**ADDENDUM NO. 1**

**TO: PLANS AND SPECIFICATIONS FOR STATE OF MISSOURI**

**Construct Bellefontaine Readiness Center**
**Bellefontaine Neighbors, Missouri**
**Project No. T2150-01**

**Bid Opening Date: 1:30 PM, Thursday, July 11, 2024** (Not Changed)

**Revised Bid Form is attached. Bidders must use the Bid Form marked REVISED PER ADDENDUM #1 to bid this project.**

**Bidders are hereby informed that the construction Plans and/or Specifications are modified as follows:**

**SPECIFICATION CHANGES:**

1. Section 004113 – Bid Form
   a. The contract completion time was revised to 480 working days in Paragraph 4.0-A. **Bidders must use the attached Bid Form marked REVISED PER ADDENDUM #1 to bid this project.**

2. Section 005213 – Construction Contract
   a. REVISE Article 2. Time of Completion as follows:
   Revise the contract performance time from 360 working days to 480 working days.

3. Section 007300 – Supplementary Conditions
   a. REVISE Paragraph 2.0 Contacts, Contract Specialist as follows:
   Contract Specialist: Paul Girouard
   Division of Facilities Management, Design and Construction
   301 West High Street, Room 730
   Jefferson City, Missouri 65101
   Telephone: 573-751-4797
   Email: Paul.Girouard@oa.mo.gov

4. Section 07 41 13 – Metal Roof Panels
   a. DELETE Specification Section from set. Metal roof panels not included in project.

5. Section 08 34 60 – Vault Doors
   a. DELETE references to fire rating requirements. Vault Door is not required to be fire rated. Day gates will not be provided for vault door.

6. Section 08 38 00 – Traffic Doors
   a. These will be traffic doors with vision panel for doors 01a, 010b, and 011. DELETE references to Hollow Metal. These will be manufacturer frames.

7. Section 10 14 00 – Signage
   a. Will be provided by General Contractor. Designer to coordinate with Owner on final sizing.

8. Section 10 15 00 – Video Display Boards
   a. DELETE Specification Section from set. Will be provided by Owner.

9. Section 14 24 00 – Hydraulic Elevators
   a. REVISE Paragraph 2.02-A.11 Elevator Pit Depth to 6’ 0” and Paragraph 2.02-A.12

Overhead Clearance at Top Floor to 12' 5".

10. Section 23 07 00 – Mechanical Insulation
    a. REPLACE with attached revised specification. Reference to "duct liner" was removed from Paragraph 1.02-C.1 and "to be used for all outdoor ductwork" was added. Paragraph 3.05-B.1 was deleted to remove reference to "duct liner".

11. Section 23 31 13 – Metal Ducts
    a. REPLACE with attached revised specification. "and do not include the thickness of internal duct liner, if any" was deleted from Paragraphs 2.04-I and 3.03-G. New sentence "Internal duct liners are not acceptable." was added to Paragraphs 2.04-I and 3.03-G.

12. Section 23 72 23.29 – Packaged, Outdoor, Fixed Plate Energy Recovery Units
    a. ADD attached new specification (pages 1 thru 5).

13. Section 31 10 00 – Site Clearing
    a. REPLACE Paragraph 3.9-B with the following: "Burning of vegetation waste and land clearing debris on the project site is prohibited."

14. Section 33 30 00 – Sanitary Utility Drainage Piping
    a. REPLACE with attached revised specification. Red text adds Closed Circuit Television Video (CCTV) Investigation and Cured-In-Place Pipe (CIPP) Lining to the specification.

15. New Readiness Center Geotechnical Exploration
    a. ADD attached Appendix B – New Readiness Center Geotechnical Exploration

**DRAWING CHANGES/CLARIFICATIONS:**

1. Sheet C001
    a. ADD General Note 21 as follows: "Contractor will be responsible for water tap and meter fee. This needs to be coordinated with Missouri American Water."
    b. ADD General Note 22 as follows: "Contractor will be responsible for paying all utility bills (Water, Sewer, Electric, Gas, etc.) until the project is found Substantially Complete."

2. Sheet C102
    a. ADD attached Benchmark and Control Point information.

3. Sheet C204
    a. REPLACE Detail 3 with attached revised detail to clarify dimensions and filter fabric label.

4. Sheet C309
    a. REPLACE with attached revised plan sheet. Detail 2 was updated to provide additional information. Pervious pavement area square footage was added. Observation well locations were added.

5. Sheet C310
    a. REPLACE with attached revised plan sheet. Elevations were updated. Pervious pavement area square footage was added. Observation well locations were added.

6. Sheet C310.1
    a. ADD attached new plan sheet. Pervious pavement sections added to clarify drainage aggregate, subgrade berm, and underdrain configurations.

7. Sheet C310.2
   a. ADD attached new plan sheet. Pervious pavement sections added to clarify drainage aggregate, subgrade berm, and underdrain configurations.

8. Sheet C401
   a. REPLACE with attached revised plan sheet. Rip rap notes were added. Underdrain legend note was updated.

9. Sheet C402
   a. REPLACE with attached revised plan sheet. Clouded notes were added for clarification. Profile from FES 1.1 to STM2.1.1 was updated.

10. Sheet C403
    a. REPLACE with attached revised plan sheet. Clouded notes were added for clarification.

11. Sheet C404
    a. REPLACE with attached revised plan sheet. Clouded notes were added for clarification.

12. Sheet C405
    a. REPLACE with attached revised plan sheet. Clouded notes were added for clarification.

13. Sheet C406
    a. REPLACE with attached revised plan sheet. Clouded notes were added for clarification.

14. Sheet C407
    a. REPLACE Detail 1 with attached revised detail to add note for sanitary sewer located under pervious pavement.

15. Sheet C410
    a. ADD Detail 5 for anti-seepage collar. ADD note to indicate where anti-seepage collars are required.

16. Sheet C412
    a. REPLACE Detail 2 with attached revised detail to change outlet orifice to a perforated riser.

17. Sheet C416
    a. REPLACE Detail 2 with attached Detail 1. ADD new attached Detail 2. Outlet orifice was revised to an internally controlled orifice. Internally controlled orifice detail was added (Detail 2/C416). Structure size and underdrain tie-in to STM 2.1 were revised.

18. Sheet C501
    a. ADD the attached Notes.

19. Sheet C502
    a. REVISE sanitary profile in accordance with attachment. Delete reference to MSD MH 10F4-041S.

20. Sheet S301
    a. REPLACE Detail 5 with attached revised detail.

21. Sheet S400
    a. REVISE Detail 5 Top of Vault to 8’-6”.

22. Sheet S800
    a. REPLACE Detail 3 with attached revised detail.

23. Sheet A102C
    a. Toilet 016 Grab bars and fixtures to be provided by General Contractor. Accessories are owner provided for GC to install.

24. Sheet A106B
    a. REVISE vault ceiling to 8'-0" and top of vault to 8'-6".

25. Sheet A602
    a. Sidelight for Frame Type F5 is 24".

26. Sheet P101
    a. Vent piping shown is to connect before and after interceptors and manway risers on the grease interceptor. Piping to be 4" all the way into the building up the vent through roof.

**GENERAL COMMENTS:**

1. The Pre-Bid Meeting was held on June 18, 2024 at 10:00 AM. The Pre-Bid Meeting sign-in sheet is attached.
2. Please contact Paul Girouard, Contract Specialist, at 573-751-4797 or Paul.Girouard@oa.mo.gov for questions about bidding procedures, MBE\WBE\SDVE Goals, and other submittal requirements.
3. The deadline for technical questions is July 2, 2024 at 12:00 PM.
4. Changes to, or clarification of, the bid documents are only made as issued in the addenda.
5. AWI and AISC certifications will not be waived for this project.
6. All correspondence with respect to this project must include the State of Missouri project number as indicated above.
7. Current Plan holders list available online at https://www.oafmdcplanroom.com/jobs/2479/plan-holders/t2150-01-construct-bellefontaine-readiness-center
8. Prospective Bidders contact American Document Solutions, 1400 Forum Blvd Suite 1C, Columbia MO 65201, 573-446-7768 to order official plans and specifications.
9. **All bids shall be submitted on the bid form without additional terms and conditions, modifications, or stipulations. Each space on the bid form shall be properly filled including a bid amount for each alternate. Failure to do so will result in rejection of the bid.**
10. **MBE/WBE/SDVE participation requirements can be found in DIVISION 00. The MBE/WBE/SDVE participation goals are 15%/15%/5%, respectively. Only certified firms as of the bid opening date can be used to satisfy the MBE/WBE/SDVE participation goals for this project. If a bidder is unable to meet a participation goal, a Good Faith Effort Determination Form must be completed. Failure to complete this process will result in rejection of the bid.**

**ATTACHMENTS:**

1. Pre-Bid Meeting Sign-In Sheet
2. Section 004113 - Bid Form
3. Section 230700 - Mechanical Insulation
4. Section 233113 - Metal Ducts
5. Section 237223.29 - Packaged, Outdoor, Fixed Plate Energy Recovery Units
6. Section 333000 - Sanitary Utility Drainage Piping
7. Appendix B – New Readiness Center Geotechnical Exploration
8. Sheet C102 Notes

9. Sheet C204 Detail 3
10. Sheet C309
11. Sheet C310
12. Sheet C310.1
13. Sheet C310.2
14. Sheet C401
15. Sheet C402
16. Sheet C403
17. Sheet C404
18. Sheet C405
19. Sheet C406
20. Sheet C407 Detail 1
21. Sheet C410 Detail 5
22. Sheet C412 Detail 2
23. Sheet C416 Details 1 and 2
24. Sheet C501 Notes
25. Sheet C502 Profile
26. Sheet S301 Detail 5
27. Sheet S800 Detail 3

**July 2, 2024**

**END OF ADDENDUM NO. 1**

**Construct Bellefontaine Readiness Center**
**Bellefontaine Neighbors, MO**

**Project No. T2150-01**
**June 18, 2024**

| Name & Title | Company Name | Phone | E-Mail Address |
|---|---|---|---|
| Eric Hibdon | OA FMDC | 573-522-0322 | Eric.Hibdon@oa.mo.gov |
| Gary Rice | MOANG | 6366864292 | gary.d.rice18.nfg@army.mil |
| Alan Berendzen | MOARNG | 573-638-9675 | alan.s.berendzen.nfg@army.mil |
| Craig Szczuka | Boelter | 314-704-2271 | CSzczuka@Boelter.com |
| Dennis Dyes | KAS Associates | 314 647 3535 | estimating@KSgcstl.com |
| John Hill | GS&S | 314 91[illegible] 3458 | Jhill@gssconstruction.com |
| Joe Escoffier | A.R.E. Masonry | 314-814-1741 | a.r.e.masonry@gmail.com |
| Jack Mullen | Kadean Construction | 314 287 0589 | Jmullen@kadean.com |
| DILLON COVER | KADEAN | 314 722 9067 | DCOVER@KADEAN.com |
| Robert Schubert | Poettker | 618 526 3358 | rschubert@Poettkerconstruction.com |
| Peyton Lovel / Daryll Smith | Budrovich | 618-521-7450 | plovel@budrovich.com |
| Anthony Petty | SIS | 314-249-2623 | apetty@suppliedindustrial.com |
| Danny Lamb | LCS | 314-920-3325 | Bids@LCSconstruct.com |
| Nick Boggs | Bell Electrical | | nicholas.boggs@bellelectrical.com |
| Alex Tillotson | Wright Construction | 636-220-6850 | bids@wrightconstruct.com |
| TONY MARLO | ICS | 314-534-6664 | BIDS@ICS-STL.com |

**Construct Bellefontaine Readiness Center**
**Bellefontaine Neighbors, MO**

**Project No. T2150-01**
**June 18, 2024**

| Name & Title | Company Name | Phone | E-Mail Address |
|---|---|---|---|
| MIKE RIENL ESTIMATOR | RAINERI CONS | 314-667-5913 | mriehl e rainericonstruction.com |
| Jackie Inve | Russell Co. | 314-874-6081 | jtave@russellco.com |
| SCOTT SNYDERS | TARLTON CORP. | 314-633-3358 | SWS @ TARLTONCORP. COM |
| Greg Sweeso | Tarlton Corp | 314-337-3466 | gjsweeso @ Tarltoncorp-com |
| Will Spencer | Supplied Industrial Solutions | 707 631-7782 | wspencer@suppliedindustrial.com |
| Leon Arties | J West Electric | 314 568-9512 | Leon @ Jwest electric.ca |
| Robert Belleville | ~~robert~~ Utilitra | 618-616-8761 | robert belleville@utilitra.com |
| John Bertolino | Jem Mech | 418-779 1693 | brad@jemmechanical.com |
| LTC Jeremy Berendzen | MO ARNG | 573-638-9750 | jeremy.d.berendzen.civ@army.mil |
| Korry Lincoln /owner | Olson Roofing Systems | (314)780-7731 | Korry @ Olson roofing.net |
| Haley Coons | OATES ASSOC. | (314) 677-5829 | haley.coons@oatesassociates.com |
| Michelle Spillers | Oates | 618 345 2200 | michelle.spillers@oatesassociates.com |
| Peter Masnica | Oates | 314-354-9859 | Peter. Masnica@oatesassociates.com |
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**Construct Bellefontaine Readiness Center**
**Bellefontaine Neighbors, MO**

**Project No. T2150-01**
**June 18, 2024**

| Name & Title | Company Name | Phone | E-Mail Address |
|---|---|---|---|
| Alex Orban Estimator | Integrate Construction Partners | 815-822-6740 | aorban@integrateCP.com |
| Paul Kolnery President | Kay Bee Electric | 314-837-3308 | pjk@kaybeeelectric.com |
| Joe Gatermann | Synthesis | 314-575-3664 | |
| Jeremy Kixmiller | MONG | 816-633-2339 | Jeremy.C.Kixmiller.NFG@Army.mil |
| Rob Forney | Oculus Inc | 314-367-6100 | robf@oculusinc.com |
| Josh West | Oculus Inc | 314-367-6100 | joshwaw@oculusinc.com |
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# STATE OF MISSOURI

Bid Time: 1:30 PM

Bid Date: _____

## SECTION 004113 - BID FORM

Revised Per Addendum #1

**1.0 BID**

A. From: _____
(Bidder's Name)

herein after called the "**Bidder".**

B. To: Director, Division of Facilities Management, Design and Construction
Room 730, Harry S Truman State Office Building
301 West High Street
Jefferson City, Missouri 65101

herein after called the **"Owner."**

C. For: Construct Bellefontaine Readiness Center
Bellefontaine Neighbors, Missouri

D. Project Number: T2150-01

hereinafter called the **"Work."**

E. Documents: The undersigned, having examined and being familiar with the local conditions affecting the work and with the complete set of contract documents, including the Drawings, the Invitation For Bid, Instructions To Bidders, Statement of Bidders Qualifications, General Conditions, Supplement to General Conditions, and the technical specifications, including: addenda number _____ through _____ hereby proposes to perform the Work for the following:

F. Bid Amount: _____

_____ Dollars ($_____)

G. Allowances: See Section 012100 for details. (15 Bad Weather Days).

H. Alternates: Alternate No. 1: Unsuitable soils, soil stabilization, site access road, and a portion of the conduit for Fiber Optic Conduit.

_____

_____ Dollars ($_____)

Alternate No. 2: Addition of second RTU to the roof for zoning and increase in HVAC performance.

_____

_____ Dollars ($_____)

Alternate No. 3: Addition of concrete base at the perimeter fence of the building on the south and east side of the property.

_____

_____ Dollars ($_____)

## 2.0 MBE/WBE/SDVE PERCENTAGE OF PARTICIPATION PROJECT GOALS

A. This project's specific goals are: **MBE 15%**, **WBE 15%**, and **SDVE 5%**. NOTE: Only MBE/WBE firms certified by the State of Missouri Office of Equal Opportunity, and SDVE(s) meeting the requirements of Section 34.074, RSMo, and 1 CSR 30-5.010, as of the date of bid opening can be used to satisfy the MBE/WBE/SDVE participation goals for this project.

## 3.0 BID BOND

A. Accompanying the bid is: ___ 5% Bid Bond or ___ Cashier's Check/Bank Draft for 5% of base bid that is payable without condition to the Division of Facilities Management, Design and Construction, State of Missouri, as per Article 5 of "Instructions To Bidders".

## 4.0 CONTRACT COMPLETION TIME AND LIQUIDATED DAMAGES

A. The Bidder agrees to complete the work within **480 working days** from the date the Notice of Intent to Award is issued as modified by additional days added by the Owner's acceptance of alternates, if applicable. This includes ten (10) working days for document mailing and processing. The Bidder further agrees to pay to, or allow the State as liquidated damages the sum of **$3,500** for each working day thereafter that the entire work is not substantially complete.

## 5.0 ATTACHMENTS TO BID

| | | |
|---|---|---|
| A. | 004336 | Proposed Subcontractors |
| | 004337 | MBE/WBE/SDVE Compliance Form |
| | 004338 | MBE/WBE/SDVE Joint Venture Form |
| | 004339 | MBE/WBE/SDVE Waiver Form |
| | 004340 | SDVE Business Form |
| | 004541 | Affidavit of Work Authorization |
| | 004545 | Anti-Discrimination Against Israel Act Certification Form |

## 6.0 BIDDER'S CERTIFICATIONS

By signing and submitting this bid form, the Bidder certifies as follows:

A. **No Undisclosed Interests or Associations, Collusion, or Solicitation of Other Bidders**

1. This bid is genuine and is not made in the interest of or on behalf of any undisclosed person, firm, or corporation, and is not submitted in conformity with any agreement or rules of any group, association or corporation.

2. The Bidder has not directly or indirectly induced or solicited any other bidder to put in a false or sham proposal.

3. The Bidder has not solicited or induced any person, firm or corporation to refrain from submitting a bid.

4. The Bidder has not sought by collusion or otherwise to obtain any advantage over any other bidder or over the Owner.

B. **Accuracy of Contract Documents**

The Bidder has based this bid upon an official/complete set of contract documents, either obtained from the Owner or from a secondary source known to the Bidder to have provided a complete and accurate set of contract documents. If the Bidder received the contract documents from such a secondary source, any errors or omissions in the contract documents shall be interpreted and construed in favor of the Owner and against the Bidder. This bid is based upon the conditions within Article 1.2 of the General Conditions.

C. **Non-Discrimination**

The Bidder will not discriminate against any employee or applicant for employment because of race, creed, color or national origin in the performance of the Work.

D. **Prevailing Wage**

**MISSOURI PREVAILING WAGE LAW (Sections 290.210 to 290.340, RSMo)**: The Contractor shall pay not less than the specified hourly rate of wages, as set out in the wage order attached to and made part of the specifications for work under this contract, to all workers performing work under the contract, in accordance with sections 290.210 to 290.340, RSMo. The Contractor shall forfeit a penalty to the Owner of one hundred dollars per day (or portion of a day) for each worker that is paid less than the specified rates for any work done under the contract by the Contractor or by any subcontractor, in accordance with section 290.250, RSMo.

E. **Transient Employers**

The Bidder will comply with the provisions of Sections 285.230-234, RSMo, regarding transient employers.

F. **Federal Work Authorization Program**

The Bidder has enrolled and is participating in, and will continue to participate in, a federal work authorization program in accordance with Sections 285.525 and 285.530, RSMo for the duration of any contract awarded because of this bid.

G. **Illegal Immigration Reform and Immigrant Responsibility Act (IIRIRA)**

1. If awarded contract for this project, the Bidder/Contractor shall only utilize personnel authorized to work in the United States in accordance with applicable federal, state and local laws. This includes, but is not limited to, the Illegal Immigration Reform and Immigrant Responsibility Act (IIRIRA) and INA Section 274A.

2. If found to be in violation of this requirement or any applicable laws, and if the State of Missouri has reasonable cause to believe that the Contractor has knowingly employed individuals who are not eligible to work in the United States, the state shall have the right to cancel the contract immediately without penalty or recourse and suspend or debar the contractor from doing business with the state.

3. The Contractor agrees to cooperate fully with any audit or investigation from federal, state or local law enforcement agencies.

H. **Anti-Discrimination Against Israel Act**

1. If the awarded Contractor meets the definition of a company as defined in section 34.600, RSMo, and has ten or more employees, the Contractor shall not engage in a boycott of goods or services from the State of Israel; from companies doing business in or with Israel or authorized by, licensed by, or organized under the laws of the State of Israel; or from persons or entities doing business in the State of Israel as defined in section 34.600, RSMo.

2. If, at any time during the life of the contract, Contractor meets the definition of a company as defined in section 34.600, RSMo, and the company's employees increases to ten or more OR the contractor's business status changes to become a company as defined in section 34.600, RSMo, and the company has ten or more employees, then the Contractor shall submit to the Division of Facilities Management, Design and Construction a completed Box C of the exhibit titled "Anti-Discrimination Against Israel Act Certification, and shall comply with the requirements of Box C.

**7.0 CONTACT INFORMATION (mandatory for all bidders)**

☐ Sole Proprietorship/General Partnership ☐ LLC ☐ Limited Partnership ☐ Corporation ☐ Joint Venture

Business Name: _____

Address: _____

_____

Telephone: _____ Fax Number: _____

Federal ID Number: _____ or Social Security Number: _____

Missouri Business Charter Number:_____ (or provide the proper certificate from the Secretary of State)

Contact Name: _____Contact email: _____

## 8.0 SIGNATURES

**FOR SOLE PROPRIETORSHIPS/GENERAL PARTNERSHIPS ONLY**

_____ Name each general partner: _____
Sole Proprietor's Name (printed)

_____

_____

Today's Date: _____

_____

I, _____, being the sole proprietor/general partner of (name of business) _____ (*and if the name of said business is other than my legal name, having filed a Registration of Fictitious Name with the Missouri Secretary of State in order to allow me to use such name in connection with my business, as provided by Section 417.200, RSMo, et seq.*), do hereby submit this bid and agree to be bound unto the State of Missouri as herein provided (if a general partnership, all partners must sign below).

Signature: _____ Signature: _____

Signature: _____ Signature: _____

**FOR LIMITED LIABILITY COMPANIES ONLY**

_____ today's date _____State(s) of organization: _____
Manager's (or Managing Member's) Name (printed)

I, _____, being the Manager (or Managing Member) of (full legal name of limited liability company from Articles of Organization) _____, and being duly authorized to act as herein provided on behalf of said limited liability company, do hereby submit this bid on behalf of said limited liability company and agree that said limited liability company shall be bound unto the State of Missouri as herein provided.

Signature: _____

**FOR LIMITED PARTNERSHIPS/LIMITED LIABILITY PARTNERSHIPS/LIMITED LIABILITY LIMITED PARTNERSHIPS ONLY**

_____ today's date: _____State(s) of organization:_____
General/Managing Partner's Name (printed)

I, _____, being the General Partner/Managing Partner of (full legal name of limited partnership/limited liability partnership/limited liability limited partnership from partnership agreement or Certificate of Limited Partnership) _____, and being duly authorized to act as herein provided on behalf of said limited partnership/limited liability partnership/limited liability limited partnership, do hereby submit this bid on behalf of said limited partnership/limited liability partnership/limited liability limited partnership and agree that said limited partnership/limited liability partnership/limited liability limited partnership shall be bound unto the State of Missouri as herein provided.

Signature:_____

**FOR CORPORATIONS ONLY**

| _____ | _____ | _____ |
|---|---|---|
| President's Name (printed) | Secretary's Name (printed) | Today's date |

State(s) of incorporation: _____

I, _____, being the (officer or title) _____ of (full legal name of corporation, from Articles of Incorporation) _____, and being duly authorized by the Board of Directors of said corporation to act as herein provided on behalf of said corporation, do hereby submit this bid on behalf of said corporation and agree that said corporation shall be bound unto the State of Missouri as herein provided.

Signature: _____ Attested by:_____

President Corporate Secretary

The President should sign as the bidder. If the signator is other than the corporate president, the bidder must provide satisfactory evidence that the signator has the legal authority to bind the corporation.

**FOR ASSOCIATIONS/JOINT VENTURES**

If multiple business entities/individuals are bidding collectively as an association or joint venture, each business entity/individual bidding as part of the association or joint venture shall sign this bid in the above sections relevant to the form that such business entity or individual does business, and the bidder shall duplicate the necessary number of signature pages so that all members of the association or joint venture shall sign this bid. If a name is adopted for use by the association or joint venture, the association or joint venture shall file a Registration of Fictitious Name with the Missouri Secretary of State in order to use such name in connection with the association or joint venture, as provided by Section 417.200, RSMo, *et seq*.

# SECTION 23 07 00
# MECHANICAL INSULATION

## PART 1 - GENERAL

### 1.01 SUMMARY

A. This Section includes mechanical insulation for ductwork and piping and other installations, including the following:
   1. Insulation Materials: Flexible elastomeric and mineral fiber.
   2. Insulating cements, adhesives, mastics, and sealants.
   3. Factory-applied jackets.
   4. Field-applied fabric-reinforcing mesh.
   5. Field-applied jackets.
   6. Tapes and securements.

### 1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 23 Section “Metal Ducts” for pre-insulated ductwork to be used for all outdoor ductwork.

### 1.03 DEFINITIONS

A. ASJ: All-service jacket.

B. FSK: Foil, scrim, kraft paper.

C. SSL: Self-sealing lap.

D. Thermal Resistivity: “R-values” represent the reciprocal of thermal conductivity (k-value). Thermal conductivity is the rate of heat flow through a homogenous material exactly 1-inch thick. Thermal resistivities are expressed by the temperature difference in degrees F between two exposed faces required to cause one BTU to flow through one square foot of material, in one hour, at a given mean temperature.

E. VOC: Volatile Organic Compound as defined by LEED v4 Credit EQc2.

F. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, and spaces above ceilings.

G. Exposed Installations: Exposed to view. Examples include finished occupied spaces without ceilings, mechanical equipment rooms, courtyards and rooftop locations.

H. Concealed Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings or within duct shafts.

I. Conditioned Space: Spaces that are served by both a mechanical heating and mechanical cooling system are conditioned spaces. Heating-only spaces are not conditioned spaces. The space above a ceiling is considered conditioned space if the space directly below that ceiling is conditioned space. A vertical shaft is considered conditioned space if the spaces on all sides surrounding the shaft are conditioned spaces.

### 1.04 SUBMITTALS

A. Product Data: For each type of product indicated, identify thermal conductivity, thickness, and jackets (both factory and field applied, if any).

B. MSDS (Material Safety Data Sheet) for each adhesive, mastic, sealant, and cement furnished.

C. LEED Submittals: Submit product data for LEED v4 Credit EQc2 for each adhesive, mastic, sealant, and cement, including printed statement of VOC content.

D. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section “Basic Mechanical Requirements.”

**1.05 QUALITY ASSURANCE**

A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.

B. Fire-Test-Response Characteristics: Insulation and related materials shall have flame-spread index of 25 or less, and smoke-developed index of 50 or less, as determined by testing identical products per ASTM E84, by a testing and inspecting agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, and cement material containers, with appropriate markings of applicable testing and inspecting agency.

1. Exception: Flame-spread index of 25 or less, and smoke-developed index of 150 or less; is acceptable for insulation not installed in an air-handling duct, plenum, space above ceilings if used as a return air plenum, or air-handling equipment rooms if used as a return/exhaust/relief air plenum, or any other air-handling situation.

**1.06 DELIVERY, STORAGE, AND HANDLING**

A. Packaging: Insulation material containers shall be marked by manufacturer with appropriate ASTM standard designation, type and grade, and maximum use temperature.

**1.07 COORDINATION**

A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section “Hangers and Supports.”

B. Coordinate clearance requirements with piping Installer for piping insulation application and duct Installer for duct insulation application. Establish and maintain clearance requirements for installation of insulation and finishes and for space required for maintenance.

**1.08 SCHEDULING**

A. Schedule insulation application after pressure testing systems. Insulation application may begin on segments that have satisfactory test results.

B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

**PART 2 - PRODUCTS**

**2.01 MANUFACTURERS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following manufacturers:

1. Flexible Elastomeric Insulation:
    1. Aeroflex USA Inc.; Aerocel.
    2. Armacell LLC; AP/Armaflex.
    3. K-Flex USA; Insul-Lock® Seam-Seal.
    4. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.
2. Mineral Fiber Insulation:
    1. CertainTeed Corp.
    2. Johns Manville.
    3. Knauf Insulation.

4. Manson Insulation Inc.
5. Owens Corning.

3. Insulating Cements: Same as insulation manufacturer, or
   1. Insulco, Division of MFS, Inc.
   2. P. K. Insulation Mfg. Co., Inc.
   3. Rock Wool Manufacturing Company.
4. Sealants, Adhesives and Mastics: Same as insulation manufacturer, or
   1. H.B. Fuller Construction Products Inc. (Childers and/or Foster brands)
   2. ITW TACC, Division of Illinois Tool Works.
   3. Marathon Industries, Inc.
   4. Mon-Eco Industries, Inc.
   5. Vimasco Corporation.
5. Field-Applied Jackets: Same as insulation manufacturer, or
   1. P.I.C. Plastics, Inc.
   2. PABCO Metals Corporation.
   3. Pittsburgh Corning Corporation.
   4. Polyguard Products, Inc.
   5. Proto PVC Corporation.
   6. RPR Products, Inc.
   7. Speedline Corporation.
6. Tapes: Same as insulation manufacturer, or
   1. Avery Dennison Corporation, Specialty Tapes Division.
   2. Compac Corp.
   3. Ideal Tape Co., Inc., an American Biltrite Company.
   4. Polyguard Products, Inc.
   5. Venture Tape.
7. Bands and Wire: Same as insulation manufacturer, or
   1. ACS Industries, Inc.
   2. C & F Wire.
   3. Childers Products.
   4. PABCO Metals Corporation.
   5. RPR Products, Inc.
8. Insulation Pins and Hangers: Same as insulation manufacturer, or
   1. AGM Industries, Inc.
   2. GEMCO.
   3. Midwest Fasteners, Inc.
   4. Nelson Stud Welding.

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

**2.02 INSULATION MATERIALS**

A. Refer to Schedule in Part 4 for requirements about where insulating materials shall be applied.

B. Restrictions: Products shall not contain asbestos, lead, mercury, or mercury compounds. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.

C. Adhesives shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.

D. Product manufacturers and/or their product numbers notwithstanding, each adhesive, mastic, sealant, and cement shall have a VOC content not greater than the maximum allowable under LEED v4 Credit EQc2 regardless of whether or not this project is seeking LEED certification.

E. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C534, Type I for tubular materials and Type II for sheet materials.
   1. Thermal Conductivity: 0.28 average maximum at 75ºF mean temperature using test method ASTM C177 or C518.
   2. Water Vapor Permeability: Maximum 0.1 perm-inch using test method ASTM E96 Procedure A.
   3. Water Absorption: Maximum 0.2% by volume using test method ASTM C209.
   4. Product shall pass mold growth, fungi resistance, and bacterial resistance tests per UL 181, ASTM G21, G22, and C1338.
   5. Adhesive: Comply with MIL-A-24179A, Type II, Class I; VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

F. Mineral-Fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C553, Type II and ASTM C1290, Type III with factory-applied jacket.
   1. Thermal Conductivity: 0.26 average maximum at 75°F mean temperature.
   2. Density: 1.5 lb/cf (24-kg/cu. m) minimum.
   3. Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

G. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type IA or Type IB.
   1. Thermal Conductivity: 0.26 average maximum at 75°F mean temperature.
   2. Density: 2.0 lb/cf (32-kg/cu. m) minimum.
   3. Jacket (Ducts): Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C1136, Type II.

**2.03 CEMENTS AND MASTICS**

A. Materials shall be compatible with insulation materials, jackets, and substrates. Comply with ASTM C755-19 *Standard Practice for Selection of Water Vapor Retarders for Thermal Insulation* Table 2, for the selection of vapor retarder systems.

B. Insulating Cements: Select one or more of the following at contractor's option.
   1. Mineral-Fiber Insulating Cement: Comply with ASTM C195.
   2. Expanded or Exfoliated Vermiculite Insulating Cement: Comply with ASTM C196.
   3. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C449.

C. Vapor-Barrier Mastic: Water based; suitable for indoor and outdoor use on below-ambient services, for applications on seams, punctures, penetrations, and terminations of vapor retarder membranes. Equal to Foster 30-80 or Childers CP-35 or Vimasco 749.
   1. Service Temperature Range: -20 to +180ºF (-29 to +82ºC).
   2. Solids Content: ASTM D1644, 59 percent by volume and 71 percent by weight.
   3. Color: White.

D. Breather Mastic: Water based; suitable for indoor and outdoor use on above-ambient services. Equal to Foster 46-50 or Childers CP-10/11 or Vimasco WC-5.
   1. Water-Vapor Permeance: ASTM F1249, 3 perms (2 metric perms) at 0.0625-inch (1.6-mm) dry film thickness.
   2. Service Temperature Range: -20 to +200ºF (-29 to +93ºC).
   3. Solids Content: 63 percent by volume and 73 percent by weight.
   4. Color: White.

## 2.04 SEALANTS

A. Joint Sealants: Permanently flexible, elastomeric sealant. Materials shall be compatible with insulation materials, jackets, and substrates.
   1. Service Temperature Range: -100 to +200ºF (-73 to +94ºC).
   2. Color: White, tan, or gray.
   3. VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

B. FSK and Metal Jacket Flashing Sealants: Fire- and water-resistant, flexible, elastomeric sealant. Materials shall be compatible with insulation materials, jackets, and substrates.
   1. Service Temperature Range: -40 to +250ºF (-40 to +121°C).
   2. Color: Aluminum.
   3. VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

C. ASJ Flashing Sealants, and Vinyl and PVC Jacket Flashing Sealants: Fire- and water-resistant, flexible, elastomeric sealant. Materials shall be compatible with insulation materials, jackets, and substrates.
   1. Service Temperature Range: -40 to +250ºF (-40 to +121°C).
   2. Color: White.
   3. VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

## 2.05 FIELD-APPLIED CLOTHS AND FABRIC-REINFORCING MESH

A. Woven Glass-Fiber Fabric for Duct Insulation: Approximately 4 oz./sq. yd. (135 g/sq. m) with a thread count of 5 strands by 5 strands/sq.-inch (2 strands by 2 strands/sq. mm); equal to Childers Chil Glas #5.

B. Woven Polyester Fabric: Approximately 1 oz./sq. yd. (34 g/sq. m) with a thread count of 10 strands by 10 strands/sq.-inch (4 strands by 4 strands/sq. mm), in a Leno weave for duct equal to Foster Mast-a-Fab.

## 2.06 FIELD-APPLIED JACKETS

A. Field-applied jackets shall comply with ASTM C921, Type I, unless otherwise indicated.

B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D1784, Class 16354-C; thickness 30 mils (0.8 mm); roll stock ready for shop or field cutting and forming.
   1. Adhesive: Compatible with PVC, as recommended by jacket material manufacturer.
   2. Color: White.
   3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
   4. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
   5. Factory-fabricated tank heads and tank side panels

C. Metal Jackets: Sheet and roll stock ready for shop or field sizing. Factory pre-cut and rolled to size is also acceptable.
   1. Aluminum Jacket: Comply with ASTM B209, Alloy 3003, 3005, 3105 or 5005, Temper H-14. Finishes and thickness as follows:

   2. Indoor Ducts and Plenums: Smooth, 0.016-inch (0.41 mm) thick.
   3. Indoor Equipment: Stucco Embossed, 0.016-inch (0.41 mm) thick.
   4. Outdoor Ducts, Equipment, and Piping: Stucco embossed, with Z-shaped locking seam, 0.024-inch (0.61 mm) thick.

D. Stainless-Steel Jacket: ASTM A167 or ASTM A240; Type 304 stucco embossed, with Z-shaped locking seam; 0.016-inch (0.41 mm) thick.

E. Moisture Barrier for Indoor Applications: 1-mil- (0.025-mm-) thick, heat-bonded polyethylene and kraft paper.
F. Moisture Barrier for Outdoor Applications: 3-mil- (0.075-mm-) thick, heat-bonded polyethylene and kraft paper.
G. Factory-Fabricated Fitting Covers: Same material, finish, and thickness as jacket; provide as required for preformed 2-piece or gore, 45- and 90-degree, short- and long-radius elbows, tee covers, flange and union covers, end caps, beveled collars, and valve covers.
H. Field-fabricate fitting covers only if factory-fabricated fitting covers are not available

**2.07 TAPES**

A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C1136 and UL listed.
   1. Width: 3-inches (75 mm).
   2. Thickness: 11.5 mils (0.29 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.

