

SECTION 02200**EARTHWORK****PART 1 GENERAL****1.1 SUMMARY**

- A. Furnish all labor, materials, equipment and incidentals required and perform earthwork, which includes clearing and stripping, procurement of fill material (on-site and imported), excavating, placing, and compacting fill and backfill, structural excavating and backfilling, procurement, transportation and placing of riprap, transportation and storage of excess earthwork materials; disposal of unsuitable, waste and surplus materials, restoration of excavation and trench surfaces, and subsidiary work necessary to complete the grading of the developed areas to conform with the lines, grades, and slopes as shown on the Contract Drawings and as specified herein.
- B. The Work shall include, but not be limited to, excavation for Structures, foundations, manholes, vaults, conduits, cables, pipes, paving, embankments, grading, and all related work such as sheeting, bracing, trenching, and dewatering.
- C. Furnish and install temporary excavation support systems, including sheeting, trench box, shoring and bracing, and/or other measures necessary to ensure the safety of personnel and protect adjacent Structures, utilities, piping, etc., per Contract Documents, and federal, state, and local laws, regulations, and requirements. Temporary excavation support systems shall be per Specification Section 02311 – Support of Excavation.
- D. Furnish and install temporary dewatering and surface water control systems and operate to dewater and maintain excavations in a dry condition. Control drainage into excavations and remove seepage water and rainwater. Dewatering and surface water control shall be per Specification Section 02240 – Construction Dewatering and Groundwater Control.
- E. Examine the site and review the available geological and geotechnical and environmental data prior to submitting the site plan, taking into consideration all conditions that may affect the Work. The Authority does not warrant or guarantee subsurface conditions at any location.
- F. Furnish and install all erosion control measures as required in Specification Section 02370 – Erosion and Sedimentation Controls.
- G. No extra work shall be initiated without written notification to the Authority in writing and the written approval of the Authority in response.

- H. Protect any trees or plantings, existing structures, and utilities identified on the Contract Drawings.

1.2 RELATED SECTIONS

- A. Section 01300 – Submittals
- B. Section 01400 – Quality Control Testing
- C. Section 02226 – Excavated Material Handling and Disposal
- D. Section 02240 – Construction Dewatering and Groundwater Control
- E. Section 02311 – Support of Excavation
- F. Section 02370 – Erosion and Sedimentation Controls
- G. Section 02495 – Geotechnical Instrumentation
- H. Section 02660 - Geosynthetics
- I. Section 02900 – Restoration and Landscaping
- J. Section 03302 – Miscellaneous Cast-In-Place Concrete

1.3 CODES AND STANDARDS

- A. American Association of State Highway and Transportation Officials (AASHTO).
- B. ASTM International (ASTM):
 - 1. ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN-m/m³)).
 - 2. ASTM D3740 – Standard Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction.
 - 3. ASTM D6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
 - 4. ASTM D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
- C. Code of Massachusetts Regulations:

1. 454 CMR - Department of Labor Standards.
- D. United States Department of Labor – Occupational Safety and Health Administration (OSHA):
1. OSHA 29 CFR Part 1926 Subpart P.
- E. United States Environmental Protection Agency (EPA):
1. EPA 8260 – Analysis of Volatile Organic Compounds by GS-MS.
 2. EPA 8270E – Semi volatile Organic Compounds by Gas Chromatography/Mass Spectrometry (GC-MS).
 3. EPA 8081 – Organochlorine Pesticides and PCBs.
 4. EPA 9071/418.1 – Hexane Extractable Material (HEM) for Sludge, Sediment, and Solid Samples.
 5. EPA 7000 Series
 - a. EPA 7000A – Atomic Absorption Methods.
 - b. EPA 7061A – Arsenic (Atomic Absorption, Gaseous Hydride).
 - c. EPA 7196 – Hexavalent Chromium: Colorimetric Method.
 - d. EPA 7470 – Mercury (Manual Cold-Vapor Technique).
 - e. EPA 7471B – Mercury in Solid or Semisolid Waste (Manual Cold-Vapor Technique).
 - f. EPA SW-846 Method 7741 – Selenium (Atomic Absorption, Gaseous Hydride).
 6. EPA 9012B – Total and Amenable Cyanide (Automated Colorimetric, With Off-Line Distillation).
- F. Where reference is made to one (1) of the above standards, the revision in effect at the time of bid opening shall apply.

