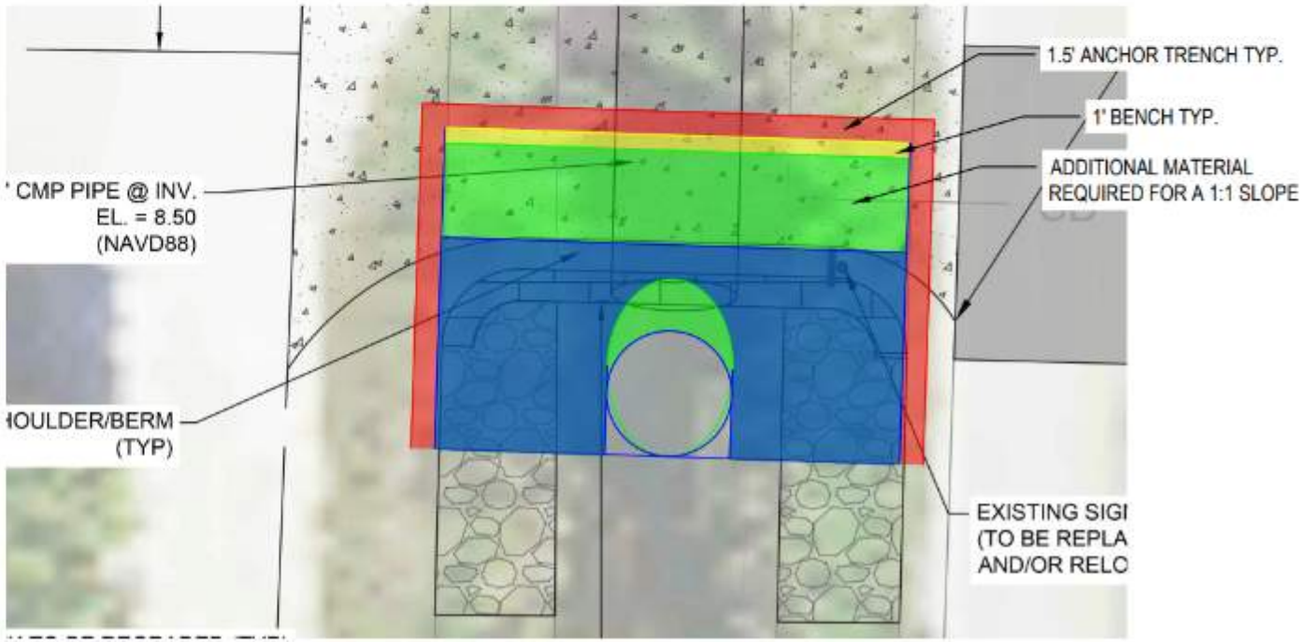
770 399 5051 | 800 225 0023
info@synthetex.com

MAP KEY
=PLAN VIEW
=SLOPE
=TRENCH
=BENCH



ELEVATION - TYP.
NTS

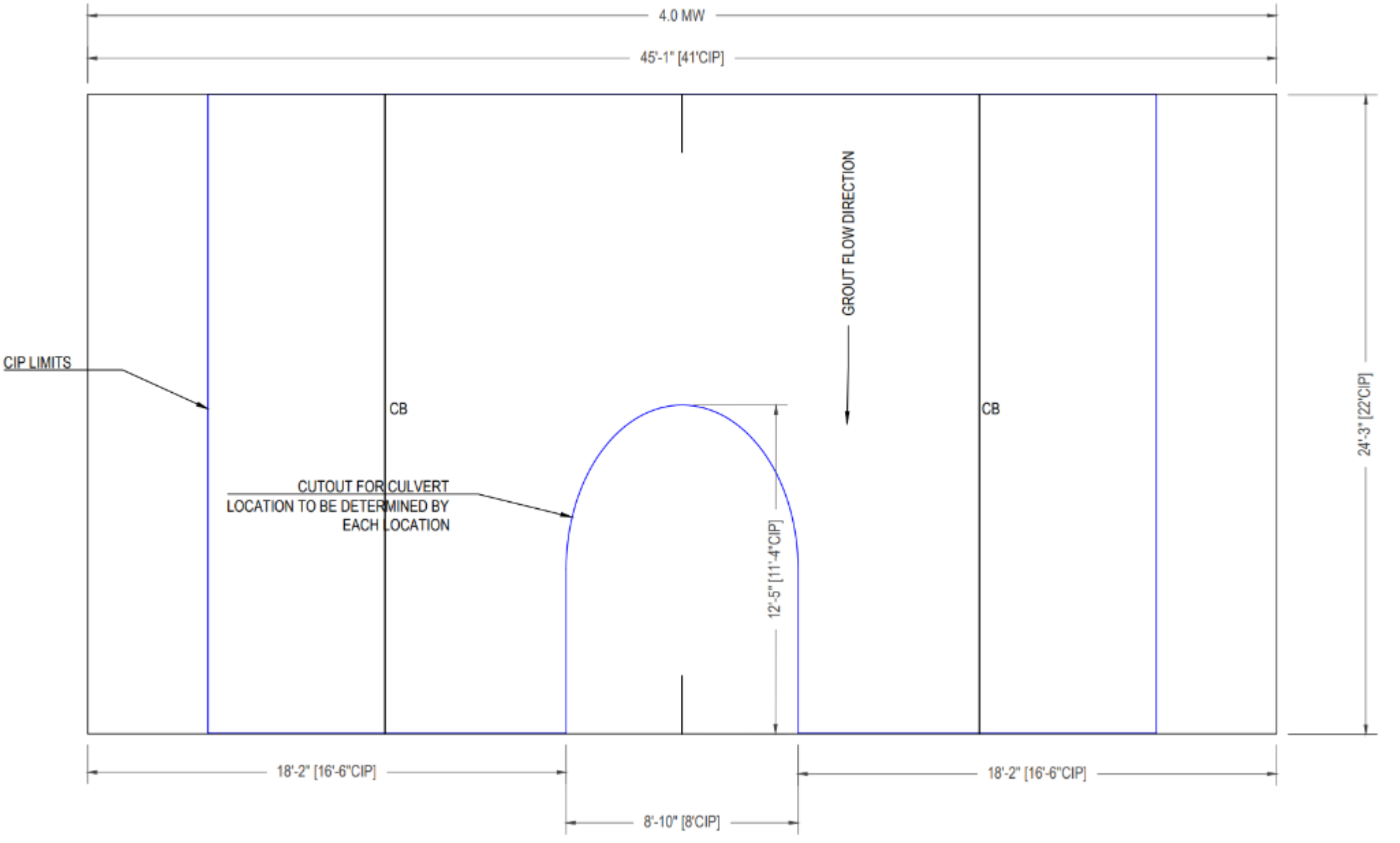
FILTER POINT CULVERT CUTOUT
PICTURE JUST FOR REFERENCE

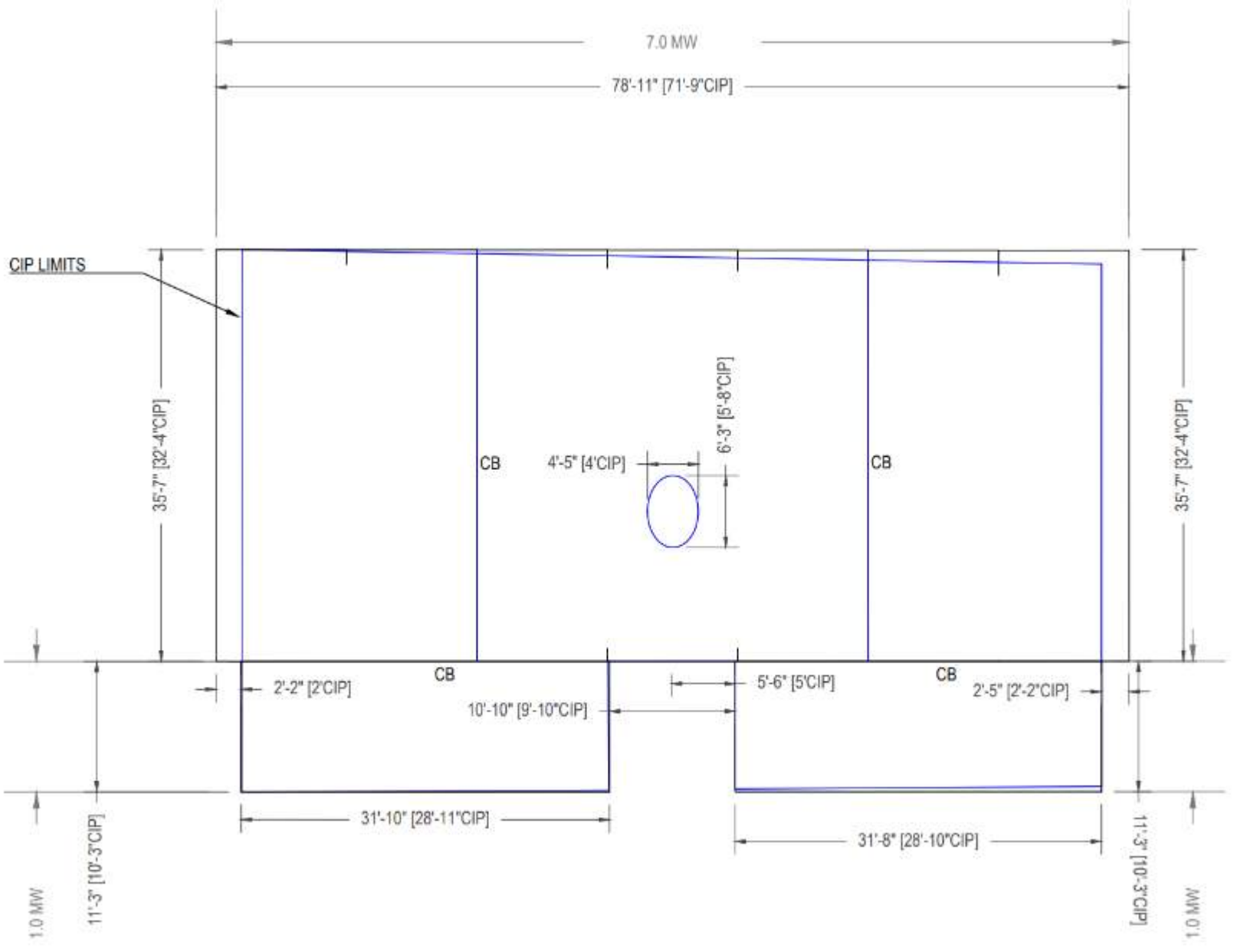


PLAN VIEW - BUNNY LN
NTS

NOTES:

CB - CONCRETE BAFFLE
CIP - CAST IN PLACE
MW - MILL WIDTH
CIP AREA
ZIPPER
BILLED WIDTH = 11'-8"
SEWN (UNFILLED) WIDTH = 11'-4"
CIP WIDTH = 10'-3"


4.0 MW
45'-1" [41'CIP]
GROUT FLOW DIRECTION
CIP LIMITS
CB
CB
CUTOUT FOR CULVERT
LOCATION TO BE DETERMINED BY
EACH LOCATION
12'-5" [11'-4"CIP]
24'-3" [22'CIP]
18'-2" [16'-6"CIP]
18'-2" [16'-6"CIP]
8'-10" [8'CIP]


7.0 MW
78'-11" [71'-9"CIP]
CIP LIMITS
35'-7" [32'-4"CIP]
CB
4'-5" [4'CIP]
6'-3" [5'-8"CIP]
CB
35'-7" [32'-4"CIP]
CB
2'-2" [2'CIP]
10'-10" [9'-10"CIP]
CB
5'-6" [5'CIP]
2'-5" [2'-2"CIP]
31'-10" [28'-11"CIP]
31'-8" [28'-10"CIP]
11'-3" [10'-3"CIP]
1.0 MW
11'-3" [10'-3"CIP]
1.0 MW

Appendix D. Plans, Specifications & Estimate

D.1 Final Plans

D.2 Notes to Specification

D.3 Cost Estimate

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	D1

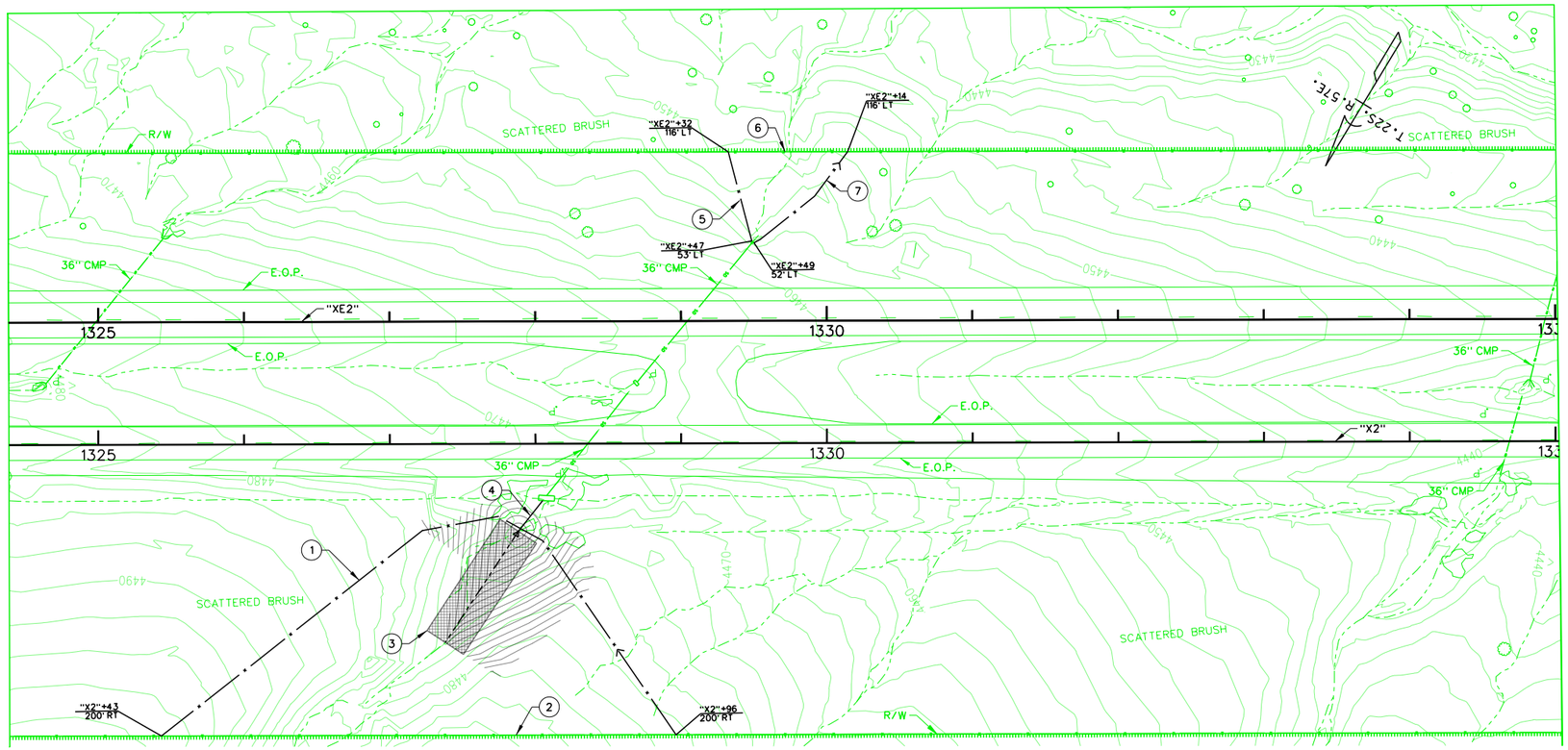
NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION

(5) "XE2" 1329+32 / "XE2" 1329+47 — INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING, LT.

(6) "XE2" 1329+32 / "XE2" 1330+14 — REMOVE EXISTING FENCE, LT.

(7) "XE2" 1329+49 / "XE2" 1330+14 — INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, LT.



(1) "X2" 1325+43 / "X2" 1328+96 — INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.

(2) "X2" 1325+43 / "X2" 1328+96 — REMOVE EXISTING FENCE, RT.