B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C1136 and UL listed.
   1. Width: 3-inches (75 mm).
   2. Thickness: 6.5 mils (0.16 mm).
   3. Adhesion: 90 ounces force/inch (1.0 N/mm) in width.
   4. Elongation: 2 percent.
   5. Tensile Strength: 40 lbf/inch (7.2 N/mm) in width.
   6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.

C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
   1. Width: 2-inches (50 mm).
   2. Thickness: 6 mils (0.15 mm).
   3. Adhesion: 64 ounces force/inch (0.7 N/mm) in width.
   4. Elongation: 500 percent.
   5. Tensile Strength: 18 lbf/inch (3.3 N/mm) in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive and UL listed.
   1. Width: 2-inches (50 mm).
   2. Thickness: 3.7 mils (0.093 mm).
   3. Adhesion: 100 ounces force/inch (1.1 N/mm) in width.
   4. Elongation: 5 percent.
   5. Tensile Strength: 34 lbf/inch (6.2 N/mm) in width.

**2.08 SECUREMENTS**

A. Bands:
   1. Stainless Steel: ASTM A167 or ASTM A240, Type 304; 0.015-inch (0.38 mm) thick, ½-inch (13 mm) wide with wing or closed seal.
   2. Aluminum: ASTM B209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020-inch (0.51 mm) thick, ½-inch (13 mm) wide with wing or closed seal.
   3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.

B. Insulation Pins and Hangers:
   1. Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated.
   2. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch- (2.6-mm-) diameter shank, length to suit depth of insulation indicated with integral 1½-inch (38-mm) galvanized carbon-steel washer.
   3. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch (0.41-mm) thick, aluminum or stainless-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1½-inches (38 mm) in diameter. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

C. Staples: Outward-clinching insulation staples, nominal ¾-inch- (19-mm-) wide, stainless steel or Monel.

D. Wire: 0.062-inch (1.6-mm) soft-annealed, stainless steel.

## PART 3 - EXECUTION

### 3.01 EXAMINATION

A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application. Verify that systems to be insulated have been tested and are free of defects. Verify that surfaces to be insulated are clean and dry. Proceed with installation only after unsatisfactory conditions have been corrected.

### 3.02 PREPARATION

A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.

B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

### 3.03 COMMON INSTALLATION REQUIREMENTS

A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings, and piping including fittings, valves, and specialties.

B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each duct system and pipe system as specified in insulation system schedules.

C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.

D. Install insulation with longitudinal seams at top and bottom of horizontal runs. Install multiple layers of insulation with longitudinal and end seams staggered.

E. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.

F. Keep insulation materials dry during application and finishing.

G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer. Install insulation with least number of joints practical.

H. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
   1. Install insulation continuously through hangers and around anchor attachments.

2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.

I. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

J. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

K. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.

L. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4-inches (100 mm) beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

M. At the following locations, omit jacket and provide a separate cutaway removable segment of insulation clearly labeled “Access.” For below-ambient services, provide a design that allows access but maintains vapor barrier.
1. Vibration-control devices.
2. Testing agency labels and stamps.
3. Nameplates and data plates.
4. Manholes.
5. Handholes.
6. Cleanouts.

**3.04 PENETRATIONS**

A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
1. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.

B. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Seal jacket to wall flashing with flashing sealant.

C. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

D. Insulation Installation at Fire-Rated Wall and Partition Penetrations:
1. Install pipe insulation continuously through pipe penetrations of fire-rated walls and partitions.
2. Install duct insulation continuously through duct penetrations of fire-rated walls and partitions, for cases where no fire damper is required.
3. Terminate duct insulation at fire damper sleeves for cases where fire dampers are used but overlap duct insulation at least 2-inches (50 mm) onto sleeve.

4. Firestopping and fire-resistive joint sealers are specified in Division 07 Section “Penetration Firestopping.”

E. Insulation Installation at Floor Penetrations:
1. Duct: Install insulation continuously through floor penetrations that are not fire rated. For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2-inches (50 mm).
2. Pipe: For below-ambient piping services, install insulation continuously through floor penetrations. For above-ambient piping services, either do the same as for below-ambient piping, or it is acceptable to install uninsulated piping through the slab and butt the pipe insulation tight to the slab on both the top side and the underneath side.
3. Seal penetrations through fire-rated assemblies according to Division 07 Section “Penetration Firestopping.”

**3.05 DUCT INSULATION INSTALLATION**

A. See Part 4 Insulation Schedules for specific requirements.

B. The following ductwork items need not be insulated, unless noted otherwise:
1. Pre-insulated duct systems.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums, casings, fan housings, and air terminal units.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

C. Secure all insulation on ducts with insulation pins. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
1. On duct sides with dimensions 18-inches (450 mm) and smaller, pins may be omitted.
2. On duct sides with dimensions 18-inches (450 mm) and larger, place pins along longitudinal centerline of duct. Space 3-inches (75 mm) maximum from insulation end joints, and 16-inches (400 mm) o.c.
3. On duct sides with dimensions larger than 36-inches (900 mm), place pins 16-inches (400 mm) o.c. each way, and 3-inches (75 mm) maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
4. Pins may be omitted from top surface of horizontal, rectangular ducts.
5. Do not over-compress insulation during installation.
6. If using blanket insulation, impale insulation over pins and attach speed washers.
7. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

D. For ducts with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2-inches (50 mm) from 1 edge and 1 end of insulation segment. Secure laps to adjacent insulation section with ½-inch (13-mm) outward-clinching staples, 1-inch (25 mm) o.c. Complete the vapor barrier by applying FSK tape specified in Part 2, or vapor-barrier mastic and sealant, at all joints, seams, and protrusions.
1. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

E. If using blanket insulation, overlap unfaced blankets a minimum of 2-inches (50 mm) on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18-inches (450 mm) o.c.

F. Unless factory-insulated, install duct insulation continuously and unbroken over duct-mounted accessories such as fans, coils, terminal units, damper housings, airflow measuring station housings, etc.

G. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. If using board insulation, groove and score insulation to fit as closely as possible to outside and inside radius of elbows.

H. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

I. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-(150-mm-) wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6-inches (150 mm) o.c.

**3.06 PIPE INSULATION INSTALLATION**

A. See Part 4 Insulation Schedules for specific requirements.

B. Requirements in this Article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.

C. Flexible Elastomeric Insulation Installation: Seal all transverse seams, longitudinal seams, end joints, and section joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.

**3.07 FIELD-APPLIED JACKET INSTALLATION**

A. See Part 4 Insulation Schedules for specific requirements.

B. Where PVC jackets are indicated, install with 1-inch (25-mm) overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

C. Where metal jackets are indicated, install with 2-inch (50-mm) overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12-inches (300 mm) o.c. and at end joints

**3.08 FINISHES**

A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

**PART 4 - SCHEDULES**

**4.01 INSULATION SCHEDULES**

A. Furnish and install duct and piping insulation as specified above and in accordance with the schedules below. All insulation thicknesses and pipe sizes in the following tables are given in nominal inches. Where more than one type of allowable material or more than one type of field jacket is listed, the choice is contractor’s option.

B. Cold Surfaces: For piping and ductwork surfaces operating below surrounding ambient temperature (including supply, return, and exhaust air ductwork associated with the rooftop unit(s) routed through areas that are not air-conditioned), all surfaces including but not limited to pipe, duct, flanges, fittings, valves of every kind, dampers, strainers, unions, and other appurtenances shall be insulated and shall include uninterrupted vapor barrier to avoid potential condensation.

| **DUCT INSULATION**<br>Service | Duct<br>Shape | Duct<br>Location | Minimum<br>R-Value | Allowable<br>Materials | Insulation<br>Thickness | Field<br>Jacket | Keyed<br>Notes |
|---|---|---|---|---|---|---|---|
| Supply Air Service | Round, Oval | ICC,ICN | R-3.5 | FGBK | 1.50 | --- | (4) |
| | | IEC,IEN | R-3.5 | FGBK | 1.50 | AL | (3) (4) |
| | Rectangular | ICC,ICN | R-3.5 | FGBK | 1.50 | --- | (4) |
| | | IEC,IEN | R-3.5 | FGBD | 1.50 | --- | (4) |
| Return Air Service | Round, Oval | ICC,IEC | --- | --- | --- | --- | |
| | | ICN | R-3.5 | FGBK | 1.50 | --- | (4) |
| | | IEN | R-3.5 | FGBK | 1.50 | AL | (3) (4) |
| | Rectangular | ICC,IEC | --- | --- | --- | --- | |
| | | ICN | R-3.5 | FGBK | 1.50 | --- | (4) |
| | | IEN | R-3.5 | FGBD | 1.50 | --- | (4) |
| Exhaust Air Service | Round, Oval | ICC, IEC | R-3.5 | FGBK | 1.50 | --- | (2) (4) |
| | | ICN, IEN | R-3.5 | FGBK | 1.50 | --- | (1) (4) |
| | Rectangular | ICC, IEC | R-3.5 | FGBK | 1.50 | --- | (2) (4) |
| | | ICN, IEN | R-3.5 | FGBD | 1.50 | --- | (1) (4) |

**KEYED NOTES:**

(1) *Insulate only if the exhaust is routed to an energy-recovery device.*
(2) *Insulate only between final isolation damper and penetration of building exterior.*
(3) *The specified field jacket is required only if less than 84-inches AFF.*
(4) *Omit insulation if duct is expressly called out to be internally lined.*

**LEGEND:**

| | | | |
|---|---|---|---|
| ICC | Indoor, Concealed, in Conditioned space | AL | Aluminum |
| ICN | Indoor, Concealed, in Non-conditioned space | SS | Stainless Steel |
| IEC | Indoor, Exposed, in Conditioned space | | |
| IEN | Indoor, Exposed, in Non-conditioned space | | |
| FGBK | Fiberglass Insulation, 1.5-lb density, Blanket | | |
| FGBD | Fiberglass Insulation, 1.5-lb density, Board | | |

| **PIPE INSULATION** Services | Temperature Range °F | Size Range | Location | Allowable Materials | Thickness | Field Jacket | Keyed Notes |
|---|---|---|---|---|---|---|---|
| Coil condensate | below 60 | ¾ to 6 | Indoors | FE | 0.50 | --- | |
| Refrigerant suction and hot gas piping | All | All | Indoors | FE | 1.00 | --- | |
| | | | Outdoors | FE | 2.00 | AL,SS | |

**KEYED NOTES:**

**LEGEND:**

| | |
|---|---|
| FE | Flexible Elastomeric |
| MF | Mineral Fiber |
| AL | Aluminum |
| SS | Stainless Steel |

**END OF SECTION**

# SECTION 23 31 13
# METAL DUCTS

## PART 1 - GENERAL

### 1.01 SUMMARY

A. This Section includes metal ducts and plenums for supply, return, outside, and exhaust air-distribution systems in pressure classes from minus 2- to plus 10-inch wg (minus 500 to plus 2500 Pa). Metal ducts include the following:
   1. Single-wall rectangular ducts and fittings.
   2. Single-wall round and flat-oval ducts and fittings.
   3. Sheet metal materials.
   4. Sealants and gaskets.
   5. Hangers and supports.
   6. Seismic-restraint devices.

### 1.02 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. Section 13 05 41 “Seismic Restraints,” Section 23 01 00 “Basic Mechanical Requirements,” and Section 23 05 00 “Basic Mechanical Materials and Methods” all apply to the work of this Section as if fully repeated herein.

C. The following Sections contain requirements that relate to this Section:
   1. Division 07 Sections “Penetration Firestopping” for fire-resistant sealants for use around duct penetrations and fire-damper installations in fire-rated floors, partitions, and walls.
   2. Division 08 Section “Access Doors and Frames” for wall- and ceiling-mounted access doors and for access to concealed ducts.
   3. Division 08 Section “Louvers and Vents” for intake and relief louvers and vents connected to ducts and installed in exterior walls.
   4. Division 23 Section “Mechanical Insulation.”
   5. Division 23 Section “Duct Accessories” for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.
   6. Division 23 Section “Air Terminals” for temperature control terminal units.
   7. Division 23 Section “Diffusers, Registers and Grilles.”
   8. Division 23 Section “HVAC Instrumentation and Controls” for automatic control dampers and actuators.
   9. Division 23 Section “Testing, Adjusting and Balancing” for air balancing and final adjusting of manual volume dampers.

### 1.03 DEFINITIONS

A. Thermal Conductivity and Apparent Thermal Conductivity (k-Value): As defined in ASTM C168.

### 1.04 PERFORMANCE REQUIREMENTS

A. Duct system design, as indicated, has been used to select size and type of air-moving and distribution equipment and other air system components. Changes to layout or configuration of duct system must be specifically approved in writing by the design professional. Accompany requests for layout modifications with calculations showing that proposed layout will provide original design results without increasing system total pressure.

B. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA *HVAC Duct*

*Construction Standards – Metal and Flexible* and performance requirements and design criteria indicated in Part 3 of this Section.

C. Structural Performance: Duct hangers and supports and seismic restraints shall withstand the effects of gravity and seismic loads and stresses within limits and under conditions described in SMACNA *HVAC Duct Construction Standards – Metal and Flexible* and SMACNA's "Seismic Restraint Manual: Guidelines for Mechanical Systems." Seismic force factors are specified in Division 13 Section "Seismic Restraints."

D. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2016.

**1.05 SUBMITTALS**

A. Product Data: For each type of the following products:
   1. Adhesives.
   2. Sealants and gaskets.
   3. Seismic-restraint devices.
   4. Manufactured ductwork and duct fittings (if applicable).
   5. MSDS (Material Safety Data Sheet) for each adhesive and sealant furnished.
   6. Sheet metal thicknesses.
   7. Joint and seam construction and sealing.
   8. Reinforcement details and spacing.
   9. Materials, fabrication, assembly, and spacing of hangers and supports.

B. LEED-NC v4 Submittals:
   1. Product Data for Prerequisite EQp1: Documentation indicating that duct systems comply with ASHRAE 62.1-2010, Section 5 – "Systems and Equipment."
   2. Product Data for Prerequisite EAp2: Documentation indicating that duct systems comply with ASHRAE 90.1-2010, Section 6.4.4 – "HVAC System Construction and Insulation."
   3. Leakage Test Report for Prerequisite EAp2: Documentation of work performed for compliance with ASHRAE 90.1-2010, Section 6.4.4.2.2 – "Duct Leakage Tests."
   4. Duct-Cleaning Test Report for Prerequisite EQp1: Documentation of work performed for compliance with ASHRAE 62.1-2010, Section 7.2.4 – "Ventilation System Start-Up."
   5. Product Data for Credit EQc2: For adhesives and sealants, including printed statement of VOC content.

C. Demonstrate compliance with the Buy American Act (41 USC 10a-10d) by either certifying that the materials and components furnished under this Section meet the required criteria or that a formal waiver has been granted by an authorized agency. Refer to Division 23 Section "Basic Mechanical Requirements."

**1.06 QUALITY ASSURANCE**

1. AWS D1.1/D1.1M, "Structural Welding Code – Steel," for hangers and supports.
2. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. NFPA Compliance: Comply with NFPA 90A-2018 *Standard for the Installation of Air Conditioning and Ventilating Systems*.

C. AMCA Compliance: All spiral ducts shall bear the AMCA Certified Ratings Program seal for Air Leakage.

D. Comply with NFPA 96 *Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations* for range hood ducts, unless otherwise indicated.

E. ASHRAE Compliance: Applicable requirements in ASHRAE Standard 62.1-2016, Section 5 - "Systems and Equipment" and Section 7 – "Construction and System Start-Up."

F. ASHRAE Compliance: Applicable requirements in ASHRAE Standard 90.1-2016, Section 6.4.4 – "HVAC System Construction and Insulation."

**1.07 REFERENCES**

A. ANSI/SMACNA Standard 001-2008 *Seismic Restraint Manual; Guidelines for Mechanical Systems*, as published by the Sheet Metal and Air Conditioning Contractors National Association. 3rd ed. Chantilly, VA: SMACNA, 2008. All references to this document throughout this Section refer to this specific edition.

B. ANSI/SMACNA Standard 006-2006 *HVAC Duct Construction Standards – Metal and Flexible*, as published by the Sheet Metal and Air Conditioning Contractors' National Association. 3rd ed. Chantilly, VA: SMACNA, 2005. All references to this document throughout this Section refer to this specific edition.

C. ANSI/SMACNA Standard 016-2012 *HVAC Air Duct Leakage Test Manual*, as published by the Sheet Metal and Air Conditioning Contractors' National Association. 2nd ed. Chantilly, VA: SMACNA, 2012. All references to this document throughout this Section refer to this specific edition.

D. ACR 2006: National Air Duct Cleaners Association. *Assessment, Cleaning, & Restoration of HVAC Systems.* 4th ed. Washington, DC: NADCA, 2006. All references to this document throughout this Section refer to this specific edition.

**1.08 DELIVERY, STORAGE, AND HANDLING**

A. Deliver sealant and firestopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.

B. Store and handle sealant and firestopping materials according to manufacturer's written recommendations.

C. Deliver and store stainless-steel sheets with mill-applied adhesive protective paper maintained through fabrication and installation.

**PART 2 - PRODUCTS**

**2.01 MANUFACTURERS**

A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
   1. Factory Pre-Insulated Duct Systems:
      a. Kingspan Insulation Ltd. (indoor ducts only)
      b. Thermaduct, LLC (outdoor ducts).
      c. or approved equal.
   2. Field-Applied Duct Sealant Materials:
      a. Ductmate, Inc.
      b. H.B. Fuller Construction Products Inc. (Childers and/or Foster brands)
      c. Hardcast, Inc.
      d. McGill Air Seal Corporation.
   3. Optional Manufactured Duct Slide-on Flange System:
      a. Ductmate, Inc.
      b. Nexus Inc.
      c. Ward Industries, Inc.
   4. Optional Round Duct Coupling System:
      a. Lindab, Inc. "Spirosafe"
      b. Sheet Metal Connectors, Inc.

c. Spiramir Corp.
d. Stamped Fittings Inc. “The Edge”

B. Buy American: Furnish only domestic materials and components in accordance with the Buy American Act (41 USC 10a-10d) or one of its exceptions as further specified in Division 23 Section “Basic Mechanical Requirements.” Comply by either certifying that the materials purchased for the project meet the criteria or apply for a waiver. Document compliance by one of these methods as part of each product’s shop drawing submittal.

**2.02 SHEET METAL MATERIALS**

A. General Material Requirements: Comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.

B. Galvanized Sheet Steel: Comply with ASTM A653 / A653M.
1. Galvanized Coating Designation: G60 (Z180) or G90 (Z275).
2. Finishes for Surfaces Exposed to View: Mill-phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A1008 / A1008M or ASTM A366 / A366M, cold-rolled sheets; commercial quality with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A480 / A480M, Type 304 or 316, as indicated in Part 3 of this Section; cold rolled, annealed, sheet. Surface finish shall be No. 4 where exposed to view and No. 2B where concealed.

E. Aluminum Sheets: Comply with ASTM B209 (ASTM B209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.

F. Reinforcement Shapes and Plates: ASTM A36 / A36M, steel plates, shapes, and bars; black and galvanized. Where black- and galvanized-steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.

G. Tie Rods: Comply with Articles 2.5 through 2.9, including all accompanying Tables and Figures, of the SMANCA HVAC Duct Construction Standards.

**2.03 SEALANT MATERIALS**

A. Two-Part Sealing System: Woven-fiber tape impregnated with gypsum mineral compound and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal; Hardcast® Two-Part Sealing System, Uni-Cast® by McGill AirSeal Corporation, or equal.

B. One-Part Sealing System: Flexible, adhesive sealant, fiber-reinforced, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts. Examples of acceptable products include Uni-Mastic 181 by McGill, Foster 32-19, and Childers CP-146.

C. Water-Based Seam Sealant: Flexible, adhesive sealant, resistant to UV light when cured, UL 723 listed, and complying with NFPA requirements for Class 1 ducts.

D. Formed-on Duct Connectors: Flange shop roll-formed onto edge of ductwork, with corner closures, cleats and gaskets for seal; TDC or TDF constructed per SMACNA T-25a or T-25b.
1. Flanged Joint Mastic: One-part, acid-curing, silicone, elastomeric joint sealant complying with ASTM C920, Type S, Grade NS, Class 25, Use O.
2. Flange Gaskets: Butyl rubber or EPDM polymer with polyisobutylene plasticizer.

3. Contractor's Option: Proprietary manufactured slide-on duct connectors by Ductmate, Ward, or Nexus meeting the above requirements will be accepted wherever formed-on duct connectors are required by these specifications.

**2.04 RECTANGULAR DUCT FABRICATION**

A. General: Fabricate ducts, elbows, transitions, offsets, branch connections, and other construction according to SMACNA *HVAC Duct Construction Standards – Metal and Flexible*. Comply with requirements for metal thickness, reinforcing types and intervals, tie-rod applications, deflection limits, and joint types and intervals, except where more stringent requirements are specified herein.

B. All sheet metal shall be a minimum of 24-gage thickness in any case. Use 24-gage sheet metal where SMACNA allows thinner material.

C. Lengths: Fabricate rectangular ducts in lengths appropriate to reinforcement and rigidity class required for pressure classification.

D. Materials: Free from visual imperfections such as pitting, seam marks, roller marks, stains, and discolorations.

E. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches (480 mm) and larger and 0.0359-inch (0.9 mm) thick or less, with more than 10 sq. ft. (0.93 sq. m) of unbraced panel area, unless ducts are lined.

F. Pressure Classification: See Schedule in Part 3 of this Section.

G. Seal Classification: See Schedule in Part 3 of this Section.

H. Longitudinal Seams: Contractor's choice of Pittsburgh lock (SMACNA Figure 2-2 Type L-1) or Button Punch Snap Lock (SMACNA Figure 2-2 Type L-2) shall be used on all longitudinal seams. See "Seam and Joint Sealing" in Part 3 of this Section for further requirements.

I. Duct sizes shown on plans are free area sizes. Internal duct liners are not acceptable.

J. Contractor is free to alter the indicated sizes of rectangular duct to suit field conditions, provided that revised size is selected for friction loss no greater than that of indicated size. No prior approval by the Engineer is required for equal-friction duct size changes unless proposed size has an aspect ratio greater than 4 to 1.

K. All changes of direction shall be fabricated as elbows in accordance with SMACNA Figure 4-2 except that RE-4, RE-9 and RE-10 are prohibited. RE-6 is limited to a change-of-direction angle of 45 degrees or less.

L. Divided flow branches shall be Type 1 or Type 2 per SMACNA Figure 4-5. Type 3 divided flow branches are permitted only where expressly shown. Seek Engineer's approval of Type 3 where space and/or layout clearances prohibit Type 1 or Type 2.

M. Branch connections shall be per SMACNA Figure 4-6, except that straight taps are not permitted on any ducts 2-inch pressure class or above. Straight-tap "spin-in" fittings are permitted on ½-inch and 1-inch pressure class ductwork only.

N. Offsets and transitions shall be per SMACNA Figure 4-7, except that offset Type 2 (mitered) is limited to an angle of 45° or less.

O. Fittings at obstructions shall be per SMACNA Figure 4-8, except that Figure D is not permitted. Use Figure 4-8.B in lieu of Figure 4-8.D. Seek Engineer's approval of Figure 4-8.D where space and/or layout clearances prohibit use of Figure 4-8.B.

**2.05 ROUND AND FLAT-OVAL DUCT AND FITTING FABRICATION**

A. Diameter as applied to flat-oval ducts in this Section is the diameter of a round duct with a circumference equal to the perimeter of a given size of flat-oval duct.

B. Contractor's Option: The contractor is permitted to furnish spiral lock-seam round or flat-oval ductwork anywhere rectangular duct is indicated, provided the that adequate ceiling clearances and space required by other trades will permit round ductwork. If this option is chosen, round duct sizes shall be selected by the Contractor according to "equal friction" with respect to the rectangular sizes shown.

C. Round, Spiral Lock-Seam Ducts: Fabricate supply ducts of galvanized steel according to SMACNA *HVAC Duct Construction Standards – Metal and Flexible* except that 26-gage is the thinnest material acceptable.

D. Longitudinal-seam round ducts ("stovepipe") of a minimum 24-gage thickness, will be permitted on ½-inch and 1-inch pressure classifications only; and only if the Seal Class specified in Part 3 of this Section can be achieved.

E. Flat-Oval, Spiral Lock-Seam Ducts: Fabricate supply ducts according to SMACNA *HVAC Duct Construction Standards – Metal and Flexible* except that 24-gage is the thinnest material available. With approval of Engineer, contractor may substitute flat oval duct where round duct is indicated, provided that revised size is selected for friction loss no greater than that of indicated size.

F. 90-Degree Tees and Laterals and Conical Tees: Fabricate to comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible*, with metal thicknesses specified for longitudinal-seam straight ducts.

G. Diverging-Flow Fittings: Fabricate with reduced entrance to branch taps and with no excess material projecting from fitting onto branch tap entrance.

H. Fabricate elbows using die-formed, gored, pleated, or mitered construction. Bend radius of die-formed, gored, and pleated elbows shall be 1½ times duct diameter. Adjustable-angle elbow fittings are not permitted. Unless elbow construction type is indicated, fabricate elbows as follows:
   1. Mitered-Elbow Radius and Number of Pieces: Welded construction complying with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* unless otherwise indicated.
   2. Flat-Oval Mitered Elbows: Welded construction with same metal thickness as longitudinal-seam flat-oval duct.
   3. 90-Degree, 2-Piece, Mitered Elbows: Use only if approved by the Engineer where space restrictions do not permit using radius elbows. Fabricate with turning vanes.
   4. Round Elbows 8 Inches (200 mm) and Less in Diameter: Fabricate die-formed elbows for 45- and 90-degree elbows and pleated elbows for 30, 45, 60, and 90 degrees only. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
   5. Round Elbows 9 through 14 Inches (225 through 355 mm) in Diameter: Fabricate gored or pleated elbows for 30, 45, 60, and 90 degrees unless space restrictions require mitered elbows. Fabricate nonstandard bend-angle configurations or nonstandard diameter elbows with gored construction.
   6. Round Elbows Larger Than 14 Inches (355 mm) in Diameter and All Flat-Oval Elbows: Fabricate gored elbows unless space restrictions require mitered elbows.

**2.06 SHOP- AND FIELD-FABRICATED PLENUMS**

A. Description: Provide galvanized steel (unless noted otherwise) air plenums in accordance with Chapter 9 of SMACNA *HVAC Duct Construction Standards – Metal and Flexible*. Air plenums required for this project include:
   1. Outdoor air intake plenums for attachment to exterior outdoor air intake louvers, with connection point(s) for outdoor air duct(s). Construction shall be single wall with exterior

insulation; coordinate size, orientation, and layout with Division 08 Section “Louvers and Vents” and the Drawings.

2. Exhaust air plenums for attachment to exterior exhaust louvers, with connection point(s) for exhaust air duct(s). Construction shall be single wall uninsulated; coordinate size, orientation, and layout with Division 08 Section “Louvers and Vents” and the Drawings.
3. Other HVAC plenums as indicated on Drawings.

B. Shop fabricate plenums to greatest extent possible with a minimum of joints and to minimize field fabrication and assembly.

C. Fabricate plenums with standing seam construction and angle reinforcement. Fabricate close-off sheets from plenum sides, top, and bottom to damper frames. Bolt close-off sheets to frame flanges and housings.

D. Fabricate plenums with sheet metal walls, top, and bottom panels. Do not use building walls, ceilings or floors as a portion of the plenum boundary, except where expressly shown on Drawings.

E. Reinforce plenums with galvanized or painted steel angles.

F. Seal joints as required in Part 3 of this Section.

G. Slope air plenums exterior louvers to fully drain so that any moisture that accumulates inside plenum drain to the outside.

H. Fabricate plenums with reinforced openings for access doors at least 18 inches (450 mm) wide by 24 inches (600 mm) high and located for access to each item of equipment housed. Each plenum shall have at least one access door; more if shown on Drawings. Refer to Division 23 Section “Duct Accessories” for access doors.

I. Mount automatic control dampers in air mixing plenums where applicable. Control dampers are supplied as the work of Division 23 Section “HVAC Instrumentation and Controls.”

## 2.07 FACTORY PRE-INSULATED DUCT AND FITTINGS

A. Contractor’s Option: For any ductwork specified to be field-insulated as identified in Division 23 Section “Mechanical Insulation,” the contractor shall be granted the option to install factory pre-insulated ductwork in lieu thereof, as specified in this sub-section.

B. To be considered acceptable, the factory pre-insulated duct system shall meet the same performance requirements specified for each application of traditional ductwork and duct insulation specified herein and in Division 23 Section “Mechanical Insulation,” including but not limited to the following characteristics:

1. R-value and thermal conductivity.
2. UL-723 25/50 Flame/Smoke rating.
3. UL-181 Class I air duct compliance.
4. Frictional losses, pressure classes, temperature and velocity limits.
5. Air leakage class and seal class ratings.
6. CFC/HCFC–free and zero Ozone Depletion Potential requirements.

C. The factory pre-insulated duct system shall include rigid phenolic insulation panels of minimum 29 psi (200 kPa) compressive strength. The rigid phenolic insulation panels shall comprise a closed-cell insulation core, auto-adhesively bonded on both sides to a 1 mil (25 micron) aluminum foil facing, reinforced with a 0.2-inch (5 mm) glass scrim, providing a 0.02-perm water vapor transmission rating.

D. All other components required for the fabrication of the factory pre-insulated duct system including, but not limited to, the silicone sealant, contact adhesive, aluminum tape, self–adhesive gasket, ductwork reinforcements, closures, connectors and flanges shall be as approved and/or supplied by the manufacturer.

E. The fabrication and installation of the factory pre-insulated duct system shall be carried out by a fabricator and installer that has successfully completed a specialist training course provided by the manufacturer.

F. Outdoor duct systems: In addition the above requirements, the factory pre-insulated duct system shall include the following features where installed outdoors exposed to weather: 39-mil UV-stable white vinyl outer shell with a minimum tensile strength of 6000 psi, encapsulating the entire system including fittings, couplings, and jointing hardware.

G. The factory pre-insulated duct system is not acceptable for use in the following applications:
   1. Kitchen exhaust.
   2. Where stainless steel and/or welded ductwork is specified.

## 2.08 HANGERS AND SUPPORTS

A. General: Support all ductwork in accordance with Chapter 5 of SMACNA *HVAC Duct Construction Standards – Metal and Flexible* except where more stringent requirements are specified herein.

B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
   1. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches (100 mm) thick.
   2. Exception: Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches (100 mm) thick.

C. Hanger Materials: Galvanized sheet steel or threaded steel rod. Primary duct hanger systems consisting of cable or wire are not acceptable; use steel angles, straps, and/or threaded rods.
   1. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
   2. Strap and Rod Sizes: Comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* for steel sheet width and thickness and for steel rod diameters.
   3. Galvanized-steel straps attached to aluminum ducts shall have contact surfaces painted with zinc-chromate primer.

D. All supporting material surfaces in direct contact with supported ductwork (or flexible duct, or duct insulation, as applicable) shall be designed to maintain a minimum of one-inch (25 mm) contact width along full length of contact. Note that this precludes the use of wire systems (i.e., Gripple).

E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

F. Trapeze and Riser Supports: Steel shapes complying with ASTM A36.
   1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
   2. Supports for Stainless-Steel Ducts: Stainless-steel support materials.
   3. Supports for Aluminum Ducts: Aluminum support materials unless materials are electrolytically separated from ducts.

## 2.09 SEISMIC-RESTRAINT DEVICES

A. General Requirements for Restraint Components: As defined in Division 13 Section “Seismic Restraints.”

B. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.

C. Channel Support System: Shop- or field-fabricated support assembly made of slotted steel channels rated in tension, compression, and torsion forces and with accessories for attachment

to braced component at one end and to building structure at the other end. Include matching components and corrosion-resistant coating.

D. Restraint Cables: ASTM A603, galvanized-steel cables with end connections made of cadmium-plated steel assemblies with brackets, swivel, and bolts designed for restraining cable service; and with an automatic-locking and clamping device or double-cable clips. Use ASTM A492, stainless-steel cables where attached to aluminum or stainless steel ducts.

E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections to hanger rod. Reinforcing steel angle clamped to hanger rod is also acceptable.

F. Mechanical Anchor Bolts: Drilled-in and stud-wedge or female-wedge type. Select anchor bolts with strength required for anchor and as tested according to ASTM E488.

## PART 3 - EXECUTION

### 3.01 DUCT PRESSURE CLASS SCHEDULE

A. Static-Pressure Classes: Unless otherwise indicated, construct ducts according to the following:
   1. Constant-volume Supply Ducts: 2-inch wg (500 Pa).
   2. Variable-volume Supply Ducts upstream of VAV boxes: 3-inch wg (750 Pa).
   3. Variable-volume Supply Ducts downstream of VAV boxes: 1-inch wg (250 Pa).
   4. Return Ducts: 2-inch wg (500 Pa), positive or negative pressure as applicable.
   5. Transfer Ducts: 1/2-inch wg (125 Pa).
   6. Exhaust Ducts: 2-inch wg (500 Pa), positive or negative pressure as applicable.

### 3.02 DUCT MATERIAL SCHEDULE

A. All ducts shall be galvanized steel except as follows:
   1. Moisture-Laden Exhaust Ducts: Exhaust ducts originating from any room with showering facilities, for a minimum of 50 feet (or as shown on the plans), shall be fabricated of aluminum, with seams and laps arranged on top of duct.
   2. Grease Hood Exhaust Ducts: Comply with NFPA 96. Carbon-steel sheet of minimum thickness 0.054-inches if concealed; Type 304 stainless steel of minimum thickness 0.043-inches if exposed. Weld and flange seams and joints.
   3. Dishwasher Hood Exhaust Ducts: Aluminum if concealed, with seams and laps arranged on top of duct; Type 304 stainless steel if exposed, with welded or flanged seams and joints.

### 3.03 DUCT INSTALLATION

A. Construct and install ducts according to SMACNA *HVAC Duct Construction Standards – Metal and Flexible* unless otherwise indicated.

B. Install round and flat-oval ducts in lengths not less than 12 feet (3.7 m) unless interrupted by fittings.

C. Install ducts with fewest possible joints. Install fabricated fittings for changes in directions, size, and shape and for connections.

D. Install couplings tight to duct wall surface with a minimum of projections into duct. Secure couplings with sheet metal screws. Install screws at intervals of 12-inches (300 mm), with a minimum of 3 screws in each coupling.

E. Install ducts, unless otherwise indicated, vertically and horizontally and parallel and perpendicular to building lines; avoid diagonal runs. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

F. Install ducts with a clearance of 1-inch (25 mm), plus allowance for insulation thickness.

G. Duct sizes shown on plans are free area sizes. Internal duct liners are not acceptable.

H. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions unless specifically indicated.

I. Install duct accessories as required by Division 23 Section “Duct Accessories.”

J. Coordinate layout with suspended ceiling, fire- and smoke-control dampers, lighting layouts, and similar finished work.

K. Drawings are diagrammatic in nature. Not necessarily all fittings and offsets are shown. Provide all required fittings and offsets as required by field conditions and coordination with the work of other trades, whether specifically shown or not, for a complete and functional installation.

L. Seal all joints and seams. Apply sealant to male end connectors before insertion, and afterward to cover entire joint and sheet metal screws.

M. Electrical Equipment Spaces: Route ducts to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

N. Non-Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls and are exposed to view, conceal spaces between construction openings and ducts or duct insulation with sheet metal flanges of same metal thickness as ducts. Overlap openings on 4 sides by at least 1½ inches (38 mm).

O. Fire-Rated Partition Penetrations: Where ducts pass through interior partitions and exterior walls, install appropriately rated fire dampers, sleeves, and firestopping sealant. Fire and smoke dampers are specified in Division 23 Section “Duct Accessories.” Firestopping materials and installation methods are specified in Division 07 Section “Penetration Firestopping.”