1.4 SUBMITTALS

- A. Submit the following in accordance with Specification Section 01300 – Submittals, no later than 30 days after Notice to Proceed.
1. The proposed methods of construction, including earthwork operations, excavation

limits, slopes, fill material moisture conditioning and handling, compaction equipment, excavation support systems designs, filling and backfilling, and compaction for the various portions of the Work, and material sources for the various portions of the Work.

- B. Excavation support system designs shall be prepared in accordance with Specification Section 02311 – Support of Excavation. Coordinate submittals with Specification Section 02240 – Construction Dewatering and Groundwater Control and Specification Section 02311 – Support of Excavations submittals.
- C. No later than 30 days prior to construction of temporary slopes, submit a temporary excavation slope stability evaluation prepared by a licensed Professional Engineer registered in the Commonwealth of Massachusetts for all temporary slopes over 20 feet in height or where existing or proposed facilities or property limits are located at the top of the slope and within a distance from the top of the slope equal to the slope height.
- D. Quality Control Testing for Borrow, Fill, and Backfill Materials:
 - 1. Site Characterization Data: Information regarding the off-site borrow source and material, as follows:
 - a. Location of site.
 - b. Present and past usage of the source site and material.
 - c. Location within the site from which the material will be obtained.
 - 2. Chemical Test Data (only for imported materials from sources indicated by site characterization data, or suspected to be contaminated, or as required otherwise by the Authority): Samples of each proposed material shall be submitted to the chemical analytical laboratory for the following analyses. Submit the testing results to the Authority for review and approval.
 - a. Volatile Organic Compounds, (EPA 8240 plus Hazardous Substance List (HSL) Parameters).
 - b. Acid and Base Neutral Extractable Organic Compounds (EPA 8270).
 - c. Pesticides/PCBs (EPA 8080).
 - d. Total Petroleum Hydrocarbons (Infrared Method) (EPA 9071/418.1).
 - e. Thirteen Priority Pollutant Metals (EPA 7000 Series).

- f. Total Cyanide (EPA 9012).
- 3. Borrow, fill and backfill samples shall be obtained and tested to demonstrate compliance with criteria established herein and results submitted for review and approval prior to use on site.
- E. Controlled Low-Strength Material (CLSM) Mix Design:
 - 1. Mix design prepared by the Contractor and associated test results by an independent commercial laboratory retained by the Contractor that demonstrates compliance with the requirements of this Section.
- F. Furnish the Authority a representative sample weighing approximately 50 pounds of each material and crushed stone contained in sealed 5-gallon containers, at least 30 days prior to the date of anticipated use of such material for approval, in accordance with Specification Section 01400 – Quality Control Testing.
- G. Submit laboratory test results for all borrow, fill, and backfill materials (maximum density, gradation, Atterberg limits, sand equivalent, etc., as applicable) at least 72 hours prior to importing the borrow material or placing any fill.
- H. Submit for review and approval, the qualifications of the entity proposed to conduct geotechnical observation, testing, and documentation. The submittal shall include qualifications of the firm and the resumes of the soil technician(s) assigned to the project and the Contractor's licensed Geotechnical Engineer. The Authority reserves the right to request substitution of soil technician(s) assigned to field work. Assigned soil technician(s) shall not be substituted without the prior approval of the Authority.
- I. Submit for review and approval, the qualifications of the person experienced in sample collection.
- J. Submit for review and approval, the qualifications of the chemical analytical laboratory.
- K. Submit copies of field daily reports by the soil technician at the end of each working day while earthwork and grading operations are underway.
- L. Upon completion of earthwork and grading operations, submit an as-graded map showing the density test numbers and locations, a table of all density test results and depths, and a certification of compliance by the Contractor's Professional Geotechnical Engineer licensed in the Commonwealth of Massachusetts.

1.5 QUALITY ASSURANCE

- A. At Structures, prior to the placement of bedding material, concrete work mats,

Structural Fill, or structural concrete, coordinate with the Authority to verify the suitability of the existing Subgrade soil.