(3) "X2" 1327+88 / "X2" 1327+38 — CONSTRUCT GROUT FILLED FABRIC LINED V-TYPE DITCH FROM "X2" 1327+88, 60.1' RT TO "X2" 1327+38, 136.2' RT. (UIE = 4473.25', LIE = 4463.88', LSS = 4:1, RSS = 4:1, H = VARIES) (SEE SHEET DD1)

(4) "X2" 1328+05 / "X2" 1327+88 — INSTALL 36" X 28' CMP FROM "X2" 1327+88, 60.1' RT (UIE = 4463.88') TO EXISTING DROP INLET AT "X2" 1328+05, 39.0' RT (LIE = 4462.80'). INSTALL METAL END SECTION AT INLET. (SEE SHEET DD1)

NOTES
- REPAIR FENCING AND REMOVE MATERIAL AS DIRECTED BY THE ENGINEER
- FINAL FENCE AND GATE LOCATIONS AS DIRECTED BY THE ENGINEER

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

SITE A
DRAINAGE PLAN

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	D2

NOT FOR CONSTRUCTION

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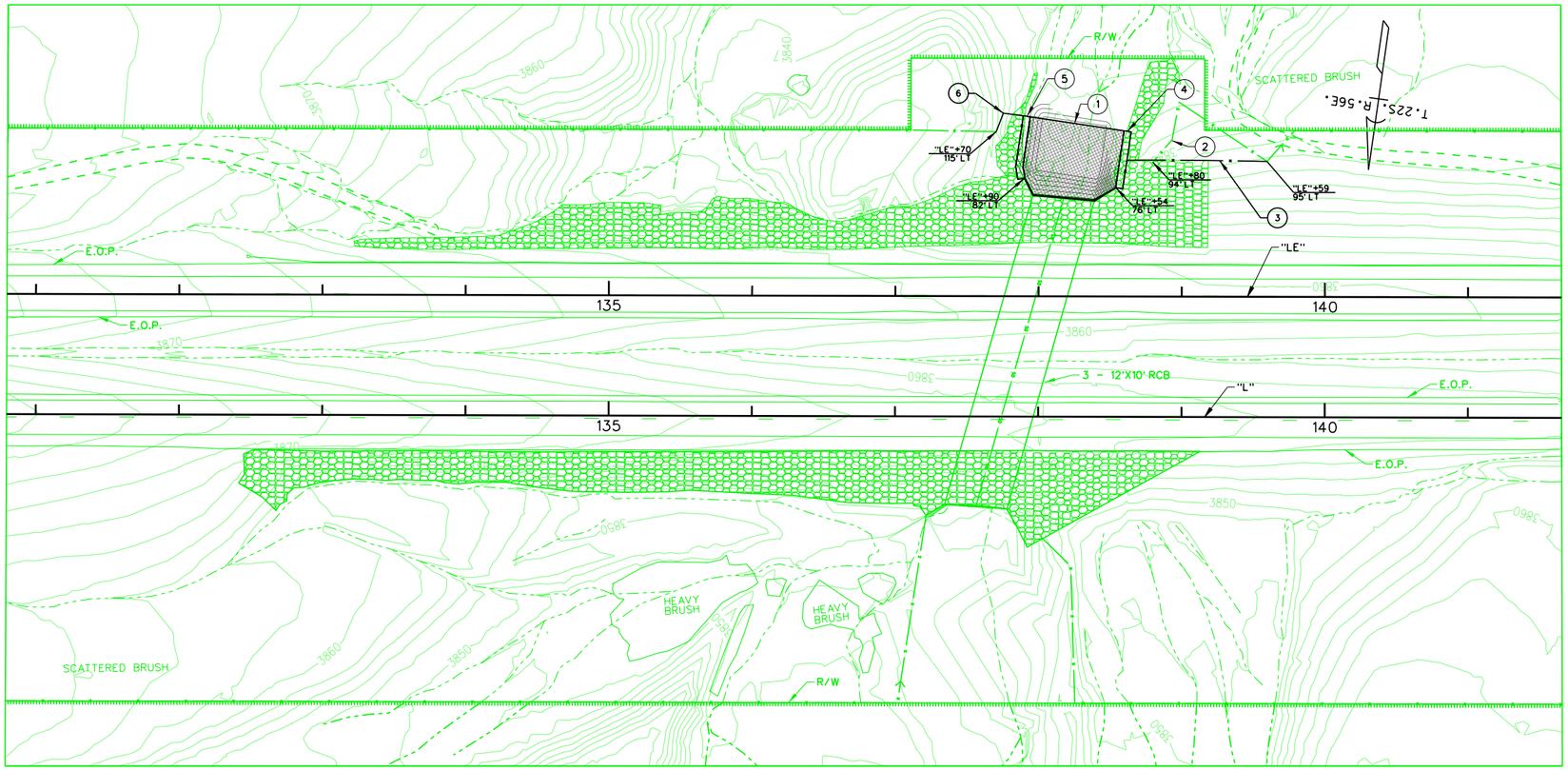
1	"LE" 138+17	CONSTRUCT SLOPING APRON WITH GROUT FILLED FABRIC LINING, LT. (SEE SHEET DD2)
2	"LE" 138+80 "LE" 139+59	REMOVE EXISTING FENCE, LT.
3	"LE" 138+54 "LE" 139+59	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AS DIRECTED BY THE ENGINEER, LT.
4	"LE" 138+56	RESET AND GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS, LT.
5	"LE" 137+88	RESET AND GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS, LT.
6	"LE" 137+70 "LE" 137+90	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AS DIRECTED BY THE ENGINEER, LT.



NOTES
- REPAIR FENCING AND REMOVE MATERIAL AS DIRECTED BY THE ENGINEER
- FINAL FENCE AND GATE LOCATIONS AS DIRECTED BY THE ENGINEER

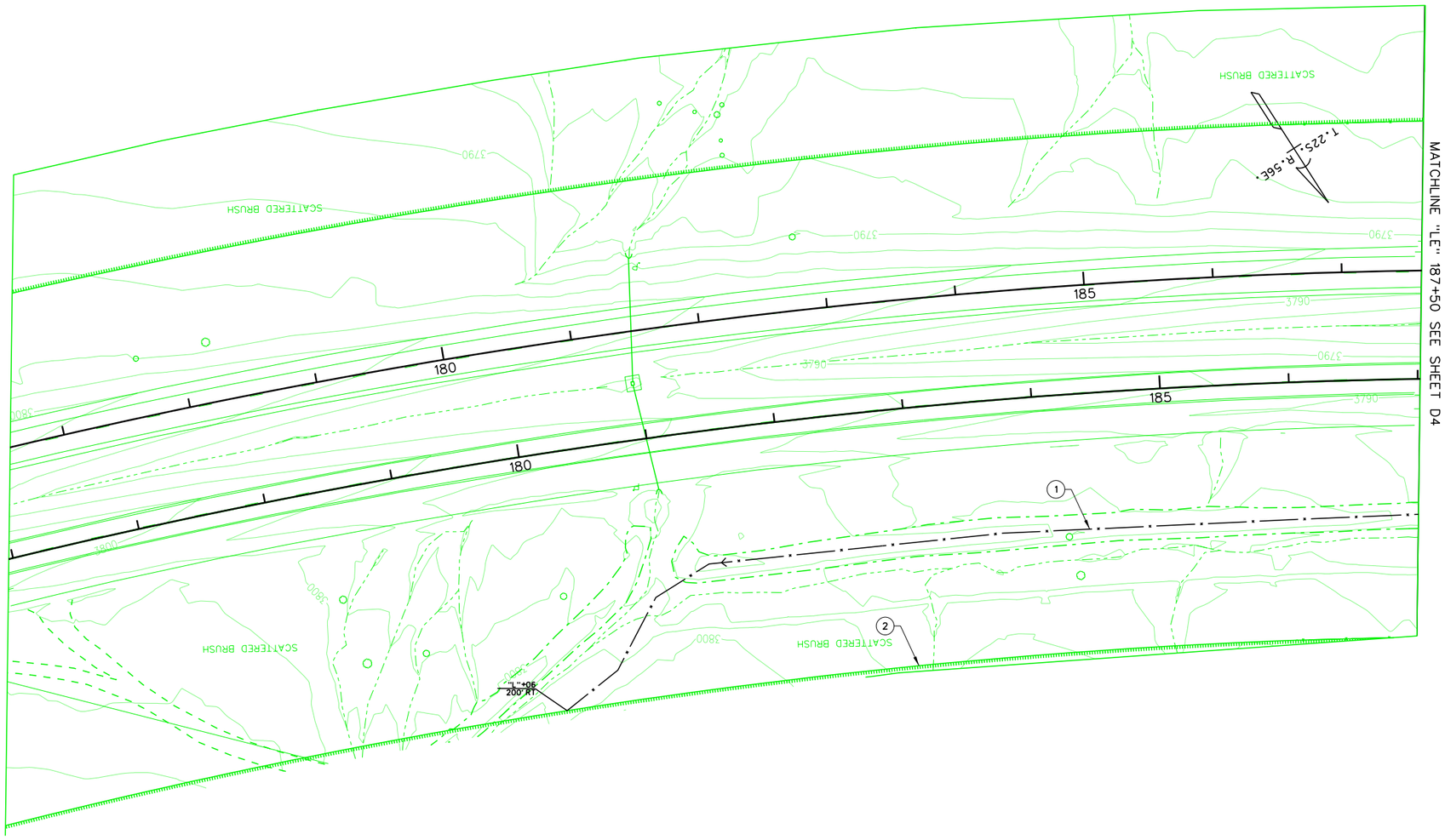
STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

SITE B
DRAINAGE PLAN

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	D3

NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION



MATCHLINE "LE" 187+50 SEE SHEET D4

(1)	"L" 180+06 "L" 195+64	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.
(2)	"L" 180+06 "L" 197+36	REMOVE EXISTING FENCE, RT.

NOTES
- REPAIR FENCING AND REMOVE MATERIAL AS DIRECTED BY THE ENGINEER
- FINAL FENCE AND GATE LOCATIONS AS DIRECTED BY THE ENGINEER

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

SITE C
DRAINAGE PLAN

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	D4

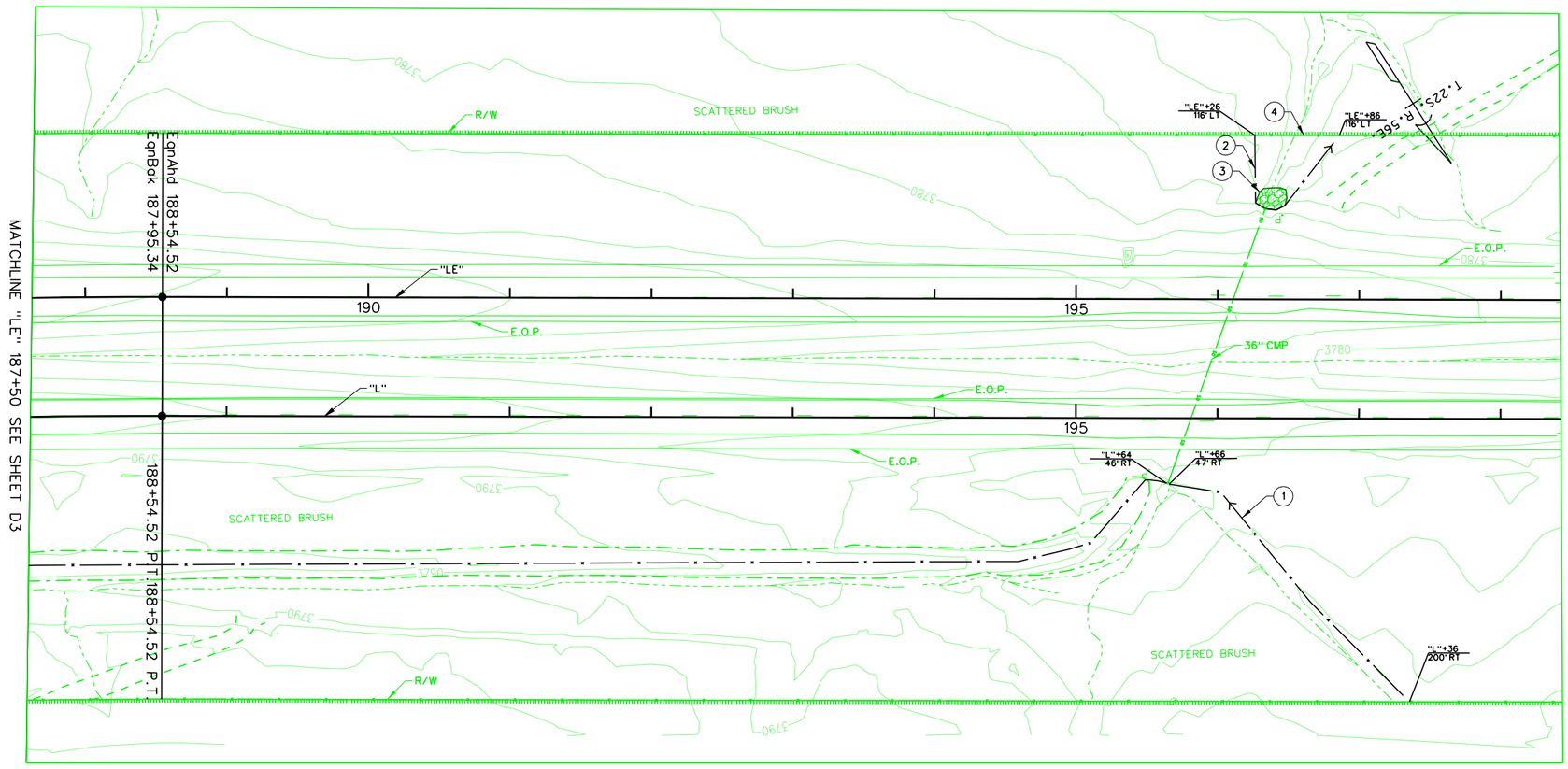
NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION

(2) "LE" 196+26 / "LE" 196+86 — INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, LT.

(3) "LE" 196+34 — GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS, LT. (SEE SHEET DD3)

(4) "LE" 196+26 / "LE" 196+86 — REMOVE EXISTING FENCE, LT.



(1) "L" 195+66 / "L" 197+36 — INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.

NOTES
- REPAIR FENCING AND REMOVE MATERIAL AS DIRECTED BY THE ENGINEER
- FINAL FENCE AND GATE LOCATIONS AS DIRECTED BY THE ENGINEER

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

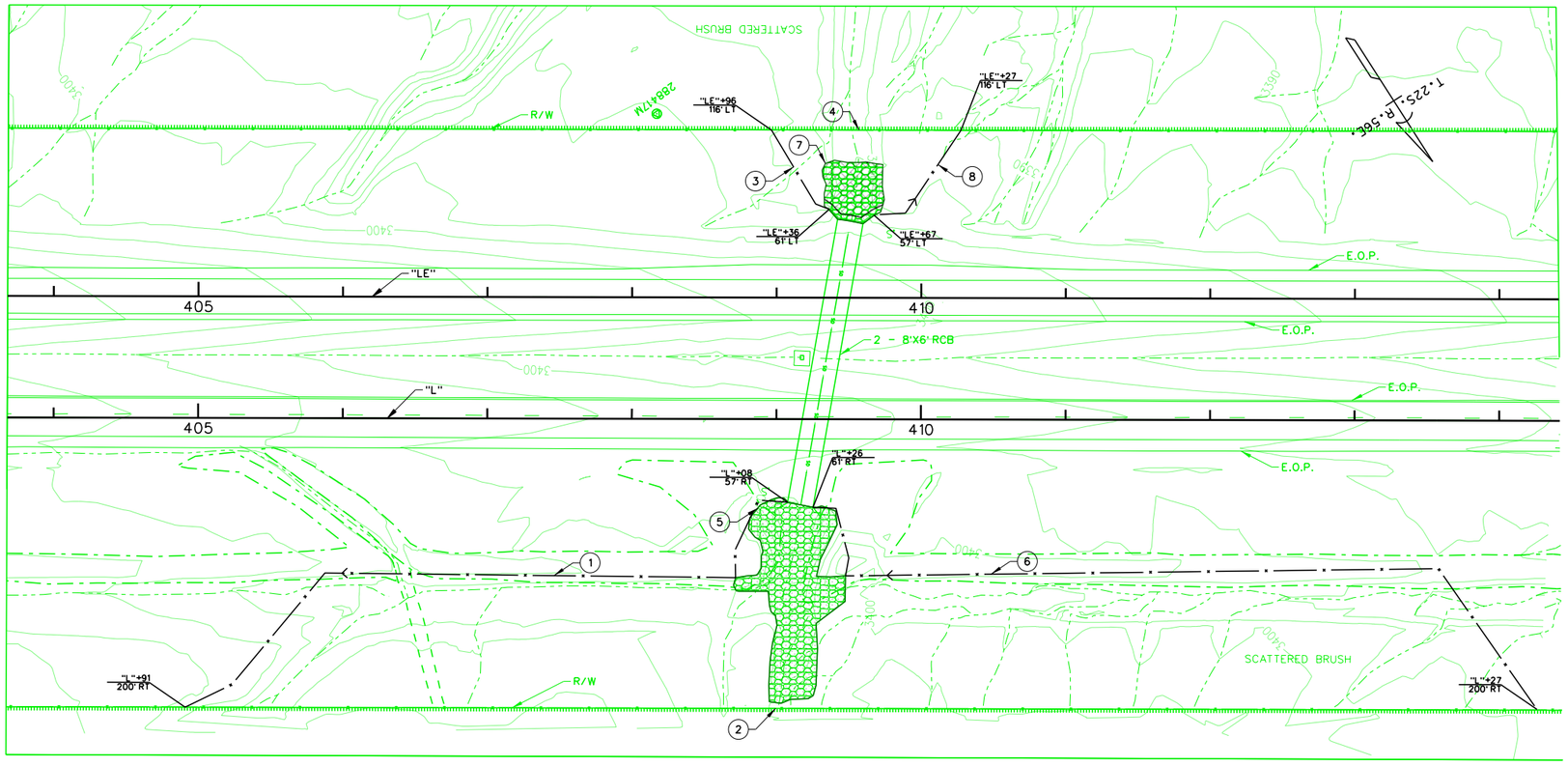
SITE C
DRAINAGE PLAN

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	D5

NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION

(3)	"LE" 408+96 "LE" 409+36	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING, LT.
(4)	"LE" 408+96 "LE" 410+27	REMOVE EXISTING FENCE, LT.
(7)	"LE" 409+46	GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS, LT. (SEE SHEET DD4)
(8)	"LE" 409+67 "LE" 410+27	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, LT.



(1)	"L" 404+91 "L" 409+08	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.
(2)	"L" 404+91 "L" 414+27	REMOVE EXISTING FENCE, RT.
(5)	"L" 409+17	GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS, RT. (SEE SHEET DD5)
(6)	"L" 409+26 "L" 414+27	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.