P. Install ducts with hangers and braces designed to withstand, without damage to equipment, seismic forces as further described in Division 13 Section “Seismic Restraints.”

Q. Protect duct interiors from the elements and foreign materials throughout construction. Follow SMACNA’s “Duct Cleanliness for New Construction.” Deliver ducts with shop-applied impervious protective covering over all open ends. Maintain protective end coverings through shipping, storage, and handling to prevent entrance of dirt, debris, and moisture. Elevate stored ducts above grade. As ductwork is installed, remove protective end covering as each successive segment is connected, but with protective end covering maintained over open ends remaining exposed.

R. Paint interiors of metal ducts for 24-inches (600 mm) upstream of registers and grilles. Apply one coat of flat, black, latex finish coat over a compatible galvanized-steel primer.

### 3.04 RANGE HOOD EXHAUST DUCTS, SPECIAL INSTALLATION REQUIREMENTS

A. Install ducts to allow for thermal expansion through 2000ºF (1110 C) temperature range.

B. Install ducts without dips or traps that may collect residues unless traps have continuous or automatic residue removal.

C. Install access openings at each change in direction and at intervals defined by NFPA 96; locate on sides of duct a minimum of 1½-inches (38 mm) from bottom; and fit with grease-tight covers of same material as duct.

D. Do not penetrate fire-rated assemblies except as permitted by applicable building codes.

### 3.05 SEAM AND JOINT SEALING SCHEDULE

A. General: Ducts noted as welded in the Duct Material Schedule above shall be made liquid-tight with all joints and seams full-penetration welded continuously along the entire length of the seam or joint. Otherwise, seal duct seams and joints according to the duct pressure class indicated and as described in SMACNA *HVAC Duct Construction Standards – Metal and Flexible* except where more stringent requirements are specified herein.

B. Seal externally insulated ducts before insulation installation.

C. Seal Class Schedule: Seal Class A and Leakage Class 6 is required for all ducts except as noted below.
   1. Spiral lock-seams need not be sealed.
   2. Transfer air ducts and transfer air boots need not be sealed.

D. Rectangular Duct: Sealant materials and methods shall be at contractor's option, chosen from among the products specified in Part 2 of this Section; provided that the above seal class and leakage class schedule is met.

E. Round or Flat Oval Duct: Transverse joints shall be made with a SMACNA RT-1 interior slip coupling beaded at center, fastened to duct with screws; in addition, apply Two-Part Sealing System continuously around exterior side of joint.
   1. Contractor's Option: Furnish prefabricated round duct connection system consisting of self-sealing gasketed fittings. Round duct joints made with this type of fitting do not require the additional sealant specified above, provided that specified seal class is achieved.

**3.06 HANGING AND SUPPORTING**

A. Install rigid round, rectangular, and flat-oval metal duct with support systems indicated in SMACNA *HVAC Duct Construction Standards – Metal and Flexible.*

B. Support horizontal ducts within 24-inches (600 mm) of each elbow and within 48-inches (1200 mm) of each branch intersection.

C. Support vertical ducts at one- or two-story intervals (i.e., 12 feet (3.66 m) to 24 feet (7.32 m).

D. Install upper attachments to structures with an allowable load not exceeding one-fourth of failure (proof-test) load.

E. Install concrete inserts before placing concrete.

F. Install powder-actuated concrete fasteners after concrete is placed and completely cured. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4-inches (100 mm) thick.

G. Repair any building insulation or building fireproofing materials, whether new or existing, that are removed or scraped away in order to attach hangers and supports, so as to maintain an equivalent insulation or fire rating as existed without said hanger or support attachment.

H. Provide seismic bracing and restraints as further described in Division 13 Section "Seismic Restraints."

**3.07 CONNECTIONS**

A. Make connections to equipment with flexible connectors according to Division 23 Section "Duct Accessories."

B. Comply with SMACNA *HVAC Duct Construction Standards – Metal and Flexible* for branch, outlet and inlet, and terminal unit connections.

**3.08 CLEANING NEW SYSTEMS**

A. Mark position of dampers and air-directional mechanical devices before cleaning, and perform cleaning before air balancing.

B. Use service openings, as required, for physical and mechanical entry and for inspection.
   1. Create other openings to comply with duct standards.
   2. Disconnect flexible ducts as needed for cleaning and inspection.
   3. Remove and reinstall ceiling sections to gain access during the cleaning process.

C. Vent vacuuming system to the outside. Include filtration to contain debris removed from HVAC systems, and locate exhaust down wind and away from air intakes and other points of entry into building.

D. Clean the following metal duct systems by removing surface contaminants and deposits:
   1. Air outlets and inlets (registers, grilles, and diffusers).
   2. Supply, return, and exhaust fans including fan housings, plenums (except ceiling supply and return plenums), scrolls, blades or vanes, shafts, baffles, dampers, and drive assemblies.
   3. Air-handling unit internal surfaces and components including mixing box, coil section, condensate drain pans, filters and filter sections, and condensate collectors and drains.
   4. Coils and related components.
   5. Return-air ducts, dampers, and actuators except in ceiling plenums and mechanical equipment rooms.
   6. Supply-air ducts, dampers, actuators, and turning vanes.

E. Mechanical Cleaning Methodology:
   1. Clean metal duct systems using mechanical cleaning methods that extract contaminants from within duct systems and remove contaminants from building.
   2. Use vacuum-collection devices that are operated continuously during cleaning. Connect vacuum device to downstream end of duct sections so areas being cleaned are under negative pressure.
   3. Use mechanical agitation to dislodge debris adhered to interior duct surfaces without damaging integrity of metal ducts or duct accessories.
   4. Clean coils and coil drain pans according to ACR 2006. Keep drain pan operational. Rinse coils with clean water to remove latent residues and cleaning materials; comb and straighten fins.

F. Cleanliness Verification:
   1. Visually inspect metal ducts for contaminants.
   2. Where contaminants are discovered, re-clean and reinspect ducts.

**END OF SECTION**

# SECTION 23 72 23.29
# PACKAGED, OUTDOOR, FIXED PLATE ENERGY RECOVERY UNITS

## PART 1 - GENERAL

### 1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

### 1.02 SUMMARY

A. Section Includes:
   1. Fixed-plate, sensible heat exchangers in packaged, outdoor, energy-recovery units.

### 1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.
   1. Include packaged, outdoor, fixed-plate, energy-recovery-unit rated capacities, operating characteristics, furnished specialties, and accessories.
   2. Fans:
      a. Certified fan-performance curves with system operating conditions indicated.
      b. Certified fan-sound power ratings.
      c. Fan construction and accessories.
      d. Motor ratings, electrical characteristics, and motor accessories.

B. Shop Drawings: For packaged, outdoor, fixed-plate, energy-recovery units.
   1. Include plans, elevations, sections, details, and [mounting] [attachment] details.
   2. Include details of equipment assemblies. Indicate dimensions, weights, loads, lifting requirements, required clearances, method of field assembly, components, and location and size of each field connection.
   3. Include diagrams for power, signal, and control wiring.

### 1.04 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, roof plans, elevations, and other details, drawn to scale. and coordinated with each other, using input from installers of items involved.

B. Seismic Qualification Data: Certificates, for packaged, outdoor, fixed-plate, energy-recovery units, accessories, and components, from manufacturer.
   1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
   2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
   3. Detailed description of equipment anchorage devices on which certification is based and their installation requirements.

C. Field quality-control reports.

### 1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For packaged, outdoor, fixed-plate, energy-recovery equipment to include in maintenance manuals.

### 1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed. Package with protective covering for storage and identify with labels describing contents.
   1. Filters: One set(s) of each type of filter specified.
   2. Fan Belts: One set(s) of belts for each belt-driven fan in energy recovery units.

### 1.07 COORDINATION

A. Coordinate sizes and locations of building openings and duct connections with actual equipment provided.

**1.08 WARRANTY**

A. Special Warranty: Manufacturer agrees to repair or replace components of packaged, outdoor, fixed-plate, energy-recovery units that fail in materials or workmanship within specified warranty period.
   1. Warranty Period for Packaged Energy-Recovery Units: One year(s) from date of Substantial Completion.
   2. Warranty Period for Fixed-Plate Heat Exchangers: Five years from date of Substantial Completion.

**PART 2 - PRODUCTS**

**2.01 MANUFACTURERS: SUBJECT TO COMPLIANCE WITH REQUIREMENTS, PROVIDE PRODUCTS BY ONE OF THE FOLLOWING:**
   1. AdaptivAir.
   2. Valent.
   3. Oxygen8.
   4. Greenheck.
   5. Trane.

**2.02 PERFORMANCE REQUIREMENTS**

A. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.

B. ASHRAE Compliance:
   1. Applicable requirements in ASHRAE 62.1.
   2. Capacity ratings for fixed-plate energy-recovery units shall comply with ASHRAE 84.

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.

D. Comply with ASTM E84.

E. Delegated Design: Engage registered professional engineer to design vibration-isolation controls and seismic restraints, including comprehensive engineering analysis using performance requirements and design criteria indicated.

F. Seismic Performance: Packaged, outdoor, fixed-plate, energy-recovery units shall withstand the effects of earthquake motions determined in accordance with ASCE/SEI 7.
   1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified."
   2. Component Importance Factor: 1.0.
   3. Minimum Efficiency Reporting Value and Average Arrestance:
      a. MERV Rating: MERV 13 and corresponding average arrestance in accordance with ASHRAE 52.2.
   4. Minimum Efficiency Reporting Value:
      a. MERV Rating: MERV 13 in accordance with ASHRAE 52.2.

**2.03 PACKAGED, OUTDOOR, FIXED-PLATE, SENSIBLE HEAT, ENERGY-RECOVERY UNITS**

A. Source Limitations: Obtain packaged, outdoor, fixed-plate, energy-recovery units from single manufacturer.

B. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1.

C. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed, hinged access doors with neoprene gaskets for inspection and access to internal parts, minimum 2-inch (50-mm) thick, thermal insulation, knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.

D. Fixed-Plate, Sensible Heat Exchanger:
   1. Casing: Aluminum.
   2. Drain Pan: Same material as casing, with drain connections on exhaust and supply side.
      a. Comply with requirements in ASHRAE 62.1.

3. Plates: Evenly spaced, sealed, and arranged for crossflow.
    a. Plate Material: Embossed aluminum.

E. Supply and Exhaust Fans: Forward-curved centrifugal fan with spring isolators of 1-inch (25-mm) static deflection.
1. Motors and Drives: Direct driven.
    a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 05 13 "Common Motor Requirements for HVAC Equipment."
    b. Motor Sizes: Minimum size as indicated. If size is not indicated, provide motor large enough so driven load will not require motor to operate in service factor range above 1.0.

F. Filters:
1. Particulate air filtration is specified in Section 23 41 00 "Particulate Air Filtration."

G. Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls so only external connections are required during installation.
1. Outdoor Enclosure: NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
2. Include fused disconnect switches.

## 2.04 CONTROLS

A. Control Panel: Solid-state, programmable, microprocessor-based control unit for wall mounting. Integrate to BACnet, as specified in Section 23 09 23 "Direct Digital Control (DDC) System for HVAC".

B. Starting relay, factory mounted and wired, and manual motor starter for field wiring.

C. Frost Control: Low-temperature thermostat deenergizes supply air fan.

D. Dry-bulb temperature sensor.

E. Dirty filter switch.

F. Low-Voltage Transformer: Integral transformer to provide control voltage to unit from primary incoming electrical service.

## 2.05 SOURCE QUALITY CONTROL

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by NRTL, and marked for intended location and application.

B. Fan Performance Rating: Comply with AMCA 211, and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210 and ASHRAE 51.

C. Fan Sound Ratings: Comply with AMCA 301 or AHRI 260 (IP).

D. UL Compliance:
1. Packaged, Fixed-Plate, Energy-Recovery Units: Comply with requirements in UL 1812.

# PART 3 - EXECUTION

## 3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before packaged, outdoor, fixed-plate, energy-recovery unit installation. Replace insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

## 3.02 INSTALLATION OF PACKAGED, OUTDOOR, FIXED-PLATE, ENERGY-RECOVERY UNITS

A. Install packaged, outdoor, fixed-plate, energy-recovery units, so supply and exhaust airstreams flow in opposite directions.
   1. Install access doors in both supply and exhaust ducts, both upstream and downstream, for access to interior components.
   2. Install removable panels or access doors between supply and exhaust ducts on building side for bypass during startup.
   3. Access doors and panels are specified in Section 23 33 00 "Air Duct Accessories."

B. Equipment Mounting:
   1. Install roof-mounted packaged, outdoor, fixed-plate, energy-recovery units on manufacturer's-recommended-height equipment roof curbs. Comply with requirements for equipment curbs specified in Section 07 72 00 "Roof Accessories."
   2. Comply with requirements for vibration-isolation and seismic-control devices specified in Section 23 05 48 "Vibration and Seismic Controls for HVAC."

C. Install units with clearances for service and maintenance.

D. Do not operate equipment fans until temporary or permanent filters are in place. Replace temporary filters used during construction and testing with new, clean filters prior to final inspection.

## 3.03 DUCTWORK CONNECTIONS

A. Comply with requirements for ductwork in accordance with Section 23 31 13 "Metal Ducts."

B. Connect duct to units with flexible connections. Comply with requirements in Section 23 33 00 "Air Duct Accessories."

C. Isolation Dampers: Install isolation dampers in accordance with Section 23 09 23.12 "Control Dampers."

## 3.04 ELECTRICAL CONNECTIONS

A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

B. Connect wiring in accordance with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

C. Ground equipment in accordance with Section 26 05 26 "Grounding and Bonding for Electrical Systems."

D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
   1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 26 05 53 "Identification for Electrical Systems."

## 3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring in accordance with Section 26 05 23 "Control-Voltage Electrical Power Cables."

## 3.06 STARTUP SERVICE

A. Perform startup service.
   1. Complete installation and startup checks in accordance with manufacturer's written instructions.

## 3.07 ADJUSTING

A. Adjust moving parts to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust initial temperature and humidity setpoints.

C. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

### 3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections with assistance of factory-authorized service representative.

B. Tests and Inspections:
   1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
   2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Packaged, outdoor, fixed-plate, energy-recovery units will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

### 3.09 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

**END OF SECTION**

# SECTION 33 30 00

# SANITARY UTILITY DRAINAGE PIPING

## PART 1 - GENERAL

### 1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

B. The Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities, Latest Edition.

### 1.2 SUMMARY

A. Section Includes:
   1. General Contractor to provide:
      a. Pipe and fittings.
      b. Cleanouts.
      c. Manholes.
      d. Closed Circuit Television Video (CCTV) Investigation
      e. Cured-In-Place Pipe (CIPP) Lining

B. Related Work:
   1. Section 31 20 00 - “Earth Moving” for utility trench backfill, excavation, trenching and backfilling.

### 1.3 SUBMITTALS

A. Product Data: For the following:
   1. Pipe and fittings.

B. Shop Drawings: For manholes. Include plans, elevations, sections, details, and frames and covers.

C. Field quality-control reports.

D. Record Drawings: Identifying and accurately showing locations of utilities and other related field conditions

E. CCTV Report for existing conditions and post-construction of CIPP lined sewers in accordance with Part 7, Section B 17 of Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities, except Engineer shall also be provided with the final CCTV Report.

### 1.4 DELIVERY, STORAGE, AND HANDLING

A. Protect pipe, pipe fittings, and seals from dirt and damage.

B. Handle manholes according to manufacturer's written rigging instructions.

## 1.5 QUALITY ASSURANCE

A. Comply with the applicable requirements of the most current version of Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities.
   1. Measurement and payment provisions included in the Standard Specifications do not apply to this work.

B. Preinstallation Conference: Conduct conference at Project site.

C. Contractor is responsible to remove items to the lines, grades, and elevations as shown on the Plans and Specifications. The Architect will provide the initial survey control, but the Contractor shall perform their own survey and layout work.

## 1.6 PROJECT CONDITIONS

A. Interruption of Existing Sanitary Sewerage Service: Do not interrupt service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary service according to requirements indicated:
   1. Notify Architect no fewer than two working days in advance of proposed interruption of service.
   2. Contractor shall develop a plan to convey sewage during the interruption.
   3. Contractor shall indicate the planned duration of the interruption.
   4. Do not proceed with interruption of service without Architect's written permission.

B. Prior to sanitary work beginning, CCTV investigation of existing sanitary sewer from the EX MH to MSD MH 10F4-041S is required to determine existing condition of the sanitary sewer. This work shall include cleaning of the existing sewer as required to obtain video acceptable to the MSD inspector. CCTV inspection shall be in accordance with Part 7, Section B 17 of Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities except as follows:
   a. Replace the first 2 sentences of paragraph 17a with "The MSD inspector and Engineer shall be notified 48hrs prior to CCTV inspection of the existing sanitary sewer."
   b. Edit the reference to the video label at the end of paragraph 17a to read "Closed Circuit Television Inspection – Existing Conditions".

# PART 2 - PRODUCTS

## 2.1 MATERIALS

A. The following material is specified in the most current version of the Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities.
   1. PVC Pipe and Fittings
   2. Cleanouts
   3. Manholes and Frames
   4. Concrete
   5. CIPP

# PART 3 - EXECUTION

## 3.1 INSTALLATION

A. The following construction and installation of material is specified in the most current version of the Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities.
   1. Earthwork
   2. Piping Sewer Construction
   3. Pipe joint construction
   4. Manhole Installation
   5. Concrete Placement
   6. Cleanout Installation
   7. Connections

B. CIPP lining shall be completed in accordance with the CIPP manufacturer's recommended installation procedures and ASTM F1216-09 or F1743-08, as applicable and as approved by Metropolitan St. Louis Sewer District. If there is a conflict between the manufacturer's procedures and the ASTM designations, the more stringent specification shall apply.

**3.2 IDENTIFICATION**

A. Materials and their installation are specified in Section 31 20 00 - "Earth Moving." Arrange for installation of green warning tapes directly over piping and at outside edges of underground manholes.
   1. Use detectable warning tape over nonferrous piping and over edges of underground manholes.

**3.3 FIELD QUALITY CONTROL**

A. Comply with the applicable sections of the most current version of the Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers and Drainage Facilities.

B. Inspect interior of piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place, and again at completion of Project.
   1. Submit separate report for each system inspection.
   2. Defects requiring correction include the following:
      a. Alignment: Less than full diameter of inside of pipe is visible between structures.
      b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
      c. Damage: Crushed, broken, cracked, or otherwise damaged piping.
      d. Infiltration: Water leakage into piping.
      e. Exfiltration: Water leakage from or around piping.

   3. Replace defective piping using new materials and repeat inspections until defects are within allowances specified.

   4. Reinspect and repeat procedure until results are satisfactory.

C. Test new piping systems, and parts of existing systems that have been altered, extended, or repaired, for leaks and defects.
   1. Do not enclose, cover, or put into service before inspection and approval.
   2. Schedule tests and inspections by authorities having jurisdiction with at least 24 hours' advance notice.
   3. Submit separate report for each test.
   4. Hydrostatic Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction and the following:
      a. Fill sewer piping with water. Test with pressure of at least 10-foot head of water, and maintain such pressure without leakage for at least 15 minutes.

b. Close openings in system and fill with water.
c. Purge air and refill with water.
d. Disconnect water supply.
e. Test and inspect joints for leaks.

5. Air Tests: Test sanitary sewerage according to requirements of authorities having jurisdiction, and the following:
   a. Option: Test plastic gravity sewer piping according to ASTM F 1417.
6. Manholes: Perform hydraulic test according to ASTM C 1244
7. Post-Construction CCTV of existing sanitary sewer that has been CIPP lined in accordance with Part 7, Section B 17 of Metropolitan St. Louis Sewer District, Standard Construction Specifications for Sewers.

D. Leaks and loss in test pressure constitute defects that must be repaired.

E. Replace leaking piping using new materials and repeat testing until leakage is within allowances specified.

### 3.4 CLEANING

A. Clean dirt and superfluous material from interior of piping. Flush with potable water.

**END OF SECTION 33 30 00**

APPENDIX B

# GEOTECHNICAL EXPLORATION
# NEW READINESS CENTER
# MISSOURI ARMY NATIONAL GUARD
# ST. LOUIS, MISSOURI

Prepared for:

**OATES ASSOCIATES**
**COLLINSVILLE, ILLINOIS**

Prepared by:

**GEOTECHNOLOGY, LLC**
**ST. LOUIS, MISSOURI**

Date:

**JULY 22, 2022**

Geotechnology Project No.:

**J032996.04**

SAFETY
QUALITY
INTEGRITY
PARTNERSHIP
OPPORTUNITY
RESPONSIVENESS

GEOTECHNOLOGY
A Universal Engineering Sciences Company

July 22, 2022

Ms. Michelle Spillers, P.E.
Oates Associates
100 Lanter Court, Suite 1
Collinsville, Illinois 62234

Re: Geotechnical Exploration
New Readiness Center
Missouri Army National Guard
St. Louis, Missouri
Geotechnology Project No. J032996.04

Dear Ms. Spillers:

Presented in this report are the results of a geotechnical exploration conducted for the referenced project. This report includes our project understanding, observed site conditions, conclusions and/or recommendations, and support data as given in the Table of Contents.

It has been our pleasure to provide geotechnical services to you, and we would welcome the opportunity to provide other services during the course of the project. Please contact us if you need further information or clarification about this document.

Very truly yours,

**GEOTECHNOLOGY, LLC**

Senthil Kumar, P.E.
Principal Engineer

Daniel W. Greenwood, P.E., R.G.
Geotechnical Manager

STATE OF MISSOURI
SENTHIL KUMAR
NUMBER E-023728
PROFESSIONAL ENGINEER

SK/DWG:sk/jf

Copies submitted: (1) pdf

## TABLE OF CONTENTS



## LIST OF TABLES

## EXECUTIVE SUMMARY

The executive summary is provided solely for the purpose of overview and a number of details are omitted, each of which could be crucial to the recommended application of this report. A party who relies on this report should read the entire report.

- The project involves the design and construction of an approximately 50,000 square-foot, two-story building for the Missouri Army National Guard (MoNG) in St. Louis, Missouri. The site is a vacant 14-acre parcel located at the southwest corner of Interstate 270 and Lewis & Clark Boulevard (SR 367). Structural loads were not provided. We have assumed maximum column and wall loads will not exceed 160 kips per column and 8.5 kips per linear foot, respectively. The lower level finished grade is planned to be at El 540[1].

- The stratigraphy at the east half of the site generally consists of occasional fill underlain by naturally occurring lean and fat clay soils. At the west half of the site, 17 feet or more of asphalt, sand and gravel fill is present. The fill is underlain by lean clay. Weathered shale was encountered in the deeper borings, and auger/sampler refusal occurs at depths of 29 to 46 feet (El 490 to 512). Groundwater was observed in one boring at an approximate depth of 27 feet during drilling.

- The existing fill materials have been placed in an uncontrolled manner and should be considered compressible. New loads applied to these soils could result in excessive settlement. After basement excavation, any fill remaining within the building footprint should be removed and replaced as compacted fill.

- After the site is prepared as recommended in this report, the building may be supported on strip and spread footings proportioned for a net allowable bearing pressure of 2,500 pounds per square foot (psf), provided the footings bear on natural soil or compacted fill.

- Seismic parameters are provided in accordance with the 2015 Edition of the International Building Code (IBC) and St. Louis County Ordinance 27,654. Based on the results of the shear wave velocity survey the soil profile at the project site may be defined as Class D (Stiff Soil).

[1] Elevations herein are in units of feet and refer to North American Vertical Datum (NAVD) 1988.

GEOTECHNOLOGY
A Universal Engineering Sciences Company

# GEOTECHNICAL EXPLORATION
# NEW READINESS CENTER
# MISSOURI ARMY NATIONAL GUARD
# ST. LOUIS, MISSOURI

**July 22, 2022 | Geotechnology Project No. J032996.04**

## 1.0 INTRODUCTION

The services documented in this report were provided in accordance with the terms, conditions and scope of services described in Geotechnology's December 7, 2021 proposal numbered P032996.04. The project was authorized by your Subconsultant Agreement dated January 18, 2022.

The purposes of the geotechnical exploration were to develop a general subsurface profile at the site and prepare recommendations for the geotechnical aspects of the design and construction of the project as defined in our proposal. Our scope of services included site reconnaissance, review of existing geotechnical data, geotechnical borings, laboratory testing, engineering analyses, and preparation of this report.

A copy of "Important Information about This Geotechnical-Engineering Report," published by the Geotechnical Business Council (GBC) of the Geoprofessional Business Association (GBA), is included in Appendix A for your review. The publication discusses report limitations and ways to manage risk associated with subsurface conditions.

## 2.0 PROJECT INFORMATION

The Missouri Army National Guard (MoNG) is planning to construct a new Readiness Center on a vacant 14-acre parcel located in Bellefontaine Neighbors at the southwest corner of Interstate 270 and Lewis & Clark Boulevard (SR 367). The site location and general topography of the area as per the 2021 USGS map of the vicinity are shown on Figure 1 included in Appendix B. The proposed development includes a 50,000± square-foot building and paved parking areas. The building will likely be a steel-framed, two-story structure. The building first and lower levels are planned to be at El 554 and 540, respectively. Detailed loading information is not currently available for the structures; for purposes of this report, maximum column loads have been assumed to be 160 kips and maximum wall loads have been assumed to be 8.5 kips per linear foot.

A new access road is proposed from the south; the remainder of the site will be paved for parking. Currently the site slopes downwards from El 570 at the northwest to El 515 to the east and El 535 to the south. Site grades will require cutting the east end and filling to the west. Cuts of approximately 15 feet are anticipated to achieve the proposed basement grade. An approximately five- to seven-foot-tall mechanically stabilized earth (MSE) retaining wall is proposed at the west end to accommodate the proposed elevation change. The perimeter grades will be accommodated by

constructing earthen slopes at 3H:1V. Stormwater is proposed to be collected and stored at two below-grade infiltration basins at the south and west ends of the site.

A Missouri Department of Transportation (MoDOT) facility is located south of the subject site. Reportedly, the gravel covered parcel of the site to the west was used by MoDOT contractors as a disposal site for asphalt waste from resurfacing projects.

## 3.0 PREVIOUS STUDY

Geotechnology performed a preliminary geotechnical exploration[2] and a shear wave velocity survey for the subject site in 2018. Six borings designated as Borings B-1 through -6 were drilled during the geotechnical exploration. The stratigraphy consisted of fill, lean clay and fat clay. Fill consisted of asphalt, sand and gravel and was generally present to the west. Fill depth was on the order of 17 feet. Consistency of the natural cohesive soils ranged from medium stiff to very stiff, occasionally hard. Auger refusal occurred in Borings B-2 and B-5 at depths of 45 and 46 feet (El 499 and 512), respectively. Groundwater was not encountered during drilling. Relevant data from this exploration are incorporated into this report. Boring locations are shown on Figure 2 and the relevant associated logs are attached in Appendix C.

The shear wave velocity survey at the site was performed along a line oriented north-south, as shown on Figure 2. The survey indicated an average shear wave velocity in the upper 100 feet below the ground surface to be approximately 956 feet per second. This velocity corresponds to Site Class “D” (stiff soil) per IBC 2018. Refer to the previous report for details of the survey.

## 4.0 GEOTECHNICAL EXPLORATION

The field exploration consisted of drilling eight borings, designated as Borings B-7 through B-12, and P-1 and P-2, at the approximate locations shown on Figure 2 in Appendix B. The P-series borings were drilled to perform infiltration tests.

The boring locations were surveyed by the project surveyor. The elevations at the boring locations, as shown on the boring logs, were provided by the project surveyor.

The borings were drilled to predetermined depths of 6.5 to 40 feet or sampler refusal using a CME 550X rotary drill rig equipped with hollow stem augers. Standard Penetration Tests (SPTs) were performed using an automatic hammer. Split-spoon samples and relatively undisturbed Shelby tube samples were obtained at the depths indicated on the boring logs presented in Appendix D. An explanation of the terms and symbols used on the boring logs is provided in Appendix D.

[2] *Geotechnical Exploration, St. Louis Readiness Center, Missouri Army National Guard, Bellefontaine Neighbors, Missouri*; prepared for Oates Associates; Geotechnology, Inc., Report No. J032996.02, dated November 7, 2018.

An engineer of Geotechnology provided direction during field exploration, observed drilling and sampling, assisted in obtaining samples and prepared logs of the material encountered. The boring logs represent conditions observed at the time of exploration, and have been edited to incorporate results of the laboratory tests.

Unless noted on the boring logs, the lines designating the changes between various strata represent approximate boundaries. The transition between materials could be gradual or could occur between recovered samples. The stratification given on the boring logs, or described herein, is for use by Geotechnology in its analyses and should not be used as the basis of design or construction cost estimates without realizing that there can be variation from that shown or described.

The boring logs and related information depict subsurface conditions only at the specific locations and times where sampling was conducted. The passage of time could result in changes in conditions, interpreted to exist, at or between the locations where sampling was conducted.

### 4.1 Field Infiltration Tests

Two field infiltration tests were conducted in Borings P-1 and P-2 for use with storm water calculations. The test holes were drilled to depths of approximately 15 and 6.5 feet below existing ground surface, respectively. A nominal 4-inch diameter PVC casing was installed in each test hole, and a field infiltration test conducted in general accordance with Appendix D.1, “Testing Requirements for Infiltration, Bioretention and Sand Filter Subsoils,” as specified by Metropolitan St. Louis Sewer District guidelines for “Best Management Practices” (BMP) facilities. The test hole was filled with clean water to a level approximately 36 inches above the bottom and allowed to pre-soak for approximately 24 hours prior to testing. The following day, the water level was measured at 24 inches above the hole bottom and a field infiltration test performed over a four-hour period. After completion of the test, the casing was removed and the test hole backfilled with soil cuttings. The soil in the test holes were logged as rubble fill underlain by lean clay. The field infiltration tests results indicated no infiltration (i.e., zero infiltration rate) in both holes, over the four-hour period.

## 5.0 LABORATORY TESTING

Laboratory testing was performed on the soil samples to estimate engineering and index properties. Moisture contents and Atterberg limits tests were performed on selected cohesive samples. Unconfined compression tests were performed on selected Shelby tube samples. Laboratory test results are presented on the boring logs included in Appendix D.

## 6.0 SUBSURFACE CONDITIONS

### 6.1 Stratigraphy

Fill occurs to depths of approximately 2.5 to 16.5 feet. Exceptions are Borings B-7 and B-11, where the fill is not present. The fills are generally deeper to the west. The fill is generally

comprised of a matrix of asphalt, sand, gravel and concrete. The amount of rubble in the fill varies widely. SPT 'N'-values in the fill were generally above 30 blows per foot (bpf), occasionally lower.

Below the fill, and below the topsoil in Borings B-7 and B-11, the natural soil consists of 3 to 21 feet of low plasticity, lean clay. The lean clay is generally brown in color and medium stiff to stiff, occasionally soft in consistency. All borings, except Borings B-9 and B-11 were terminated in the lean clay. In Boring B-9, the lean clay is underlain 5 feet of medium stiff, fat clay, which transitions to a shaly clay to the depth explored. In Boring B-11, the lean clay is underlain by 5 feet of stiff, shaly clay, which transitions to shale.

Weathered shale was encountered below the natural soil in deeper borings. Sampler refusal occurred in Boring B-11 at an approximate depth of 29 feet (El 490). Split-spoon sampler refusal is considered to be a penetration resistance of 50 blows per 6 inches or less. Split spoon refusal in shale can be indicative of the horizon at which the compressive strength of the shale increases due to a decrease in moisture content and weathering. Auger/sampler refusal elevations at the boring locations are shown on Figure 2 in Appendix B. Drill rig augers can often penetrate several feet into soft or broken rock, and therefore these elevations do not necessarily represent top of rock. Auger/sampler refusal may represent either a hard soil layer, rock remnants (rock layers within the soil), or bedrock. Since rock coring was not performed at these locations, the character of these materials could not be determined.

### 6.2 Groundwater

Groundwater was observed while drilling Boring B-9 approximately at a depth of 27 feet. In other borings, groundwater was not observed while drilling. Groundwater levels shown on the boring logs might not have stabilized before backfilling, which is typical in less permeable cohesive soil. Consequently, the indicated/lack of observed groundwater levels might not represent present or future levels. Groundwater levels could vary over time due to the effects of seasonal variation in precipitation, recharge, presence of creeks or lakes nearby or other factors not evident at the time of exploration. Free water could be trapped in permeable zones of fill, in pavement base course, and in utility trenches backfilled with clean rock. Excavations that remain open might collect water.

## 7.0 CONCLUSIONS AND RECOMMENDATIONS

Geotechnology has prepared the following conclusions and recommendations based on our understanding of the proposed project, the field and laboratory data presented in this report, engineering analyses, and our experience and judgment.

### 7.1 Site Grading

Temporary Excavation. The contractor should review slope height, slope inclination or excavation depths with respect to local, state or federal safety regulations, e.g. OSHA Health and Safety Standards for Excavations, 29 CFR Part 1926, or successor regulations. We anticipate that the site geometry will permit, excavation slopes for the basement to be laid back to a stable configuration. For excavations less than 20 feet deep, the OSHA classification for the natural soil

encountered in the excavation can be considered as Type B. Fill materials should be considered as Type C. Consequently, temporary slopes in Type C soil may be constructed at 1V:1.5H, and temporary slopes in Type B soils at 1V: 1H. However, cut slopes that intersect the water table should be graded to 1V:1.5H, or flatter. Temporary slopes taller than 20 feet must be designed by a professional engineer. The owner, contractor or earthwork or utility subcontractors could be liable for substantial penalties if regulations are not followed. Ultimately construction site safety and OSHA classification of the soil is the sole responsibility of the contractor.

Existing Fill. Existing fill is present mostly to the west of the site. These fill materials have been placed in an uncontrolled manner and should be considered compressible. Where fill remains in place, there is a risk that detrimental building and/or floor slab settlement could occur. Based on the proposed building floor grade, we anticipate that most of the fill within the building footprint will be removed during basement excavation. Any remaining fill below the building should be removed and replaced with new, compacted fill materials or processed and compacted in a controlled manner. The existing fill can be processed and reused if deleterious and compressible materials such as wood can be removed. Unsuitable materials should be discarded. After the existing fill is remediated, the building can be designed for shallow footing foundations and a grade-supported slab.

In the pavement area, the owner may elect to accept some risk, partially excavate the existing fill, and allow some deeper fill to remain in exchange for the costs savings. If this risk-based approach is taken, we suggest undercutting the fill that is present within 2 feet of finished pavement subgrade and placing a layer of compacted fill. If this risk is unacceptable, the fill should be entirely removed.

Site Preparation. In general, cut areas and areas to receive fill and backfill should be stripped of asphalt, soft soil, and other deleterious materials. The exposed subgrade should be proofrolled. Soft soil or yielding areas should be excavated and backfilled with fill or crushed rock compacted to the levels provided in Table 1, Compaction Summary.

Suitable Fill Materials. In general, fill materials should consist of low plasticity, cohesive soils or crushed rock. On-site fill can be reused if compressible or other deleterious materials are removed. Oversized rubble should be processed to a maximum particle size of 4 inches or discarded. Care should be taken so that the larger pieces are not placed in a concentrated manner such that voids would develop between nested pieces.

Acceptable non-organic fill soils include materials designated CL, ML, CL-ML, SW, and GW as defined by ASTM D 2487. On-site low plasticity soils can be reused as fill.

Poorly-graded “clean” granular materials should not be used as fill, as these materials tend to create a reservoir for water, resulting in softening of the underlying cohesive soil subgrade. If clean granular aggregate is used as fill, full encapsulation in 4–ounce nonwoven synthetic filter

fabric (e.g., Mirafi 140N) is required to reduce the potential for infiltration of silts and fine sands into the void space which can cause settlements adjacent to the trench.

Fill and Backfill Placement. Fill or backfill should be placed in uniformly thick lifts and compacted. The loose lift thickness should not exceed 8 inches. The fill should be systematically compacted to the levels given in Table 1, Compaction Summary. Fill containing rubble should be compacted with a 10-ton vibratory roller until no subgrade yielding is observed. The soil should be placed at a moisture content compatible with the required unit weight. Depending on the soil moisture at the time of construction, aeration or wetting could be required to achieve proper compaction. Deleterious material should not be included in fill, and the fill should not be placed on soft materials or frozen ground.