- B. Prior to and during the placement of fill and backfill, coordinate with the Authority to perform in-place soil density tests to verify that the fill/backfill material has been placed and compacted in accordance with the compaction requirements specified elsewhere. At least 72-hour notice shall be provided prior to placement of fill and backfill.
- C. Subgrades shall not be covered with fill nor fill placed without the observation, testing, and approval by the Authority. Earthwork activities performed without properly scheduled inspection are subject to removal and replacement, or to additional testing, as directed by the Authority at no additional cost to the Authority.
- D. Perform testing of materials as described in the following paragraphs.
 - 1. Engage and bear all costs for a certified independent laboratory to test materials to be used in the Work, to demonstrate conformance with the requirements of these Specifications. Cooperate by allowing free access to the Work for selection of test materials and observations.
 - 2. Bear all costs involved in correcting deficiencies in compacted materials to the satisfaction of the Authority and for re-testing of materials after correction of deficiencies.
 - 3. Earthwork activities performed without properly scheduled inspection are subject to removal and replacement, or to additional testing as directed by the Authority at no additional cost to the Authority.
 - 4. Testing methods shall comply with the latest applicable ASTM or equivalent AASHTO Standards specified.
 - 5. During the placement of bedding, fill, and backfill, perform in-place soil density testing to confirm that fill material has been compacted in accordance with the requirements of this section. The Authority may designate areas to be tested. Notify the Authority at least 72 hours in advance of scheduled compaction testing. In-place soil density tests on fill/backfill material shall be as required by municipal, state, and federal codes, the Contract Documents, and the Authority, but in no instance shall be less than those listed below:
 - a. Structures and Embankments. At least one (1) density and moisture content test for each 2,500 square feet of surface area for each lift of fill at embankment, structure and manhole locations.
 - b. Trench Excavations. At least one (1) density and moisture content test shall be conducted at a maximum of 50-foot intervals for each lift of fill placed or as

directed by the Authority.

- c. The Authority may designate additional areas to be tested.
- 6. Materials which have been previously tested may be subjected to further testing from time to time and may be rejected if the Authority determines that they do not conform to the requirements of the Contract Documents. Rejected materials shall be removed from the Work immediately when so directed by the Authority, notwithstanding the results of previous testing.
- E. The Authority may conduct additional soil testing. Cooperate fully in obtaining the information desired and allowing free access to the Work.

1.6 QUALIFICATIONS

- A. The qualifications of the entity proposed to conduct geotechnical observations, testing, and documentation shall meet ASTM D3740. The soil technician shall have a minimum of three (3) years demonstrated experience in earthwork and grading operations and satisfy the certification requirements of agency having local jurisdiction.
- B. Sampling of materials shall be performed by a person experienced in sample collection who is a licensed Professional Engineer registered in the Commonwealth of Massachusetts, Licensed Site Professional (LSP), registered Professional Geologist, certified Groundwater or Environmental Professional, or duly authorized representative thereof.
- C. The chemical analytical laboratory shall be certified by the Massachusetts Department of Environmental Protection (MassDEP) and approved by the Authority.

1.7 DELIVERY, STORAGE, AND HANDLING (NOT USED)

1.8 PROJECT/SITE CONDITIONS

- A. Refer to the Appendix A of the Contract Specifications for subsurface information.
- B. The Contract Documents are based on available information and limited field investigation and inspection and may not represent the actual conditions across the entire site. Actual field conditions may vary. Field verify elevations and dimensions of the existing structures. If discrepancies are observed and elevations and dimensions of excavations and structures need adjustment, the proposed adjustments shall be submitted by the Contractor for approval prior to the start of work.
- C. Nested cobbles and boulders shall be anticipated within existing fill, glacial deposits, and other overburden materials throughout the site, regardless of whether such materials were encountered in the exploration borings. The Contractor shall assume

that excavation may encounter cobbles and boulders of varying sizes. Removal of these materials may require the use of rock excavation techniques including, but not limited to, jackhammering, splitting, barring, or other approved methods. All labor, equipment, and operations required for the excavation and removal of cobbles and boulders shall be considered incidental to earth work.