NOTES
- REPAIR FENCING AND REMOVE MATERIAL AS DIRECTED BY THE ENGINEER
- FINAL FENCE AND GATE LOCATIONS AS DIRECTED BY THE ENGINEER

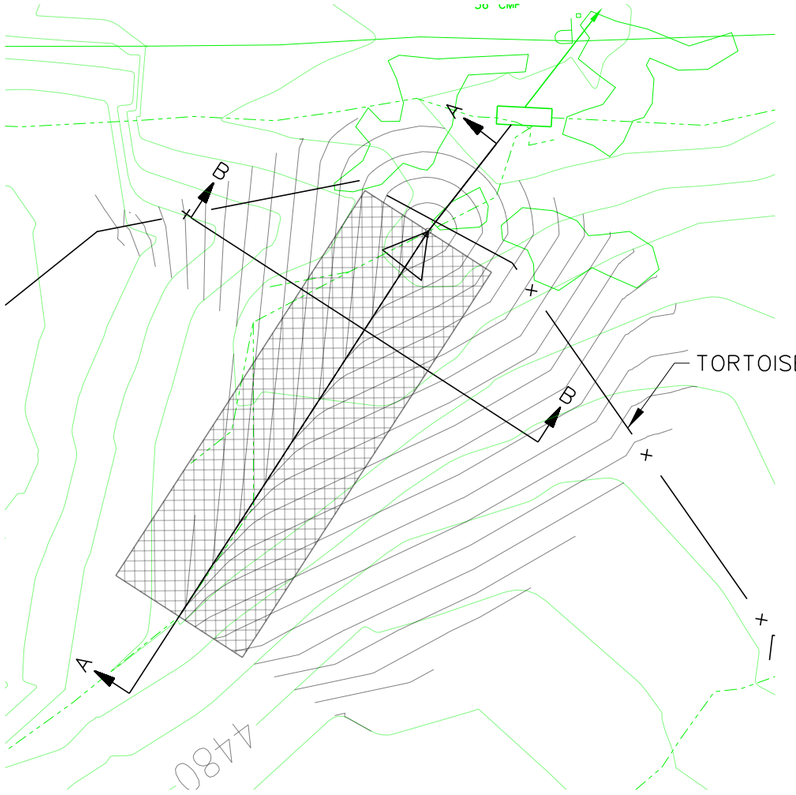
STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

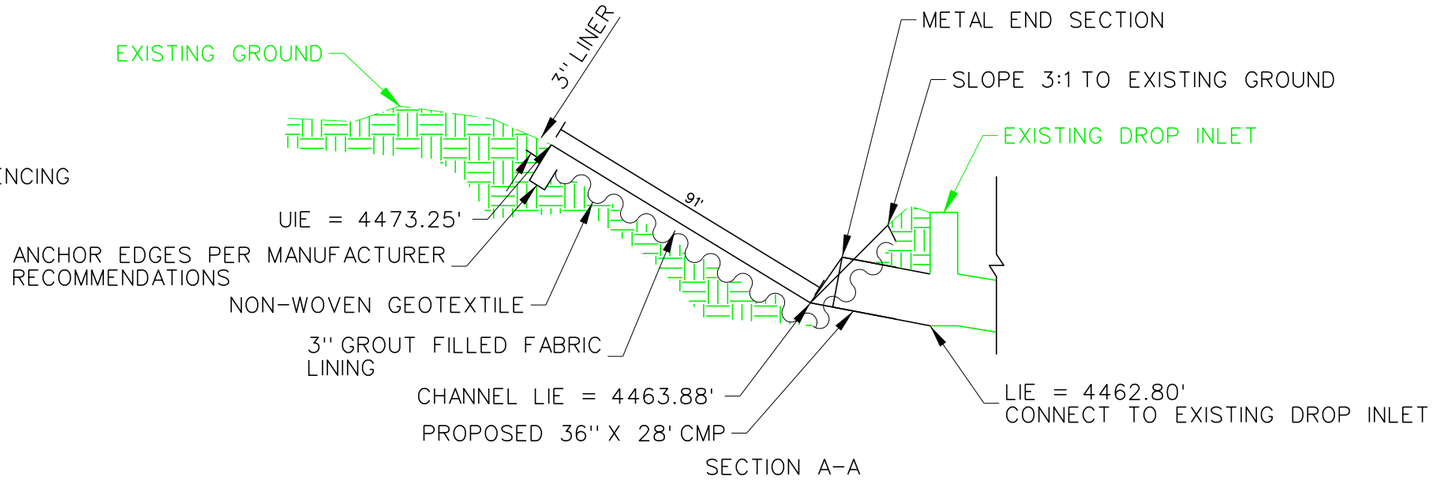
SITE D
DRAINAGE PLAN

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	DD1

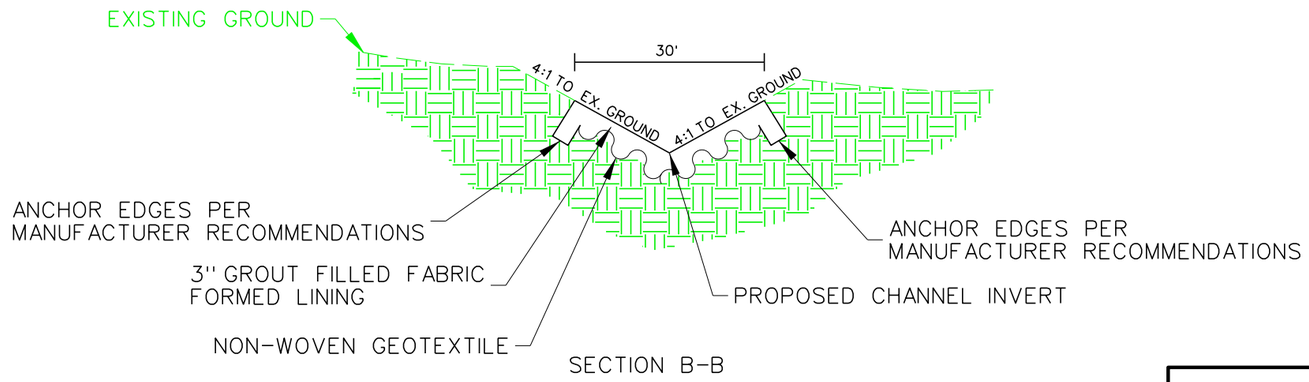
NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION





SECTION A-A



SECTION B-B

CULVERT A DETAIL
''X2'' 1327+88, RT

= 3'' GROUT FILLED FABRIC LINER

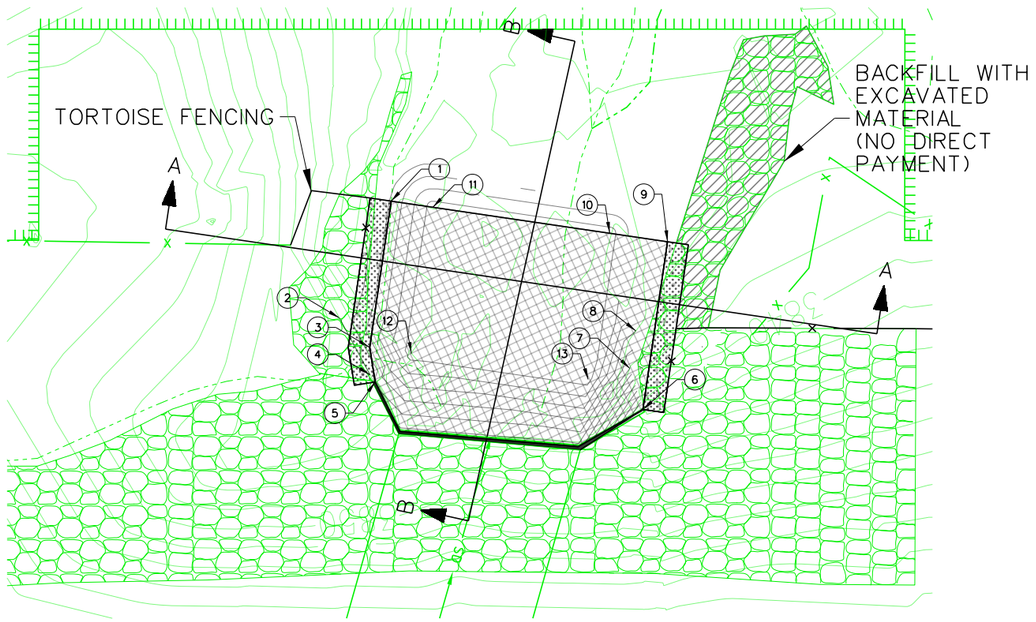
STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

SITE A
DRAINAGE DETAILS

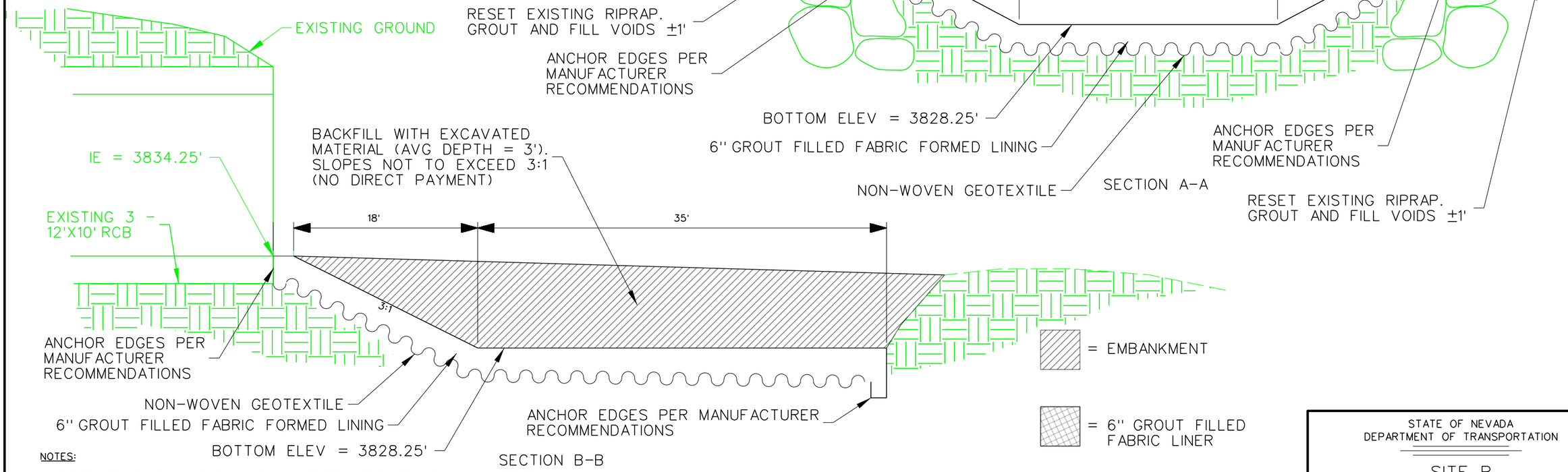
STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	DD2

NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION



POINT	STATION	ELEVATION
①	"LE" 137+94, 125.30' LT	3831.85'
②	"LE" 137+82, 97.66' LT	3840.00'
③	"LE" 137+89, 90.67' LT	3832.51'
④	"LE" 137+89, 84.15' LT	3840.00'
⑤	"LE" 137+90, 82.49' LT	3838.76'
⑥	"LE" 138+54, 75.98' LT	3841.26'
⑦	"LE" 138+51, 85.70' LT	3834.00'
⑧	"LE" 138+52, 94.54' LT	3832.00'
⑨	"LE" 138+60, 115.69' LT	3832.92'
⑩	"LE" 138+46, 117.70' LT	3828.52'
⑪	"LE" 138+04, 123.85' LT	3828.52'
⑫	"LE" 137+99, 89.22' LT	3828.52'
⑬	"LE" 138+41, 83.08' LT	3828.52'



NOTES:

1. SMOOTH GROUT AND FILL EXISTING RIPRAP VOIDS TO A DEPTH OF 1'. FINISH WITH GROUT SO THAT A SEMI-SMOOTH SURFACE IS PROVIDED FOR TORTOISE USE/PASSAGE. MINOR ROCK PROTRUSIONS UP TO 3-INCHES ARE ALLOWED FROM TOP OF GROUTED SURFACE.

CULVERT B DETAIL

"LE" 138+17, LT

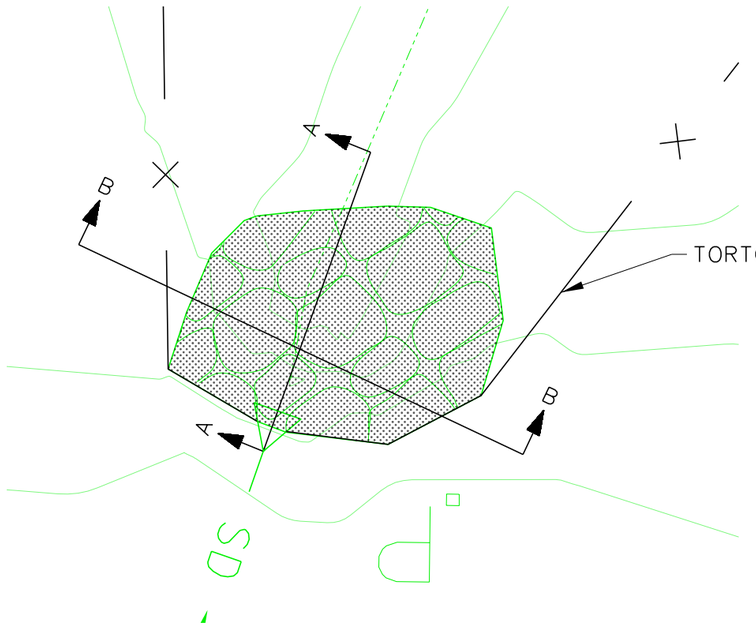
STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

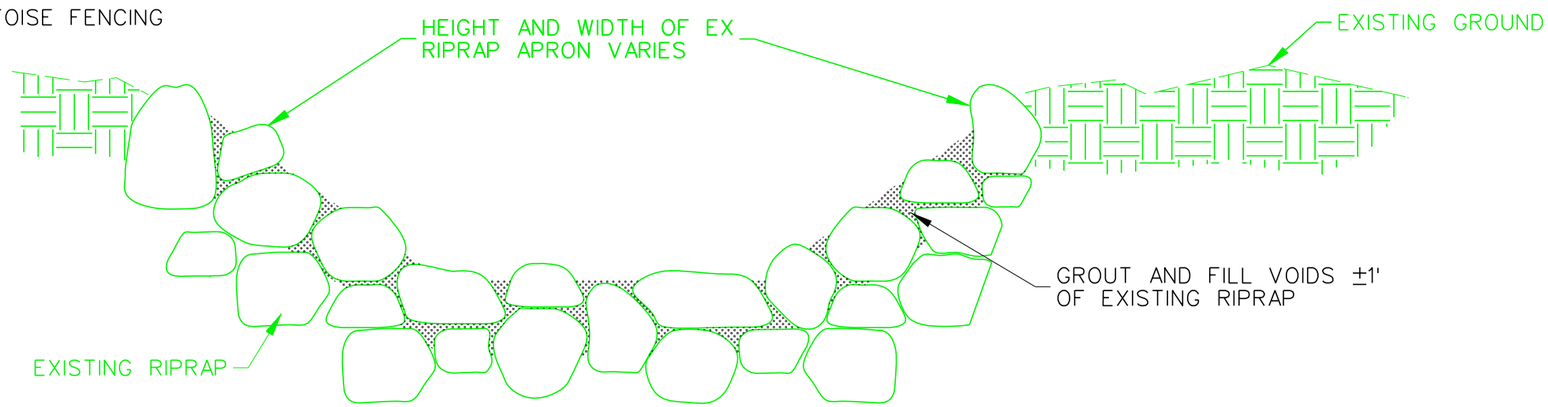
SITE B
DRAINAGE DETAILS

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	DD3

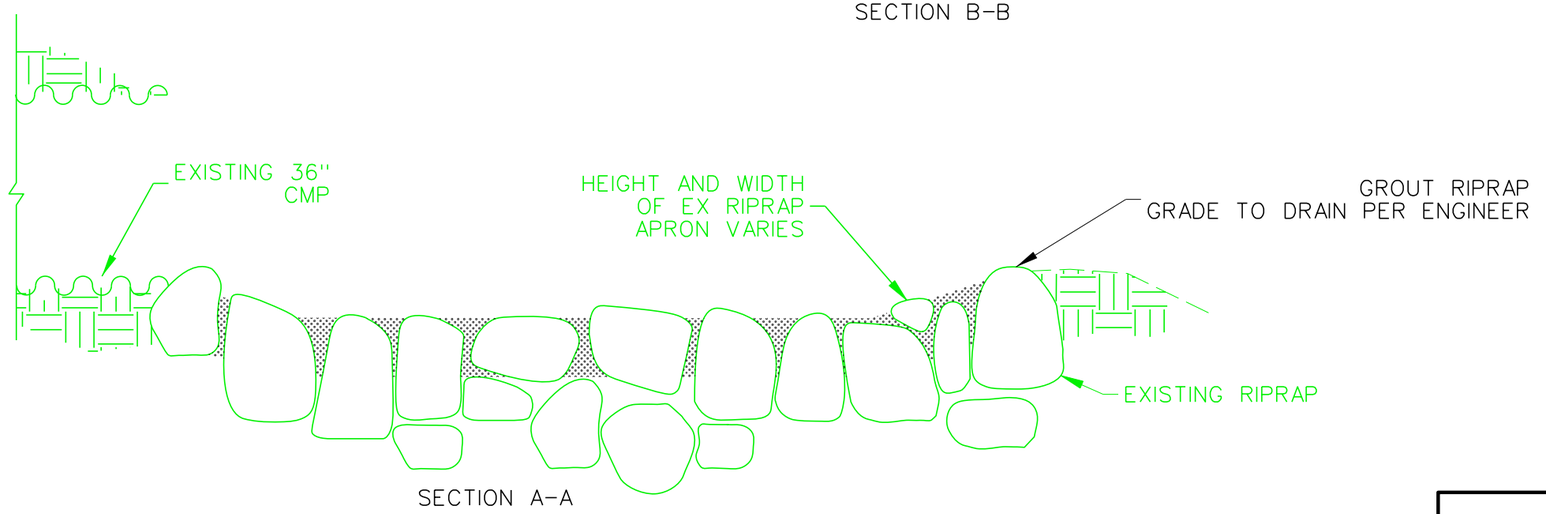
NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION





SECTION B-B



SECTION A-A

NOTES:

1. SMOOTH GROUT AND FILL EXISTING RIPRAP VOIDS TO A DEPTH OF 1'. FINISH WITH GROUT SO THAT A SEMI-SMOOTH SURFACE IS PROVIDED FOR TORTOISE USE/PASSAGE. MINOR ROCK PROTRUSIONS UP TO 3-INCHES ARE ALLOWED FROM TOP OF GROUTED SURFACE.