**Table 1. Compaction Summary**

| Category | Minimum Compaction [a] |
|---|---|
| General soil fill | 90% |
| Rock backfill | 95% |
| Pavement and floor slab subgrade | 90%[b] |
| Pavement and floor slab rock base course | 95% |

[a] Measured as a percent of the maximum dry unit weight as determined by the modified Proctor test in a laboratory (ASTM D 1557).
[b] Moisture content within 3% of optimum moisture content.

Trench Backfill. Settlement of utility trench backfill can result in depressions and localized pavement failures. Settlement of trench backfill can be reduced by mechanically compacting the backfill in lifts to the minimum compaction levels given in Table 1, Compaction Summary. Permeable backfill (i.e., clean rock and sand) should not be used for backfill. Permeable backfill can collect water and promote subgrade softening and/or result in the migration of fines and loss of subgrade support.

Subgrade Protection. Drainage of the construction areas should be provided to protect the foundation excavations, floor slab subgrades and temporary slopes from the detrimental effects of weather conditions during construction. Finished subgrades and foundation excavations should be kept free of standing water. Concrete should be placed in foundations the same day they are excavated.

Floor slab and pavement areas will be exposed to weather and disturbances from installation of utilities and normal construction traffic. Disturbance is generally easier to repair in summer and fall months by reworking of the upper soils. More difficulty will be experienced in the wetter seasons, such as spring and winter. We recommend minimizing construction traffic on the prepared subgrades.

Collection and Disposal of Site Water. Management of the site water is important in the successful performance of pavement and foundations. Water from surface runoff, downspouts, and subsurface drains, if any, should be collected and discharged through an effective site drainage

system. Control of surface runoff should be maintained in compliance with the rules and regulations set forth in the Federal Water Pollution Control Act. Additionally, permits related to site grading activities and control of storm water during construction activities should be obtained from the applicable governmental jurisdiction(s).

### 7.2 Shallow Foundations

Bearing Capacity. Strip and spread footings should be proportioned for a net allowable bearing pressure of 2,500 psf, provided they bear on natural or compacted soil. The minimum lateral dimensions for strip and spread footings should be 18 and 24 inches, respectively. Exterior footings and footings in unheated interior areas should be embedded 30 inches below the lowest adjacent exterior grade to provide protection from seasonal moisture variations and frost penetration. The allowable end bearing pressure may be increased by 33 percent to calculate resistance to seismic, wind, and other transitory loads.

Shallow foundations, proportioned and constructed as recommended above, are expected to settle approximately 1 inch. Differential settlement between any two adjacent footings could be approximately 3/4-inch. Estimated values of settlement contained in this report are based on our experience. Consolidation tests and corresponding settlement calculations have not been made.

Uplift Capacity. Uplift loads can be resisted with the dead weight of the footing, and the weight of soil above the footing. A unit weight of 120 pounds per cubic foot (pcf) can be used for determining the soil weight above the footing, and the volume of soil acting on the footing can include a wedge of material within a line that extends from the top of footing and away from the footing edge to the ground surface at an angle of 30 degrees from the vertical.

Lateral Capacity. Lateral loads can be resisted considering frictional resistance between the base of the foundation and supporting soil and passive resistance acting on the side of the footing. Resistance to sliding can be computed assuming an ultimate coefficient of friction of 0.4; however, the ultimate resistance must be limited to 750 psf. The ultimate passive resistance may be computed based on an equivalent fluid pressure of 225 pcf but the upper 30 inches should be neglected. Safety factors of 2 and 3 should be applied to determine the allowable sliding and passive resistance, respectively.

### 7.3 Floor Slabs

The slab-on-grade should be underlain by 4- to 6-inch layer of crushed rock placed atop properly prepared subgrades and compacted as indicated in Table 1, Compaction Summary. A 15-mil or thicker plastic sheet should be placed below the floor to reduce the potential for moisture to permeate the slab and reduce the potential for mold growth in the building. Notwithstanding other structural considerations, the slab-on-grade floor should be designed to allow for differential movements that normally occur between the floor slab, columns, and foundation walls.

### 7.4 Lateral Earth Pressures

Below-grade walls shall be designed to resist lateral soil loads. Design lateral pressures from surcharge loads shall be added to the lateral earth pressure load. Lateral earth pressures can vary with wall restraint conditions, type of backfill, slope of ground surface behind the wall, and method of backfill compaction.

Design values are given herein for soil lateral loads on walls with horizontal backfill, subject to active and at-rest conditions. Conventional concrete walls may be designed for active earth pressures if the top is permitted to tilt (after construction) approximately 0.5 percent of its height. Walls with fixed-heads or rigid walls should be designed for at-rest earth pressures.

**Table 2. Lateral Earth Pressures for Level (Horizontal) Ground Surface**

| Description of Backfill | Design soil lateral load (psf per foot of depth) | |
|---|---|---|
| | At-Rest | Active |
| Inorganic clays of low to medium plasticity (CL) | 69h + 0.58q | 49h + 0.41q |
| Well graded gravel-sand mix (GW/SW) (e.g. 1-inch-minus, but not screenings) | 57h + 0.44q | 36h + 0.28q |

Where:

h = depth below adjacent grade, feet
q = surcharge load, psf

In giving these values, it is assumed that hydrostatic pressures will not develop behind walls and that the wall backfill will be compacted as recommended in Table 1, Compaction Summary. Therefore, the walls should be provided with a drain system to allow for dissipation of hydrostatic pressures. Undrained walls may be subjected to additional pressures from groundwater, perched water, pipe leakages or surface water infiltration.

For the above equations to be valid for sand or gravel backfill, the backfill should be placed in a wedge extending upward and away from the edge of the wall footing at a 45-degree angle or flatter. If sand and gravel are to be placed within a steeper wedge, the values for low plasticity soil given above should be used. Further, any soft uncompacted soil on the excavation slope should be removed prior to placement of backfill. Design drawings should reflect this requirement.

### 7.5 Dynamic Lateral Loads

In seismic conditions, seismic earth pressure is applied on yielding (active) and non-yielding (at-rest) walls. Yielding walls, provided they can accommodate an approximately 2-inch horizontal displacement, can be designed for seismic active earth pressure ($P_E$) using the dynamic seismic coefficient, $K_E$, provided in Table 3. The $K_E$ values for non-yielding walls should be used

for rigid or fixed-head walls. Design values for the seismic coefficients are provided in Table 3 assuming a vertical wall with horizontal backfill conditions.

The Dynamic Seismic Coefficient, $K_E$, was calculated based on the Mononobe-Okabe Method using a seismic horizontal acceleration coefficient ($k_h$) adjusted for wall height and ground motion characteristics. For yielding walls, $k_h$ was further reduced to account for allowable wall displacement.

The seismic lateral loading force for both yielding and non-yielding retaining walls, adjacent to level ground may be estimated using the following equation:

$P_E = ½ K_E \gamma H^2$

Where:

$P_E$ = Total thrust for seismic conditions (includes the static lateral earth pressure)
$K_E$ = Earthquake dynamic earth pressure coefficient
$\gamma$ = moist unit weight of soil (120 pcf)
H = wall height in feet (bottom of foundation to top of wall)

**Table 3. Dynamic Earth Pressure Coefficients.**

| Description of Backfill/ Wall Height (ft) | Inorganic clays of low to medium plasticity (CL) | | Well graded gravel-sand mix (GW/SW) | | Horizontal Acceleration Coefficient ($k_h$) | |
|---|---|---|---|---|---|---|
| | Dynamic Earth Pressure Coefficient ($K_E$) | | | | | |
| | At-Rest | Active | At-Rest | Active | At-Rest | Active |
| 15 and under | 0.622 | 0.440 | 0.516 | 0.359 | 0.309 | 0.155 |

The total lateral thrust $P_E$ can be assumed to act on yielding walls at a distance equal to one-third of the wall height, measured from the base of the wall. The total thrust on non-yielding walls can be assumed to act at a distance equal to one-half of the wall height, measured from the base of the wall. Note that $P_E$ already includes the static lateral earth pressure. The dynamic component of the total thrust, $\Delta P_E$, is obtained by subtracting the static thrust on wall from the total thrust.

Design seismic lateral loads from surcharge loads should be added to the total lateral thrust for seismic conditions, $P_E$. The seismic load due to surcharge is equal to surcharge load multiplied by seismic horizontal acceleration coefficient ($k_h$). The seismic load due to surcharge is applied at the ground surface level. Design values for $k_h$ is given in Table 3.

### 7.6 Perimeter Drain and Damp Proofing

Although the regional groundwater table is expected to be below proposed substructure grades, infiltration of surface water could occur. A drain system should be constructed around the perimeter of below-grade structures as shown on Figure 3 in Appendix B. The perimeter drain system should consist of 4-inch PVC or equivalent pipe with 1/4 or 3/8 inch perforations; the pipe should be laid with the perforations down and enveloped with drain filter having the gradation shown on Figure 3. The drain filter should be surrounded with Mirafi 140 filter cloth or equivalent. The drainage system should be routed to a sump for collection and disposal, or the water discharged by a gravity system.

Design measures should also be taken to waterproof the below-grade areas of the building. These measures can include installation of a moisture barrier beneath the floor slab and water stops at all joints.

### 7.7 MSE Walls

An approximately 5- to 7-foot high MSE retaining wall is planned to the west to accommodate the planned grade change. The design of MSE wall is beyond the scope of our work. However, any wall design should consider the internal and external stability of the retaining wall. MSE walls are gravity structures constructed by embedding reinforcing strips in the compacted fill behind the wall panels that form the face of the wall.

The following geotechnical parameters can be used for design of the MSE wall.

- For the natural soil below the wall, friction angle of 28 degrees and cohesion of 20 psf may be used for long term conditions. Undrained shear strength of 800 psf may be used for short term conditions. If the wall will be bearing on new fill, the fill strength will be dependent on the fill type.

- Ultimate bearing capacity of 6,000 psf may be assumed for the natural soils below the wall.

- The preliminary global stability analysis provided in Section 7.8 should be evaluated as part of the final design of the MSE structure. The wall embedment depth and geogrid length used to obtain a satisfactory factor of safety should be incorporated into the design. Geotechnology can assist in the final global stability analysis when the final wall details are provided.

- Appropriate factors of safety should be used in the wall design.

### 7.8 Global Stability Analysis

Slope stability analysis consists of comparing the driving forces within a slope to the resisting forces and determining the factor of safety. Gravitational forces tend to move the slope downwards (driving force), while resisting forces derived from the soil shear strength tend to keep

the slope in place. When the driving force acting on the slope is greater than the resisting force, sliding can occur. The factor of safety of the slope is the ratio of the restraining force divided by the driving force. Generally, when the factor of safety is 1 or less, the slope is considered to be unstable. The accepted standard in local practice is to have a factor of safety of 1.5 for long term stability condition of a slope.

Preliminary global stability analyses were performed for representative wall sections at Sections AA' and BB' as shown on Figure 2. Long-term stability was considered critical. Hence, we performed our analyses for effective stress conditions. The wall embedment was assumed to include geogrids. The MSE wall backfill was assumed to be well-graded compact granular material. The soil properties used in our analyses are based on empirical correlations from the laboratory soil index tests, our experience with similar materials, and are summarized in Table 4.

**Table 4. Soil Properties for Global Stability Analysis**

| Soil Type | Density (pcf) | Cohesion (psf) | Friction Angle (°) |
|---|---|---|---|
| Existing Fill | 110 | 0 | 29 |
| New Lean Clay Fill | 120 | 25 | 30 |
| Lean Clay | 120 | 20 | 28 |
| Fat Clay | 120 | 20 | 24 |
| MSE Wall | 130 | Infinite Strength | |

Groundwater was not included in the analysis. A surcharge load of 240 psf was included in the analysis to account for the traffic load on the pavement areas. The Morgenstern-Price procedure was used to compute factors of safety. The computer program SLIDE was used to perform the computations. The calculated resultant factors of safety are given in Table 5. The analyzed sections with critical failure arcs are presented in Appendix E.

**Table 5. Global Stability Analysis Results**

| Section[a] | Wall Height (ft) | Required Minimum Wall Embedment (ft) | Grid Lengths (ft) | Calculated Factor of Safety | Remarks[b] |
|---|---|---|---|---|---|
| AA' | 7 | 2 | 5 | 1.5 | Two layers of geogrids in wall embedment |
| BB' | 6 | 1 | 5 | 1.5 | One layer of geogrid in wall embedment |

[a] Refer to Figure 2, Appendix B, *Aerial Photograph of Site and Boring Locations* for section location.
[b] Layer thickness of 12 inches between grids assumed.

Generally, we recommend a minimum factor of safety of 1.5 for long-term stability. Our analyses indicate that the factors of safety for the retaining walls with wall embedment and grid lengths indicated in Table 5 will achieve a factor of safety of 1.5. The wall embedment should include

geogrid layers as indicated in Table 5 and compacted granular backfill. Seismic effects on the walls were not considered.

If the soils within the envelope of the wall become saturated, however, a significant reduction in the factor of safety is likely. Hence, we recommend that surface water from the top be directed away from the walls and the soils within the wall envelope. Utility installations behind the walls should be avoided. If this is not possible, special design and construction techniques will be required, such as the use of leak-proof joints, impermeable backfill or drain tiles.

Please note that the retaining wall designer is responsible for the internal stability of the wall. An evaluation of the internal stability is beyond our scope of services.

### 7.9 Pavement Design and Construction

A pavement design and analysis was beyond the scope of our services. Standard asphaltic concrete pavement design for a given service life requires evaluation of the soil by California Bearing Ratio (CBR) tests or other methods, estimates of daily traffic volumes and axle weights, drainage requirements, and the desired level of maintenance.

Asphaltic pavement sections are frequently used in the St. Louis region that are thinner than would typically result from a pavement design. These reduced thickness sections often perform adequately; however, maintenance or an overlay is generally required sooner than would be required for a thicker, designed section. Based on our experience with projects of similar nature, pavement sections consisting of 3 inches of asphalt over 6 inches of well-graded crushed rock and 4 inches of asphalt over 8 inches of well-graded, crushed rock are often used in parking areas and main drive lanes, respectively, subjected to automobile traffic only. The pavement performance can be enhanced by lime treating the subgrade soils or incorporating a geogrid below the crushed rock. Where heavy wheel loads are concentrated, particularly at approaches to trash dumpsters and truck loading areas, concrete pavement should be used.

Regardless of which pavement sections are selected, the soil subgrade should be stable and the top 12 inches compacted to the levels provided in Table 1, Compaction Summary. Pavement service life can decrease substantially if the pavement is constructed on a poor subgrade, if it has poor surface or subsurface drainage, and/or if the pavement is not maintained. Periodic maintenance, such as filling cracks and sealing, is required for any pavement section.

If pavements are not constructed immediately after grading, the subgrade should be shaped to prevent ponding. Minor ponding, of even short duration, can cause softening of a soil subgrade. If there is a lapse of time between grading and paving, or if the subgrade is disturbed by construction activities, the subgrade should be proof-rolled with a loaded, tandem-wheeled dump truck. Soft spots observed during initial construction or proof-rolling should be removed and replaced with compacted soil or rock, possibly combined with a geotextile or geogrid. The rock base course and soil subgrade should be compacted to the levels provided in Table 1, Compaction Summary.

Depending on when the pavement is constructed, the subgrade might not support construction equipment such as rock trucks or asphalt trucks which have heavier axle loads than those vehicles which the pavement section is expected to support. Such conditions will be more apparent during wetter periods of the year. Overexcavation of soft subgrade and placement of additional base course and/or geogrid could be required to construct the pavement during these periods.

### 7.10 Seismic Site Classification and Seismic Design Parameters

Site Class. Based on the shear wave velocity survey described our previously referenced report and per the general procedures of the IBC, the soil profile at the project site may be defined as Class D (stiff soil).

Spectral Acceleration Values. The site is under the jurisdiction of St. Louis County and hence by Ordinance No. 27654 for the adoption of the IBC 2015, spectral response acceleration at short period ($S_S$), and at 1-second period ($S_1$) of 0.48 g and 0.18 g, respectively, are recommended by the county. However, IBC 2015 indicates 0.39 g and 0.155 g, respectively for the subject site.

## 8.0 RECOMMENDED ADDITIONAL SERVICES

The conclusions and recommendations given in this report are based on: Geotechnology's understanding of the proposed design and construction, as outlined in this report; site observations; interpretation of the exploration data; and our experience. Since the intent of the design recommendations is best understood by Geotechnology, we recommend that Geotechnology be included in the final design and construction process, and be retained to review the project plans and specifications to confirm that the recommendations given in this report have been correctly implemented. We recommend that Geotechnology be retained to participate in prebid and preconstruction conferences to reduce the risk of misinterpretation of the conclusions and recommendations in this report relative to the proposed construction of the subject project.

Since actual subsurface conditions between boring locations could vary from those encountered in the borings, our design recommendations are subject to adjustment in the field based on the subsurface conditions encountered during construction. Therefore, we recommend that Geotechnology be retained to provide construction observation services as a continuation of the design process to confirm the recommendations in this report and to revise them accordingly to accommodate differing subsurface conditions. Construction observation is intended to enhance compliance with project plans and specifications. It is not insurance, nor does it constitute a warranty or guarantee of any type. Regardless of construction observation, contractors, suppliers, and others are solely responsible for the quality of their work and for adhering to plans and specifications.

## 9.0 LIMITATIONS

This report has been prepared on behalf of, and for the exclusive use of, the client for specific application to the named project as described herein. If this report is provided to other parties, it should be provided in its entirety with all supplementary information. In addition, the client should

make it clear that the information is provided for factual data only, and not as a warranty of subsurface conditions presented in this report.

Geotechnology has attempted to conduct the services reported herein in a manner consistent with that level of care and skill ordinarily exercised by members of the profession currently practicing in the same locality and under similar conditions. The recommendations and conclusions contained in this report are professional opinions. The report is not a bidding document and should not be used for that purpose.

Our scope for this phase of the project did not include any environmental assessment or investigation for the presence or absence of wetlands or hazardous or toxic materials in the soil, surface water, groundwater, or air, on or below or around this site. Any statements in this report or on the boring logs regarding odors noted or unusual or suspicious items or conditions observed are strictly for the information of our client. Our scope did not include an assessment of the effects of flooding and erosion of creeks or rivers adjacent to or on the project site.

Our scope did not include: any services to investigate or detect the presence of mold or any other biological contaminants (such as spores, fungus, bacteria, viruses, and the by-products of such organisms) on and around the site; or any services, designed or intended, to prevent or lower the risk of the occurrence of an infestation of mold or other biological contaminants.

The analyses, conclusions, and recommendations contained in this report are based on the data obtained from the geotechnical exploration. The field exploration methods used indicate subsurface conditions only at the specific locations where samples were obtained, only at the time they were obtained, and only to the depths penetrated. Consequently, subsurface conditions could vary gradually, abruptly, and/or nonlinearly between sample locations and/or intervals.

The conclusions or recommendations presented in this report should not be used without Geotechnology's review and assessment if the nature, design, or location of the facilities is changed, if there is a lapse in time between the submittal of this report and the start of work at the site, or if there is a substantial interruption or delay during work at the site. If changes are contemplated or delays occur, Geotechnology must be allowed to review them to assess their impact on the findings, conclusions, and/or design recommendations given in this report. Geotechnology will not be responsible for any claims, damages, or liability associated with any other party's interpretations of the subsurface data or with reuse of the subsurface data or engineering analyses in this report.

The recommendations included in this report have been based in part on assumptions about variations in site stratigraphy that can be evaluated further during earthwork and foundation construction. Geotechnology should be retained to perform construction observation and continue its geotechnical engineering service using observational methods. Geotechnology cannot assume liability for the adequacy of its recommendations when they are used in the field without Geotechnology being retained to observe construction.

# APPENDIX A – IMPORTANT INFORMATION ABOUT THIS GEOTECHNICAL-ENGINEERING REPORT

# Important Information about This

# Geotechnical-Engineering Report

**Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.**

**While you cannot eliminate all such risks, you can manage them. The following information is provided to help.**

## Geotechnical Services Are Performed for Specific Purposes, Persons, and Projects

Geotechnical engineers structure their services to meet the specific needs of their clients. A geotechnical-engineering study conducted for a civil engineer may not fulfill the needs of a constructor — a construction contractor — or even another civil engineer. Because each geotechnical- engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client. No one except you should rely on this geotechnical-engineering report without first conferring with the geotechnical engineer who prepared it. *And no one — not even you* — should apply this report for any purpose or project except the one originally contemplated.

## Read the Full Report

Serious problems have occurred because those relying on a geotechnical-engineering report did not read it all. Do not rely on an executive summary. Do not read selected elements only.

## Geotechnical Engineers Base Each Report on a Unique Set of Project-Specific Factors

Geotechnical engineers consider many unique, project-specific factors when establishing the scope of a study. Typical factors include: the client's goals, objectives, and risk-management preferences; the general nature of the structure involved, its size, and configuration; the location of the structure on the site; and other planned or existing site improvements, such as access roads, parking lots, and underground utilities. Unless the geotechnical engineer who conducted the study specifically indicates otherwise, do not rely on a geotechnical-engineering report that was:

- not prepared for you;
- not prepared for your project;
- not prepared for the specific site explored; or
- completed before important project changes were made.

Typical changes that can erode the reliability of an existing geotechnical-engineering report include those that affect:

- the function of the proposed structure, as when it's changed from a parking garage to an office building, or from a light-industrial plant to a refrigerated warehouse;
- the elevation, configuration, location, orientation, or weight of the proposed structure;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project changes—even minor ones—and request an assessment of their impact. *Geotechnical engineers cannot accept responsibility or liability for problems that occur because their reports do not consider developments of which they were not informed.*

## Subsurface Conditions Can Change

A geotechnical-engineering report is based on conditions that existed at the time the geotechnical engineer performed the study. *Do not rely on a geotechnical-engineering report whose adequacy may have been affected by*: the passage of time; man-made events, such as construction on or adjacent to the site; or natural events, such as floods, droughts, earthquakes, or groundwater fluctuations. *Contact the geotechnical engineer before applying this report to determine if it is still reliable.* A minor amount of additional testing or analysis could prevent major problems.

## Most Geotechnical Findings Are Professional Opinions

Site exploration identifies subsurface conditions only at those points where subsurface tests are conducted or samples are taken. Geotechnical engineers review field and laboratory data and then apply their professional judgment to render an opinion about subsurface conditions throughout the site. Actual subsurface conditions may differ — sometimes significantly — from those indicated in your report. Retaining the geotechnical engineer who developed your report to provide geotechnical-construction observation is the most effective method of managing the risks associated with unanticipated conditions.

## A Report's Recommendations Are Not Final

Do not overrely on the confirmation-dependent recommendations included in your report. *Confirmation-dependent recommendations are not final,* because geotechnical engineers develop them principally from judgment and opinion. Geotechnical engineers can finalize their recommendations *only* by observing actual subsurface conditions revealed during construction. *The geotechnical engineer who developed your report cannot assume responsibility or liability for the report's confirmation-dependent recommendations if that engineer does not perform the geotechnical-construction observation required to confirm the recommendations' applicability.*

## A Geotechnical-Engineering Report Is Subject to Misinterpretation

Other design-team members' misinterpretation of geotechnical-engineering reports has resulted in costly

problems. Confront that risk by having your geotechnical engineer confer with appropriate members of the design team after submitting the report. Also retain your geotechnical engineer to review pertinent elements of the design team's plans and specifications. Constructors can also misinterpret a geotechnical-engineering report. Confront that risk by having your geotechnical engineer participate in prebid and preconstruction conferences, and by providing geotechnical construction observation.

## Do Not Redraw the Engineer's Logs

Geotechnical engineers prepare final boring and testing logs based upon their interpretation of field logs and laboratory data. To prevent errors or omissions, the logs included in a geotechnical-engineering report should *never* be redrawn for inclusion in architectural or other design drawings. Only photographic or electronic reproduction is acceptable, *but recognize that separating logs from the report can elevate risk.*

## Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can make constructors liable for unanticipated subsurface conditions by limiting what they provide for bid preparation. To help prevent costly problems, give constructors the complete geotechnical-engineering report, *but* preface it with a clearly written letter of transmittal. In that letter, advise constructors that the report was not prepared for purposes of bid development and that the report's accuracy is limited; encourage them to confer with the geotechnical engineer who prepared the report (a modest fee may be required) and/or to conduct additional study to obtain the specific types of information they need or prefer. A prebid conference can also be valuable. *Be sure constructors have sufficient time* to perform additional study. Only then might you be in a position to give constructors the best information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions.

## Read Responsibility Provisions Closely

Some clients, design professionals, and constructors fail to recognize that geotechnical engineering is far less exact than other engineering disciplines. This lack of understanding has created unrealistic expectations that have led to disappointments, claims, and disputes. To help reduce the risk of such outcomes, geotechnical engineers commonly include a variety of explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

## Environmental Concerns Are Not Covered

The equipment, techniques, and personnel used to perform an *environmental* study differ significantly from those used to perform a *geotechnical* study. For that reason, a geotechnical-engineering report does not usually relate any environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated environmental problems have led to numerous project failures.* If you have not yet obtained your own environmental information, ask your geotechnical consultant for risk-management guidance. *Do not rely on an environmental report prepared for someone else.*

## Obtain Professional Assistance To Deal with Mold

Diverse strategies can be applied during building design, construction, operation, and maintenance to prevent significant amounts of mold from growing on indoor surfaces. To be effective, all such strategies should be devised for the *express purpose* of mold prevention, integrated into a comprehensive plan, and executed with diligent oversight by a professional mold-prevention consultant. Because just a small amount of water or moisture can lead to the development of severe mold infestations, many mold- prevention strategies focus on keeping building surfaces dry. While groundwater, water infiltration, and similar issues may have been addressed as part of the geotechnical- engineering study whose findings are conveyed in this report, the geotechnical engineer in charge of this project is not a mold prevention consultant; *none of the services performed in connection with the geotechnical engineer's study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not of itself be sufficient to prevent mold from growing in or on the structure involved.*

## Rely, on Your GBC-Member Geotechnical Engineer for Additional Assistance

Membership in the Geotechnical Business Council of the Geoprofessional Business Association exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project. Confer with you GBC-Member geotechnical engineer for more information.

GEOTECHNICAL BUSINESS COUNCIL
of the Geoprofessional Business Association

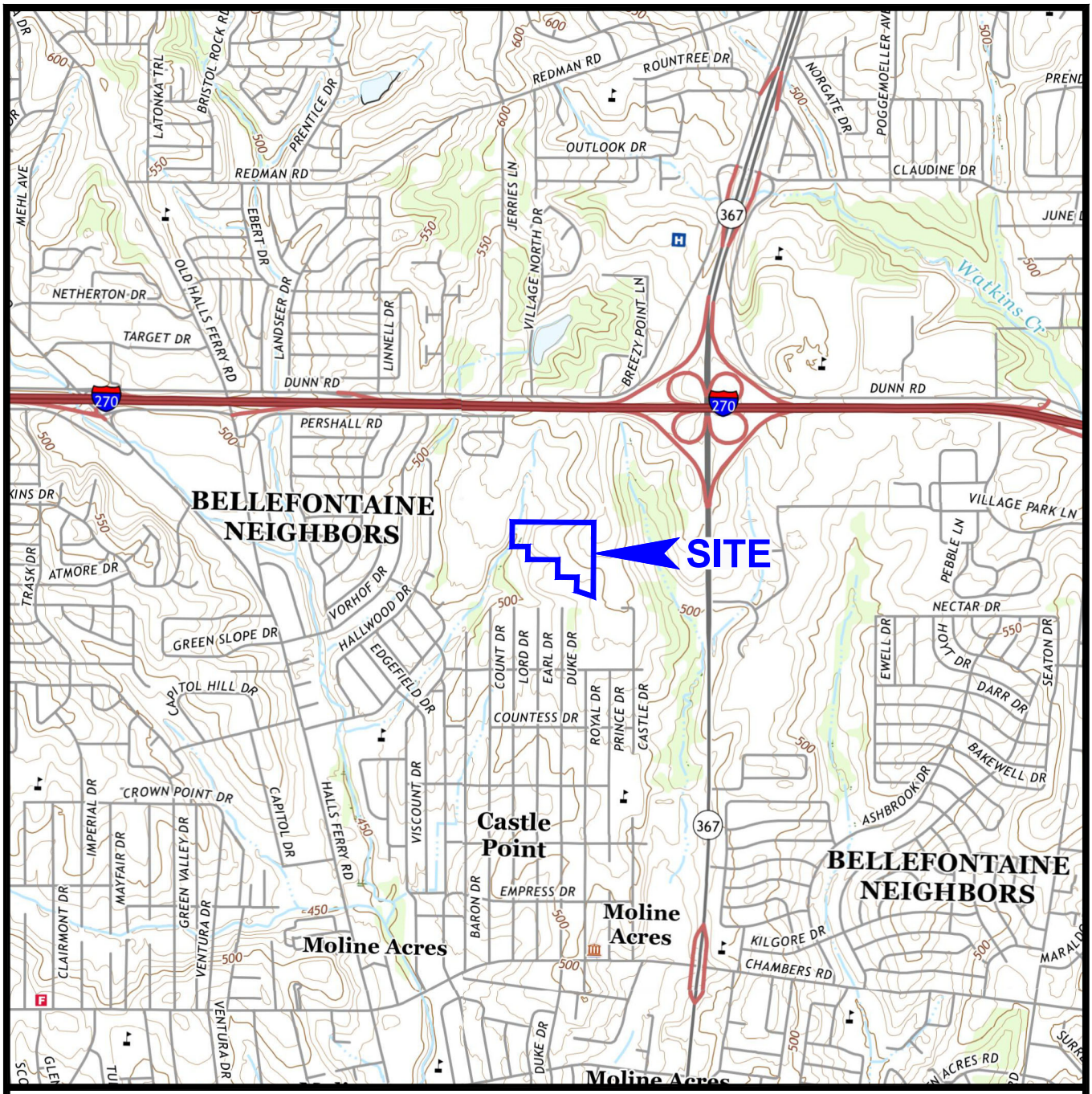
8811 Colesville Road/Suite G106, Silver Spring, MD 20910
Telephone: 301/565-2733 Facsimile: 301/589-2017
e-mail: info@geoprofessional.org www.geoprofessional.org

**APPENDIX B – FIGURES**

Figure 1 - Site Location and Topography

Figure 2 - Aerial Photograph of Site and Boring Locations

Figure 3 - Below-Grade Wall Schematic Drainage Detail




NOTES

1. Plan adapted from 7.5 minute U.S.G.S. maps for Columbia Bottom, Missouri-Illinois quadrangle, and Granite City, Illinois-Missouri quadrangle, and Florissant and Clayton, Missouri quadrangles, last revised in 2021.

0 2,000 4,000

SCALE IN FEET

N

| Drawn By: WAH | Ck'd By: SK | App'vd By: DWG |
|---|---|---|
| Date: 1-27-22 | Date: 7-22-22 | Date: 7-22-22 |

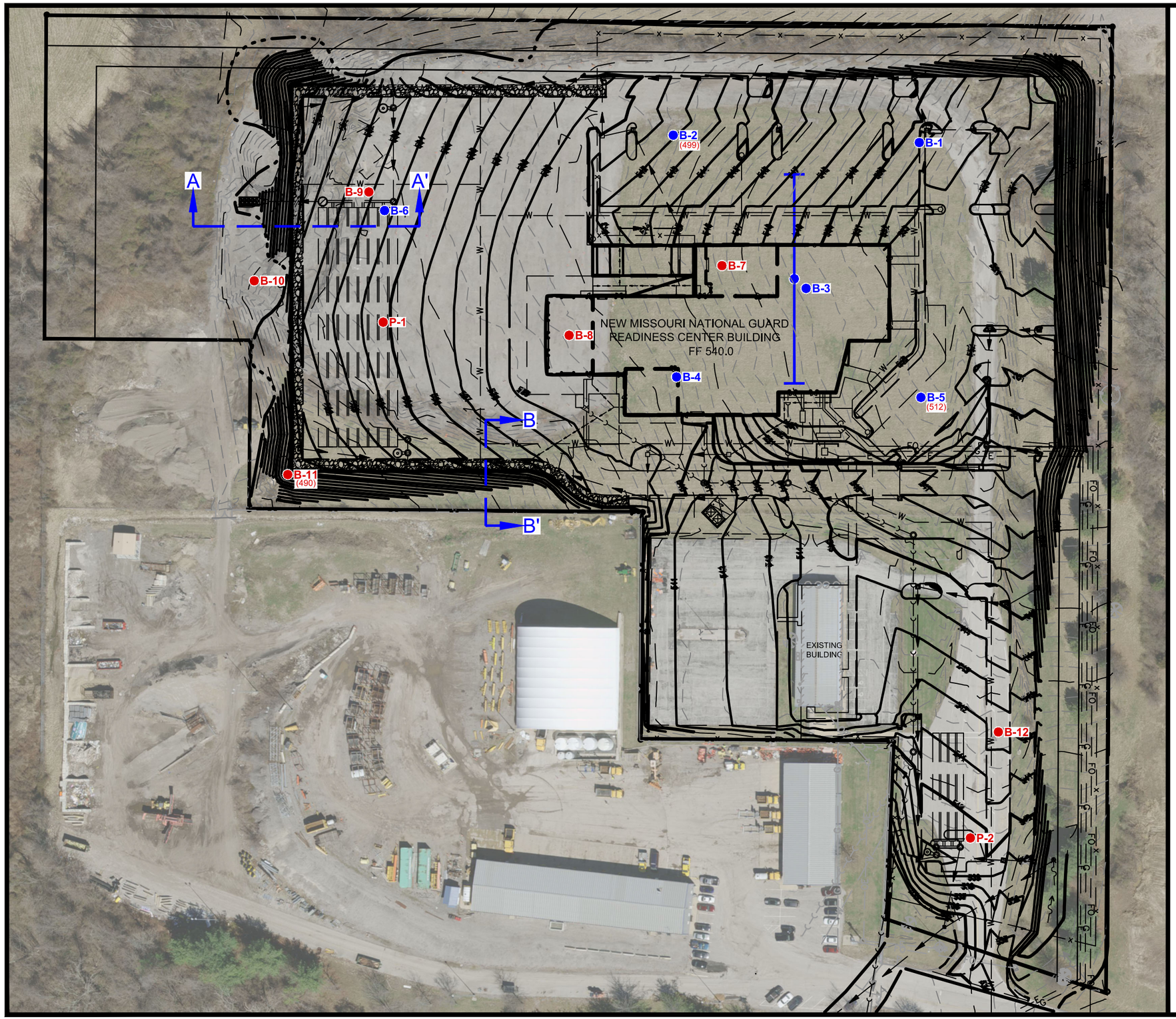
GEOTECHNOLOGY
A Universal Engineering Sciences Company

New Readiness Center
Missouri Army National Guard
St. Louis, Missouri

**SITE LOCATION AND TOPOGRAPHY**

Project Number
J032996.04

FIGURE 1




NOTES

1. Plan adapted from "2015 Aerial Imagery for the St. Louis Region" supplied by East-West Gateway Council of Governments and a drawing dated July 18, 2022, titled "Grading Plan", prepared by Ross & Baruzzini.

2. Borings B-1 through -6 were located in the field with reference to site features and are shown approximate only. Borings B-7 through -12, and P-1 and -2 locations were surveyed.