1.9 DEFINITIONS

- A. Coverage – Pass of compaction equipment over the complete surface area of exposed lift or Subgrade to receive compaction.
- B. Finished Grade – Required final grade elevation indicated on the Contract Drawings. Spot elevations shall be precedent over proposed contours.
- C. In-the-Dry – An excavation Subgrade where the groundwater level has been lowered to at least 2 feet below the lowest level of the excavation, is stable with no ponded water, mud, or muck, and shall be able to support construction equipment without rutting or disturbance and shall be suitable for the placement and compaction of fill material, pipe, or concrete foundations.
- D. On-site Soil – Designated material excavated from within the project site limits indicated on the Contract Drawings.
- E. Moisture-Sensitive Soil – On-site soil containing more than five (5) percent fines (silt- or clay-sized particles) based on the fraction passing the 0.00295-inch sieve (Sieve No.200).
- F. Objectionable Material – Includes topsoil, organic matter, vegetation, roots, organic soils, contaminated soil, construction debris, perishable materials, trash, snow, ice, frozen earth, and rocks or lumps of cemented soils over six (6) inches in maximum dimension.
- G. Optimum Moisture Content – Moisture content (percent by dry weight) corresponding to the maximum dry density of the same material as determined by ASTM D1557.
- H. Over-excavation – Removal of Unsuitable Soil or Objectionable Material at or below the normal grade of the excavation or Subgrade as indicated on the Contract Drawings.
- I. Percent Compaction – Required in-place dry density of the material, expressed as a percentage of the maximum dry density of the same material, as determined in the laboratory by ASTM D1557.
- J. Obstruction – Material encountered within the project limits that prevents, restricts, or alters the planned excavation, trenching, grading, or filling operations. Obstruction is defined as intact bedrock.

- K. Structures – Buildings, bridges, outfall, wet wells, manholes, vaults, chambers, pipelines and utilities, and slabs-on-grade both above and below ground.
- L. Subgrade – Required surface of subsoil, borrow fill or compacted fill. This surface is immediately beneath site improvements, especially dimensioned fill, paving, or other surfacing material.
- M. Unsuitable Soil – Includes, but is not limited to, soft, wet, plastic soils which may be expansive, contaminated soil, ash-laden, refuse, excessive standing water, stumps, soils containing more than five percent (5%) (by weight) fibrous organic materials, soils having a plasticity index greater than 30, other deleterious materials, clays with a water content of greater than 30, or weak native soils. Weak native soils are defined as soils exhibiting low shear strength (less than 25 kPa), high compressibility, or organic content exceeding five percent (5%), including soft clays, silts, peats, and loose saturated sands. Existing fill materials should be considered unsuitable soils unless in-situ observations and laboratory testing confirm they meet the requirements for fill and backfill materials as specified in Part 2 – Products below. Submit the laboratory testing results of the existing fill materials to the Authority for approval.

1.10 TOLERANCE (NOT USED)

1.11 STATUTORY REQUIREMENTS

- A. All excavation, trenching, sheeting, bracing, etc., shall comply with the requirements of OSHA excavation safety standards (29 CFR Part 1926 Subpart P) and to the Massachusetts Department of Labor and Workforce Development, Division of Industrial Safety "Rules and Regulations for the Prevention of Accidents in Construction Operations" (Chapter 454 CMR), State and local requirements. Where conflict between OSHA, state and local regulations exists, the most stringent requirements shall apply.
- B. At least three (3) working days prior to starting any excavation, notify [Digsafe](http://www.digsafe.com/) (<http://www.digsafe.com/>) for locating underground utilities and underground utility owners.

1.12 PROTECTION

- A. Existing facilities which include, but are not limited to, Structures, utilities, tanks, pavements, sidewalks, curbing, driveway aprons, fencing, landscaping, and other improvements in the vicinity of the Work shall be adequately protected. Permission to remove and restore and replace after backfilling can be requested for curbing, driveway aprons, and fencing, but may not be granted. Existing facilities damaged by the construction shall be replaced with material fully equal to that existing prior to construction at no additional cost to the Authority.

- B. Notify utility owners prior to the start of excavation within the vicinity of existing utilities. Protect all nearby utilities and underground structures.
- C. Install warning tape above all underground utilities. Place tape approximately 12 inches above the utility line, centered along its alignment. Tape shall be durable, color-coded per APWA standards, and continuously marked with the appropriate utility warning.
- D. Excavations within the zone of influence of any existing Structures or utility will require the use of excavation support system. Design, furnish, install, monitor, and maintain excavation support system as required and as specified in Specification Section 02311 – Support of Excavation.
- E. Excavations below the level of the base of any adjacent foundation or retaining wall shall not be permitted unless the design of the excavation and bracing includes an analysis of the stability of the structure supported by the foundation and as necessary, incorporates required bracing/underpinning of the foundation.
- F. Furnish, install, monitor, and maintain settlement monitoring as required and as specified in Specification Section 02495 – Geotechnical Instrumentation.
- G. Furnish, install, monitor and maintain dewatering and drainage systems as required and as specified in Specification Section 02240 – Construction Dewatering and Groundwater Control.