CULVERT C DETAIL

"LE" 196+34, LT

= SMOOTH GROUT

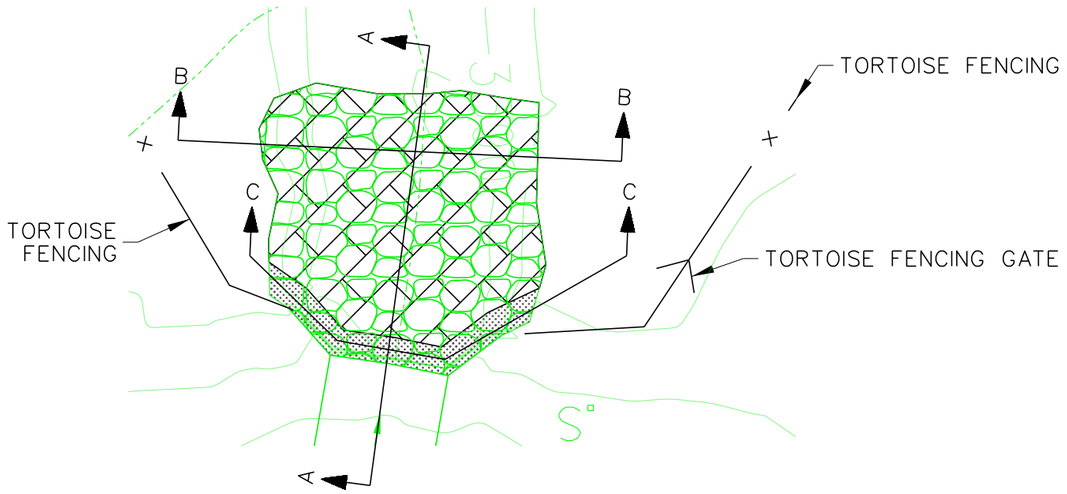
STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

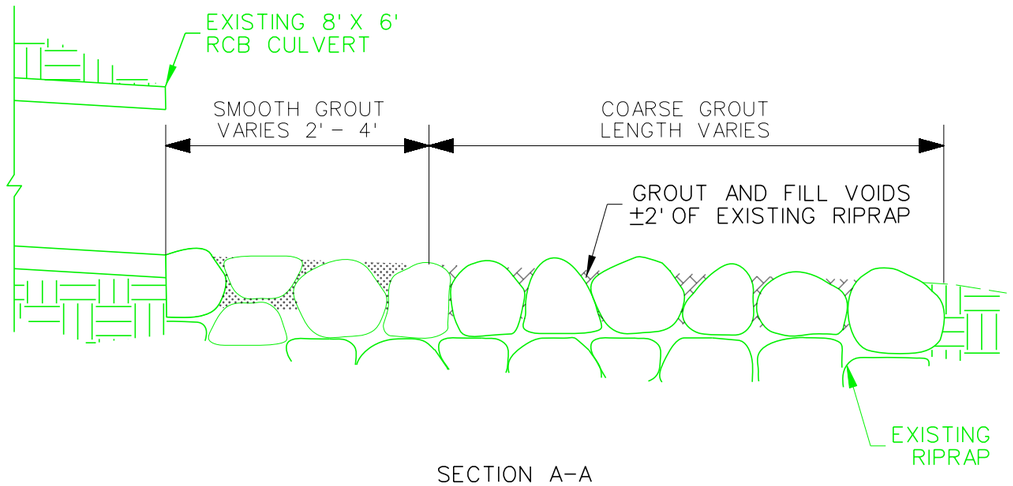
SITE C
DRAINAGE DETAILS

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	DD4

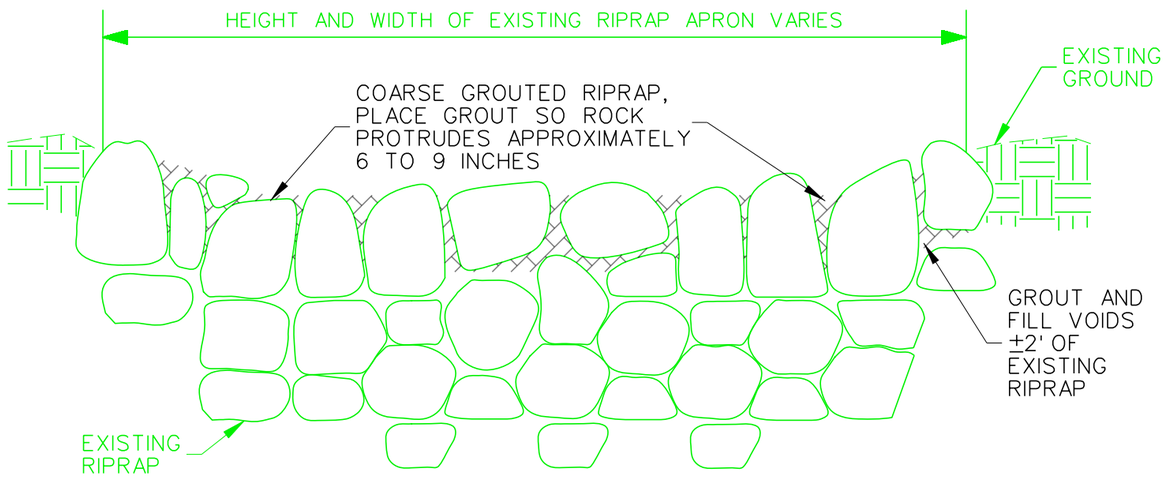
NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION

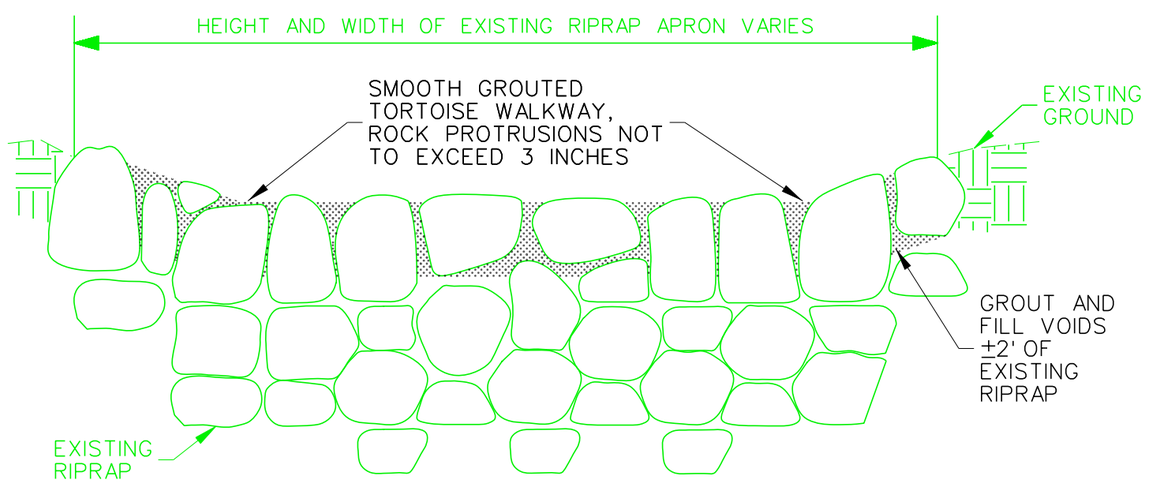




SECTION A-A



SECTION B-B
COARSE GROUT



SECTION C-C
SMOOTH GROUT

NOTES:

1. SMOOTH GROUT AND FILL EXISTING RIPRAP VOIDS TO A DEPTH OF 2'. FINISH WITH GROUT SO THAT A SEMI-SMOOTH SURFACE IS PROVIDED FOR TORTOISE USE/PASSAGE. MINOR ROCK PROTRUSIONS UP TO 3-INCHES ARE ALLOWED FROM TOP OF GROUTED SURFACE.
2. COARSE GROUT AND FILL EXISTING RIPRAP VOIDS TO A DEPTH OF 2'. FINISH WITH GROUT SO THAT A SEMI-SMOOTH SURFACE IS PROVIDED FOR TORTOISE USE/PASSAGE. ROCK PROTRUSIONS ARE TO BE BETWEEN 6-INCHES TO 9-INCHES FROM THE GROUTED SURFACE.

CULVERT D DETAIL
"LE" 409+46, LT

= SMOOTH GROUT

= COARSE GROUT

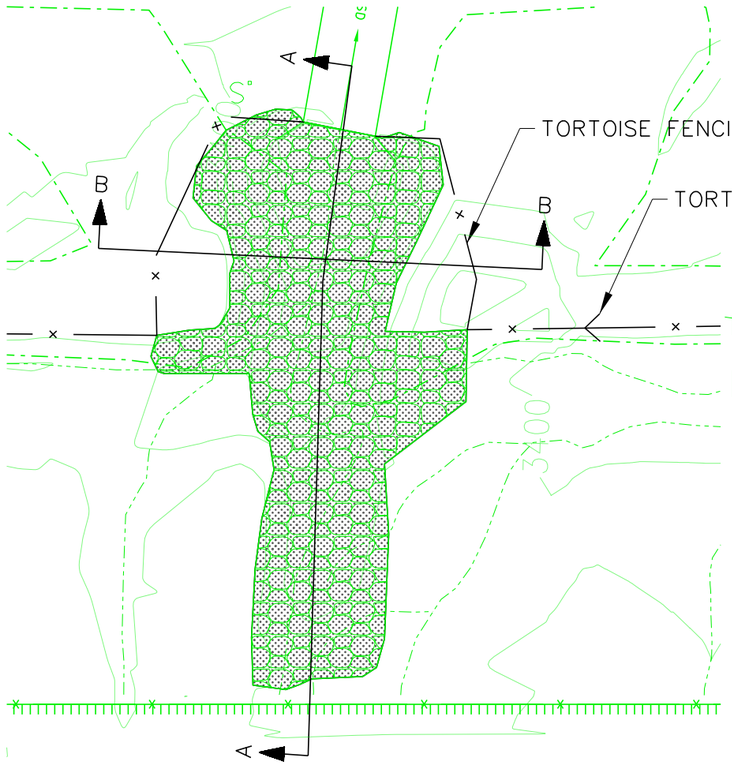
STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

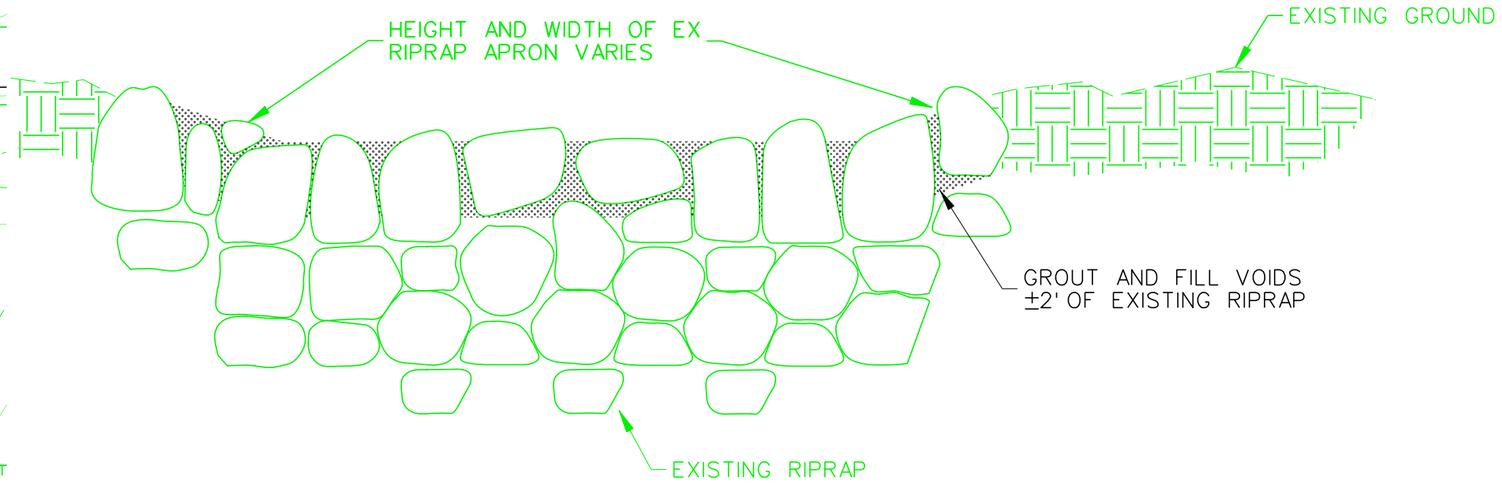
SITE D
DRAINAGE DETAILS

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	DD5

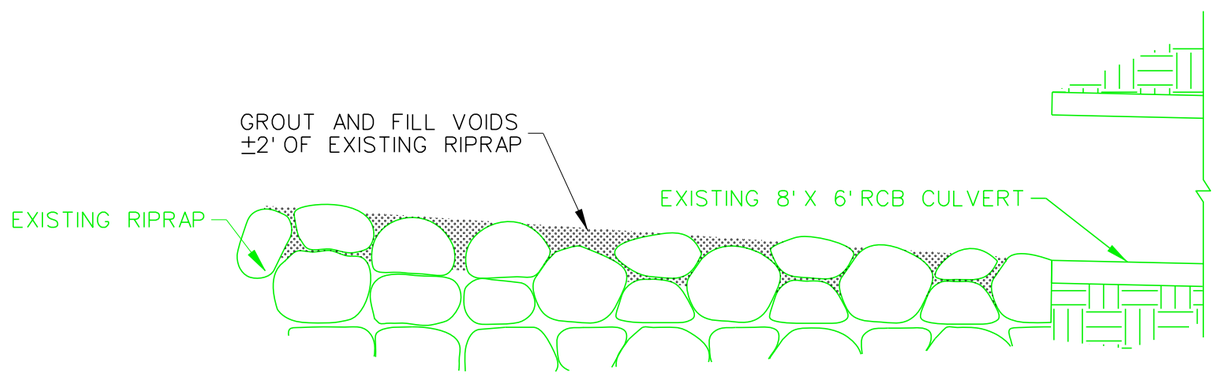
NOT FOR CONSTRUCTION

FINAL SUBMITTAL
SUBJECT TO REVISION





SECTION B-B



SECTION A-A

NOTES:

1. SMOOTH GROUT AND FILL EXISTING RIPRAP VOIDS TO A DEPTH OF 2'. FINISH WITH GROUT SO THAT A SEMI-SMOOTH SURFACE IS PROVIDED FOR TORTOISE USE/PASSAGE. MINOR ROCK PROTRUSIONS UP TO 3-INCHES ARE ALLOWED FROM TOP OF GROUTED SURFACE.

CULVERT D DETAIL
"L" 409+17, RT

= SMOOTH GROUT

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

SITE D
DRAINAGE DETAILS

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	S1

STRUCTURE LIST

PRE FINAL

SUBJECT TO REVISION
25-Jun-2026

NOTE NO.	DESCRIPTION	STATION TO STATION	REPAIR FENCE 616 1455 FA	TORTOISE FENCE 616 1080 LINFT	12-FOOT METAL DRIVE GATE 616 0180 EACH	GROUT FILLED FABRIC FORMED LINER, CABLE REVETED 61005xy SQYD	GROUT FILLED FABRIC FORMED LINER, NON-CABLE REVETED 61005xx SQYD	GEOTEXTILE (CLASS 1) 610 0050 SQYD	36-INCH CORR. METAL PIPE (12 GAGE) 604 6515 LINFT	36-INCH METAL END SECTION 604 2475 EACH	GROUT 502 1960 CUYD	DRAINAGE EXCAVATION 203 0160 CUYD	RESET RIPRAP 202 0641 LS	REMOVAL OF FENCE 202 0585 LINFT
	NOTE: ALL LOCATIONS ARE APPROXIMATE AND MAY BE ADJUSTED BY THE ENGINEER													
	SHEET D1													
1	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE	"X2" 1325+43		477	1									
	WITH TORTOISE FENCING, RT.	"X2" 1328+96												
2	REMOVE EXISTING FENCE, RT.	"X2" 1325+43												435
		"X2" 1328+96												
3	CONSTRUCT GROUT FILLED FABRIC LINED V-TYPE DITCH FROM	"X2" 1327+88					305	305				610.0		
	"X2" 1327+88, 60.1' RT TO "X2" 1327+38, 136.2' RT. (UIE = 4473.25'	"X2" 1327+38												
	, LIE = 4463.88' , LSS = 4:1 , RSS = 4:1 , H = VARIES) (SEE SHEET													
	DD1)													
4	INSTALL 36" X 28' CMP FROM "X2" 1327+88, 60.1' RT (UIE =4463.88')	"X2" 1328+05							28	1				
	4463.88') TO EXISTING DROP INLET AT "X2" 1328+05, 39.0' RT	"X2" 1327+88												
	(LIE = 4462.80'). INSTALL METAL END SECTION AT INLET. (SEE													
	SHEET DD1)													
5	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING, LT.	"XE2" 1329+32		64										
		"XE2" 1329+47												
6	REMOVE EXISTING FENCE, LT	"XE2" 1329+32												82
		"XE2" 1330+14												
7	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE	"XE2" 1329+49		91	1									
	WITH TORTOISE FENCING, LT.	"XE2" 1330+14												
	SHEET D2													
1	CONSTRUCT SLOPING APRON WITH GROUT FILLED FABRIC	"LE" 138+17				367		367				249.0		
	LINING, LT. (SEE SHEET DD2)													
2	REMOVE EXISTING FENCE, LT.	"LE" 138+80												121
		"LE" 139+59												
3	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AS	"LE" 138+54		123										
	DIRECTED BY THE ENGINEER, LT.	"LE" 139+59												
4	RESET AND GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS,	"LE" 138+56									3			
	LT.													
5	RESET AND GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS,	"LE" 137+88									3			
	LT.													