LEGEND

- Boring Location
- Previous Boring Location (2018)
- (XXX) Approximate Auger/Sampler Refusal Elevation
- MASW Survey Location
- Slope Stability Location (Cross-Section A-A' & B-B')

N

0 100 200

SCALE IN FEET

| | | |
|---|---|---|
| Drawn By: WAH | Ck'd By: SK | App'vd By: DWG |
| Date: 1-27-22 | Date: 7-22-22 | Date: 7-22-22 |

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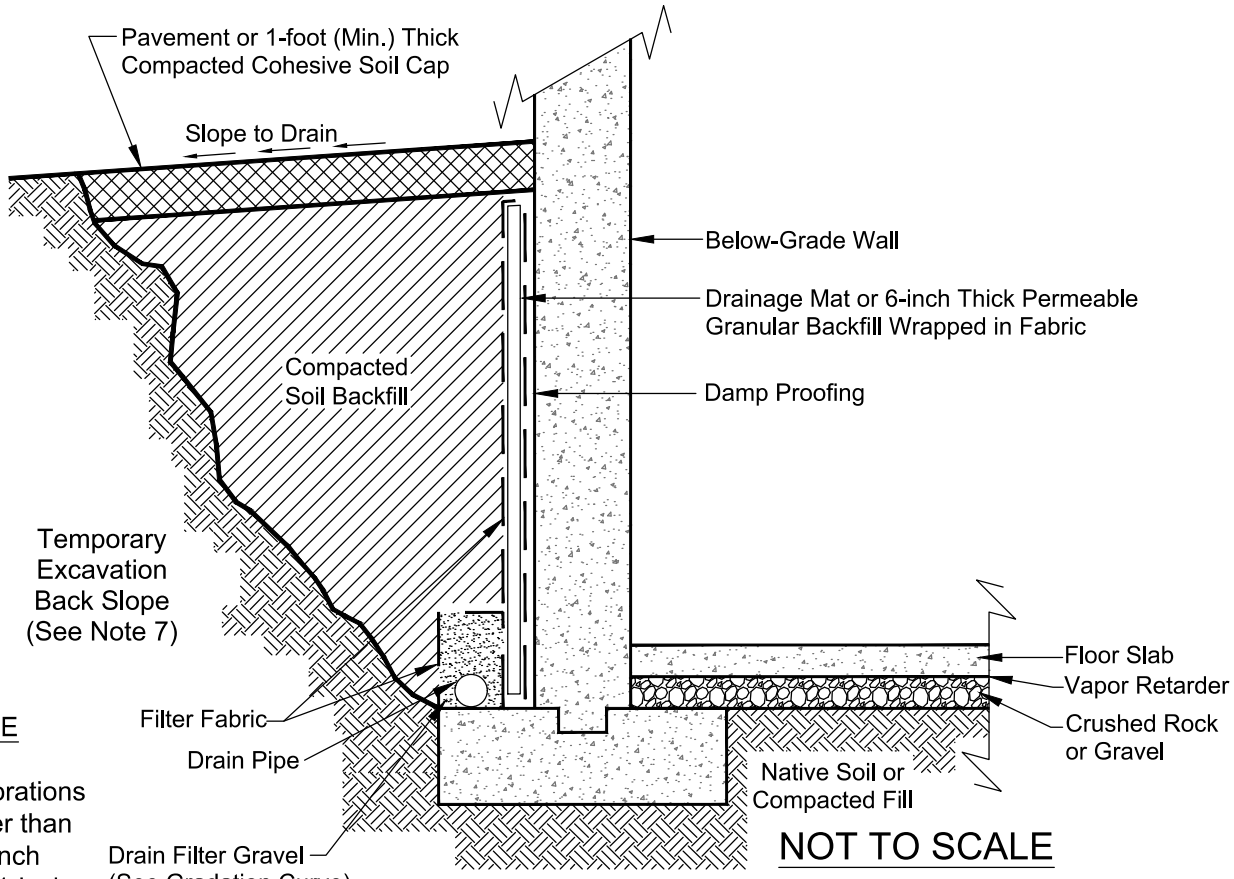
Missouri Army National Guard
St. Louis, Missouri

**AERIAL PHOTOGRAPH OF SITE AND BORING LOCATIONS**

Project Number J032996.04

FIGURE 2

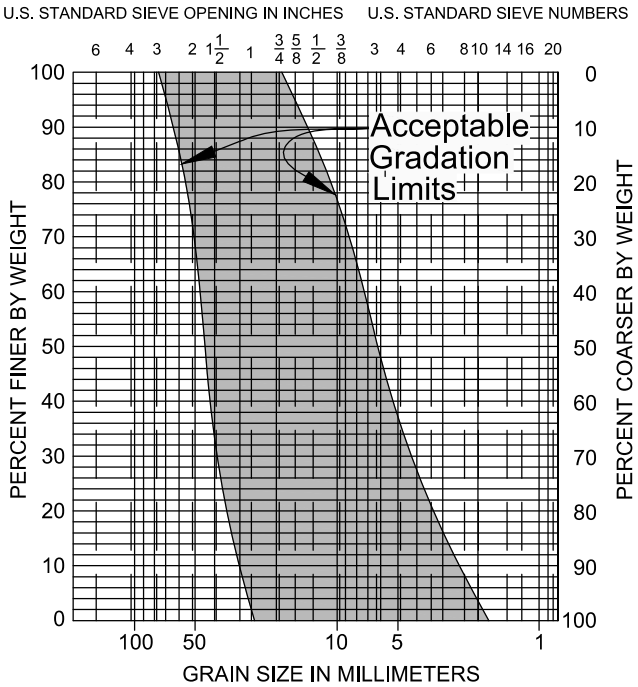



NOTE
For perforations larger than 3/8-inch use 1-inch clean rock.

NOT TO SCALE

NOTES

1. 4-inch or larger, Sch. 40 PVC drain pipe or equivalent with 1/4-inch to 3/8-inch perforations.
2. Perforations positioned downward.
3. Location and invert of pipe as required for drainage.
4. Route drain pipe to daylight to outside slope.
5. Cleanouts advisable at changes of direction.
6. As an alternate, ASTM D2729 sewer pipe may be used in conjunction with 1-inch clean filter rock and filter fabric.
7. A minimum 45-degree back slope may be required if the structural engineer designs the wall using lateral pressures for a granular backfill.




| COBBLES | GRAVEL | | SAND | |
|---|---|---|---|---|
| | COARSE | FINE | COARSE | MEDIUM |

DRAIN FILTER GRADATION

| | | |
|---|---|---|
| Drawn By: WAH | Ck'd By: SK | App'vd By: DWG |
| Date: 2-14-22 | Date: 7-22-22 | Date: 7-22-22 |

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Missouri Army National Guard
St. Louis, Missouri

**BELOW-GRADE WALL SCHEMATIC DRAINAGE DETAIL**

Project Number J032996.04

FIGURE 3

# APPENDIX C – PREVIOUS BORINGS

Surface Elevation: 560 Completion Date: 10/15/2018

Datum: WGS84 EGM96

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Topsoil - 12 inches | | | |
| | Medium stiff to stiff, brown, LEAN CLAY - CL | | 3-4-6 | SS1 |
| | | | 2-3-3 | SS2 |
| 5 | | | 3-4-5 | SS3 |
| | | | 2-2-3 | SS4 |
| 10 | | | | |
| | | | 99 | ST5 |
| 15 | | | | |
| | | | 2-2-3 | SS6 |
| 20 | Boring terminated at 20 feet. | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

**SHEAR STRENGTH, tsf**

△ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

**STANDARD PENETRATION RESISTANCE**

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

**WATER CONTENT, %**

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

JF DRILLER RFW LOGGER

CME 750Y DRILL RIG

HAMMER TYPE Auto

**REMARKS:**

| Drawn by: EKG | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 10/25/2018 | Date: 10/31/2018 | Date: 11/6/2018 |

GEOTECHNOLOGY INC
FROM THE GROUND UP

**St. Louis Readiness Center**
**Missouri Army National Guard**
**Bellefontaine Neighbors, Missouri**

**LOG OF BORING: B-1**

**Project No. J032996.02**

LOG OF BORING 2002.WL J032996.02 - MO NATIONAL GUARD.GPJ 00 CLONE ME.GPJ 11/6/18

Surface Elevation: 544 Completion Date: 10/15/2018

Datum: WGS84 EGM96

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Topsoil - 12 inches | | | |
| | Stiff to medium stiff, brown, LEAN CLAY - CL | | 3-4-6 | SS1 |
| | | | 3-5-6 | SS2 |
| 5 | | | | |
| | | | 2-2-3 | SS3 |
| 10 | | | | |
| | | | 93 | ST4 |
| 15 | | | | |
| | | | 2-2-3 | SS5 |
| 20 | | | | |
| | Medium stiff, brown, FAT CLAY - (CH) | | 3-3-5 | SS6 |
| 25 | | | | |
| | some sand and gravel | | 3-4-4 | SS7 |
| 30 | | | | |
| | Hard to very stiff, tan and gray, shaley, FAT CLAY - CH | | 10-14-20 | SS8 |
| 35 | | | | |
| | | | 6-8-10 | SS9 |

SHEAR STRENGTH, tsf
△ - UU/2 ○ - QU/2 □ - SV
0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE
▲ N-VALUE (BLOWS PER FOOT)
(ASTM D 1586)

WATER CONTENT, %
PL 10 20 30 40 50 LL

75 >>

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002.WL J032996.02 - MO NATIONAL GUARD.GPJ 00 CLONE ME.GPJ 11/6/18

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM
WASHBORING FROM ___ FEET
JF DRILLER RFW LOGGER
CME 750Y DRILL RIG
HAMMER TYPE Auto

**REMARKS:**
**Rough drilling between 28 and 31 feet.**
**Slow drilling between 31 and 45 feet.**

| Drawn by: EKG | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 10/25/2018 | Date: 10/31/2018 | Date: 11/6/2018 |

GEOTECHNOLOGY INC
FROM THE GROUND UP

**St. Louis Readiness Center**
**Missouri Army National Guard**
**Bellefontaine Neighbors, Missouri**

**LOG OF BORING: B-2**

**Project No. J032996.02**

Surface Elevation: 544 Completion Date: 10/15/2018

Datum: WGS84 EGM96

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Hard to very stiff, tan and gray, shaley, FAT CLAY - CH *(continued)* | | | |
| | Maroon, weathered, clayey SHALE | | 11-45 -50/0" | SS10 |
| 45 | Auger refusal at 45 feet. | | | |

**SHEAR STRENGTH, tsf**

△ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

**STANDARD PENETRATION RESISTANCE**

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

**WATER CONTENT, %**

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002.WL J032996.02 - MO NATIONAL GUARD.GPJ 00 CLONE ME.GPJ 11/6/18

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

JF DRILLER RFW LOGGER

CME 750Y DRILL RIG

HAMMER TYPE Auto

**REMARKS:**
**Rough drilling between 28 and 31 feet.**
**Slow drilling between 31 and 45 feet.**

| Drawn by: EKG | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 10/25/2018 | Date: 10/31/2018 | Date: 11/6/2018 |

GEOTECHNOLOGY INC
FROM THE GROUND UP

**St. Louis Readiness Center**
**Missouri Army National Guard**
**Bellefontaine Neighbors, Missouri**

**CONTINUATION OF LOG OF BORING: B-2**

**Project No. J032996.02**

Surface Elevation: 553 | Completion Date: 10/15/2018

Datum: WGS84 EGM96

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Topsoil - 12 inches | | | |
| | FILL: gravel, sand, and lean clay | | 3-5-5 | SS1 |
| | Stiff to medium stiff, brown, LEAN CLAY - (CL) | | | |
| | | | 3-4-6 | SS2 |
| 5 | | | | |
| | | | 2-2-4 | SS3 |
| | | | | |
| | | | 2-2-2 | SS4 |
| 10 | | | | |
| | | | | |
| | | | 2-3-3 | SS5 |
| 15 | | | | |
| | trace sand | | 2-3-4 | SS6 |
| 20 | Boring terminated at 20 feet. | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

**SHEAR STRENGTH, tsf**

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

**STANDARD PENETRATION RESISTANCE**

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

**WATER CONTENT, %**

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002.WL J032996.02 - MO NATIONAL GUARD.GPJ 00 CLONE ME.GPJ 11/6/18

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

JF DRILLER RFW LOGGER

CME 750Y DRILL RIG

HAMMER TYPE Auto

**REMARKS:**

| Drawn by: EKG | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 10/25/2018 | Date: 10/31/2018 | Date: 11/6/2018 |

GEOTECHNOLOGY INC
FROM THE GROUND UP

**St. Louis Readiness Center**
**Missouri Army National Guard**
**Bellefontaine Neighbors, Missouri**

**LOG OF BORING: B-3**

**Project No. J032996.02**

Surface Elevation: 542 | Completion Date: 10/16/2018

Datum: WGS84 EGM96

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Topsoil - 12 inches | | | |
| | Stiff to medium stiff, brown, LEAN CLAY - (CL) | | 3-4-6 | SS1 |
| | | | 3-4-5 | SS2 |
| 5 | | | 2-2-3 | SS3 |
| | | | 96 | ST4 |
| 10 | | | | |
| | | | 2-2-3 | SS5 |
| 15 | | | | |
| | | | 2-2-3 | SS6 |
| 20 | Boring terminated at 20 feet. | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

**SHEAR STRENGTH, tsf**

△ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

**STANDARD PENETRATION RESISTANCE**

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

**WATER CONTENT, %**

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

JF DRILLER RFW LOGGER

CME 750Y DRILL RIG

HAMMER TYPE Auto

**REMARKS:**

| Drawn by: EKG | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 10/25/2018 | Date: 10/31/2018 | Date: 11/6/2018 |

GEOTECHNOLOGY INC
FROM THE GROUND UP

**St. Louis Readiness Center**
**Missouri Army National Guard**
**Bellefontaine Neighbors, Missouri**

**LOG OF BORING: B-4**

**Project No. J032996.02**

LOG OF BORING 2002.WL J032996.02 - MO NATIONAL GUARD.GPJ 00 CLONE ME.GPJ 11/6/18

Surface Elevation: 558 Completion Date: 10/15/2018

Datum: WGS84 EGM96

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Topsoil - 12 inches | | | |
| | Medium stiff, brown, LEAN CLAY - CL | | 3-3-4 | SS1 |
| | Medium stiff, brown, FAT CLAY - (CH) | | 3-3-5 | SS2 |
| 5 | | | | |
| | Soft to medium stiff, brown, LEAN CLAY - CL | | 3-3-5 | SS3 |
| | | | 2-2-2 | SS4 |
| 10 | | | | |
| | | | 93 | ST5 |
| 15 | | | | |
| | | | 2-2-3 | SS6 |
| 20 | | | | |
| | Medium stiff to very stiff, brown and gray, FAT CLAY - CH | | 3-3-4 | SS7 |
| 25 | | | | |
| | some sand and gravel | | 6-12-8 | SS8 |
| 30 | | | | |
| | | | 3-5-6 | SS9 |
| 35 | | | | |
| | | | 3-5-7 | SS10 |

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

WATER CONTENT, %

PL 10 20 30 40 50 LL

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

JF DRILLER RFW LOGGER

CME 750Y DRILL RIG

HAMMER TYPE Auto

**REMARKS:**

**Rough drilling between 28 and 32 feet and 41.5 and 46 feet.**

| Drawn by: EKG | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 10/25/2018 | Date: 11/5/2018 | Date: 11/6/2018 |

GEOTECHNOLOGY INC
FROM THE GROUND UP

**St. Louis Readiness Center**
**Missouri Army National Guard**
**Bellefontaine Neighbors, Missouri**

**LOG OF BORING: B-5**

**Project No. J032996.02**

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002.WL J032996.02 - MO NATIONAL GUARD.GPJ 00 CLONE ME.GPJ 11/6/18

Surface Elevation: 558 | Completion Date: 10/15/2018

Datum: WGS84 EGM96

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Medium stiff to very stiff, brown and gray, FAT CLAY - CH *(continued)* | | | |
| | Stiff, brown, FAT CLAY, some sand and rock fragments - CH | | | |
| 45 | | | 4-9-12 | SS11 |
| | Sampler and auger refusal at 46 feet. | | 50/0" | SS12 |
| 50 | | | | |
| 55 | | | | |
| 60 | | | | |
| 65 | | | | |
| 70 | | | | |
| 75 | | | | |

**SHEAR STRENGTH, tsf**

△ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

**STANDARD PENETRATION RESISTANCE**

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

**WATER CONTENT, %**

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002.WL J032996.02 - MO NATIONAL GUARD.GPJ 00 CLONE ME.GPJ 11/9/18

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

JF DRILLER RFW LOGGER

CME 750Y DRILL RIG

HAMMER TYPE Auto

**REMARKS:**

**Rough drilling between 28 and 32 feet and 41.5 and 46 feet.**

| Drawn by: EKG | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 10/25/2018 | Date: 11/5/2018 | Date: 11/6/2018 |

GEOTECHNOLOGY INC
FROM THE GROUND UP

**St. Louis Readiness Center**
**Missouri Army National Guard**
**Bellefontaine Neighbors, Missouri**

**CONTINUATION OF LOG OF BORING: B-5**

**Project No. J032996.02**

Surface Elevation: 537 | Completion Date: 10/16/2018

Datum: WGS84 EGM96

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | FILL: gravel and asphalt | | | |
| | FILL: asphalt, sand, and gravel | | 10-17-16 | SS1 |
| | | | 9-14-13 | SS2 |
| 5 | | | 8-11-12 | SS3 |
| | | | 6-9-9 | SS4 |
| 10 | | | | |
| | | | 9-14-17 | SS5 |
| 15 | | | | |
| | Stiff, olive gray, LEAN CLAY - CL | | 3-4-5 | SS6 |
| 20 | Boring terminated at 20 feet. | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

**SHEAR STRENGTH, tsf**

△ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

**STANDARD PENETRATION RESISTANCE**

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

**WATER CONTENT, %**

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

LOG OF BORING 2002.WL J032996.02 - MO NATIONAL GUARD.GPJ 00 CLONE ME.GPJ 11/6/18

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

JF DRILLER RFW LOGGER

CME 750Y DRILL RIG

HAMMER TYPE Auto

**REMARKS:**

| Drawn by: EKG | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 10/25/2018 | Date: 11/5/2018 | Date: 11/6/2018 |

GEOTECHNOLOGY INC
FROM THE GROUND UP

**St. Louis Readiness Center**
**Missouri Army National Guard**
**Bellefontaine Neighbors, Missouri**

**LOG OF BORING: B-6**

**Project No. J032996.02**

# APPENDIX D – BORING INFORMATION

Boring Logs

Boring Log Terms and Symbols

Surface Elevation: 548.4 Datum: NAVD88

Completion Date: 1/26/2022

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Topsoil - 12 inches | | | |
| | Soft to stiff, brown, LEAN CLAY - (CL) | | 3-3-5 | SS1 |
| | | | 4-5-6 | SS2 |
| 5 | | | 3-3-4 | SS3 |
| | | | 1-2-2 | SS4 |
| 10 | | | 97 | ST5 |
| 15 | | | | |
| | | | 2-2-3 | SS6 |
| 20 | Boring terminated at 20 feet. | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

WATER CONTENT, %

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

TD DRILLER RFW LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 75 %

**REMARKS:**

| Drawn by: WAH | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 1/27/2022 | Date: 2/14/2022 | Date: 2/14/2022 |

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**Missouri Army National Guard**
**St. Louis, Missouri**

**LOG OF BORING: B-7**

**Project No. J032996.04**

LOG OF BORING 2002 WL J032996.04 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/10/22

Surface Elevation: 538.5 Datum: NAVD88

Completion Date: 1/26/2022

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Asphalt - 6 inches | | | |
| | FILL: asphalt, sand and gravel | | 7-10-3 | SS1 |
| | Soft to medium stiff, brown, LEAN CLAY - (CL) | | 2-3-3 | SS2 |
| 5 | | | 1-2-2 | SS3 |
| 10 | | | 91 | ST4 |
| 15 | | | 1-2-3 | SS5 |
| 20 | Boring terminated at 20 feet. | | 1-2-3 | SS6 |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

WATER CONTENT, %

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

TD DRILLER RFW LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 75 %

**REMARKS:**

| Drawn by: WAH | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 1/27/2022 | Date: 2/14/2022 | Date: 2/14/2022 |

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**St. Louis, Missouri**

**LOG OF BORING: B-8**

**Project No. J032996.04**

LOG OF BORING 2002 WL J032996.04 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/10/22

Surface Elevation: 534.2 Datum: NAVD88

Completion Date: 1/26/2022

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Asphalt - 12 inches | | | |
| | FILL: asphalt, sand, gravel and concrete | | 12-24-21 | SS1 |
| | | | 12-16-16 | SS2 |
| 5 | | | 15-20-21 | SS3 |
| | | | 15-20-23 | SS4 |
| 10 | | | | |
| | | | 13-15-18 | SS5 |
| 15 | | | | |
| | Stiff to medium stiff, brown, LEAN CLAY - (CL) | | 3-4-5 | SS6 |
| 20 | | | | |
| | | | 92 | ST7 |
| 25 | | | | |
| | | | 2-3-3 | SS8 |
| 30 | | | | |
| | Medium stiff, brown, FAT CLAY - CH | | 2-3-4 | SS9 |
| 35 | | | | |
| | Very stiff, brown and tan, SHALY CLAY - CH | | 5-7-13 | SS10 |
| 40 | Boring terminated at 40 feet. | | | |

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

WATER CONTENT, %

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

ENCOUNTERED AT 27 FEET ▽

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

TD DRILLER RFW LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 75 %

**REMARKS:**

| Drawn by: WAH | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 1/27/2022 | Date: 2/14/2022 | Date: 2/14/2022 |

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**Missouri Army National Guard**
**St. Louis, Missouri**

**LOG OF BORING: B-9**

**Project No. J032996.04**

LOG OF BORING 2002 WL J032996.04 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/10/22

Surface Elevation: 520.7 Datum: NAVD88

Completion Date: 1/25/2022

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | FILL: asphalt, sand, gravel and concrete | | | |
| | | | 11-24-26 | SS1 |
| 5 | | | 12-24-24 | SS2 |
| | | | 13-17-18 | SS3 |
| | Medium stiff, to stiff, gray to brown, LEAN CLAY - CL | | | |
| 10 | | | 2-2-3 | SS4 |
| | | | 95 | ST5 |
| 15 | | | | |
| | | | 3-4-5 | SS6 |
| 20 | Boring terminated at 20 feet. | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

WATER CONTENT, %

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

TD DRILLER RFW LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 75 %

**REMARKS:**

| Drawn by: WAH | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 1/27/2022 | Date: 2/14/2022 | Date: 2/14/2022 |

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**St. Louis, Missouri**

**LOG OF BORING: B-10**

**Project No. J032996.04**

LOG OF BORING 2002 WL J032996.04 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/10/22

Surface Elevation: 519.3 Datum: NAVD88

Completion Date: 1/25/2022

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Topsoil - 12 inches | | | |
| | Medium stiff to stiff, brown, LEAN CLAY - (CL) | | 2-3-4 | SS1 |
| | | | 2-3-4 | SS2 |
| 5 | | | 2-3-3 | SS3 |
| | | | 92 | ST4 |
| 10 | | | | |
| | | | 1-2-3 | SS5 |
| 15 | | | | |
| | | | 2-3-3 | SS6 |
| 20 | | | | |
| | Stiff, brown and tan, SHALY CLAY - CH | | 3-4-6 | SS7 |
| 25 | | | | |
| | Weathered, gray SHALE | | 30-50/3" | SS8 |
| | Sampler and auger refusal at 29.3 feet. | | | |
| 30 | | | | |
| 35 | | | | |

**SHEAR STRENGTH, tsf**

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

**STANDARD PENETRATION RESISTANCE**

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

**WATER CONTENT, %**

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

TD DRILLER RFW LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 75 %

**REMARKS:**

| Drawn by: WAH | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 1/27/2022 | Date: 2/14/2022 | Date: 2/14/2022 |

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**Missouri Army National Guard**
**St. Louis, Missouri**

**LOG OF BORING: B-11**

**Project No. J032996.04**

LOG OF BORING 2002 WL J032996.04 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/10/22

Surface Elevation: 542.7 Completion Date: 1/25/2022

Datum: NAVD88

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Asphalt - 7 inches | | | |
| | Crushed rock - 11 inches | | | |
| | FILL: concrete debris | | | |
| 5 | Medium stiff, brown, LEAN CLAY - CL | | 3-4-4 | SS1 |
| | | | 2-2-3 | SS2 |
| 10 | | | 2-3-4 | SS3 |
| | Boring terminated at 10 feet. | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

WATER CONTENT, %

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

TD DRILLER RFW LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 75 %

**REMARKS:**

| Drawn by: WAH | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 1/27/2022 | Date: 2/14/2022 | Date: 2/14/2022 |

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**St. Louis, Missouri**

**LOG OF BORING: B-12**

**Project No. J032996.04**

LOG OF BORING 2002 WL J032996.04 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/10/22

Surface Elevation: 533.2 Completion Date: 1/25/2022

Datum: NAVD88

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Asphalt - 6 inches | | | |
| | FILL: asphalt, gravel, sand and concrete | | | |
| | | | 9-23-25 | SS1 |
| 5 | | | | |
| | | | 16-17-11 | SS2 |
| 10 | | | | |
| | Medium stiff, brown and gray, LEAN CLAY - CL | | | |
| | | | 2-3-4 | SS3 |
| 15 | Boring terminated at 15 feet. | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

SHEAR STRENGTH, tsf

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

STANDARD PENETRATION RESISTANCE

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

WATER CONTENT, %

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

TD DRILLER RFW LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 75 %

**REMARKS:**

| Drawn by: WAH | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 1/27/2022 | Date: 2/14/2022 | Date: 2/14/2022 |

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**New Readiness Center**
**Missouri Army National Guard**
**St. Louis, Missouri**

**LOG OF BORING: P-1**

**Project No. J032996.04**

LOG OF BORING 2002 WL J032996.04 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/10/22

Surface Elevation: 537.6 Datum: NAVD88

Completion Date: 1/25/2022

| DEPTH IN FEET | DESCRIPTION OF MATERIAL | GRAPHIC LOG | DRY UNIT WEIGHT (pcf) SPT BLOW COUNTS CORE RECOVERY/RQD | SAMPLES |
|---|---|---|---|---|
| | Asphalt - 10 inches | | | |
| | Crushed rock - 12 inches | | | |
| | FILL: gravel, sand and silt | | 6-5-3 | SS1 |
| | Medium stiff, gray, LEAN CLAY - CL | | 5-3-4 | SS2 |
| 5 | | | 5-3-5 | SS3 |
| | Boring terminated at 6.5 feet. | | | |
| 10 | | | | |
| 15 | | | | |
| 20 | | | | |
| 25 | | | | |
| 30 | | | | |
| 35 | | | | |

**SHEAR STRENGTH, tsf**

Δ - UU/2 ○ - QU/2 □ - SV

0.5 1.0 1.5 2.0 2.5

**STANDARD PENETRATION RESISTANCE**

▲ N-VALUE (BLOWS PER FOOT)

(ASTM D 1586)

**WATER CONTENT, %**

PL 10 20 30 40 50 LL

NOTE: STRATIFICATION LINES REPRESENT THE APPROXIMATE BOUNDARIES BETWEEN SOIL TYPES AND THE TRANSITION MAY BE GRADUAL. GRAPHIC LOG FOR ILLUSTRATION PURPOSES ONLY.

**GROUNDWATER DATA**

X FREE WATER NOT ENCOUNTERED DURING DRILLING

**DRILLING DATA**

___ AUGER 3 3/4" HOLLOW STEM

WASHBORING FROM ___ FEET

TD DRILLER RFW LOGGER

CME 550X DRILL RIG

HAMMER TYPE Auto

HAMMER EFFICIENCY 75 %

**REMARKS:**

| Drawn by: WAH | Checked by: SK | App'vd. by: DWG |
|---|---|---|
| Date: 1/27/2022 | Date: 2/14/2022 | Date: 2/14/2022 |

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**New Readiness Center**
**Missouri Army National Guard**
**St. Louis, Missouri**

**LOG OF BORING: P-2**

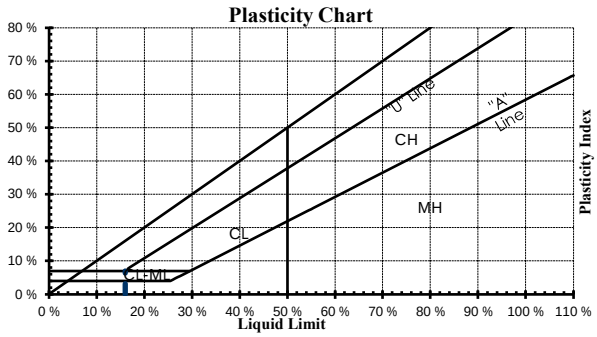
**Project No. J032996.04**

LOG OF BORING 2002 WL J032996.04 BORING LOGS.GPJ 00 CLONE ME.GPJ 2/10/22

# BORING LOG: TERMS AND SYMBOLS

## LEGEND

| | |
|---|---|
| CS | Continuous Sampler |
| GB | Grab Sample |
| NQ | NQ Rock Core |
| PST | Three-Inch Diameter Piston Tube Sample |
| SS | Split-Spoon Sample (Standard Penetration Test) |
| ST | Three-Inch Diameter Shelby Tube Sample |
| * | Sample Not Recovered |
| PL | Plastic Limit (ASTM D4318) |
| LL | Liquid Limit (ASTM D4318) |
| SV | Shear Strength from Field Vane (ASTM D2573) |
| UU | Shear Strength from Unconsolidated-Undrained Triaxial Compression Test (ASTM D2850) |
| QU | Shear Strength from Unconfined Compression Test (ASTM D2166) |




## SOIL GRAIN SIZE

US STANDARD SIEVE

| 12" | 3" | 3/4" | 4 | 10 | 40 | 200 |
|---|---|---|---|---|---|---|

| BOULDERS | COBBLES | GRAVEL | | SAND | | | SILT | CLAY |
|---|---|---|---|---|---|---|---|---|
| | | COARSE | FINE | COARSE | MEDIUM | FINE | | |

| 300 | 76.2 | 19.1 | 4.76 | 2.00 | 0.42 | 0.074 | 0.005 |
|---|---|---|---|---|---|---|---|

SOIL GRAIN SIZE IN MILLIMETERS

## UNIFIED SOIL CLASSIFICATION SYSTEM

| Major Divisions | | | Symbol | Description |
|---|---|---|---|---|
| Coarse-Grained Soils (More than 50% Larger than No. 200 Sieve Size) | Gravel and Gravelly Soil | Clean Gravels Little or no Fines | GW | Well-Graded Gravel, Gravel- Sand Mixture |
| | | | GP | Poorly-Graded Gravel, Gravel-Sand Mixture |
| | | Gravels with Appreciable Fines | GM | Silty Gravel, Gravel-Sand-Silt Mixture |
| | | | GC | Clayey-Gravel, Gravel-Sand-Clay Mixture |
| | Sand and Sandy Soils | Clean Sands Little or no Fines | SW | Well-Graded Sand, Gravelly Sand |
| | | | SP | Poorly-Graded Sand, Gravelly Sand |
| | | Sands with Appreciable Fines | SM | Silty Sand, Sand-Silt Mixture |
| | | | SC | Clayey-Sand, Sand-Clay Mixture |
| Fine-Grained Soils (More than 50% Smaller than No. 200 Sieve Size) | Silts and Clays | Liquid Limit Less Than 50 | ML | Silt, Sandy Silt, Clayey Silt, Slight Plasticity |
| | | | CL | Lean Clay, Sandy Clay, Silty Clay, Low to Medium Plasticity |
| | | | OL | Organic Silts or Lean Clays, Low Plasticity |
| | Silts and Clays | Liquid Limit Greater Than 50 | MH | Silt, High Plasticity |
| | | | CH | Fat Clay, High Plasticity |
| | | | OH | Organic Clay, Medium to High Plasticity |
| | Highly Organic Soils | | PT | Peat, Humus, Swamp Soil |

## STRENGTH OF COHESIVE SOILS

| Consistency | Undrained Shear Strength (tsf) | Unconfined Comp. Strength (tsf) |
|---|---|---|
| Very Soft | less than 0.125 | less then 0.25 |
| Soft | 0.125 to 0.25 | 0.25 to 0.5 |
| Medium Stiff | 0.25 to 0.5 | 0.5 to 1.0 |
| Stiff | 0.5 to 1.0 | 1.0 to 2.0 |
| Very Stiff | 1.0 to 2.0 | 2.0 to 3.0 |
| Hard | greater than 2.0 | greater than 4.0 |

## DENSITY OF GRANULAR SOILS

| Descriptive Term | Approximate $N_{60}$-Value Range |
|---|---|
| Very Loose | 0 to 4 |
| Loose | 5 to 10 |
| Medium Dense | 11 to 30 |
| Dense | 31 to 50 |
| Very Dense | >50 |

N-Value (Blow Count) is the last two, 6-inch drive increments (i.e. 4/7/9, N = 7 + 9 = 16). Values are shown as a summation on the grid plot and shown in the Unit Dry Weight/SPT column.

## RELATIVE COMPOSITION

| | |
|---|---|
| Trace | 0 to 10% |
| Little | 10 to 20% |
| Some | 20 to 35% |
| And | 35 to 50% |

## OTHER TERMS

Layer - Inclusion greater than 3 inches thick.

Seam - Inclusion 1/8-inch to 3 inches thick

Parting - Inclusion less than 1/8-inch thick

Pocket - Inclusion of material that is smaller than sample diameter

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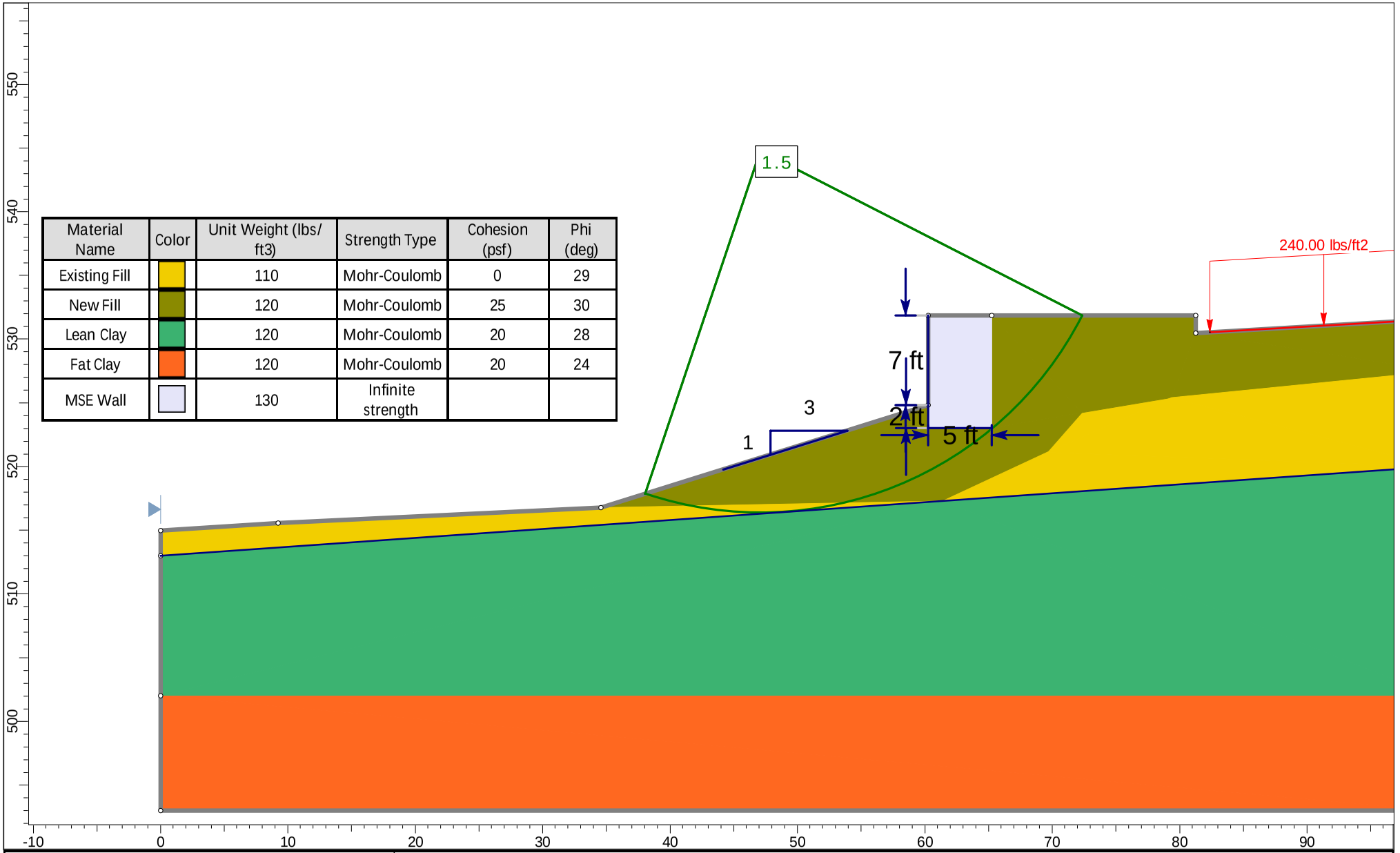
Relative composition and Unified Soil Classification System (USCS) designations are based on visual descriptions and are approximate only. If laboratory tests were performed to classify the soil, the USCS designation is shown in parenthesis.