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	S2

STRUCTURE LIST

PRE FINAL

SUBJECT TO REVISION
25-Jun-2026

	REPAIR FENCE	TORTOISE FENCE	12-FOOT METAL DRIVE GATE	GROUT FILLED FABRIC FORMED LINER, CABLE REVETED	GROUT FILLED FABRIC FORMED LINER, NON-CABLE REVETED	GEOTEXTILE (CLASS 1)	36-INCH CORR. METAL PIPE (12 GAGE)	36-INCH METAL END SECTION	GROUT	DRAINAGE EXCAVATION	RESET RIPRAP	REMOVAL OF FENCE	NOTE NO.	DESCRIPTION	STATION TO STATION
	616 1455	616 1080	616 0180	61005xy	61005xx	610 0050	604 6515	604 2475	502 1960	203 0160	202 0641	202 0585			
	FA	LINFT	EACH	SQYD	SQYD	SQYD	LINFT	EACH	CUYD	CUYD	LS	LINFT			
		78											3	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AS DIRECTED BY THE ENGINEER, LT.	"LE" 137+70 "LE" 137+90
														SHEET D3	
		1541	1										1	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.	"L" 180+06 "L" 195+64
												1639	2	REMOVE EXISTING FENCE, RT.	"L" 180+06 "L" 197+36
														SHEET D4	
		236	1										1	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.	"L" 195+66 "L" 197+36
		131	1										2	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, LT.	"LE" 196+26 "LE" 196+86
									4				3	GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS, LT. (SEE SHEET DD3)	"LE" 196+34
												60	4	REMOVE EXISTING FENCE, LT.	"LE" 196+26 "LE" 196+86
														SHEET D5	
		498	1										1	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.	"L" 404+91 "L" 409+08
												935	2	REMOVE EXISTING FENCE, RT.	"L" 404+91 "L" 414+27
		73											3	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING, LT.	"LE" 408+96 "LE" 409+36
												131	4	REMOVE EXISTING FENCE, LT.	"LE" 408+96 "LE" 410+27
									46				5	GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS, RT. (SEE SHEET DD5)	"L" 409+17
		593	1										6	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, RT.	"L" 409+26 "L" 414+27

STATE	PROJECT NO.	COUNTY	SHEET NO.
NEVADA		CLARK	S3

STRUCTURE LIST

PRE FINAL

SUBJECT TO REVISION
25-Jun-2026

NOTE NO.	DESCRIPTION	STATION TO STATION	REPAIR FENCE 616 1455 FA	TORTOISE FENCE 616 1080 LINFT	12-FOOT METAL DRIVE GATE 616 0180 EACH	GROUT FILLED FABRIC FORMED LINER, CABLE REVETED 61005xy SQYD	GROUT FILLED FABRIC FORMED LINER, NON-CABLE REVETED 61005xx SQYD	GEOTEXTILE (CLASS 1) 610 0050 SQYD	36-INCH CORR. METAL PIPE (12 GAGE) 604 6515 LINFT	36-INCH METAL END SECTION 604 2475 EACH	GROUT 502 1960 CUYD	DRAINAGE EXCAVATION 203 0160 CUYD	RESET RIPRAP 202 0641 LS	REMOVAL OF FENCE 202 0585 LINFT
7	GROUT EXISTING RIPRAP WITHIN OUTLINED LIMITS, LT. (SEE SHEET DD4)	"LE" 409+46									175			
8	INSTALL TYPE A-3S FENCE WITH TORTOISE FENCING AND GATE WITH TORTOISE FENCING, LT.	"LE" 409+67 "LE" 410+27		91	1									
Total			FA 3996	8	367	305	672	28	1	231	859	LS 3403		

NOTES TO SPECIFICATIONS

Notes to Specifications

(Clark County)

SECTION 502

CONCRETE STRUCTURES (GROUTING RIPRAP)

DESCRIPTION

502.01.01 GENERAL

A. This work shall consist of constructing slope and channel protection structures to the lines and grades established by the Engineer using riprap or wire mesh gabions in accordance with the design shown on the plans and these specifications.

B. Grouting riprap construction shall consist of furnishing and placing grout in existing riprap.

MATERIALS

502.02.01 GENERAL

A. All materials shall conform to the following sections and subsections:

Materials	Section/Subsection
Water	***722***
Hydraulic Cement	***701***
Riprap Grout	***706.03.05***

502.02.02 GROUT

A. Grout shall be composed of 1 part by volume of Portland cement and 3 parts by volume of sand and shall be of such consistency that it will fill all voids in the riprap.

B. Comply with ***Subsection 706.03.05, "Riprap Grout."***

CONSTRUCTION

502.03.01 EARTHWORK

A. The areas where riprap grouting or wire mesh gabions are to be placed shall be graded to the required lines and grades as shown on the plans or as directed by the Engineer.

B. Any excavations or backfill required to achieve such grade shall conform to the provisions of ***Section 206, "Structure Excavation,"*** and ***Section 207, "Structure Backfill."***

502.03.02 GROUTING RIPRAP

A. When grouting riprap is specified, the spaces between the rock shall then be filled with grout as directed, and in accordance with ***Subsection 706.03.05, "Riprap Grout."***

B. Sufficient grout shall be used to completely fill all voids, except that the face surface of the stone as directed on the plans.

C. After grouting is completed, the surface shall be cured as specified in ***Section 502, "Concrete Structures"*** for a period of at least 3 days.

METHOD OF MEASUREMENT

502.04.01 MEASUREMENT

A. The quantity of grout, will be the number of cubic yards or square yards complete and in place.

B. Only work placed within the dimensions shown on the plans or ordered by the Engineer will be measured for payment. All measurements will be made in accordance with ***Subsection 109.01, "Measurement and Payment."***

BASIS OF PAYMENT

502.05.01 PAYMENT

A. The accepted quantities of riprap grouting, measured as provided in ***Subsection 502.04.01, "Measurement,"*** will be paid for at the contract unit price bid per cubic yard for the type specified, which shall be full compensation for furnishing and placing stone, grout, concrete, wire mesh gabions, filter material, filter fabric, and all other miscellaneous items that are appurtenant to the construction of riprap or gabion structures, including the cost incurred for a manufacturer's representative at the construction site. The above prices shall also include all excavation, grading, and backfill necessary to complete the work.

B. All payments will be made in accordance with ***Subsection 109.02, "Scope of Payment."***

C. Payment will be made under:

PAY ITEM	**PAY UNIT**
Riprap Grouting	Cubic Yard or Square Yard

SECTION 610

SLOPE AND CHANNEL PROTECTION (GROUTED RIPRAP)

DESCRIPTION

610.01.01 GENERAL

A. This work shall consist of constructing slope and channel protection structures to the lines and grades established by the Engineer using riprap or wire mesh gabions in accordance with the design shown on the plans and these specifications.

B. Riprap construction shall consist of furnishing and placing riprap (with or without grout) or sacked Portland cement concrete riprap.

MATERIALS

610.02.01 REQUIREMENTS

A. All materials shall conform to the following sections and subsections:

Materials	Section/Subsection
Water	***722***
Hydraulic Cement	***701***
Grout and Mortar Sand	***706.03.04***
Riprap Grout	***706.03.05***

B. When so provided and with prior approval of the Engineer, crushed concrete may be substituted for the above designated stone. In such a case, the concrete shall be sound and meet all requirements as specified for stone.

610.02.02 GROUT

A. Grout shall be composed of 1 part by volume of Portland cement and 3 parts by volume of sand and shall be of such consistency that it will fill all voids in the riprap.

B. Comply with ***Subsection 706.03.01, "Riprap Grout."***

610.02.03 STONES FOR RIPRAP

A. Stones used for riprap shall be hard, durable, angular in shape, resistant to weathering and erosion, and free from spoils, cracks, and organic matter.

1. The stone for non-grouted riprap shall have a minimum of 2 fractured faces with neither width nor thickness of a single stone less than 1/3 its length.
2. The specific gravity of the riprap shall not be less than 2.45.
3. The nominal stone size shall be as follows:

RIPRAP GRADATIONS

Percent Passing By Mass	Riprap D50=12" (Inches)	Heavy Riprap D50=18" (Inches)
100	20	30
70-85	18	27
35-50	12	18
5-15	5	7
0	2	3

B. This stone shall conform to the following requirements:

Source Requirements Test	Test Method	Requirements
Percent of Wear (500 Rev.)	ASTM C131	45% Maximum
Bulk Specific Gravity	ASTM C127	2.5 Minimum

C. Control of gradation will be by visual inspection.

1. Upon request by the Engineer, the Contractor shall provide a sample of stone of at least 5 tons meeting the gradation for each location riprap is indicated.
2. Each sample shall be located at the construction site near the location where the riprap is to be placed.
3. The sample shall be used as a frequent reference for judging the gradation of the riprap supplied.
4. The sample riprap shall be in place and acceptable to the Engineer before riprap placing work begins.
5. The Contractor shall maintain the placed riprap until the project is completed and any material displaced by any cause shall be repaired to the lines and grades indicated on the plans.

D. Caliche stone or cementitious materials meeting the requirements of this section may be used as riprap with prior approval of the Engineer.

1. The riprap shall be fully cemented material. Only materials designated as hard (scratches leave only dust, requires many hammer blows to break) or very hard (difficult to scratch or break) shall be utilized.
2. Moderately hard (crumbles with several hammer blows) or partially cemented materials are not acceptable.

E. The Contractor may be required to provide riprap test results from an approved testing laboratory and a Certificate of Compliance in accordance with ***Subsection 106.05, "Certificate of Compliance."***

CONSTRUCTION

610.03.01 EARTHWORK

A. The areas where riprap or wire mesh gabions are to be placed shall be graded to the required lines and grades as shown on the plans or as directed by the Engineer.

B. Any excavations or backfill required to achieve such grade shall conform to the provisions of ***Section 206, "Structure Excavation,"*** and ***Section 207, "Structure Backfill."***

610.03.02 FILTER PLACEMENT

A. Filter material shall be spread uniformly on the prepared foundation surface in a manner satisfactory to the Engineer, and to the slopes, lines, and grades as shown on the plans or as specified by the Engineer.

1. Placing of a filter material by methods that will segregate particle sizes will not be permitted.

2. Any damage to the foundation surface during filter placement shall be repaired before proceeding with the work.
3. The filter materials shall be placed and placement shall be approved and accepted before proceeding with the work.
4. The filter materials shall be placed and finished to present a reasonably even surface free from mounds or windrows.
5. Compaction of the filter materials shall conform to the requirements shown on the plans or as outlined in the Special Provisions.

B. Filter fabric shall be installed in accordance with the manufacturer's recommendations and in manner that will not tear, puncture, or shift the fabric.

C. Joining edges of the filter fabric shall be overlapped a minimum of 18 inches.

D. Filter fabric placed behind and/or beneath gabion or gabion mattress structures shall have a minimum permeability of 0.15 inch/second and shall be designed to retain the fine particles of the subsoil while releasing any hydrostatic pressure buildup.

610.03.03 RIPRAP

A. Stone for riprap shall be placed in a manner that will produce a well-graded mass of stone with a minimum percentage of voids.
1. The entire mass of stone shall be placed in conformance with the lines, grades, and thicknesses shown on the plans.
2. Riprap shall be placed to its course thickness in 1 operation and in such a manner as to avoid displacing underlying material.
3. When filter fabric is used under the riprap, the height from which the stone is dropped shall be minimized to avoid fabric damage.
4. Placement of stones shall begin at the bottom of the slope and proceed upward to the top.

B. The large stones shall be well distributed and the entire mass of stone shall conform to the gradation specified.
1. All material placed as riprap protection shall be so placed and distributed that there is no large accumulation of either the larger or smaller sizes of stone.
2. Placing of riprap in layers, or by dumping into chutes, or by similar methods likely to cause segregation will not be permitted.

610.03.04 GROUTED RIPRAP

A. When grouted riprap is specified, the stone shall be laid as set forth for riprap.

B. The spaces between the stones shall then be filled with grout as directed, and in accordance with ***Subsection 706.03.05, "Riprap Grout."***

C. Sufficient grout shall be used to completely fill all voids, except that the face surface of the stone shall be left exposed.

D. After grouting is completed, the surface shall be cured as specified in ***Section 502, "Concrete Structures"*** for a period of at least 3 days.

METHOD OF MEASUREMENT

610.04.01 MEASUREMENT

A. The quantity of riprap, grouted riprap, and wire mesh gabions measured for payment will be the number of cubic yards or square yards complete and in place.

B. The quantity of sacked concrete riprap to be measured for payment will be the number of cubic yards at the mixer or the number of square yards of sacked riprap in the completed work.

C. Only work placed within the dimensions shown on the plans or ordered by the Engineer will be measured for payment. All measurements will be made in accordance with ***Subsection 109.01, "Measurement of Quantities."***

BASIS OF PAYMENT

610.05.01 PAYMENT

A. The accepted quantities of riprap, grouted riprap, sacked concrete riprap, and wire mesh gabions measured as provided in ***Subsection 610.04.01, "Measurement,"*** will be paid for at the contract unit price bid per cubic yard or square yard for the type specified, which shall be full compensation for furnishing and placing stone, grout, concrete, wire mesh gabions, filter material, filter fabric, and all other miscellaneous items that are appurtenant to the construction of riprap or gabion structures, including the cost incurred for a manufacturer's representative at the construction site. The above prices shall also include all excavation, grading, and backfill necessary to complete the work.

B. All payments will be made in accordance with ***Subsection 109.02, "Scope of Payment."***

C. Payment will be made under:

PAY ITEM	PAY UNIT
Riprap	Cubic Yard or Square Yard
Heavy Riprap	Cubic Yard or Square Yard
Grouted Riprap	Cubic Yard or Square Yard

AtkinsRéalis

SECTION 706

AGGREGATES FOR PORTLAND CEMENT PRODUCTS

SCOPE

706.01.01 MATERIALS COVERED

A. This specification covers the quality and size of aggregates used in Portland cement products.

REQUIREMENTS

706.02.01 GENERAL

A. The mineral aggregate shall be the product of approved deposits. The Engineer reserves the right to prohibit the use of aggregates from any source when:

1. The character of the material is such, in the opinion of the Engineer, as to make improbable the furnishing of aggregates conforming to the requirements of these specifications.
2. The character of the material is such that, in the opinion of the Engineer, undue additional costs may be accrued by the Department.
3. The mobile mixer shall use aggregate from an approved source. Each mixer shall not change source product without a new mix design. The certificate of the source shall include the appropriate test data.

B. For mix design approval, the proposed proportions of Riprap Grout Gradation, combined mathematically by volume or mass, shall produce a mixture within the grading limits for combined aggregates as shown in Table 13 (not applicable to lightweight concrete):

C. If the Contractor proposes to use an admixture other than an air-entraining agent, Contractor shall state the complete brand name and the quantity proposed to be used per sack of cement.

D. Should the Contractor change Contractor's source of supply, Contractor shall submit in writing to the Engineer the new gradation before their intended use.

E. In addition to the Rip Rap Grout Gradation, the material shall meet the following source requirement:

Table 1 - Alkali-Silica Reaction

Source Requirement Test, Combined Aggregates	Test Method	Requirement
Accelerated Detection of Potentially Deleterious Expansion of Mortar Bars Due to Alkali-Silica Reaction	AASHTO T303	0.10% Max. Expansion[1]

[1] This requirement applies to all aggregate used in the concrete bridge structures, including approach slabs, reinforced concrete boxes, walkways, or sidewalks on the bridge structure itself, and all concrete bridge rail.

F. Previous AASHTO T303 qualified aggregates for concrete mix designs will not automatically qualify for approval. Submit new AASHTO T303 test results with concrete mix design.

G. Perform this test on the Riprap Grout Gradation, combined in the same proportions as the proposed mix design.

1. The test may be performed on each size separately and the results combined mathematically.

2. Perform the test using the proposed sources together with proposed job cement and job pozzolan or other admixture, if used.

3. The pozzolan and silica fume quantities will be considered as cement in meeting the requirements of cement in Table 2 of ***Subsection*** *501.03.04****, "Classification and Proportions."***

H. Prior to mix design approval, the Department reserves the right to verify the AASHTO T303 test results, using the sources and proportions of materials as indicated by the mix design.

I. Conduct another test upon changes in source of cementitious materials, including fly ash, or changes in cement type or mitigating admixture suppliers.

PHYSICAL PROPERTIES AND TESTS

706.03.01 RIPRAP GROUT

A. Riprap Grout shall have a minimum compressive strength of 2500 PSI and a maximum W/C ratio of 0.47.

B. The mix design for the placing requirements addresses two placement methods:

1. Direct discharge from the transit mixer.

2. Placement by small diameter line pumping methods.

C. Gradation requirements shall comply with Table 13 below:

Table 13 – Riprap Grout Gradation

Sieve Sizes	Direct Discharge - Percentage by Weight Passing Sieve	Pumpable Mix - Percentage by Weight Passing Sieve
1/2-inch	100	100
3/8-inch	95-100	100
No. 4	50-80	70-100
No. 8	35-65	45-75
No. 16	20-45	30-55
No. 30	15-40	20-45
No. 50	5-20	10-25
No. 100	0-15	0-15
No. 200	0-5	0-5

D. Factors which shall be considered for a given grout mix are:

1. Fine and coarse aggregates.

2. Consistency.

3. Elapse time between placement and initial set.

4. Length of time between batching and placement during which continuous or intermittent mixing is required.

E. Materials used in the production of riprap grout shall meet the minimum following material standards:

1. Fine and Coarse Aggregate: ASTM C33; ***Section 206, "Structure Excavation."***

2. Portland Cement: ASTM C150, Type V; ***Section 701, "Hydraulic Cement."***
3. Fly Ash: ASTM C618; ***Section 729, "Fly Ash."***
4. Water: ***Section 722, "Water."***
5. Air Entraining Admixture: ASTM C260; ***Section 702, "Concrete Curing Materials and Admixtures."***

F. A trial batch shall be placed for review by the Engineer for final approval for the project or for IQAC acceptance.

G. The Engineer shall be provided with a legible ticket with each load of grout delivered to the project site which shall contain the following information:

1. Name of Vendor.
2. Name of Contractor.
3. Number of Cubic Yards in the Load.
4. Actual Weights of Cement and of each Size of Aggregate.
5. Amount of Water Added at the Plant.
6. Amount of Water in the Aggregate.
7. Brand and Type of Cement.
8. Brand and Amount of Admixture.
9. Time and Date of Batching.

H. Materials submitted for IQAC acceptance shall meet all of the criteria above and shall have a visual inspection on the first placement within 90 days. Placement of grout shall fully encapsulate Riprap and be free of air pockets or voids.

Notes to Specifications

Sections 202, 502 and 610

EROSION CONTROL LINING SYSTEM SPECIFICATION
UNIFORM SECTION (US) - PET FABRIC FORMED CONCRETE

PART 1.0: GENERAL

1.1 Scope of Work

The work shall consist of furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the fabric formed concrete erosion control lining systems in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein. If the contractor is inexperienced, then the fabric formed concrete manufacturer's representative shall provide on-site technical assistance at the beginning of the installation for a length of time the contractor is sufficiently experienced to complete the remaining installation.

1.2.1 Description

The work shall consist of installing an unreinforced concrete lining by positioning specially woven, double-layer synthetic forms on the surface to be protected and filling them with a pumpable fine aggregate concrete (structural grout) in such a manner as to form a stable lining of required thickness, weight and configuration.

1.3 Referenced Documents

1.3.1 American Society for Testing and Materials (ASTM)

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 109	Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-inch or [50-mm] Cube Specimens)
ASTM C 150	Standard Specification for Portland Cement
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 618	Standard Specification for Coal Fly Ash and Calcined Natural Pozzolan for Use in Concrete
ASTM C 685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C 1603	Standard Test Method for Measurement of Solids in Water
ASTM D 2061	Standard Test Method of Strength of Zippers
ASTM D 2256	Standard Test Method for Tensile Properties of Yarns by the Single-Strand Method
ASTM D 4354	Practice for Sampling of Geotextiles for Testing
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoidal Tearing Strength of Geotextiles
ASTM D 4595	Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method
ASTM D 4632	Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
ASTM D 4751	Test Method for Determining Apparent Opening Size for a Geotextile
ASTM D 4759	Practice for Determining the Specification Conformance of Geotextiles
ASTM D 4873	Standard Guide for Identification, Storage, and Handling of Geotextiles
ASTM D 4884	Test Method for Seam Strength of Sewn Geotextiles
ASTM D 5199	Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
ASTM D 5261	Test Method for Measuring Mass per Unit Area of Geotextiles
ASTM D 6241	Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 2-inch [50-mm] Probe
ASTM D 6449	Standard Method for Flow of Fine Aggregate Concrete for Fabric Formed Concrete

1.4 Terminology

For the purpose of these specifications, the following definitions shall apply:

1.4.1 Compaction:

The densification of a soil by means of mechanical manipulation.

1.4.2 Subgrade:

The ground surface usually specially prepared against which lining shall be placed. In cases where lining is to be retained the same shall be considered as subgrade.

1.4.3 "Lining" Fabric Form:

The fabric forms are constructed of woven, double-layer synthetic fabric. "LINING" linings are installed by positioning fabric forms over the areas to be protected and then pumping, high-strength, fine aggregate concrete into the forms. The fabric forms can be placed and filled either underwater or in-the-dry. The high-strength, fine aggregate concrete is used in place of conventional concrete because of its pumpability, high-strength, impermeability, and absorption resistance.

1.4.4 "Lining" Uniform Section (US) Lining:

"Lining" Uniform Section linings provide an erosion resistant, impermeable concrete lining having a brick pattern surface and a relatively low coefficient of hydraulic friction in order to maintain optimum water velocities. The thickness and weight of the lining is controlled by spacer cords.

1.4.5 Baffle:

Baffles are flow-directing vertical geotextile walls constructed between fabric form sections layers. Baffles are an integral part of the fabric form design. Baffles are designed to support the panel section, determine the concrete area of the section and direct the flow of fine aggregate concrete for maximum efficiency.

1.4.6 Slide Fastener (Zipper):

A zipper or zipper like devise having two grooved plastic edges joined by a sliding tab or pull.

1.5 Submittals

1.5.1 The Contractor shall furnish the fine aggregate concrete manufacturer's certificates of compliance, mix design, fine aggregate gradation and fineness modulus for the fine aggregate concrete.

1.5.2 The Contractor shall furnish the fabric form manufacturer's certificates of compliance for the fabric forms. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.

1.5.3 Alternative fabric formed concrete lining materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to the bid date. Alternative material packages must be submitted to the Engineer a minimum of fourteen (14) days prior to the bid date. Submittal packages must include, as a minimum, the following:

Material testing reports prepared by a certified geotextile laboratory attesting to the alternative fabric form material's compliance with this Specification. Material laboratory testing shall have been performed within ninety (90) days of the bid date.

PART 2.0: PRODUCT

2.1 General - Fabric Formed Concrete Lining

Table 1.0 UNIFORM SECTION (US) CONCRETE LININGS								
Physical Properties	**Units**	**US200**	**US300**	**US400**	**US600**	**US800**	**US1000**	**US1200**
Average Thickness	in	2	3	4	6	8	10	12
Mass Per Unit Area	lb/ft^2	22	34	45	68	90	113	135
Hydraulic Design Properties								
Shear Resistance	lb/ft^2	9.2	13.8	18.4	27.6	36.8	46	55.2

Fabric formed concrete lining shall be Uniform Section (US) type and have a finished average thickness of _ inches, a nominal mass per unit area of __ lb/ft^2, and a comparatively uniform section with a brick pattern surface appearance. The shear resistance of the concrete lining shall be a minimum of __ lb/ft^2, as demonstrated by full scale flume testing.

2.2 Fabric Forms

The fabric forms for casting the concrete lining(s) shall be as specified, "LINING" ® Uniform Section (US400) fabric forms as manufactured by:

Synthetex, LLC; 5550 Triangle Parkway, Suite 220 Peachtree Corners, Georgia 30092
Tel: 800.253.0561 or 770.399.5051
E-Mail: info@synthetex.com

The fabric forms shall be composed of synthetic yarns formed into a woven fabric. Yarns used in the manufacture of the fabric shall be composed of polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight). Partially-oriented (POY), draw-textured, and/or staple yarns shall not be used in the manufacture of the fabric. Each layer of fabric shall conform to the physical, mechanical and hydraulic requirements Mean Average Roll Values listed in Table 1.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 1.0 PROPERTY REQUIREMENTS – "LINING" FABRIC [1, 2]			
	Test Method	**Units**	**MARV**
Physical Properties			
Composition of Yarns	-	-	Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2	≥13
Thickness (single-layer)	ASTM D 5199	mils	≥14
Mill Width (Woven)		inch	141
Mechanical Properties			
Wide-Width Strip Tensile Strength - MD | TD	ASTM D 4595	lbs/inch	≥300
Elongation at Break - MD | TD - Max.		%	15±5
Trapezoidal Tear Strength - MD | TD	ASTM D 4533	lbs	≥175
CBR Puncture Strength	ASTM D 6241	lbs	≥1250
Mullen Burst Strength	ASTM D 3786 (Mod.)	psi	500
	Test Method	**Units**	**MARV Range**
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve	≥20
Flow Rate	ASTM D 4491	gal/min/ft^2	≥25

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

2. All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Lots shall be sampled according to ASTM D 4354.

2.2.1 Fabric forms shall consist of double-layer woven fabric joined together by spaced, interwoven cords of uniform length to form a concrete lining of the specified average thickness. The cords shall be interwoven between the two layers of fabric, in parallel pairs, so that the two (2) cords together in the top layer and two (2) cords together in the bottom layer cross between layers at drop points. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256.

2.2.2 Mill widths of fabric shall be a minimum of 84 inches. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches by adding a minimum of 6 warp yarns to each selvage construction. Mill width rolls shall be cut to the length required, and the double-layer fabric separately joined, bottom layer to bottom layer and top layer to top layer, by means of sewing thread, to form multiple mill width panels with sewn seams on not less than 80-inch centers.

2.2.3 Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches to 0.75 inches apart. Each row of stitching shall consist of 4 to 7 stitches per inch. Thread used for seaming shall be polyester.

2.2.4 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 180 lbf/inch when tested in accordance with ASTM D 4632.

2.2.5 The fabric forms shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. If stored outdoors, they shall be elevated and protected with a waterproof cover that is opaque to ultraviolet light. The fabric forms shall be labeled as per ASTM D 4873.

2.2.6 The Contractor shall submit a manufacturer's certificate that the supplied fabric forms meet the criteria of these Specifications, as measured in full accordance with the test methods and standards referenced herein. The certificates shall include the following information about each fabric form delivered:

Manufacturer's name and current address;
Full product name;
Style and product code number;
Form number(s);
Composition of yarns; and
Manufacturer's certification statement.

2.3 Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.70. The pumping of fine aggregate concrete into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate concrete thereby increasing its strength and durability. The sand/cement ratio should be determined by the ready-mix manufacturer and should be on the order of 2.4:1.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-15 seconds when passed through the 19 mm orifice of the standard flow

cone that is described in ASTM C6449-99. Additional Pozzolan and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The Contractor should demonstrate the suitability by placing the proposed fine aggregate concrete mix into three (3) 2 in concrete cubes. The mix should exhibit a minimum compressive strength of 3500 psi at 28 days, when made and tested in accordance ASTM C109/C109M-13.

With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete. The mixing water reduction will also result in an increase of approximately 8% in the sand and cement per cubic foot of concrete. The range of fine aggregate concrete mix proportions provided in Table 2.0 has been developed under a variety of field conditions.

Table 2.0 Typical Range of Mix Proportions

Material	Mix Proportions lb/yd^3	After Placement Mix Proportions lb/yd^3
Cement	750-850	805-915
Sand	2120-2030	2290-2190
Water	540-555	460-470
Air	As Required	As Required

2.3.1 Components

2.3.1.1 Portland Cement

Portland cement should conform to ASTM C 150/150M, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 35% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing course sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

2.3.1.2 Fine Aggregate (sand)

Fine aggregate should consist of suitable clean, hard, strong and durable natural or manufactured sand. It should not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack any embedded steel, neoprene, rubber, plastic, etc. Motorized sand washing machines should be used to remove impurities from the fine aggregate. Fine aggregate having positive alkali-silica reaction should not be used. All fine aggregates should conform to ASTM C33/C33M-13. The fine aggregate should not have more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 3.0. The fineness modulus of fine aggregate should neither be less than 2.3 nor greater than 3.1. Fine aggregate with grading near the minimum for passing the No. 50 and No. 100 sometimes have difficulties with workability or pumping. The additions of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.

ASTM C33/C33M-13 defines the requirements for grading and quality of fine aggregate for use in fine aggregate concrete and is for use by a contractor as part of the purchase document describing the material to be furnished.

Table 3.0 Grading Requirement for Fine Aggregate

Sieve	Percent by Weight Passing the Sieve
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85

600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

2.3.1.3 Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

Potable water is permitted to be used as mixing water in fine aggregate concrete without testing for conformance with the requirements of ASTM C1602/C1602M-12.

ASTM C1602/C1602M-12 covers the compositional and performance requirements for water used as mixing water in hydraulic cement fine aggregate concrete. It defines sources of water and provides requirements and testing frequencies for qualified individual or combined water sources.

2.3.2 Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494/C494M and ASTM C260/C260M, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw and sulfate resistance of the hardened concrete.

2.4 Ready-Mixed Concrete

The basis of standard specifications for ready-mixed concrete should be ASTM C94/C94M-13a.

2.4.1 Ordering

The contractor should require the manufacturer to assume full responsibility for the selection of the proportions for the concrete mixture, the contractor should also specify the following:

1. Requirements for compressive strength as determined on samples taken from the transportation unit at the point of discharge. Unless otherwise specified the age at test should be 28 days.

2. That the manufacturer, prior to the actual delivery of the fine aggregate concrete, furnish a statement to the contractor, giving the dry mass of cement and saturated surface-dry-mass of fine aggregate and quantities, type, and name of admixtures (if any) and the water per cubic yard or cubic metre of fine aggregate concrete that will be used in the manufacture. The manufacturer should also furnish evidence satisfactory to the contractor that the materials to be used and proportions selected will produce fine aggregate concrete of the quality specified.

2.4.2 Mixing and Delivery

Ready-mixed fine aggregate concrete should be mixed and delivered to the point of discharge by means of one of the following combinations of operation:

Central-Mixed Concrete is mixed completely in a stationary mixer and transported to the point of delivery in a truck agitator, or a truck mixer operating at agitating speed, or in non-agitating equipment meeting the

requirements of Section 13 of ASTM C94/C94M-13a. The acceptable mixing time for mixers having capacity of 1 yd^3 or less is one (1) minuet. For mixers of greater capacity, this minimum should be increased 15 seconds for each cubic yard [cubic metre] of fraction thereof of additional capacity.

Shrink-Mixed Concrete—Concrete that is first partially mixed in a stationary mixer, and then completely in a truck mixer, should conform to the following: The time for the partial mixing should be the minimum required to intermingle the ingredients. After transfer to a truck mixer the amount of mixing at the designated mixing speed will be that necessary to meet the requirements for uniformity of concrete.

Truck-Mixed Concrete—Concrete that is completely mixed in a truck mixer, 70 to 100 revolutions at the mixing speed designated by the manufacturer to produce the uniformity of concrete.

No water from the truck water system should or elsewhere should be added after the initial introduction of mixing water for the batch except when on arrival to the project site the flow rate of the fine aggregate concrete is less than 9 seconds. If the flow rate is less than 9 seconds obtain the desired flow rate within 9 to 15 seconds with a one-time addition of water. A one-time addition of water is not prohibited from being several distinct additions of water provided that no fine aggregate concrete has been discharged except for flow testing. All water additions should be completed within 15 minutes from the start of the first water addition. Such addition should be injected into the mixer under such pressure and direction of flow to allow for proper distribution within the mixer. The drum should be turned an additional 30 revolutions, or more if necessary, at mixing speed to ensure that a homogenous mixture is attained. Water should not be added to the batch at any later time.

Discharge of fine aggregate concrete should be completed within 1 1/2 hours after the introduction of mixing water to the cement and fine aggregate. This limitation may be waived by the contractor if concrete is of such flow after 1 1/2 hours time has been reached that it can be placed, without the addition of water to the batch. In hot weather, or under conditions contributing to rapid stiffening of the fine aggregate concrete, a time less than 1 1/2 hours is permitted to be specified by the contractor. *Depending on the project requirements the technology is available to the manufacture to alter fresh fine aggregate properties (such as setting time or flow.) On some projects the manufacturer may request changes to certain fresh fine aggregate concrete properties due to the distance or projected transportation time between the batch plant and the point of delivery.*

Fine aggregate concrete delivered in cold weather should have the minimum temperature indicated in Table 4.0. The maximum temperature of fine aggregate concrete produced with heated aggregate, heated water, or both, should at no time during its production or transportation exceed 90 °F.

Table 4.0 Minimum Fine Aggregate Temperature as Placed

Section Size, inch	Temperature, min, °F
< 12	55
12—36	50

2.4.3 Sampling for Uniformity

The fine aggregate concrete should be discharged at the normal operating rate for the mixer being tested, with care being exercised not to obstruct or retard the discharge by an incompletely opened gate or seal. As the mixer is being emptied, individual samples should be taken after discharge of approximately 15% and 85% of the load. *No samples should be taken before 10% or after 90% of the batch has been discharged. Due to the difficulties of determining the actual quantity of fine aggregate discharged, the intent is to provide samples that are representative of widely separated portions, but not the beginning and end of the load.*

2.4.4 Batch Ticket Information

The manufacturer of the concrete should furnish to the contractor with each batch of fine aggregate concrete before unloading at the site, a delivery ticket with the following information:

- Name of ready-mix company and batch plant, or batch plant number.

- Serial number of ticket,
- Date,
- Truck number,
- Specific designation of job (name and location),
- Specific call or designation of the concrete in conformance with that employed in project specifications,
- Amount of fine aggregate concrete in cubic yards,
- Time loaded or of first mixing of cement and fine aggregate, and
- Amount of water added to the fine aggregate concrete by the contractor, at site, or the contractor's designated representative and their initials.

The following information, for certification purposes, required by the project specifications should be furnished:

- Type, brand, and amount of cement,
- Class, brand, and amount of coal fly ash, or raw or calcined natural pozzolans,
- Type, brand, and amount of admixtures.
- Source and amount of each metered or weighted water,
- Information necessary to calculate the total mixing water. Total mixing water includes water on fine aggregates, batch water (metered or weighted) including ice batched at the plant, wash water retained in the mixing drum, and water added by the truck operator from the mixer tank,
- Amount of fine aggregate,
- Ingredients certified as being previously approved, and
- Signature or initials of manufacturer's' representative.

2.3 **Geotextile Filter Fabrics**

2.4.1 The geotextile filter fabrics shall be composed of synthetic fibers or yarns formed into a nonwoven or woven fabric. Fibers and yarns used in the manufacture of filter fabrics shall be composed of at least 85% by weight of polypropylene, polyester or polyethylene. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

2.4.2 The geotextile filter fabric must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the geotextile. The geotextile filter fabric shall be as specified elsewhere in the Contract Specifications. Final acceptance of the geotextile filter fabric by the Engineer shall be based on project specific soil information, provided by the Contractor/Owner. The geotextile filter shall meet the minimum physical requirements listed in Table 5 or greater as required by the Engineer based on site soil conditions.

2.4.3 The geotextile filter fabric shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. If stored outdoors, they shall be elevated and protected with a waterproof cover that is opaque to ultraviolet light. The fabric forms shall be labeled as per ASTM D 4873.

Table 5.0 MINIMUM PROPERTY REQUIREMENTS – FILTER FABRIC

	Test Method	**Units**	**Minimum Value**
Mechanical Properties			
Grab Tensile Strength	ASTM D 4632	lbf	180 (in any principal direction)
Elongation at Break	ASTM D 4632	%	50 max. (in any principal direction)
Trapezoidal Tear Strength	ASTM D 4533	lbf	75 (in any principal direction)
Puncture Strength	ASTM D 4833	lbs	105 (in any principal direction)
CBR Puncture Strength	ASTM D 6241	lbs	475 (in any principal direction)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	As Specified Elsewhere in the Contract Specifications
Permittivity	ASTM D 4491	sec^{-1}	As Specified Elsewhere in the Contract Specifications

Flow Rate	ASTM D 4491	gal/min/ft^2	As Specified Elsewhere in the Contract Specifications

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

2. All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Lots shall be sampled according to ASTM D 4354.

PART 3.0: DESIGN REQUIREMENTS

3.1 Certification (Open Channel Flow)

3.1.1 Fabric formed concrete lining will only be accepted when accompanied by documented full-scale hydraulic flume performance characteristics that are derived from tests under controlled flow conditions. Test guidelines shall conform to testing protocol as documented in "Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow."

3.1.2 The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings for the design discharges along the structure(s). The stability analysis for each concrete lining shall be accomplished using a factor-of-safety methodology. A minimum factor of safety of 1.3 shall be required or higher as determined by lock conditions or critical structures.

3.2 Performance (Open Channel Flow)

3.2.1 The Contractor shall provide to the Engineer calculations and design details, provided by the manufacturer or a professional engineer, attesting to the suitability of each fabric formed concrete lining for the purpose contemplated. Each concrete lining shall be accepted only when accompanied by the documented hydraulic performance characteristics derived from full-scale flume tests performed under controlled flow conditions.

PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation - Grading

4.1.1 Areas on which fabric forms are to be placed shall be constructed to the lines, grades, contours, and dimensions shown on the Contract Drawings. The areas shall be graded and uniformly compacted to a smooth plane surface with an allowable tolerance of plus or minus 0.2 feet from bottom grade, as long as ponding does not occur, and plus or minus 0.2 foot from a side slope grade as long as humps or pockets are removed.

4.1.2 The areas shall be free of organic material and obstructions such as roots and projecting stones and grade stakes shall be removed. Where required by the Contract Specifications, soft and otherwise unsuitable subgrade soils shall be identified, excavated and replaced with select materials in accordance with the Contract Specifications. Where areas are below the allowable grades, they shall be brought to grade by placing compacted layers of select material. The thickness of layers and the amount of compaction shall be as specified by the Engineer.