# APPENDIX E – SLOPE STABILITY ANALYSIS RESULTS

| Material Name | Color | Unit Weight (lbs/ ft3) | Strength Type | Cohesion (psf) | Phi (deg) |
|---|---|---|---|---|---|
| Existing Fill | | 110 | Mohr-Coulomb | 0 | 29 |
| New Fill | | 120 | Mohr-Coulomb | 25 | 30 |
| Lean Clay | | 120 | Mohr-Coulomb | 20 | 28 |
| Fat Clay | | 120 | Mohr-Coulomb | 20 | 24 |
| MSE Wall | | 130 | Infinite strength | | |

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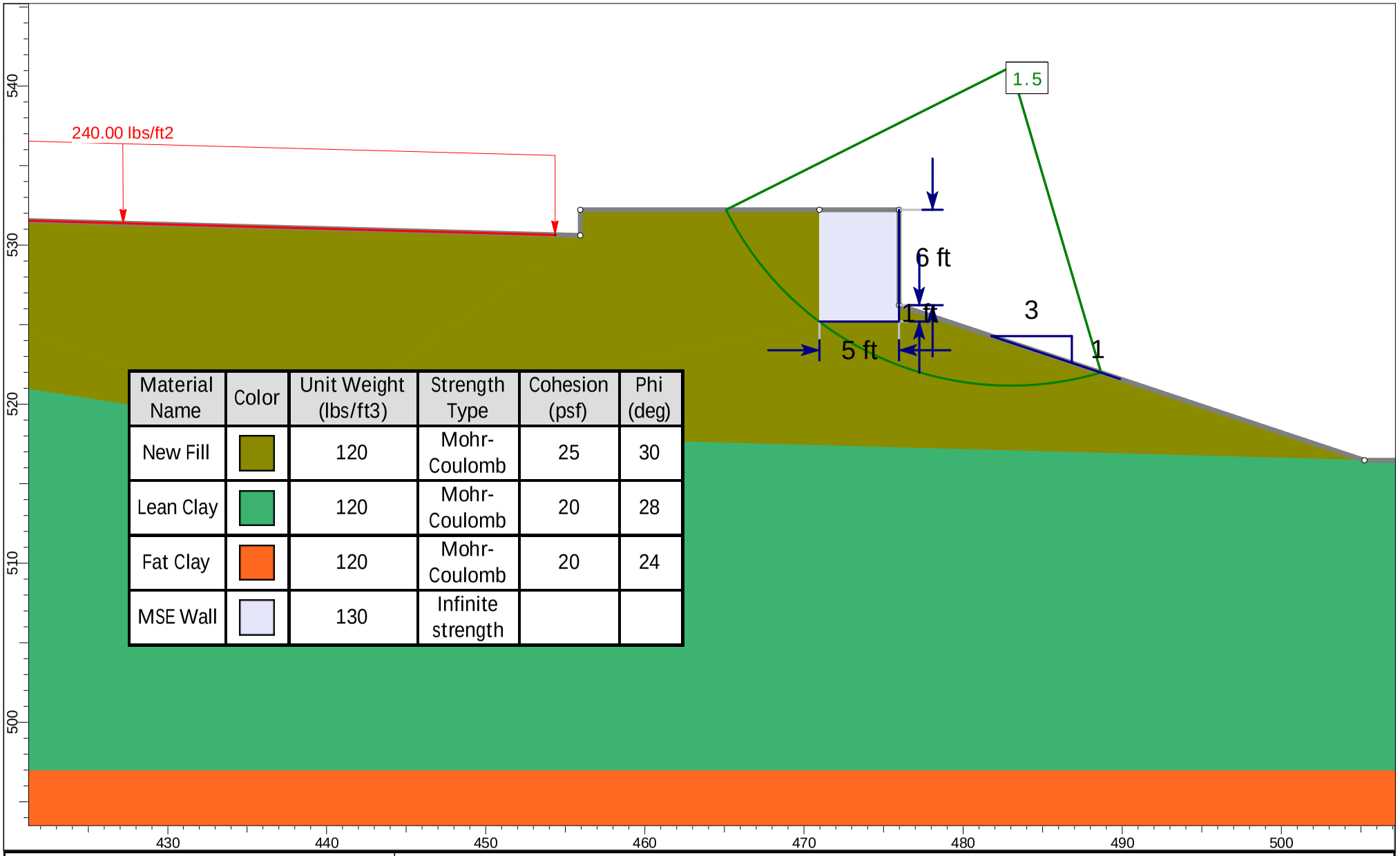
SLIDEINTERPRET 9.023

| | |
|---|---|
| Project | New Readiness Center, Missouri National Guard |
| *Analysis Description* | Section AA, Long-Term Stability, Effective Stress Analysis |
| *Drawn By* | sk |
| *Figure* | *File* AA.slmd |




| Material Name | Color | Unit Weight (lbs/ft3) | Strength Type | Cohesion (psf) | Phi (deg) |
|---|---|---|---|---|---|
| New Fill | | 120 | Mohr-Coulomb | 25 | 30 |
| Lean Clay | | 120 | Mohr-Coulomb | 20 | 28 |
| Fat Clay | | 120 | Mohr-Coulomb | 20 | 24 |
| MSE Wall | | 130 | Infinite strength | | |

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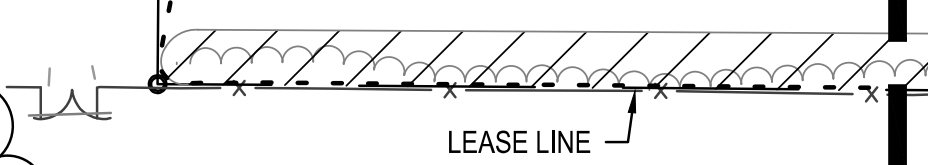
A Universal Engineering Sciences Company

SLIDEINTERPRET 9.023

| | |
|---|---|
| Project | New Readiness Center, Missouri National Guard |
| Analysis Description | Section BB, Long-Term Stability, Effective Stress Analysis |
| Drawn By | sk |
| Figure | |
| File | AA.slmd |




# MSD BENCHMARK

THIS BENCHMARK IS INCLUDED FOR MSD REFERENCE ONLY. THIS POINT WAS NOT TIED INTO THE SURVEY. THE POINT IS FROM CHAPTER 5 (NEAR T47N-R7E) OF THE ST LOUIS COUNTY, MISSOURI BENCHMARK SYSTEM DATED 01/18/2017.

[ 5013] ST. LOUIS COUNTY BENCHMARK ELEVATION 569.92 (NGVD 29 DATUM)

"Sq" ON TOP AND AT NORTH END OF EAST ABUTMENT OF DUNN ROAD OVERPASS OF HIGHWAY 367.
SP MO EAST N=326026± E=272728± METER - ESTIMATED
ROUGH NAD83 LAT=38.770848°± (N/+) LONG=90.238456°± (W/-)

# CONTROL POINTS & BENCHMARKS

BM "A"
CUT " □ " ON NORTH SIDE OF POLE
EASTING: 893023.5326'
NORTHING: 1067181.1675'
ELEVATION: 533.71

CP#1
BAR W/ CAP (OLD CAP)
EASTING: 893102.7097'
NORTHING: 1067711.5771'
ELEVATION: 561.51

CP#2
EASTING: 892405.2870'
NORTHING: 1067812.6975'
ELEVATION: 530.59

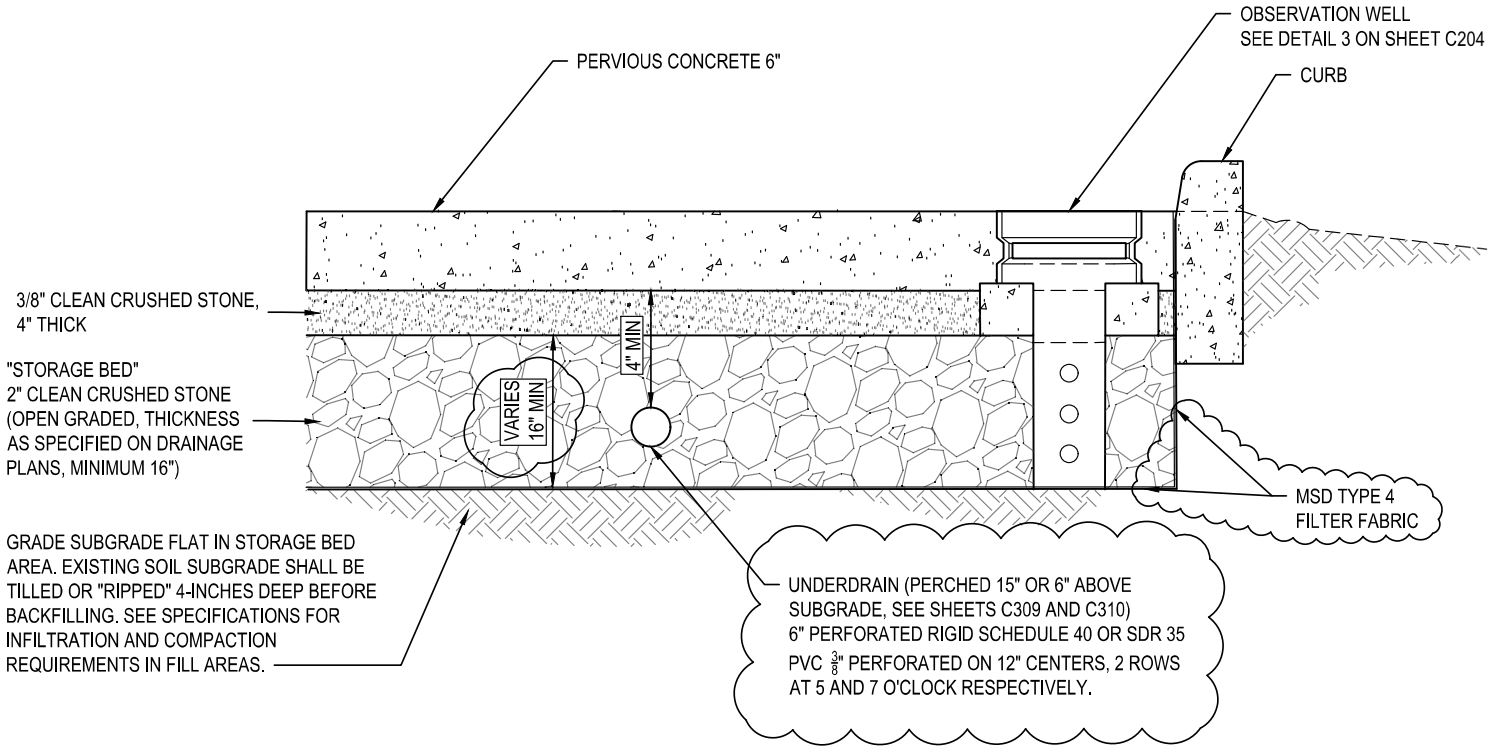
CP#5
BAR W/ CAP
EASTING: 893045.4164'
NORTHING: 1067902.5226'
ELEVATION: 563.51

CP#6
BAR W/ CAP
EASTING: 893093.2881'
NORTHING: 1067087.2606'
ELEVATION: 536.83

CP#7
BAR W/ CAP
EASTING: 893530.3054'
NORTHING: 1067104.5066'
ELEVATION: 551.08

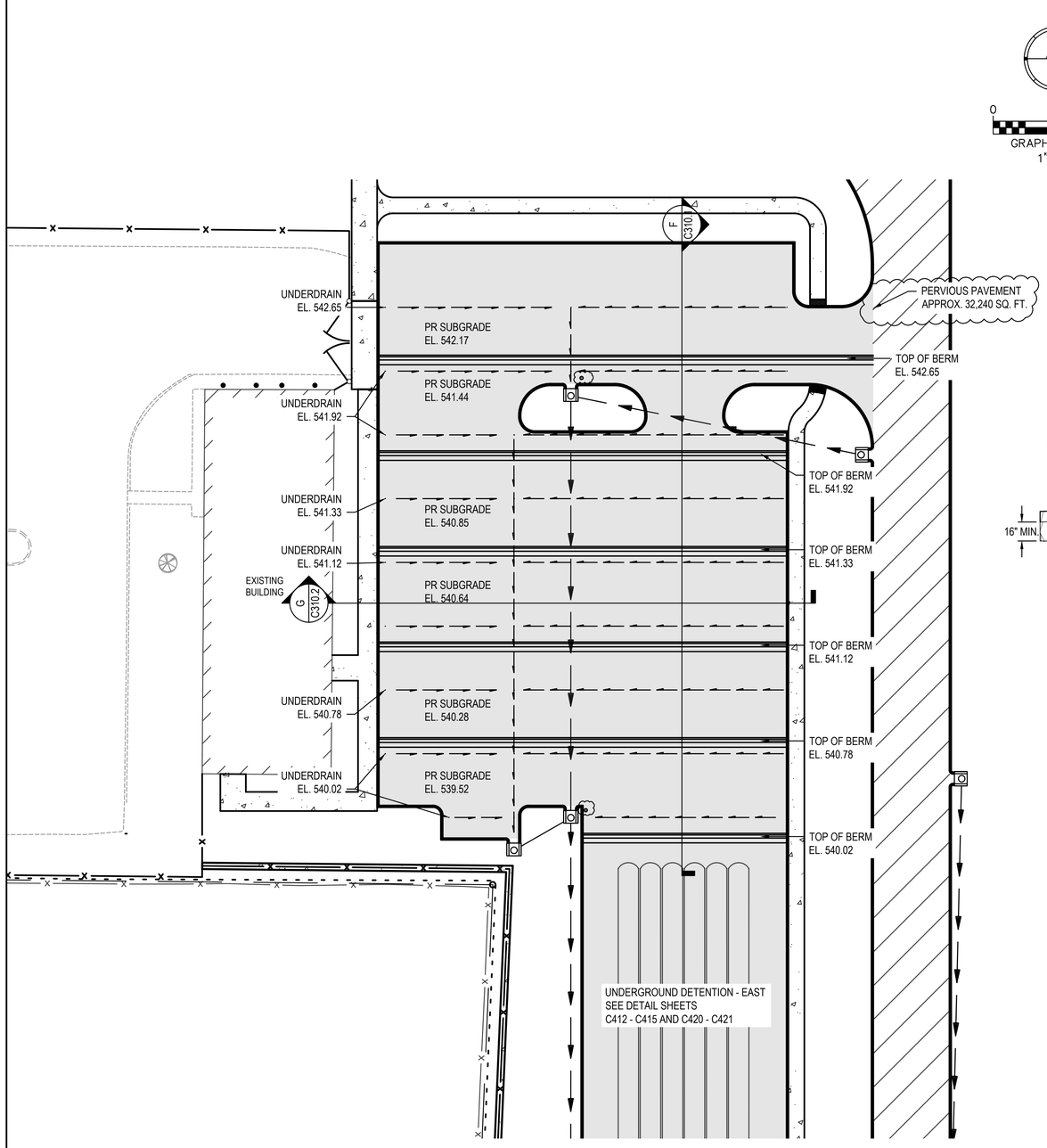
Add to
Sheet C102

# Replace in Sheet C204




3 PERVIOUS CONCRETE PAVEMENT TYPICAL SECTION

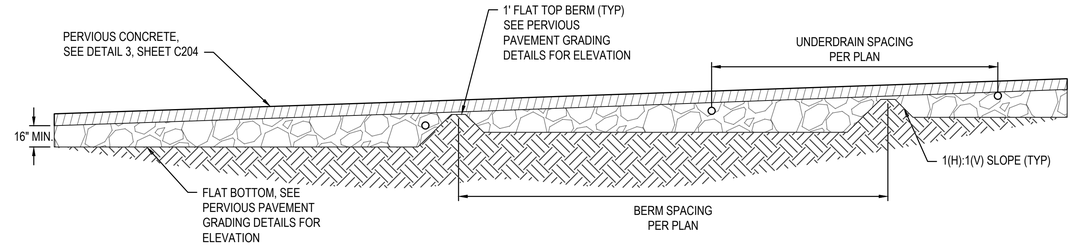
SCALE: NO SCALE




1 PERVIOUS CONCRETE PAVEMENT AREA 2
SCALE: 1" = 20'

**LEGEND**

OBSERVATION WELL, APPROXIMATE LOCATION
SEE DETAIL 2 ON SHEET C204




2 PERVIOUS CONCRETE STORAGE BED TYPICAL SECTION
SCALE: NO SCALE

NOTES:

SEE PERVIOUS CONCRETE PAVEMENT DETAILS ON SHEETS C309 AND C310 FOR ELEVATIONS OF SUBGRADE, TOPS OR BERMS, AND UNDERDRAIN FLOW LINES.

SUBGRADE BETWEEN BERMS SHALL HAVE A CONSTANT ELEVATION. THE MINIMUM DEPTH OF DRAINAGE ROCK SHALL BE 16".

EACH UNDERGROUND BERM SHALL HAVE 1(H):1(V) SLOPES AND A 1' WIDE BERM SET AT THE SAME ELEVATION AS THE FLOW LINE OF THE UPSTREAM UNDERDRAINS TO STORE THE REQUIRED INFILTRATION VOLUME. UNDERDRAINS ARE SET AT 6" ABOVE SUBGRADE IN AREA 2 AND 15" ABOVE SUBGRADE IN AREA 1.

**STATE OF MISSOURI**
**MICHAEL L. PARSON, GOVERNOR**

STATE OF MISSOURI
MICHELLE YVONNE SPILLERS
NUMBER PE-2013031862
PROFESSIONAL ENGINEER

DATE: 05/03/2024
EXPIRES: 12/31/2025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63136

PROJECT # T2150-01
SITE # 6322
FACILITY # 8136322001

REVISION: MSD COMMENTS
DATE: 06/26/2024
REVISION:
DATE:
REVISION:
DATE:
ISSUE DATE: 05/03/2024

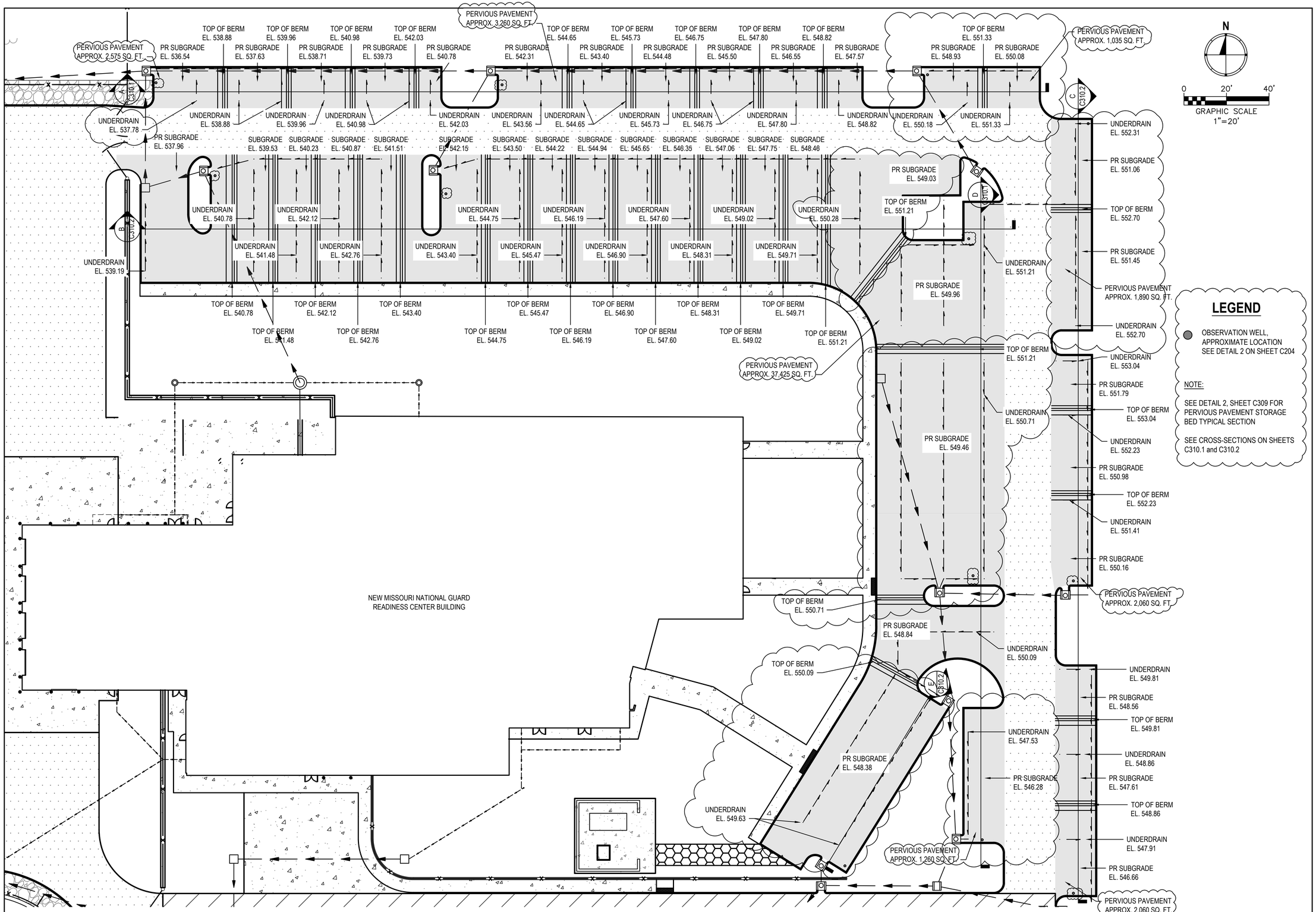
CAD DWG FILE:
DRAWN BY: PJM
CHECKED BY: PHJ
DESIGNED BY: MYS

SHEET TITLE:
Pervious Pavement Grading Details

SHEET NUMBER:
C309

30 OF 272 SHEETS
05/03/2024

MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4




1 PERVIOUS CONCRETE PAVEMENT AREA 1
SCALE: 1" = 20'

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| FACILITY # | 8136322001 |

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DATE:
REVISION:
DATE:
ISSUE DATE: 05/03/2024

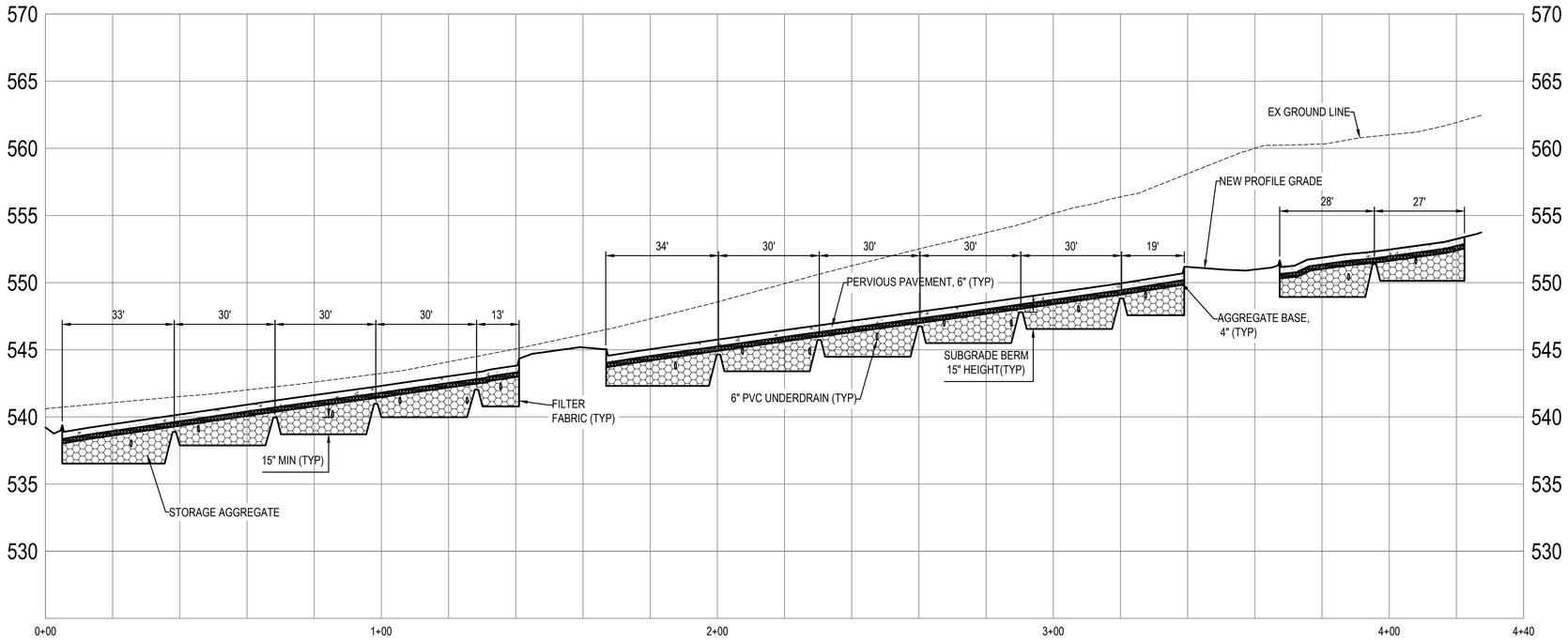
CAD DWG FILE:
DRAWN BY: SW3
CHECKED BY: MYS
DESIGNED BY: SW3

SHEET TITLE:
Pervious Pavement Grading Details

SHEET NUMBER:
C310

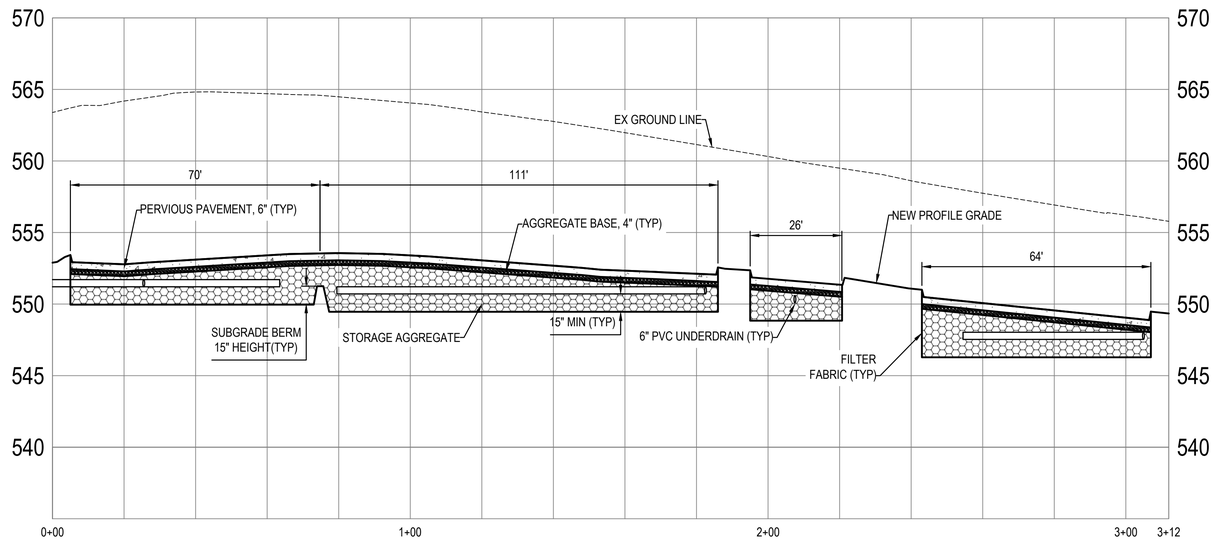
31 OF 272 SHEETS
05/03/2024

MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4



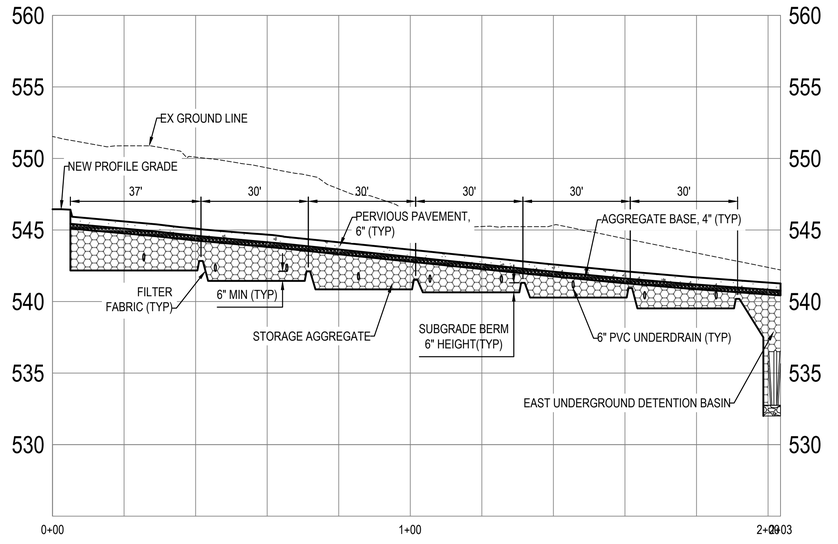

A PERVIOUS CONCRETE PAVEMENT SECTION A

SCALE: H: 1" = 20' V: 1" = 5'




D PERVIOUS CONCRETE PAVEMENT SECTION D

SCALE: H: 1" = 20' V: 1" = 5'




F PERVIOUS CONCRETE PAVEMENT SECTION F

SCALE: H: 1" = 20' V: 1" = 5'

MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4

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MICHAEL L. PARSON, GOVERNOR

STATE OF MISSOURI
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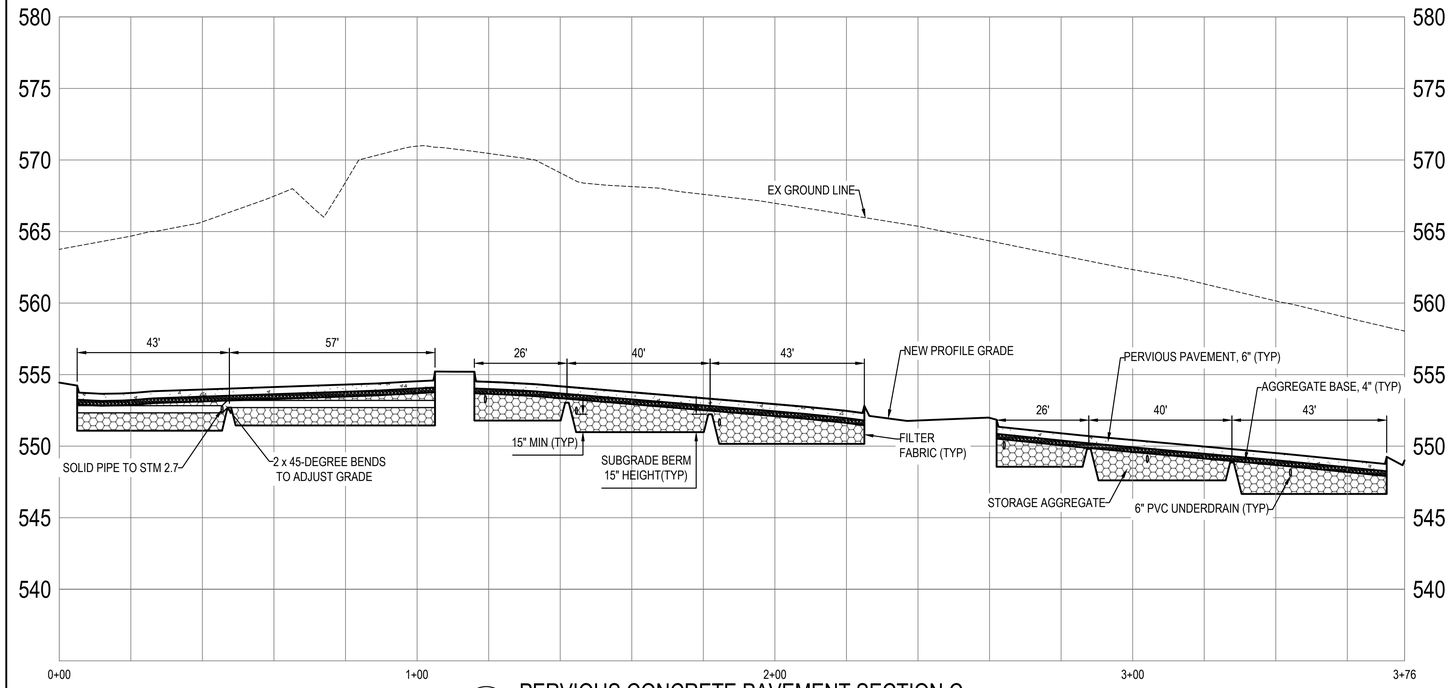
SITE # 6322
FACILITY # 8136322001

REVISION: MSD COMMENTS
DATE: 06/26/2024
REVISION:
DATE:
REVISION:
DATE:
ISSUE DATE: 05/03/2024

CAD DWG FILE:
DRAWN BY: SW3
CHECKED BY: MYS
DESIGNED BY: SW3

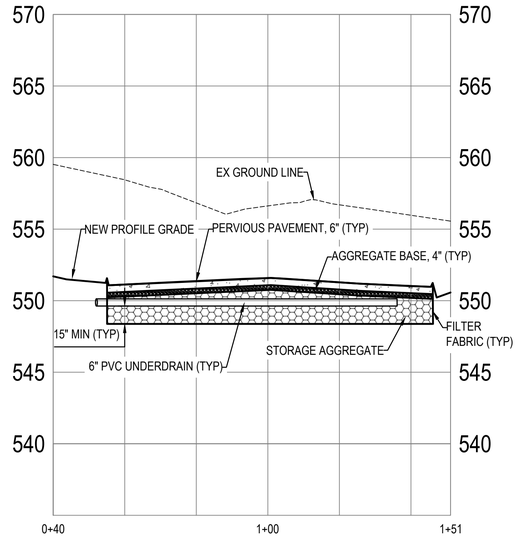
SHEET TITLE:
Pervious Pavement Grading Details