4.1.3 Excavation and preparation of aprons as well as anchor, terminal or toe trenches shall be done in accordance with the lines, grades, contours, and dimensions shown on the Contract Drawings.

4.1.4 The terminal edges of the fabric form lining should be keyed into the subgrade to the lines, grades, and dimensions shown on the Contract Drawings.

4.2 Inspection

Immediately prior to placing the fabric forms, the prepared area shall be inspected by the Engineer, and no forms shall be placed thereon until the area has been approved.

4.3 Geotextile Filter Fabric Placement

4.3.1 The geotextile filter baric shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile filter fabric shall be placed so that the upstream roll of fabric overlaps the downstream roll. The longitudinal and transverse joints will be overlapped at least two (2) feet. The geotextile will extend at least one (1) foot beyond the top and bottom concrete lining termination points, or as required by the Engineer.

4.3.2 A geotextile filter fabric, as specified elsewhere, shall be placed on the graded surface approved by the Engineer.

4.4 Fabric Form Placement

4.4.1 Factory assembled fabric form panels shall be placed over the geotextile filter fabric and within the limits shown on the Contract Drawings. Perimeter termination of the fabric forms shall be accomplished through the use of anchor, flank and toe trenches, as shown on the Contract Drawings. When placing panels an allowance for approximately 10% contraction of the form in each direction which will occur as a result of fine aggregate concrete filling. The contractor shall gather and fold the additional slope direction fabric form in the anchor trench to be secured in such a manners as to be gradually released as fabric forms contract during filling. The contractor shall gather the additional transverse direction fabric form at each baffle for self release during filling.

4.4.2 Adjacent fabric form panels shall be joined in the field by means of sewing or zippering closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing.

4.4.3 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of 3 ft to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the upstream form shall overlap the downstream form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

4.4.4 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.4.5 Immediately prior to filling with fine aggregate concrete, the assembled fabric forms shall be inspected by the Engineer, and no fine aggregate concrete shall be pumped therein until the fabric seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five (5) days.

4.5 **Fine Aggregate Concrete Placement**

4.5.1 Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of fabric. The fabric shall be removed when the concrete is no longer fluid and the concrete surface at the hole shall be cleaned and smoothed by hand.

4.5.2 Fine aggregate concrete coverage for US400 shall net 75 ft^2/yd^3 (see Section 2.3).

4.5.3 Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Consultation with the fabric form manufacturer with regard to the selection of grout/concrete pumps is recommended.

4.5.4 Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

4.5.5 The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first

be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

4.5.6 Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness of the concrete lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

4.5.7 Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

4.5.8 Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.

4.5.9 After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining. No more than five hundred (500) linear feet of pumped concrete lining with non-completed anchor, anchor, flank, or toe trenches will be permitted at any time.

PART 5.0: Method of Measurement

The fabric formed concrete erosion control lining shall be measured by the number of square feet or yards computed from the lines and cross sections shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

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Notes to Specifications

Sections 202, 502 and 610

EROSION CONTROL LINING SYSTEM SPECIFICATION
CABLE ARTICULATING BLOCK (CAB) FABRIC FORMED CONCRETE

PART 1.0: GENERAL

1.1 Scope of Work

The work shall consist of furnish all labor, materials, equipment, and incidentals required and perform all operations in connection with the installation of the fabric formed concrete erosion control lining systems in accordance with the lines, grades, design, and dimensions shown on the Contract Drawings and as specified herein. If the contractor is inexperienced, then the fabric formed concrete manufacturer's representative shall provide on-site technical assistance at the beginning of the installation for a length of time the contractor is sufficiently experienced to complete the remaining installation.

1.2.1 Description

The work shall consist of installing a reinforced concrete lining by positioning specially woven, double-layer synthetic forms on the surface to be protected and filling them with a pumpable fine aggregate concrete (structural grout) in such a manner as to form a stable lining of required thickness, weight and configuration.

1.3 Referenced Documents

1.3.1 American Society for Testing and Materials (ASTM)

ASTM C 31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C 33	Standard Specification for Concrete Aggregates
ASTM C 94	Standard Specification for Ready-Mixed Concrete
ASTM C 1019	Standard Test Method for Sampling and Testing Grout
ASTM C 150	Standard Specification for Portland Cement
ASTM C 260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C 494	Standard Specification for Chemical Admixtures for Concrete
ASTM C 618	Standard Specification for Coal Fly Ash and Calcined Natural Pozzolan for Use in Concrete
ASTM C 685	Standard Specification for Concrete Made by Volumetric Batching and Continuous Mixing
ASTM C 1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM C 1603	Standard Test Method for Measurement of Solids in Water
ASTM D 2061	Standard Test method of Strength of Zippers
ASTM D 4354	Practice for Sampling of Geotextiles for Testing
ASTM D 4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D 4533	Standard Test Method for Trapezoidal Tearing Strength of Geotextiles
ASTM D 4595	Test Method for Tensile Properties of Geotextiles by the Wide Width Strip Method
ASTM D 4632	Test Method for Breaking Load and Elongation of Geotextiles (Grab Method)
ASTM D 4751	Test Method for Determining Apparent Opening Size for a Geotextile
ASTM D 4759	Practice for Determining the Specification Conformance of Geotextiles
ASTM D 4873	Standard Guide for Identification, Storage, and Handling of Geotextiles
ASTM D 4884	Test Method for Seam Strength of Sewn Geotextiles
ASTM D 5199	Test Method for Measuring Nominal Thickness of Geotextiles and Geomembranes
ASTM D 5261	Test Method for Measuring Mass per Unit Area of Geotextiles
ASTM D 6241	Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 2-inch [50-mm] Probe
ASTM D 6449	Standard Method for Flow of Fine Aggregate Concrete for Fabric Formed Concrete

1.4 Terminology

For the purpose of these specifications, the following definitions shall apply:

1.4.1 Compaction:

The densification of a soil by means of mechanical manipulation.

1.4.2 Subgrade:

The ground surface usually specially prepared against which lining shall be placed. In cases where lining is to be retained the same shall be considered as subgrade.

1.4.3 "Fabric Formed Lining" Fabric Form:

The fabric forms are constructed of woven, double-layer synthetic fabric. "Fabric Formed Lining" linings are installed by positioning fabric forms over the areas to be protected and then pumping, high-strength, fine aggregate concrete into the forms. The fabric forms can be placed and filled either underwater or in-the-dry. The high- strength, fine aggregate concrete is used in place of conventional concrete because of its pumpability, high- strength, impermeability, and absorption resistance.

1.4.4 "Fabric Formed Lining" Cable Articulating Block (CAB) Lining:

"Fabric Formed Lining" Cable Articulating Block Linings consist of a series of compartments (blocks) linked by an interwoven perimeter and revetment cables. Ducts interconnect the compartments and high strength revetment cables are installed between and through the compartments and ducts. Once filled, the Cable Articulating Block Linings become a mattress of pillow shaped, rectangular concrete blocks. The interwoven perimeters between the blocks serve as a hinge to permit articulation. The cables remain embedded in the concrete blocks to link the blocks together and facilitate articulation. Some relief of hydrostatic pressure is accomplished through the filtration bands formed by the interwoven perimeters of the blocks.

1.4.5 Baffle:

Baffles are flow-directing vertical geotextile walls constructed between fabric form sections layers. Baffles are an integral part of the fabric form design. Baffles are designed to support the panel section, determine the concrete area of the section and direct the flow of fine aggregate concrete for maximum efficiency.

1.4.6 Slide Fastener (Zipper):

A zipper or zipper like devise having two grooved plastic edges joined by a sliding tab or pull.

1.5 Submittals

1.5.1 The Contractor shall furnish the fine aggregate concrete manufacturer's certificates of compliance, mix design, fine aggregate gradation and fineness modulus for the fine aggregate concrete.

1.5.2 The Contractor shall furnish the fabric form manufacturer's certificates of compliance for the fabric forms. The Contractor shall also furnish the manufacturer's specifications, literature, shop drawings for the layout of the concrete lining panels, and any recommendations, if applicable, that are specifically related to the project.

1.5.3 Alternative fabric formed concrete lining materials may be considered. Such materials must be pre-approved in writing by the Engineer prior to the bid date. Alternative material packages must be submitted to the Engineer a minimum of fourteen (14) days prior to the bid date. Submittal packages must include, as a minimum, the following:

Material testing reports prepared by a certified geotextile laboratory attesting to the alternative fabric form material's compliance with this Specification. Material laboratory testing shall have been performed within ninety (90) days of the bid date.

PART 2.0: PRODUCT

Table 1.0 CABLE ARTICULATING BLOCK (CAB) CONCRETE LININGS							
Physical Properties	**Units**	**AB300**	**AB400**	**AB600**	**AB800**	**AB1000**	**AB1200**
Average Thickness	in	3	4	6	8	10	12
Mass Per Unit Area	lb/ft^2	34	45	68	90	113	135
Nominal Block Dimensions	In	22 x 10	22 x 12	22 x 18	22 x 24	33 x 22	33 x 27
Hydraulic Design Properties							
Shear Resistance	lb/ft^2	19.5	26	39	52	65	78

Fabric formed concrete lining shall be Cable Articulating Block (see table 1.0)) type with concrete blocks having finished nominal block dimensions of (see table 1.0) ____inches x ____ inches, a finished average thickness of (see table 1.0) _ inches, and a nominal mass per unit area of _ lb/ft^2. Concrete blocks shall be interconnected with embedded longitudinal (and lateral, optional) revetment cables in such a manner as to provide longitudinal and lateral binding of the finished cable articulating block mattress. The shear resistance of the concrete lining shall be a minimum of (see table 1.0) ___ lb/ft^2, as demonstrated by full scale flume testing.

2.2 Fabric Forms

The fabric forms for casting the concrete lining(s) shall be as specified, "Fabric Formed Lining" ® Cable Articulating Block (AB400LL) fabric forms as manufactured by:

Synthetex, LLC; 5550 Triangle Parkway, Suite 220 Peachtree Corners, Georgia 30092
Tel: 800.253.0561 or 770.399.5051
E-Mail: info@synthetex.com

The fabric forms shall be composed of synthetic yarns formed into a woven fabric. Yarns used in the manufacture of the fabric shall be composed of polyester. Forms shall be woven with a minimum of 50% textured yarns (by weight). Partially-oriented (POY), draw-textured, and/or staple yarns shall not be used in the manufacture of the fabric. Each layer of fabric shall conform to the physical, mechanical and hydraulic requirements Mean Average Roll Values listed in Table 1.0. The fabric forms shall be free of defects or flaws which significantly affect their physical, mechanical, or hydraulic properties.

Table 1.0 PROPERTY REQUIREMENTS – "Fabric Formed Lining" [1, 2]			
	Test Method	**Units**	**MARV**
Physical Properties			
Composition of Yarns	-	-	Polyester
Mass Per Unit Area (double-layer)	ASTM D 5261	oz/yd^2	≥13
Thickness (single-layer)	ASTM D 5199	mils	≥14
Mill Width (Woven)		inch	141
Mechanical Properties			
Wide-Width Strip Tensile Strength - MD | TD	ASTM D 4595	lbs/inch	≥300
Elongation at Break - MD **|** TD - Max.		%	15±5
Trapezoidal Tear Strength - MD | TD	ASTM D 4533	lbs	≥175
CBR Puncture Strength	ASTM D 6241	lbs	≥1250
Mullen Burst Strength	ASTM D 3786 (Mod.)	psi	500
	Test Method	**Units**	**MARV**

			Range
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	U.S. Standard Sieve	≥20
Flow Rate	ASTM D 4491	gal/min/ft^2	≥25

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

2. All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Lots shall be sampled according to ASTM D 4354.

2.2.1 Fabric forms shall be double-layer woven fabric joined together by narrow perimeters of interwoven fabric into a matrix of rectangular compartments. Cords shall connect the two layers of fabric at the center of each compartment. The cords shall be interwoven in two sets of four cords each, one set shall cross from the top layer to the bottom layer and the other from the bottom layer to the top layer. Each cord shall have a minimum breaking strength of 160 lbf when tested in accordance with ASTM D 2256. Fabric form compartments shall be offset in the lateral direction, to form a bonded concrete block pattern.

2.2.2 Fabric form compartments shall each have six ducts, two on each of the long sides and one on each of the short sides to allow passage of the fine aggregate concrete between adjacent compartments. The fine aggregate concrete filled, cross-sectional area of each duct shall be no more than 10 percent of the maximum filled cross-sectional area of the block lateral to the duct.

2.2.3 Revetment cables shall be installed in the longitudinal directions between the two layers of fabric. Two longitudinal cables, on approximately 12-inch centers, shall pass through each compartment in a manner which provides for the longitudinal and binding of the finished cable articulating block mattress. The cables shall enter and exit the compartments through opposing ducts.

2.2.4 Revetment cables shall be installed in the lateral direction between the two layers of fabric. One lateral cable shall pass through each compartment in a manner which provides for the lateral binding of the finished cable articulating block mattress. The lateral cables shall enter and exit the compartments through opposing ducts.

2.2.5 Revetment cables shall be constructed of **high-strength polyester or galvanized aircraft cable (GAC)**. **Longitudinal cables shall be nominally _____ (e.g., 0.25) inches in diameter and their rated breaking strength shall be not less than _____(e.g., 3,700) lbf. Lateral cables shall be nominally _____(e.g., 0.25) inches in diameter and their rated breaking strength shall be not less than _____ (e.g., 3,700) lbf. (Consult manufacturer for cable recommendations for the application).** Cable fittings shall be selected so that the resultant cable splice shall provide a minimum of 80 percent of the rated breaking strength of the cable. All cable splices shall have a minimum cable overlap of 6 inches (15.3 cm) and be made with aluminum compression fittings. Polyester Revetment Cables. Cables shall be constructed of high tenacity, low elongation, and continuous filament polyester fibers. Cable shall consist of a core constructed of parallel fibers contained within an outer jacket or cover. The weight of the parallel core shall be between 65% to 70% of the total weight of the cable.

(Paragraph 2.2.5 is a standard guideline for the selection of revetment cables. The Engineer should consult with the Synthetex's engineering department for site specific revetment cable selections. Alternate cable strengths and constructions are available.)

2.2.6 Mill widths of fabric shall be a minimum of 84 inches. Each selvage edge of the top and bottom layers of fabric shall be reinforced for a width of not less than 1.35 inches by adding a minimum of 6 warp yarns to each selvage construction. Mill width rolls shall be cut to the length required, and the double-layer fabric separately joined, bottom layer to bottom layer and top layer to top layer, by means of sewing thread, to form multiple mill width panels with sewn seams on not less than 80-inch centers.

2.2.7 Fabric form panels shall be factory-sewn, by jointing together the layers of fabric, top layer to top layer and bottom layer to bottom layer, into predetermined custom sized panels. Sewn seams shall be downward facing as shown on the Contract Drawings. All sewn seams and zipper attachments shall be

made using a double line of U.S. Federal Standard Type 401 stitch. All seams sewn shall be not less than 100 lbf/inch when tested in accordance with ASTM D 4884. Both lines of stitches shall be sewn simultaneously and be parallel to each other, spaced between 0.25 inches to 0.75 inches apart. Each row of stitching shall consist of 4 to 7 stitches per inch. Thread used for seaming shall be polyester.

2.2.8 Baffles shall be installed at predetermined mill width intervals to regulate the distance of lateral flow of fine aggregate concrete. The baffles shall be designed to maintain a full concrete lining thickness along the full length of the baffle. The baffle material shall be nonwoven filter fabric. The grab tensile strength of the filter fabric shall be not less than 180 lbf/inch when tested in accordance with ASTM D 4632.

2.2.9 The fabric forms shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. If stored outdoors, they shall be elevated and protected with a waterproof cover that is opaque to ultraviolet light. The fabric forms shall be labeled as per ASTM D 4873.

2.2.10 The Contractor shall submit a manufacturer's certificate that the supplied fabric forms meet the criteria of these Specifications, as measured in full accordance with the test methods and standards referenced herein. The certificates shall include the following information about each fabric form delivered:

Manufacturer's name and current address;
Full product name;
Style and product code number;
Form number(s);
Composition of yarns; and
Manufacturer's certification statement.

2.3 Fine Aggregate Concrete

Fine aggregate concrete consists of a mixture of Portland cement, fine aggregate (sand) and water, so proportioned and mixed as to provide a pumpable fine aggregate concrete.

The water/cement ratio of the fine aggregate concrete shall be determined by the ready-mix manufacturer, but generally should be on the order of 0.65 to 0.70. The pumping of fine aggregate concrete into the fabric forms causes a reduction in the water content by filtering excess mixing water through the permeable fabric. The reduction of mixing water substantially improves the water/cement ratio of the in-place fine aggregate concrete thereby increasing its strength and durability. The sand/cement ratio should be determined by the ready-mix manufacturer and should be on the order of 2.4:1.

The consistency of the fine aggregate concrete delivered to the concrete pump should be proportioned and mixed as to have a flow time of 9-15 seconds when passed through the ¾-inch [19 mm] orifice of the standard flow cone that is described in ASTM C6449-99. Additional Pozzolan and/or admixtures may be used with the approval of the Engineer-in-charge. The water/cement ratio varies with the exact granulometry of the fine aggregate (sand) and should be determined by the ready-mix manufacturer using the above referenced flow cone.

The Contractor should demonstrate the suitability by placing the proposed fine aggregate concrete mix into concrete grout prisms per ASTM C1019.. The mix should exhibit a minimum compressive strength of 2500 psi at 28 days, when made and tested in accordance ASTM C1019. As a result of the following, the actual compressive strength inside the fabric forms will be higher than the sampling and testing.

With a typical loss of approximately 15% of the total mixing water, 27 ft^3 of pumpable fine aggregate concrete will reduce to approximately 25 ft^3 of hardened concrete. The mixing water reduction will also result in an increase of approximately 8% in the sand and cement per cubic foot of concrete. The range of fine aggregate concrete mix proportions provided in Table 2.0 has been developed under a variety of field conditions.

Table 2.0 Typical Range of Mix Proportions

Material	Mix Proportions lb/yd^3	After Placement Mix Proportions lb/yd^3
Cement	750-850	805-915
Sand	2120-2030	2290-2190

Water	540-555	460-470
Air	As Required	As Required

2.3.1 Components

2.3.1.1 Portland Cement

Portland cement should conform to ASTM C 150/150M, Type I, II or V. Pozzolan grade fly ash may be substituted for up to 35% of the cement as an aid to pumpability. (The pumpability of fine aggregate concrete mixes containing course sand is improved by the addition of fly ash.) Pozzolan, if used, should conform to ASTM C 618, Class C, F or N.

2.3.1.2 Fine Aggregate (sand)

Fine aggregate should consist of suitable clean, hard, strong and durable natural or manufactured sand. It should not contain dust, lumps, soft or flaky materials, mica or other deleterious materials in such quantities as to reduce the strength and durability of the concrete, or to attack any embedded steel, neoprene, rubber, plastic, etc. Motorized sand washing machines should be used to remove impurities from the fine aggregate. Fine aggregate having positive alkali-silica reaction should not be used. All fine aggregates should conform to ASTM C33/C33M-13. The fine aggregate should not have more than 45% passing any sieve and retained on the next consecutive sieve of those shown in Table 3.0. The fineness modulus of fine aggregate should neither be less than 2.3 nor greater than 3.1. Fine aggregate with grading near the minimum for passing the No. 50 and No. 100 sometimes have difficulties with workability or pumping. The additions of entrained air, additional cement, or the addition of an approved mineral admixture to supply the deficient fines, are methods used to alleviate such difficulties.
ASTM C33/C33M-13 defines the requirements for grading and quality of fine aggregate for use in fine aggregate concrete and is for use by a contractor as part of the purchase document describing the material to be furnished.

Table 3.0 Grading Requirement for Fine Aggregate

Sieve	Percent by Weight Passing the Sieve
9.5-mm (3/8-in.)	100
4.75-mm (No. 4)	95 to 100
a2.36-mm (No. 8)	80 to 100
1.18-mm (No. 16)	50 to 85
600-µm (No. 30)	25 to 60
300-µm (No. 50)	5 to 30
150-µm (No. 100)	0 to 10
75-µm (No. 200)	0 to 3

Fine aggregate failing to meet these grading requirements can be utilized provided that the supplier can demonstrate to the specifier that fine aggregate concrete of the class specified, made with fine aggregate under consideration, will have relevant properties at least equal to those of fine aggregate concrete made with same ingredients, with the exception that the referenced fine aggregate will be selected from a source having an acceptable performance record in similar fine aggregate construction.

2.3.1.3 Water

Water used for mixing and curing should be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may be deleterious to concrete.

Potable water is permitted to be used as mixing water in fine aggregate concrete without testing for conformance with the requirements of ASTM C1602/C1602M-12.

ASTM C1602/C1602M-12 covers the compositional and performance requirements for water used as mixing

water in hydraulic cement fine aggregate concrete. It defines sources of water and provides requirements and testing frequencies for qualified individual or combined water sources.

2.3.2 Plasticizing and Air Entraining Admixtures

Grout fluidifier, water reducing or set time controlling agents may be used as recommended by their manufacturers to improve the pumpability and set time of the fine aggregate concrete.

Any air entraining agent or any other admixture may be used, as approved, by the Engineer-in-charge to increase workability, to make concrete impervious and more durable. Air entraining admixture should conform to ASTM C494/C494M and ASTM C260/C260M, respectively. Mixes designed with 5% to 8% air content will improve the pumpability of the fine aggregate concrete, freeze-thaw and sulfate resistance of the hardened concrete.

2.4 Geotextile Filter Fabrics

2.4.1 The geotextile filter fabrics shall be composed of synthetic fibers or yarns formed into a nonwoven or woven fabric. Fibers and yarns used in the manufacture of filter fabrics shall be composed of at least 85% by weight of polypropylene, polyester or polyethylene. They shall be formed into a network such that the filaments or yarns retain dimensional stability relative to each other, including selvages. The geotextile shall be free of defects or flaws which significantly affect its mechanical or hydraulic properties.

2.4.2 The geotextile filter fabric must be permitted to function properly by allowing relief of hydrostatic pressure; therefore fine soil particles shall not be allowed to clog the geotextile. The geotextile filter fabric shall be as specified elsewhere in the Contract Specifications. Final acceptance of the geotextile filter fabric by the Engineer shall be based on project specific soil information, provided by the Contractor/Owner. The geotextile filter shall meet the minimum physical requirements listed in Table 5.

2.4.3 The geotextile filter fabric shall be kept dry and wrapped such that they are protected from the elements during shipping and storage. If stored outdoors, they shall be elevated and protected with a waterproof cover that is opaque to ultraviolet light. The fabric forms shall be labeled as per ASTM D 4873.

Table 5.0 PROPERTY REQUIREMENTS – FILTER FABRIC

	Test Method	**Units**	**Minimum Value**
Mechanical Properties			
Grab Tensile Strength	ASTM D 4632	lbf	180 (in any principal direction)
Elongation at Break	ASTM D 4632	%	50 max. (in any principal direction)
Trapezoidal Tear Strength	ASTM D 4533	lbf	75 (in any principal direction)
Puncture Strength	ASTM D 4833	lbs	105 (in any principal direction)
CBR Puncture Strength	ASTM D 6241	lbs	475 (in any principal direction)
Hydraulic Properties			
Apparent Opening Size (AOS)	ASTM D 4751	US Sieve	As Specified Elsewhere in the Contract Specifications
Permittivity	ASTM D 4491	sec^{-1}	As Specified Elsewhere in the Contract Specifications
Flow Rate	ASTM D 4491	$gal/min/ft^2$	As Specified Elsewhere in the Contract Specifications

Notes:

1. Conformance of fabric to specification property requirements shall be based on ASTM D 4759.

2. All numerical values represent minimum average roll values (i.e., average of test results from any sample roll in a lot shall meet or exceed the minimum values). Lots shall be sampled according to ASTM D 4354.

PART 3.0: DESIGN REQUIREMENTS

3.1 Certification (Open Channel Flow)

3.1.1 Fabric formed concrete lining will only be accepted when accompanied by documented full-scale hydraulic flume performance characteristics that are derived from tests under controlled flow conditions. Test guidelines shall conform to testing protocol as documented in “Hydraulic Stability of Fabric Formed Concrete Lining and Mat Systems During Overtopping Flow.”

3.1.2 The average thickness, mass per unit area and hydraulic resistance of each concrete lining shall withstand the hydraulic loadings for the design discharges along the structure(s). The stability analysis for each concrete lining shall be accomplished using a factor-of-safety methodology. A minimum factor of safety of 1.3 shall be required or higher as determined by lock conditions or critical structures.

3.2 Performance (Open Channel Flow)

3.2.1 The Contractor shall provide to the Engineer calculations and design details, provided by the manufacturer or a professional engineer, attesting to the suitability of each fabric formed concrete lining for the purpose contemplated. Each concrete lining shall be accepted only when accompanied by the documented hydraulic performance characteristics derived from full-scale flume tests performed under controlled flow conditions.

PART 4.0: CONSTRUCTION AND INSTALLATION REQUIREMENTS

4.1 Site Preparation - Grading

4.1.1 Areas on which fabric forms are to be placed shall be constructed to the lines, grades, contours, and dimensions shown on the Contract Drawings. The areas shall be graded and uniformly compacted to a smooth plane surface with an allowable tolerance of plus or minus 0.2 feet from bottom grade, as long as ponding does not occur, and plus or minus 0.2 foot from a side slope grade as long as humps or pockets are removed.

4.1.2 The areas shall be free of organic material and obstructions such as roots and projecting stones and grade stakes shall be removed. Where required by the Contract Specifications, soft and otherwise unsuitable subgrade soils shall be identified, excavated and replaced with select materials in accordance with the Contract Specifications. Where areas are below the allowable grades, they shall be brought to grade by placing compacted layers of select material. The thickness of layers and the amount of compaction shall be as specified by the Engineer.

4.1.3 Excavation and preparation of aprons as well as anchor, terminal or toe trenches shall be done in accordance with the lines, grades, contours, and dimensions shown on the Contract Drawings.

4.1.4 The terminal edges of the fabric form lining should be keyed into the subgrade to the lines, grades, and dimensions shown on the Contract Drawings.

4.2 Inspection

Immediately prior to placing the fabric forms, the prepared area shall be inspected by the Engineer, and no forms shall be placed thereon until the area has been approved.

4.3 Geotextile Filter Fabric Placement

4.3.1 The geotextile filter baric shall be placed directly on the prepared area, in intimate contact with the subgrade, and free of folds or wrinkles. The geotextile filter fabric shall be placed so that the upstream roll of fabric overlaps the downstream roll. The longitudinal and transverse joints will be overlapped at least two (2) feet. The geotextile will extend at least one (1) foot beyond the top and bottom concrete lining termination points, or as required by the Engineer.

4.3.2 A geotextile filter fabric, as specified elsewhere, shall be placed on the graded surface approved by the Engineer.

4.4 Fabric Form Placement

4.4.1 Factory assembled fabric form panels shall be placed over the geotextile filter fabric and within the limits shown on the Contract Drawings. Perimeter termination of the fabric forms shall be accomplished through the use of anchor, flank and toe trenches, as shown on the Contract Drawings. When placing panels an allowance for approximately 10% contraction of the form in each direction which will occur as a result of fine aggregate concrete filling. The contractor shall gather and fold the additional slope direction fabric form in the anchor trench to be secured in such a manners as to be gradually released as fabric forms contract during filling. The contractor shall gather the additional transverse direction fabric form at each baffle for self release during filling.

4.4.2 Adjacent fabric form panels shall be joined in the field by means of sewing or zippering closures. Adjacent panels shall be joined top layers to top layer and bottom layer to bottom. All field seams shall be made using two lines of U.S. Federal Standard Type 101 stitches. All sewn seams shall be downward facing.

4.4.3 When conventional joining of fabric forms is impractical or where called for on the Contract Drawings, adjacent forms may be overlapped a minimum of 3 ft to form a lap joint, pending approval by the Engineer. Based on the predominant flow direction, the upstream form shall overlap the downstream form. In no case shall simple butt joints between forms be permitted. Simple butt joints between panels shall not be allowed.

4.4.4 Expansion joints shall be provided as shown on the Contract Drawings, or as specified by the Engineer.

4.4.5 Immediately prior to filling with fine aggregate concrete, the assembled fabric forms shall be inspected by the Engineer, and no fine aggregate concrete shall be pumped therein until the fabric seams have been approved. At no time shall the unfilled fabric forms be exposed to ultraviolet light (including direct sunlight) for a period exceeding five (5) days.

4.5 **Fine Aggregate Concrete Placement**

4.5.1 Following the placement of the fabric forms over the geotextile filter fabric, fine aggregate concrete shall be pumped between the top and bottom layers of the fabric form through small slits to be cut in the top layer of the fabric form or manufacturer supplied valves. The slits shall be of the minimum length to allow proper insertion of a filling pipe inserted at the end of a 2-inch I.D. concrete pump hose. Fine aggregate concrete shall be pumped between the top and bottom layers of fabric, filling the forms to the recommended thickness and configuration.

Holes in the fabric forms left by the removal of the filling pipe shall be temporarily closed by inserting a piece of fabric. The fabric shall be removed when the concrete is no longer fluid and the concrete surface at the hole shall be cleaned and smoothed by hand.

4.5.2 Fine aggregate concrete coverage for AB400L shall net 75 ft^2/yd^3 (See section 2.3).

4.5.3 Fine aggregate concrete shall be pumped in such a manner that excessive pressure on the fabric forms is avoided. Consultation with the fabric form manufacturer with regard to the selection of grout/concrete pumps is recommended.

4.5.4 Cold joints shall be avoided. A cold joint is defined as one in which the pumping of the fine aggregate concrete into a given section of form is discontinued or interrupted for an interval of forty-five (45) or more minutes.

4.5.5 The sequence of fine aggregate concrete shall be such as to ensure complete filling of the fabric formed concrete lining to the thickness specified by the Engineer. The flow of the fine aggregate concrete shall first be directed into the lower edge of the fabric form and working back up the slope, followed by redirecting the flow into the anchor trench.

4.5.6 Prior to removing the filling pipe from the current concrete lining section and proceeding to the fine aggregate concrete filling of the adjacent lining section, the thickness of the current lining section shall be measured by inserting a length of stiff wire through the lining at several locations from the crest to the toe of the slope. The average of all thickness measurements shall be not less than the specified average thickness of the concrete lining. Should the measurements not meet the specified average thickness, pumping shall continue until the specified average thickness has been attained.

4.5.7 Excessive fine aggregate concrete that has inadvertently spilled on the concrete lining surface shall be removed. The use of a high-pressure water hose to remove spilled fine aggregate concrete from the surface of the freshly pumped concrete lining shall not be permitted.

4.5.8 Foot traffic will not be permitted on the freshly pumped concrete lining when such traffic will cause permanent indentations in the lining surface. Walk boards shall be used where necessary.

4.5.9 After the fine aggregate concrete has set, all anchor, flank and toe trenches shall be backfilled and compacted flush with the top of the concrete lining. The integrity of the trench backfill must be maintained so as to ensure a surface that is flush with the top surface of the concrete lining for its entire service life. Toe trenches shall be backfilled as shown on the Contract Drawings. Backfilling and compaction of trenches shall be completed in a timely fashion to protect the completed concrete lining. No more than five hundred (500) linear feet of pumped concrete lining with non-completed anchor, anchor, flank, or toe trenches will be permitted at any time.

PART 5.0: Method of Measurement

The fabric formed concrete erosion control lining shall be measured by the number of square feet or yards computed from the lines and cross sections shown on the Contract Drawings or from payment lines established in writing by the Engineer. This includes fabric forms, fine aggregate concrete, and filter fabric used in the aprons, overlaps, anchor, terminal, or toe trenches. Slope preparation, excavation and backfilling, and bedding are separate pay items.

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P494-24-803: Development of Alternative Desert Tortoise Crossing and Design Criteria (100114766)

SR 160

COST ESTIMATE

Final	Completed By	EBA	
	Checked By	MLN	

Item No.	Quantity	Unit	Description	Unit Price	Amount	RAW Quantity	Precision	Notes
			SITE A					
2020585	517	LINFT	REMOVAL OF FENCE	$ 5.00	$ 2,585.00	517	1	
2030160	610	CUYD	DRAINAGE EXCAVATION	$ 80.00	$ 48,800.00	610.0	0.1	
6042475	1	EACH	36-INCH METAL END SECTION	$ 3,000.00	$ 3,000.00	1	1	
6046515	28	LINFT	36-INCH CORR. METAL PIPE (12 GAGE)	$ 1,000.00	$ 28,000.00	28	0	
61005XX	305	SQYD	GROUT FILLED FABRIC FORMED LINER, NON-CABLE REVETED	$ 130.00	$ 39,650.00	305	0	
6100050	305	SQYD	GEOTEXTILE (CLASS 1)	$ 5.00	1,525.00	305	1	
6160180	2	EACH	12-FOOT METAL DRIVE GATE	$ 2,000.00	$ 4,000.00	2	1	
6161080	632	LINFT	TORTOISE FENCE	$ 25.00	$ 15,800.00	632	1	
				Subtotal	$ 143,360.00			
				3% Pollution/Dust Control	$ 4,301.00			
				10% Contingency/Incidentals	$ 14,336.00			
				5% Traffic Control	$ 7,168.00			
				5% Mobilization	$ 7,168.00			
				10% CM	$ 14,336.00			
				Site A Total	$ 190,669.00			

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COST ESTIMATE

Final	Completed By	EBA	
	Checked By	MLN	

Item No.	Quantity	Unit	Description	Unit Price	Amount	RAW Quantity	Precision	Notes
SITE B								
2020585	121	LINFT	REMOVAL OF FENCE	$ 5.00	$ 605.00	121	1	
2020641	1	LS	RESET RIPRAP	$ 10,000.00	$ 10,000.00	1.0	0	
2030160	249	CUYD	DRAINAGE EXCAVATION	$ 80.00	$ 19,920.00	249.0	0.1	
5021960	6	CUYD	GROUT	$ 400.00	$ 2,400.00	6.0	0	
6100050	367	SQYD	GEOTEXTILE (CLASS 1)	$ 5.00	$ 1,835.00	367	1	
61005XY	367	SQYD	GROUT FABRIC FORMED LINER, CABLE REVETED	$ 220.00	$ 80,740.00	367	1	
6161455	1	FA	REPAIR FENCE	$ 10,000.00	$ 10,000.00	1	0	
6161080	201	LINFT	TORTOISE FENCE	$ 25.00	$ 5,025.00	201	1	
				Subtotal	$ 130,525.00			
				3% Pollution/Dust Control	$ 3,916.00			
				10% Contingency/Incidentals	$ 14,336.00			
				5% Traffic Control	$ 7,168.00			
				5% Mobilization	$ 6,526.00			
				10% CM	$ 13,053.00			
				Site B Total	$ 175,524.00			
SITE C								
2020585	1699	LINFT	REMOVAL OF FENCE	$ 5.00	$ 8,495.00	1699	1	
5021960	4.0	CUYD	GROUT	$ 400.00	$ 1,600.00	4.0	0	
6160180	3	EACH	12-FOOT METAL DRIVE GATE	$ 2,000.00	$ 6,000.00	3	1	
6161080	1908	LINFT	TORTOISE FENCE	$ 25.00	$ 47,700.00	1908	1	
				Subtotal	$ 63,795.00			
				3% Pollution/Dust Control	$ 1,914.00			
				10% Contingency/Incidentals	$ 6,380.00			
				5% Traffic Control	$ 3,190.00			
				5% Mobilization	$ 3,190.00			
				10% CM	$ 6,380.00			
				Site C Total	$ 84,849.00			

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COST ESTIMATE

Final	Completed By	EBA	
	Checked By	MLN	

Item No.	Quantity	Unit	Description	Unit Price	Amount	RAW Quantity	Precision	Notes
			SITE D					
2020585	1066	LINFT	REMOVAL OF FENCE	$ 5.00	$ 5,330.00	1066	1	
5021960	221	CUYD	GROUT	$ 400.00	$ 88,400.00	221.0	0	
6160180	3	EACH	12-FOOT METAL DRIVE GATE	$ 2,000.00	$ 6,000.00	3	1	
6161080	1255	LINFT	TORTOISE FENCE	$ 25.00	$ 31,375.00	1255	1	
				Subtotal	$ 131,105.00			
				3% Pollution/Dust Control	$ 3,933.00			
				10% Contingency/Incidentals	$ 13,111.00			
				5% Traffic Control	$ 6,555.00			
				5% Mobilization	$ 6,555.00			
				10% CM	$ 13,111.00			
				Site D Total	$ 144,216.00			
				Grand Total	$ 595,258.00			

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