SHEET NUMBER:
C310.1



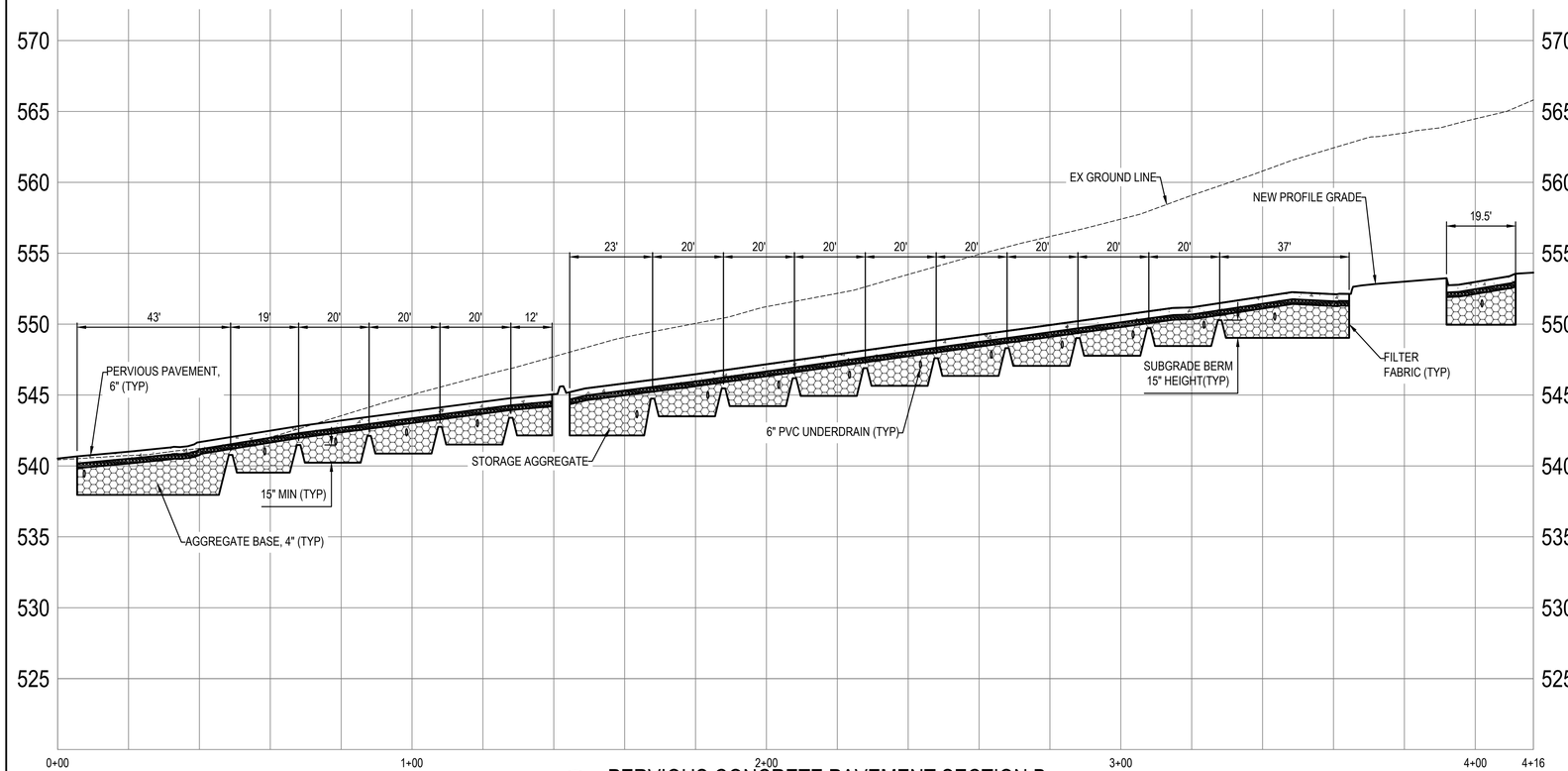

C PERVIOUS CONCRETE PAVEMENT SECTION C

SCALE: H: 1" = 20' V: 1" = 5'



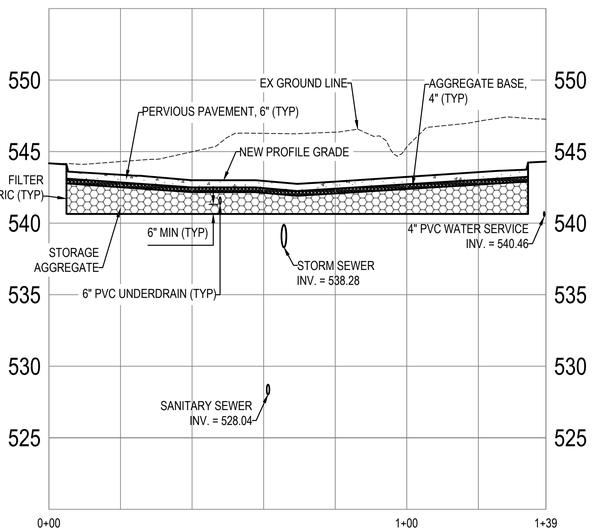

E PERVIOUS CONCRETE PAVEMENT SECTION E

SCALE: H: 1" = 20' V: 1" = 5'




B PERVIOUS CONCRETE PAVEMENT SECTION B

SCALE: H: 1" = 20' V: 1" = 5'




G PERVIOUS CONCRETE PAVEMENT SECTION G

SCALE: H: 1" = 20' V: 1" = 5'

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FACILITY # 8136322001

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DATE:
ISSUE DATE: 05/03/2024

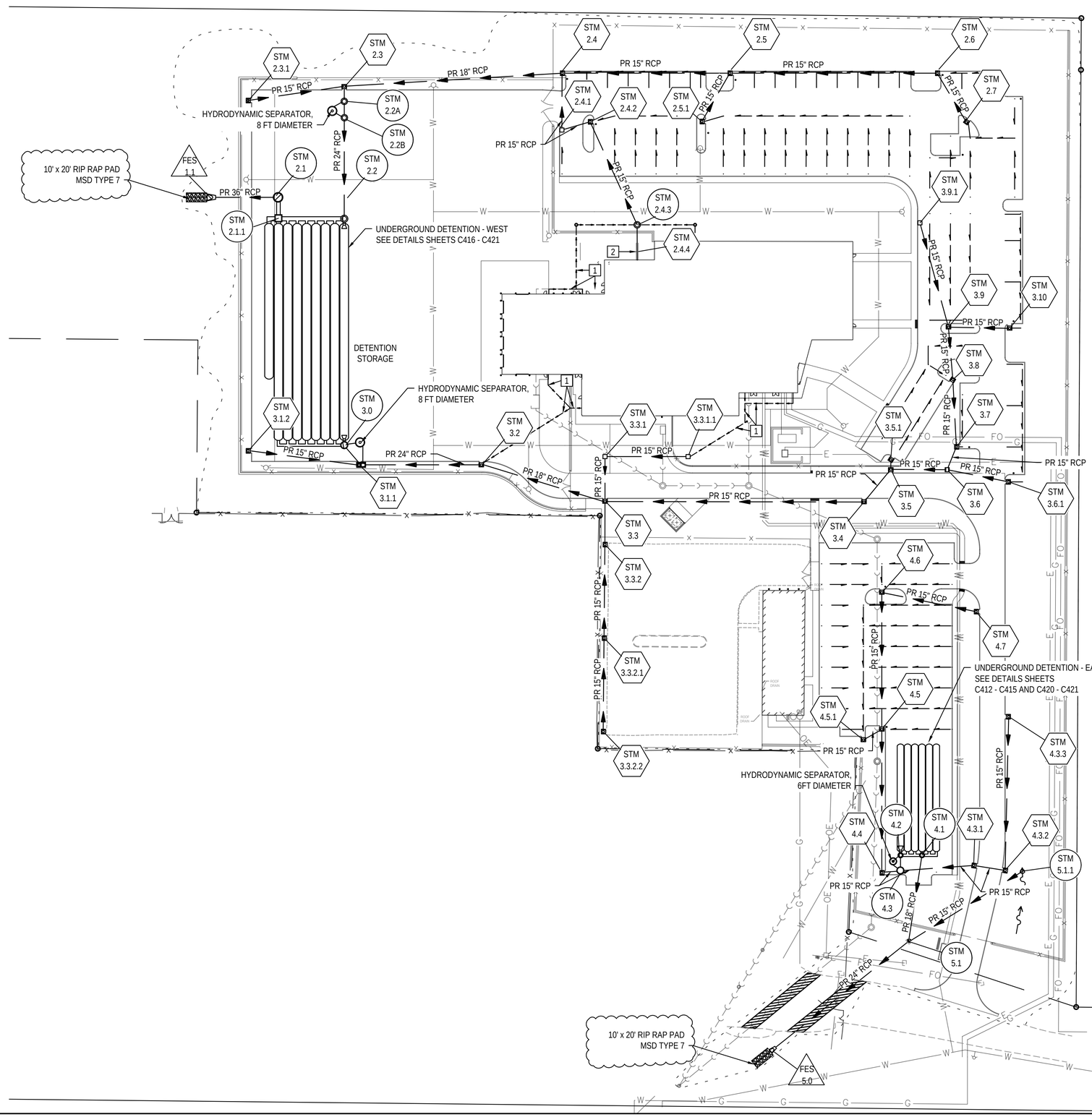
CAD DWG FILE:
DRAWN BY: SW3
CHECKED BY: MYS
DESIGNED BY: SW3

SHEET TITLE:
Pervious Pavement Grading Details

SHEET NUMBER:
C310.2

31 OF 272 SHEETS
05/03/2024

MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4




N

0 50' 100'

GRAPHIC SCALE
1"=50'

## KEYED NOTES

1. 12" PVC ROOF DRAINS
2. TRENCH DRAIN, SEE DETAIL 3 ON SHEET C408

## DRAINAGE PLAN LEGEND

UNDERDRAINS FOR PERVIOUS PAVEMENT - 6" PERFORATED RIGID SCHEDULE 40 OR SDR 35 PVC. 3/8" PERFORATED ON 12" CENTERS, @ 5 AND 7 O'CLOCK RESPECTIVELY.

STM — OPEN INLET

STM — CLOSED LID

FES — FLARED END SECTION

**STATE OF MISSOURI**
**MICHAEL L. PARSON, GOVERNOR**

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MICHELLE YVONNE SPILLERS
NUMBER PE-2013031862
PROFESSIONAL ENGINEER

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| PROJECT # | T2150-01 |
| SITE # | 6322 |
| FACILITY # | 8136322001 |

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REVISION:
DATE:
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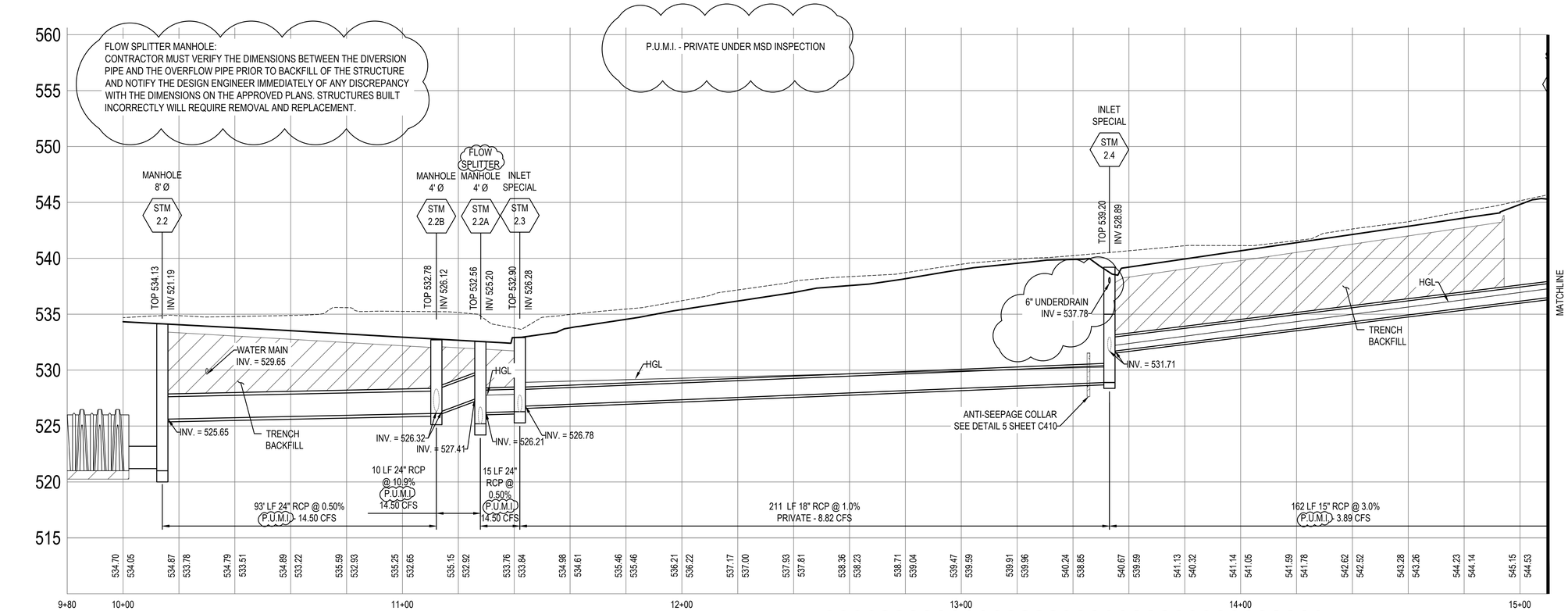
CAD DWG FILE:
DRAWN BY: AJN
CHECKED BY: PHJ
DESIGNED BY: MYS

SHEET TITLE:
Drainage Plan

SHEET NUMBER:
C401

32 OF 272 SHEETS
05/03/2024

MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4

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SITE # 6322
FACILITY # 8136322001

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DATE: 06/26/2024
REVISION:
DATE:
REVISION:
DATE:
ISSUE DATE: 05/03/2024

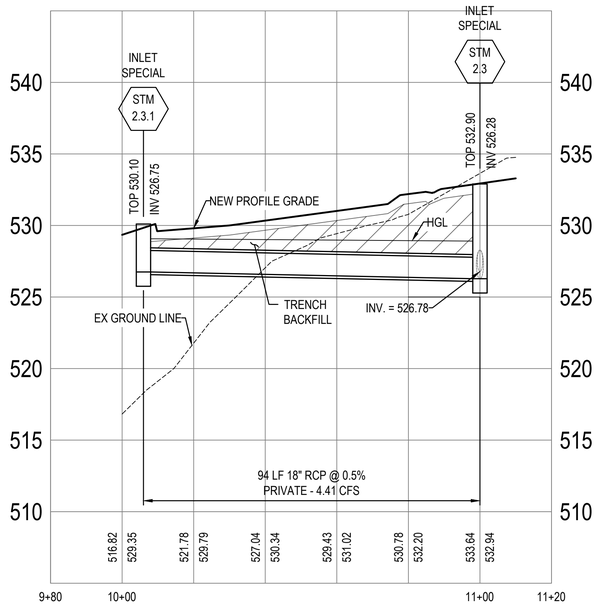
CAD DWG FILE:
DRAWN BY: AJN
CHECKED BY: PHJ
DESIGNED BY: MYS

SHEET TITLE:
Drainage Profiles

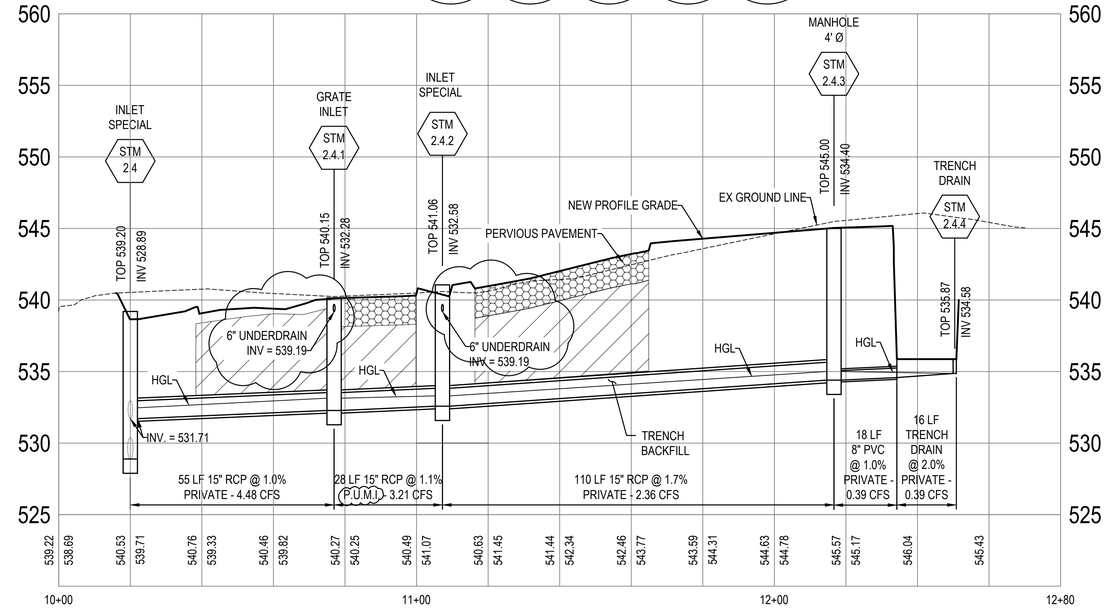
SHEET NUMBER:
C402

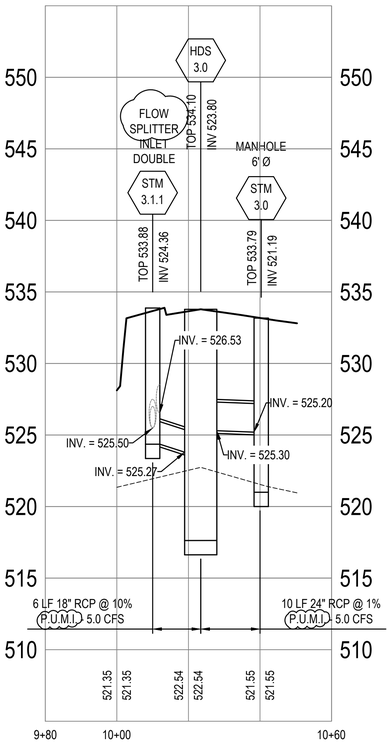
MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4

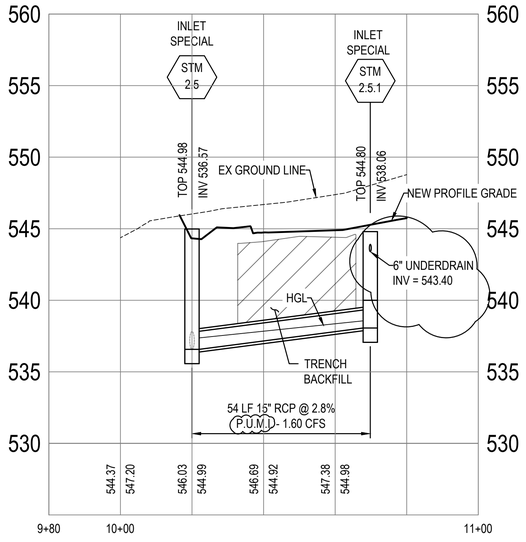
P.U.M.I. - PRIVATE UNDER MSD INSPECTION

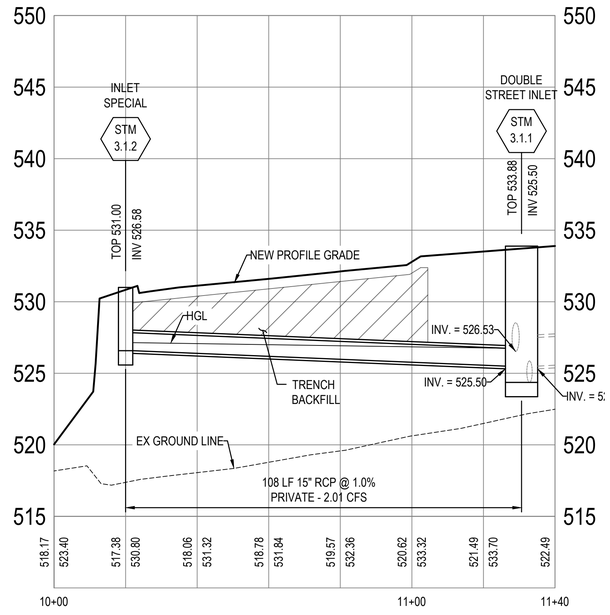


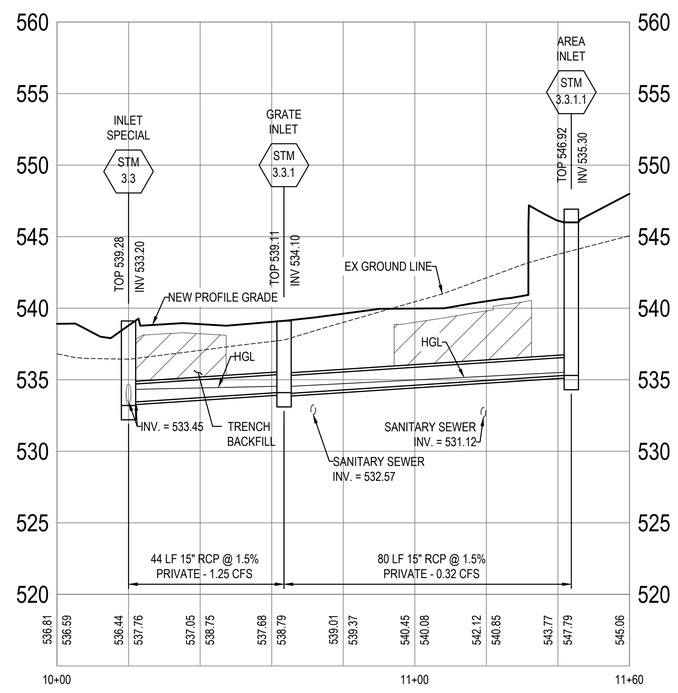

FLOW SPLITTER MANHOLE:
CONTRACTOR MUST VERIFY THE DIMENSIONS BETWEEN THE DIVERSION PIPE AND THE OVERFLOW PIPE PRIOR TO BACKFILL OF THE STRUCTURE AND NOTIFY THE DESIGN ENGINEER IMMEDIATELY OF ANY DISCREPANCY WITH THE DIMENSIONS ON THE APPROVED PLANS. STRUCTURES BUILT INCORRECTLY WILL REQUIRE REMOVAL AND REPLACEMENT.




MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4

STATE OF MISSOURI
MICHAEL L. PARSON, GOVERNOR

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SITE # 6322
FACILITY # 8136322001

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REVISION:
DATE:
REVISION:
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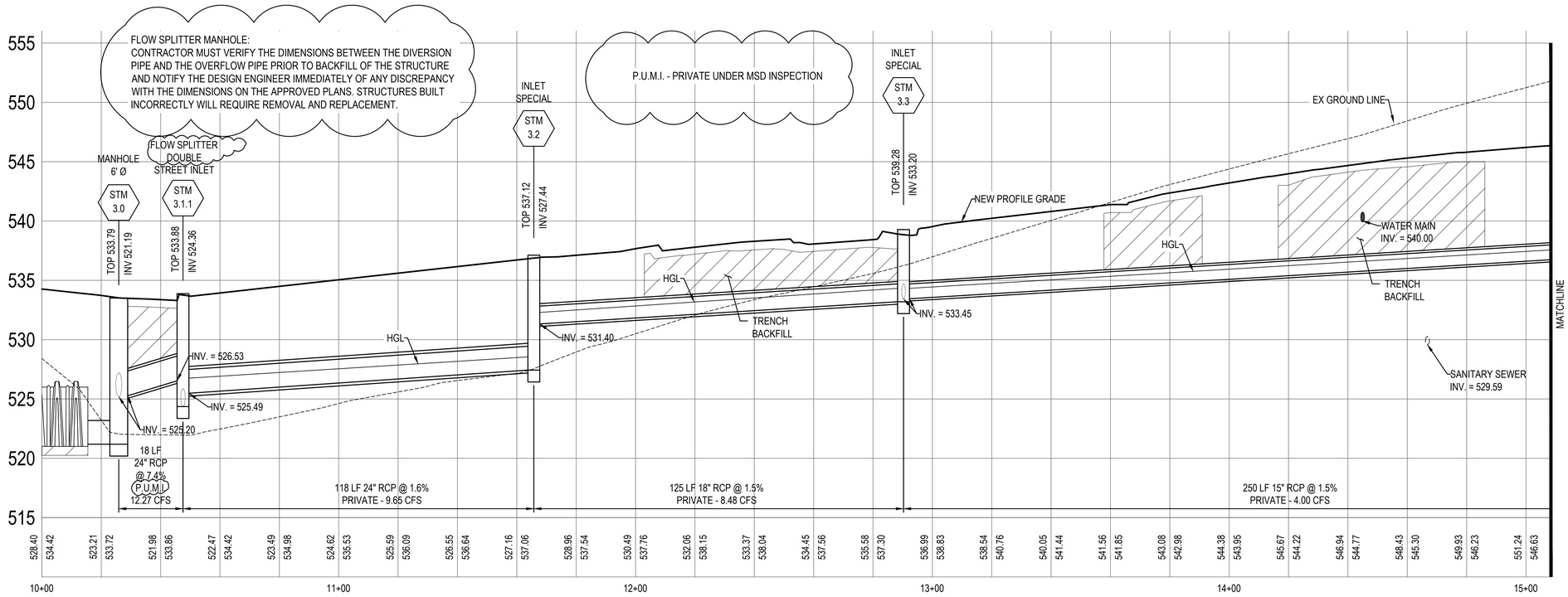
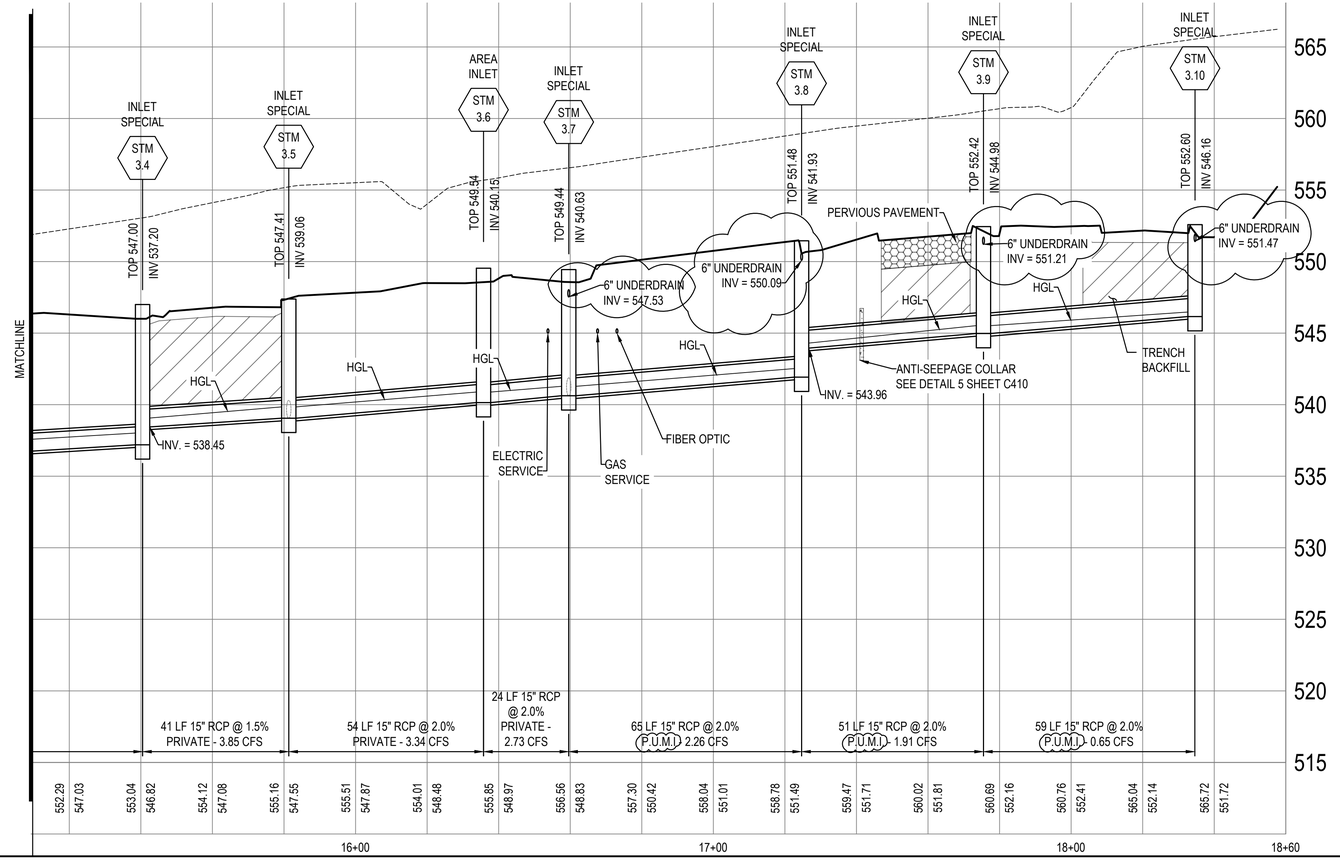
ISSUE DATE: 05/03/2024

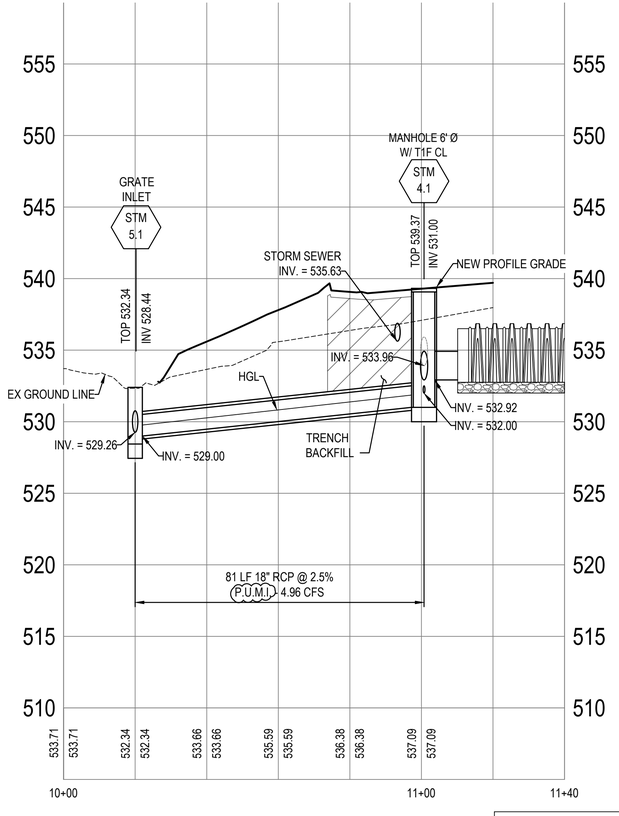
CAD DWG FILE:
DRAWN BY: AJN
CHECKED BY: PHJ
DESIGNED BY: MYS

SHEET TITLE:
Drainage Profiles

SHEET NUMBER:
C403




STATE OF MISSOURI
MICHAEL L. PARSON, GOVERNOR

STATE OF MISSOURI
MICHELLE YVONNE SPILMERS
NUMBER PE-2013031862
PROFESSIONAL ENGINEER

DATE: 05/03/2024
EXPIRES: 12/31/2025

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DEPARTMENT OF PUBLIC SAFETY

MISSOURI ARMY NATIONAL GUARD

CONSTRUCT
BELLEFONTAINE
READINESS CENTER

10625 LEWIS & CLARK BLVD, ST. LOUIS, MO 63136

PROJECT # T2150-01
SITE # 6322
FACILITY # 8136322001

REVISION: MSD COMMENTS
DATE: 06/26/2024
REVISION:
DATE:
REVISION:
DATE:
ISSUE DATE: 05/03/2024

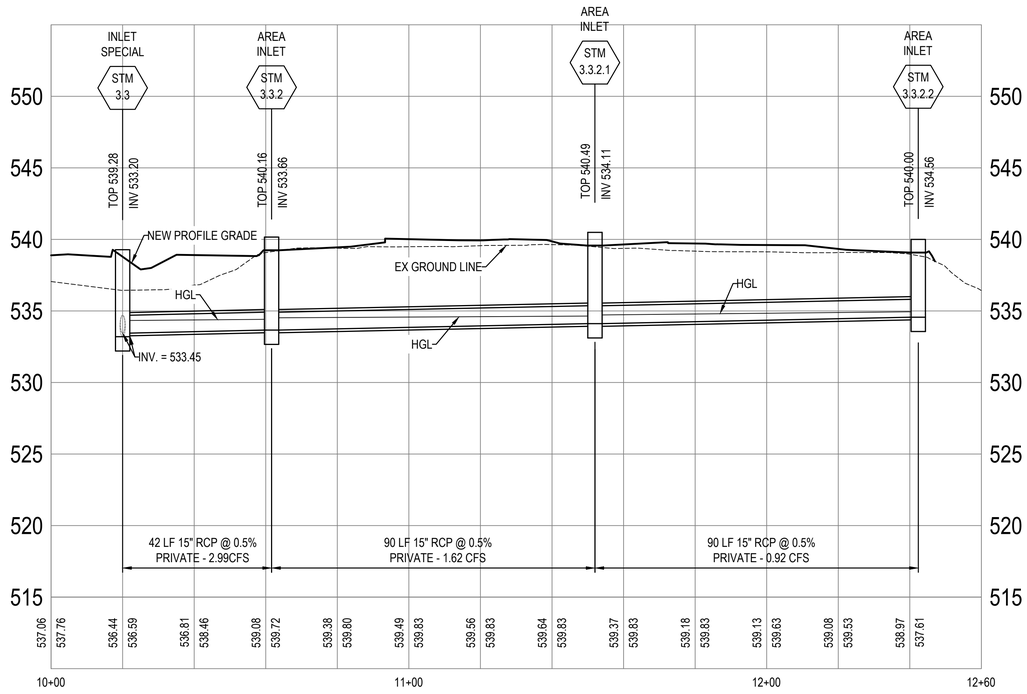
CAD DWG FILE:
DRAWN BY: AJN
CHECKED BY: PHJ
DESIGNED BY: MYS

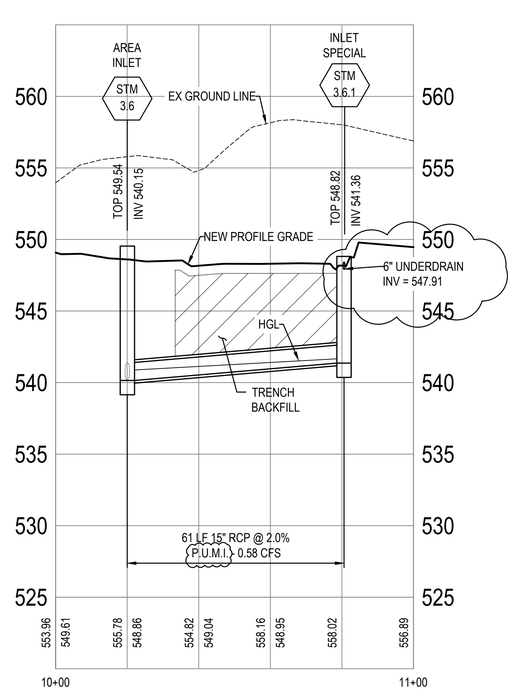
SHEET TITLE:
Drainage Profiles

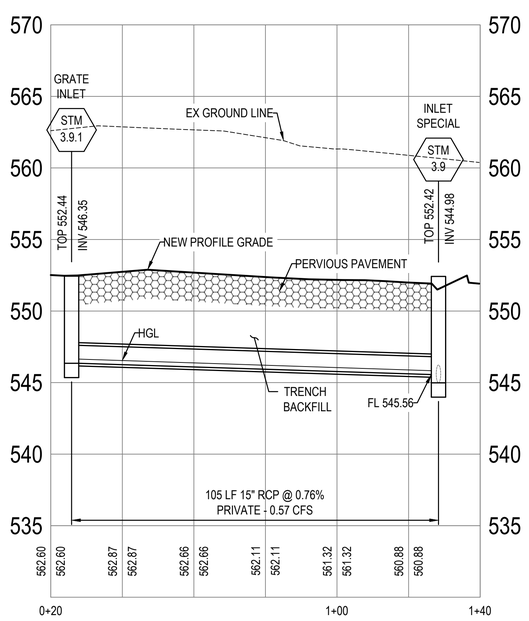
SHEET NUMBER:
C404

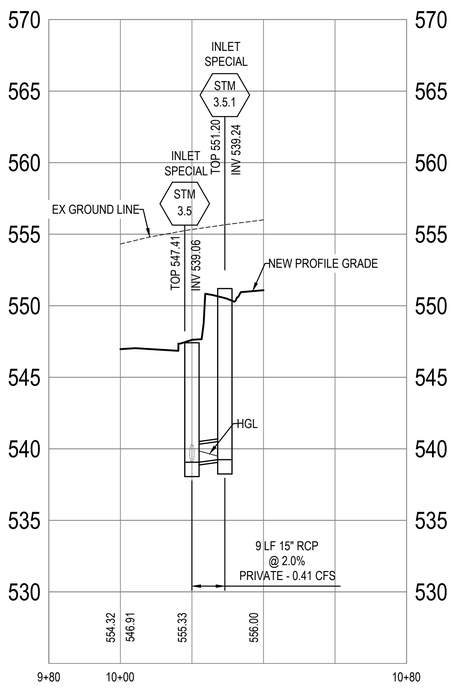
35 OF 272 SHEETS
05/03/2024

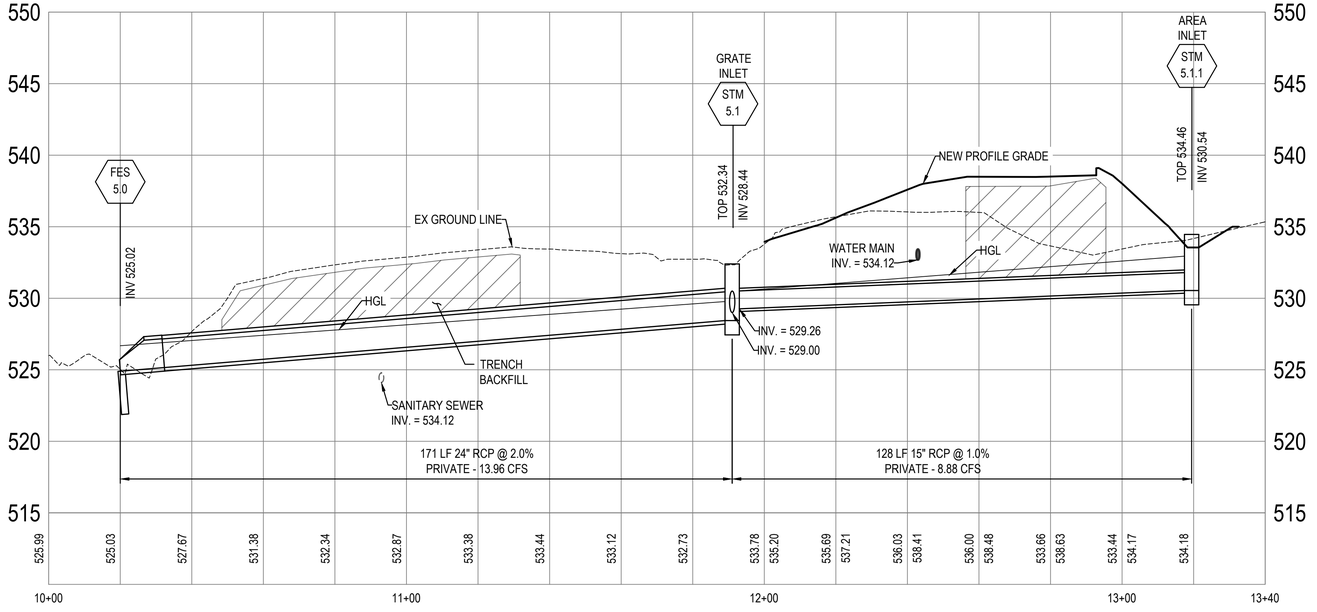
MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4

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CONSTRUCT BELLEFONTAINE READINESS CENTER

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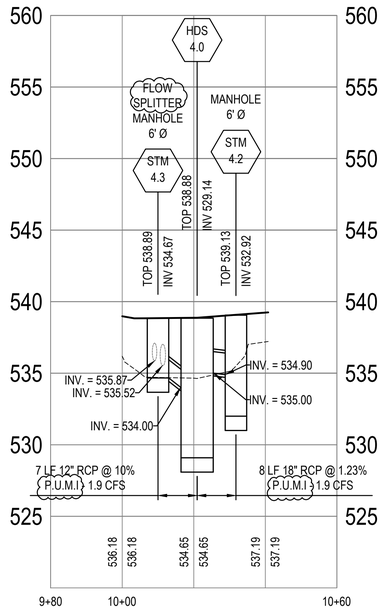
CAD DWG FILE:
DRAWN BY: AJN
CHECKED BY: PHJ
DESIGNED BY: MYS

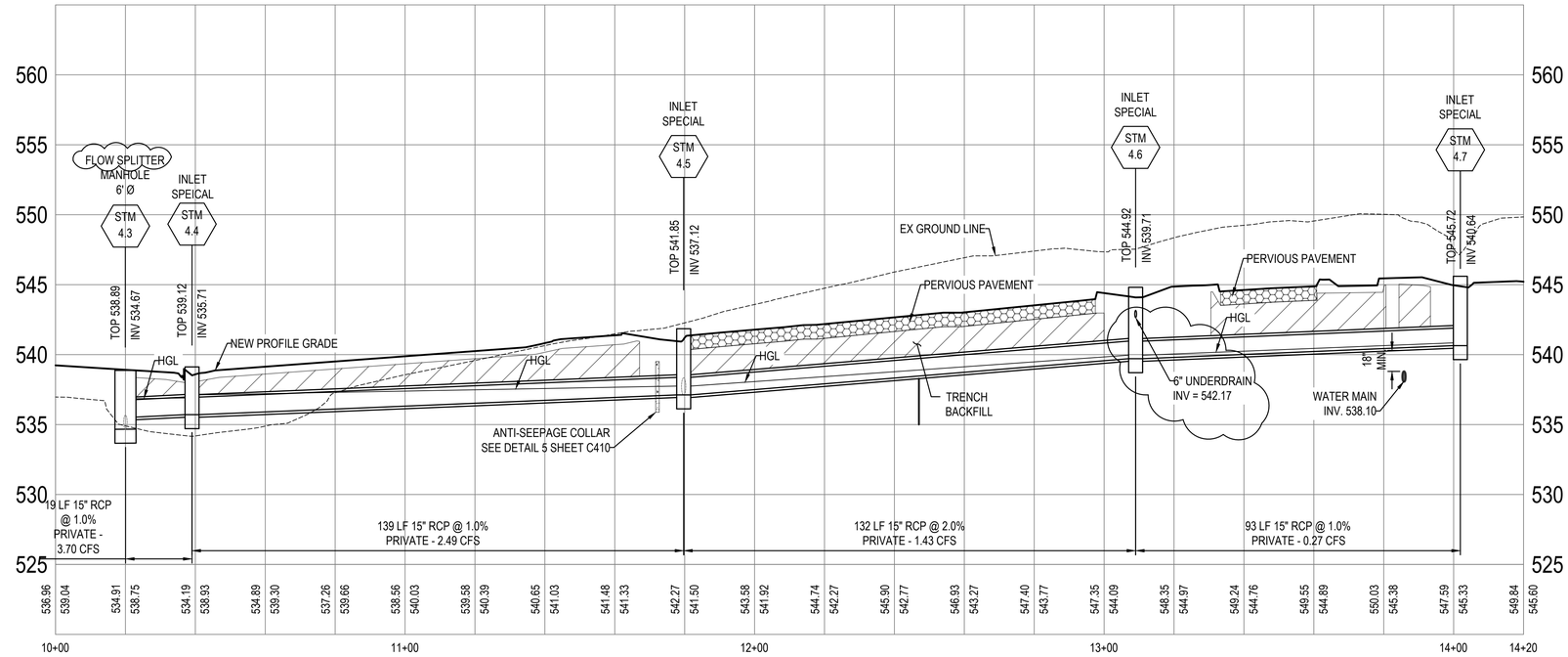
SHEET TITLE:
Drainage Profiles

SHEET NUMBER:
C405

36 OF 272 SHEETS
05/03/2024

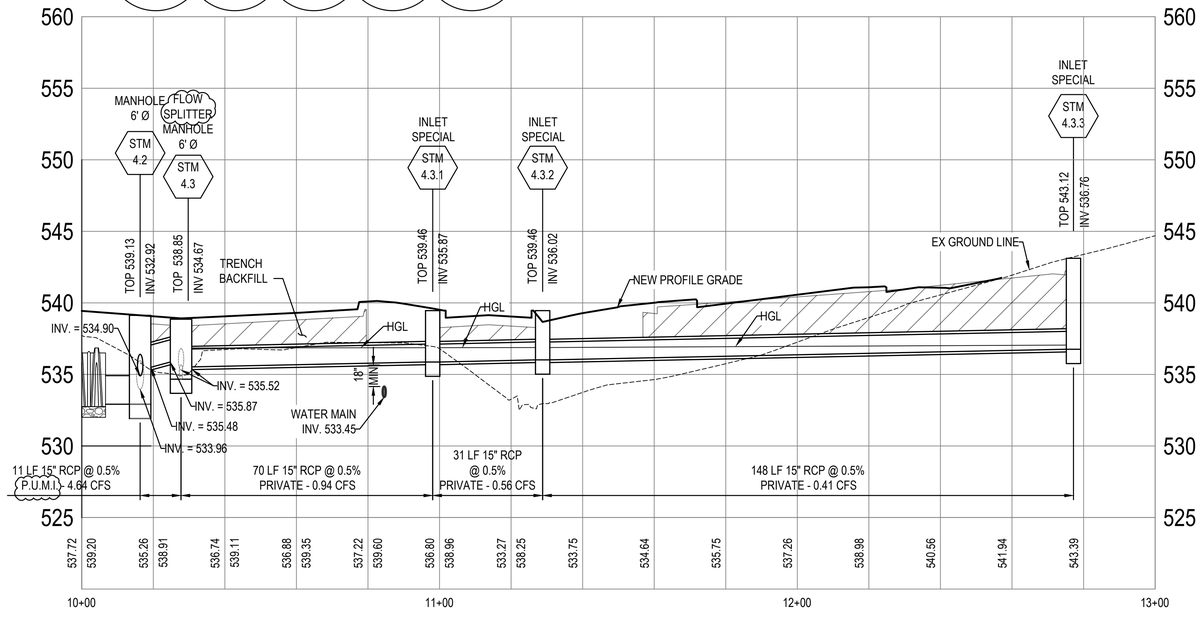
MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4

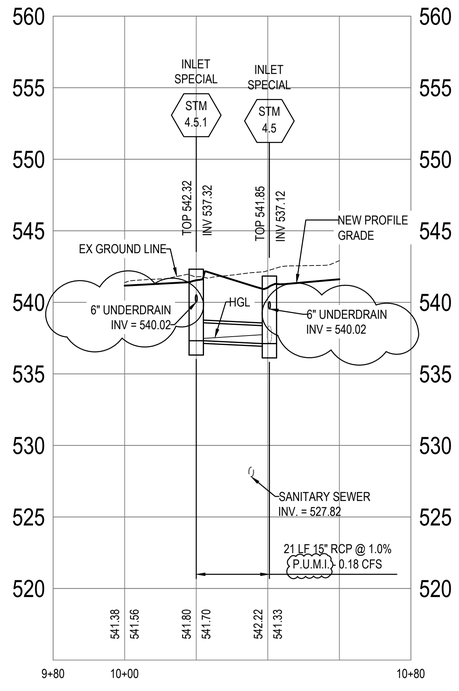



FLOW SPLITTER MANHOLE:
CONTRACTOR MUST VERIFY THE DIMENSIONS BETWEEN THE DIVERSION PIPE AND THE OVERFLOW PIPE PRIOR TO BACKFILL OF THE STRUCTURE AND NOTIFY THE DESIGN ENGINEER IMMEDIATELY OF ANY DISCREPANCY WITH THE DIMENSIONS ON THE APPROVED PLANS. STRUCTURES BUILT INCORRECTLY WILL REQUIRE REMOVAL AND REPLACEMENT.

P.U.M.I. - PRIVATE UNDER MSD INSPECTION




STATE OF MISSOURI
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CAD DWG FILE:
DRAWN BY: AJN
CHECKED BY: PHJ
DESIGNED BY: MYS

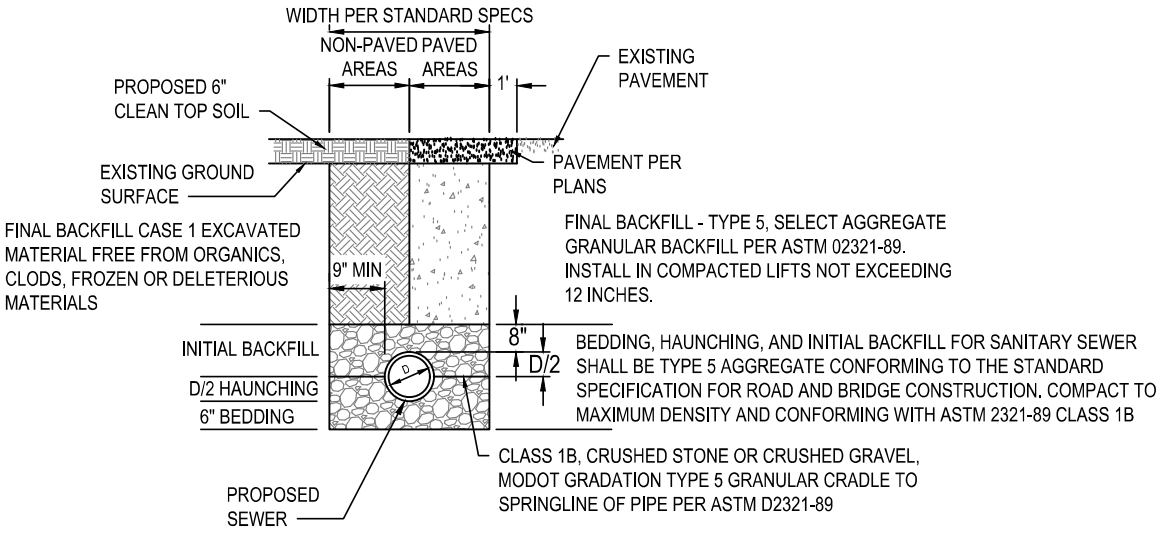
SHEET TITLE:
Drainage Profiles

SHEET NUMBER:
C406

37 OF 272 SHEETS
05/03/2024

MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4

# Replace in Sheet C407



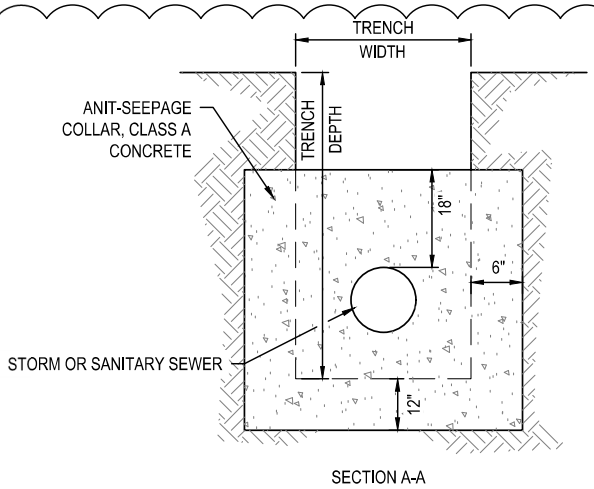

NOTE:
AT LOCATIONS WHERE SANITARY SEWER IS LOCATED UNDER PERVIOUS PAVEMENT, SANITARY SEWER SHALL BE WRAPPED IN IMPERMEABLE GEOMEMBRANE.

1

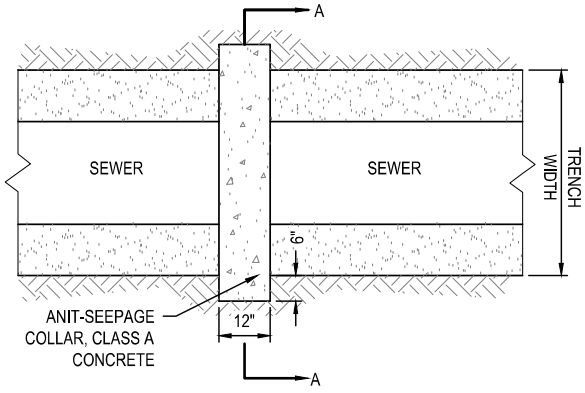
## SANITARY AND STORM SEWER DETAIL

SCALE: NO SCALE

# Add to Sheet C410




SECTION A-A




NOTE:
ANTI-SEEPAGE COLLAR TO BE INSTALLED ON STORM AND SANITARY SEWER WHEN A SEWER MAIN IS BELOW PERVIOUS PAVEMENT AND THE INFILTRATION BED AND AS SHOWN ON THE STORM AND SANITARY SEWER PROFILES.

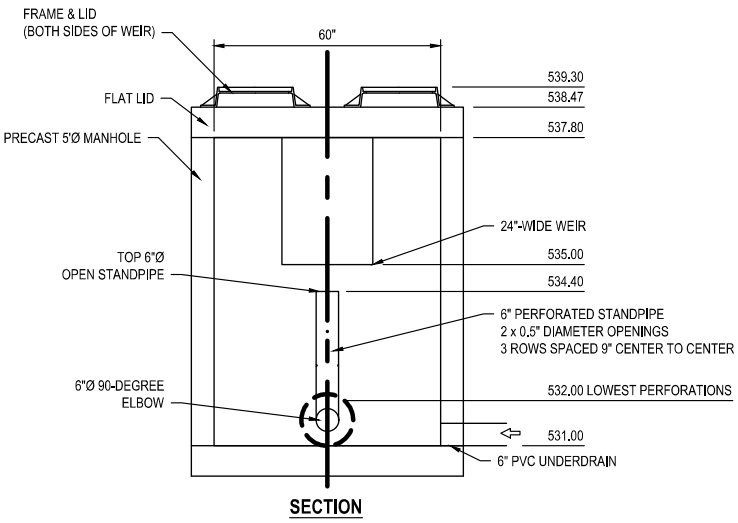
5 ANTI-SEEPAGE COLLAR

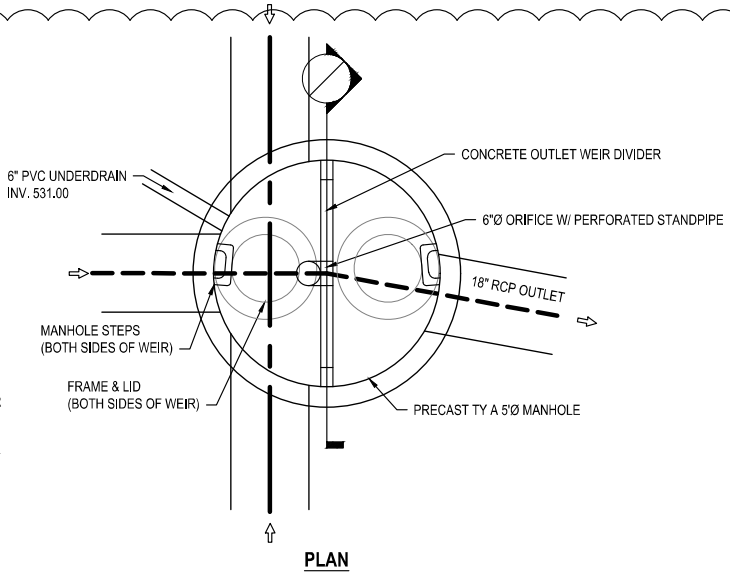
SCALE: NO SCALE

NOTE:

DETAILS SHOWN FOR PRIVATE CONSTRUCTION ONLY. REFER TO MSD SPECIFICATIONS AND DETAILS FOR PUBLIC SEWER CONSTRUCTION.

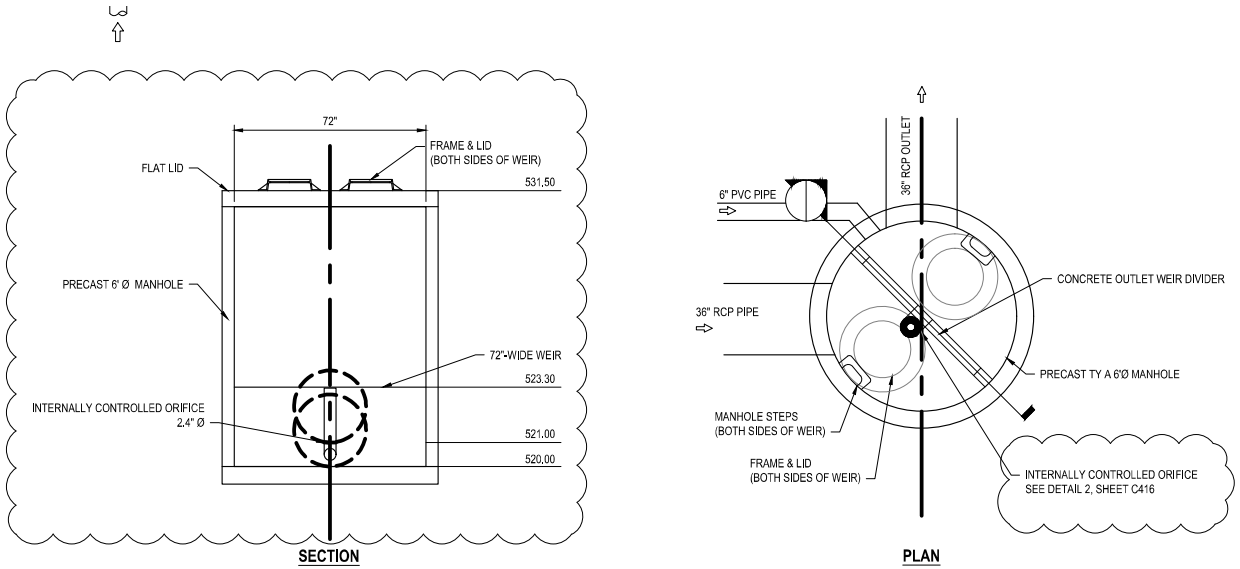
# Replace in Sheet C412




2 OUTLET STRUCTURE 4.1 DETAIL

SCALE: NO SCALE




1 OUTLET STRUCTURE 2.1 DETAIL
SCALE: NO SCALE

**LEGEND**

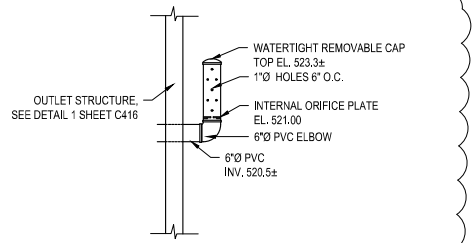
ISOLATOR ROW

PLACE MINIMUM 12.50' OF ADS GEOSYNTHETICS 315WTK WOVEN GEOTEXTILE OVER BEDDING STONE AND UNDERNEATH CHAMBER FEET FOR SCOUR PROTECTION AT ALL CHAMBER INLET ROWS

BED LIMITS

**NOTES**

1. DUE TO THE ADAPTATION OF THIS CHAMBER SYSTEM TO SPECIFIC SITE AND DESIGN CONSTRAINTS, IT MAY BE NECESSARY TO CUT AND COUPLE ADDITIONAL PIPE TO STANDARD MANIFOLD COMPONENTS IN THE FIELD AT NO ADDITIONAL COST.




2 INTERNALLY CONTROLLED ORIFICE
SCALE: NO SCALE

MSD Project No.: 24MSD - 00178
MSD Base Map No.: 10F4

Replace in Sheet C416

Add to
Sheet C501

GRAPHIC SCALE
1”=50’

# NOTES

ALL EXISTING UTILITIES ARE DRAWN FROM RECORD SOURCES AND FIELD SURVEYS AND SHOULD BE CONSIDERED APPROXIMATE ONLY.

SITE LIGHTING, SEE ELECTRICAL PLANS

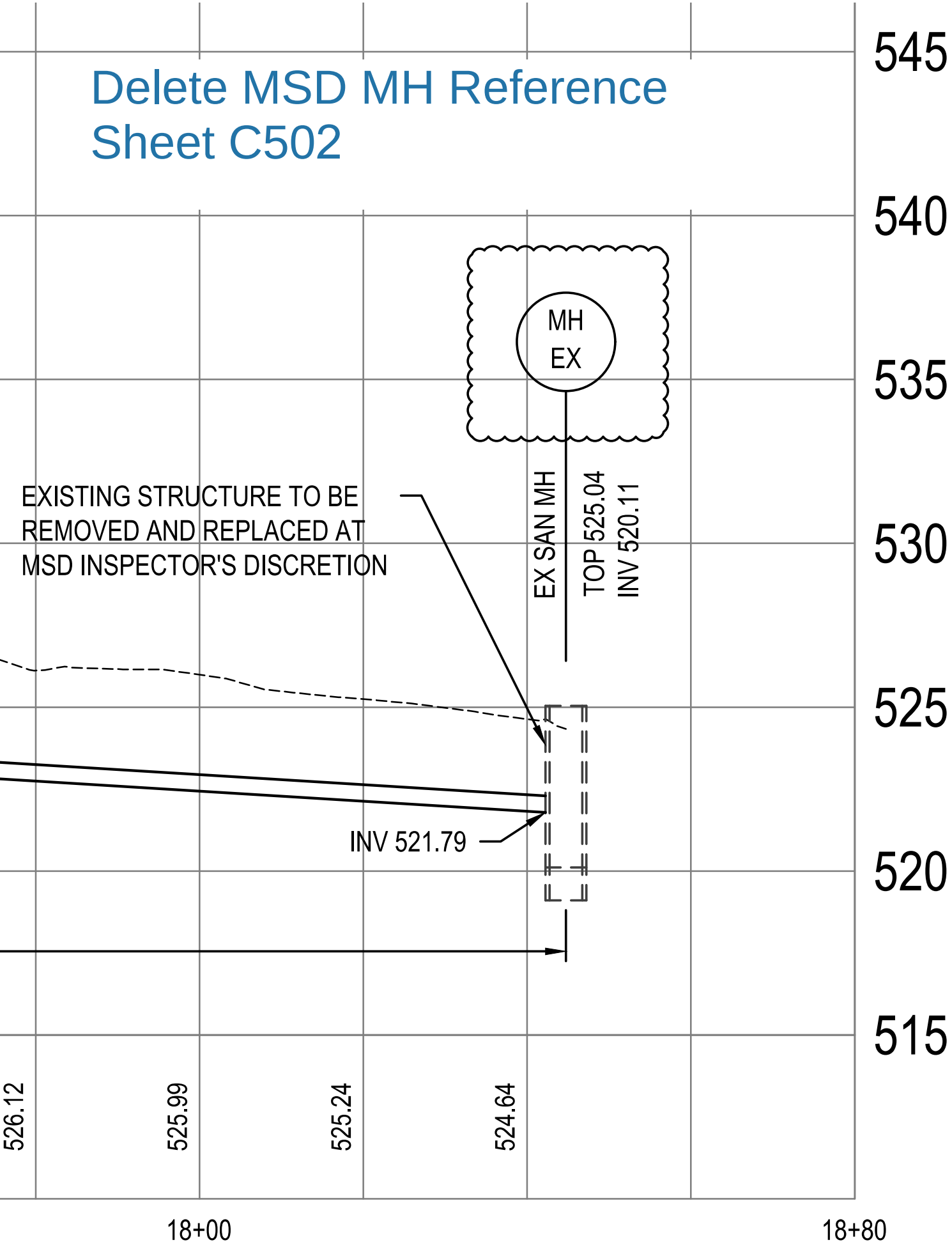
ADD ALTERNATE 1 ITEMS ARE TO BE EXCLUDED FROM THE BASE BID AND INCLUDED IN ADD ALTERNATE 1. THE INTENTION OF ADD ALTERNATE 1 IS TO SEPARATE ITEMS FUNDED BY A DIFFERENT FUNDING SOURCE THAN THE BASE BID.

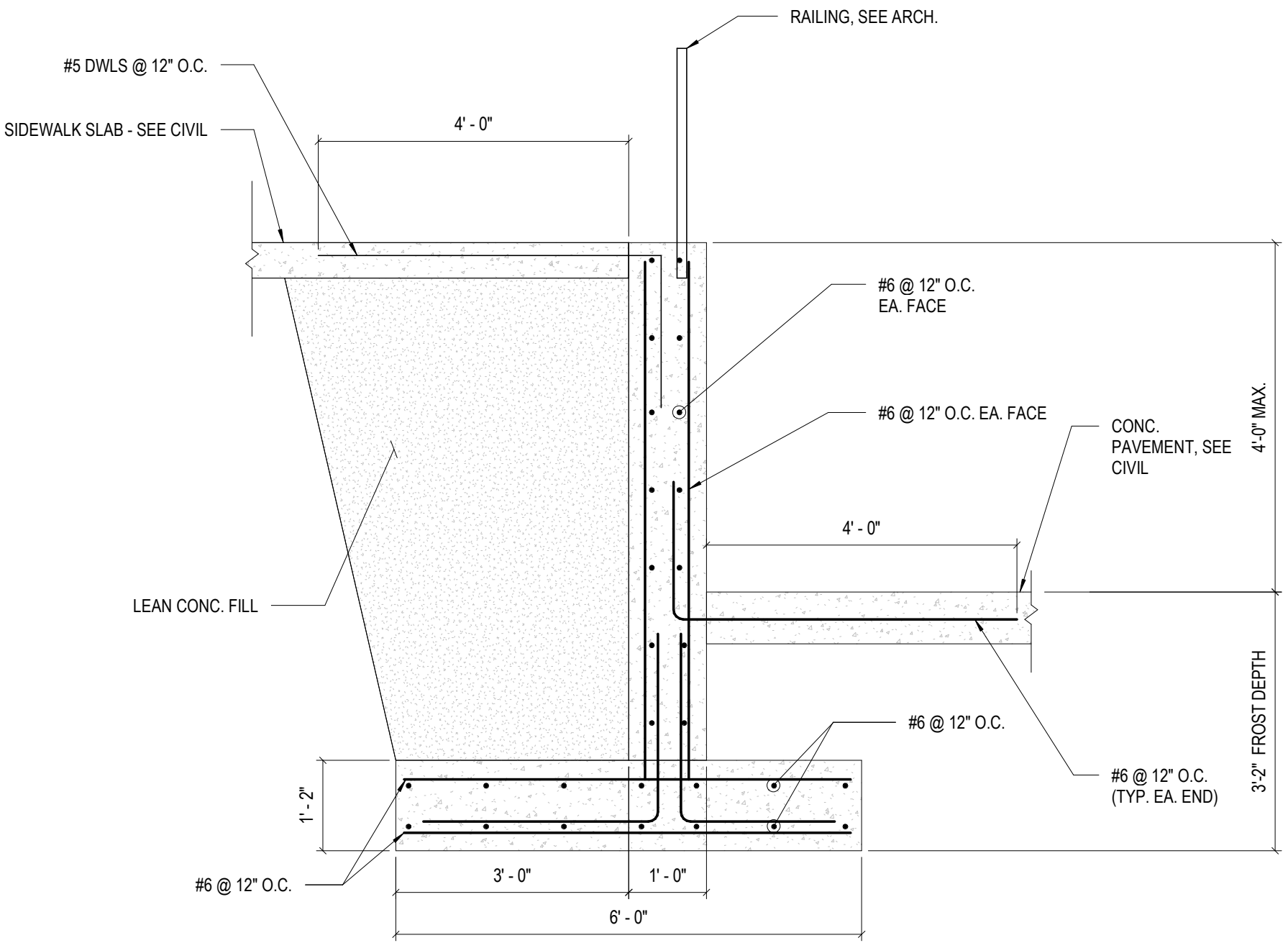
CONTRACTOR SHALL PERFORM CCTV INSPECTION OF APPROXIMATELY 100FT OF SANITARY SEWER DOWNSTREAM OF EX MH TO NEXT DOWNSTREAM MH (MSD MH 10F4-041S). CONTRACTOR SHALL PROVIDE CCTV VIDEO AND RECORDED FINDINGS IN ACCORDANCE WITH MSD SPECIFICATIONS TO MSD AND THE ENGINEER. CONTACT MSD (BRIAN DUNN 314-335-2072) AND THE ENGINEER A MINIMUM OF 48-HOURS PRIOR TO CCTV INSPECTION. MSD WILL VISIT THE SITE TO INSPECT THE FACILITIES AND REVIEW THE FINDINGS OF THE CCTV SUBMITTAL. MSD WILL EVALUATE DEFICIENCIES FOUND IN THE LINE OR STRUCTURES TO DETERMINE CORRECTIVE REPAIRS REQUIRED. THE CONTRACTOR SHALL ASSUME FOR THE BASE BID THAT REPAIRS WILL INCLUDE 100FT OF SANITARY SEWER CIPP LINING AND REPLACEMENT OF EX MH IN ACCORDANCE WITH MSD SPECIFICATIONS.

PRIOR TO OBTAINING A CONSTRUCTION PERMIT FROM THE METROPOLITAN ST. LOUIS SEWER DISTRICT, THE CONTRACTOR SHALL BE REQUIRED TO PROVIDE THE DISTRICT WITH A COPY OF AN EXECUTED CERTIFICATE OF INSURANCE INDICATING THAT THE PERMITTEE HAS OBTAINED AND WILL CARRY COMMERCIAL GENERAL LIABILITY AND COMPREHENSIVE AUTO LIABILITY INSURANCE. THE REQUIREMENTS AND LIMITS SHALL BE AS STATED IN THE RULES AND REGULATIONS AND ENGINEERING DESIGN REQUIREMENTS FOR SANITARY AND STORMWATER DRAINAGE FACILITIES, SECTION 10.090

ELECTRIC CONDUIT, FIBER OPTIC CONDUIT, AND GAS MAIN UNDER PERVIOUS PAVEMENT SHALL BE A MINIMUM OF 1FT BELOW SUBGRADE AS DETAILED ON SHEETS C309 AND 310.

# Delete MSD MH Reference Sheet C502

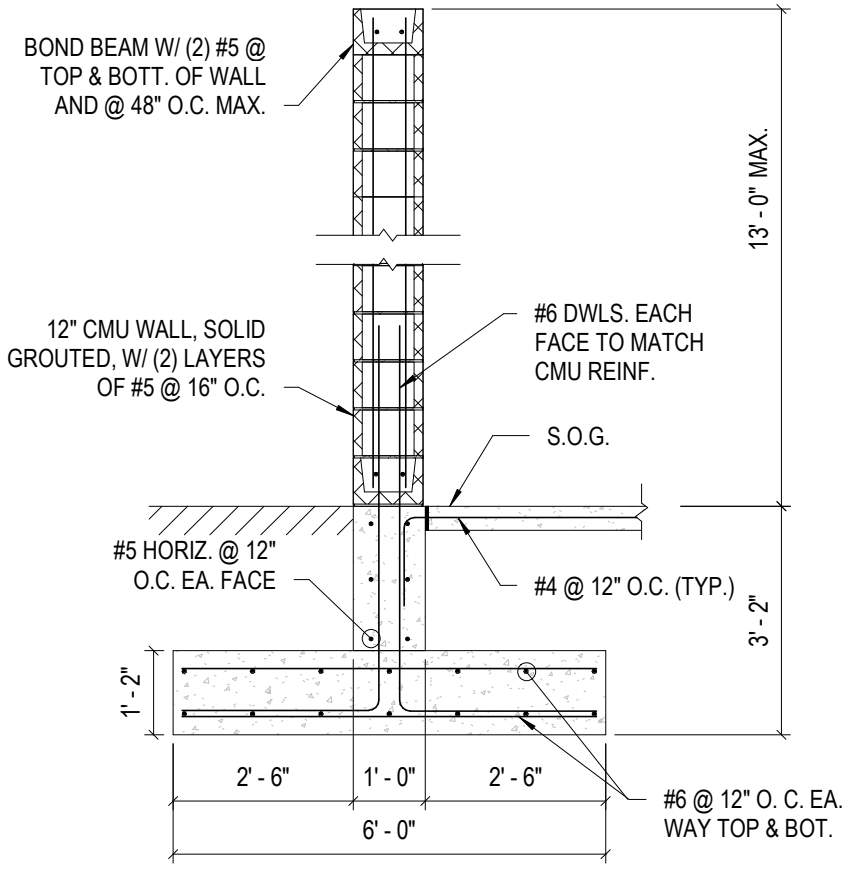





5
S301

# SECTION

SCALE: 3/4" = 1'-0"




3
S800

# WALL SECTION

SCALE: 1/2" = 1'-0"

EXTERIOR SLABS ON GRADE:

1. TRASH ENCLOSURE
   - A) CONCRETE THICKNESS: 6"
   - B) REINFORCEMENT: #5 @ 12" O.C. EA. WAY
   - C) SUB-BASE: PER GEOTECHNIAL REPORT
2. TRANSFORMER ENCLOSURE
   - A) CONCRETE THICKNESS: 8"
   - B) REINFORCEMENT: (2) LAYERS OF #5 @ 12" O.C. EA. WAY
   - C) SUB-BASE: PER GEOTECHNIAL REPORT