1.13 CONSTRUCTION CONTROL

- A. Be responsible for construction layout and reference staking necessary for the proper control and satisfactory completion of Structures, cutting, filling, grading, drainage, fencing, embankment improvements, curbing, and other appurtenances required for the completion of the construction work and acceptance of the Contract as specified and as shown on the Contract Drawings.
- B. Construction layout and staking shall be performed by a licensed Professional Land Surveyor or Professional Engineer registered in the Commonwealth of Massachusetts, experienced and skilled in construction layout and staking of the type required under this Contract, and acceptable to the Authority.

PART 2 PRODUCTS

2.1 MATERIALS

A. Fill and Backfill Materials

- 1. Shall be suitable excavated materials, natural or processed mineral soils obtained from off-site sources, or graded crushed stone or gravel. Fill and backfill materials

shall be free of Unsuitable Soils and Objectionable Materials which may be compressible, or which cannot be properly compacted. Fill and backfill materials shall have a maximum of 1 percent expansion when testing is performed on a sample remolded to 92 percent of maximum dry density (per ASTM D1157) at two (2) percent below Optimum Moisture Content under a 100 pounds per square foot surcharge.

B. Structural Fill

1. Shall be gravel, sandy gravel, or gravelly sand free of organic material, loam, wood, trash, snow, ice, frozen soil, and other Objectionable Material and shall conform to the following gradation limits:

Sieve Size (ASTM E11)	Percent Finer by Weight (%)
1-inch	100
½ inch	80-100
No. 8	35-100
No. 16	25-90
No. 50	5-50
No. 100	0-8
No. 200	0-2

C. Common Fill

1. Shall consist of mineral soil, substantially free of clay, organic material, loam, wood, trash, snow, ice, frozen soil, and other Objectionable Material which may be compressible, or which cannot be compacted properly. Common fill shall not contain rock, broken concrete, masonry rubble, asphalt pavement, or any material larger than 6-inches in any dimension. It shall have physical properties, as approved by the Authority, such that it can be readily spread and compacted. Common fill shall have a plasticity index of less than 15 and shall conform to the following gradation limits:

Sieve Size (ASTM E11)	Percent Finer by Weight (%)
6-inch	100
No. 4	40-75
No. 50	10-30
No. 200	0-10

D. Stone (2-inch)

1. 2-inch stone shall be utilized for stabilized construction entrances as shown in the Contract Drawings and as defined in Section 02370 – Erosion and Sedimentation Control.
2. 2-inch stone shall be angular, clean, hard, durable stone, and free from loam, clay, shale, friable particles, organic material, and other deleterious materials. Aggregate shall be uniformly graded and shall not contain excessive fines and conform to the following gradation:

Sieve Size (ASTM E11)	Percent Finer by Weight (%)
2 1/2 inch	90-100
2-inch	35-70
1 1/2-inch	0-15
3/4-inch	0-5

E. Crushed Stone

1. Shall be sound, durable stone, angular in shape, and free of any foreign material, structural defects, and chemical decay. Crushed stone shall conform to the following gradation limits:

Sieve Size (ASTM E11)	Percent Finer by Weight (%)
2-inch	100
1 1/2-inch	80-100
1 inch	35-70
3/4-inch	0-25

F. Granular Material

1. Shall be hard, durable, rounded, or sub-angular particles of proper size and gradation, and shall be free from sand, loam, clay, excess fines, and other deleterious materials. Granular Material shall be graded within the following limits:

Sieve Size (ASTM E11)	Percent Finer by Weight (%)
3 inches	100
1 1/2-inch	50-85
No. 4	40-75
No. 50	8-28
No. 200	0-10

G. Gravel Borrow Type C

1. Shall conform to the requirements of MassDOT M1.03.0:Gravel Borrow. It shall consist of inert material that is hard, durable stone and coarse sand, free from loam and clay, surface coating, and deleterious materials and shall conform to the following gradation. This material shall be used as “Gravel sub-base Course” and where is shown on the Contract Drawings.

Sieve Size (ASTM E11)	Percent Finer by Weight (%)
2 inches	100
½ inch	50-85
No. 4	40-75
No. 50	8-28
No. 200	0-10

H. Gravel Base Course

1. Shall consist of hard, durable particles of fragments of stone. Materials that break up when alternately frozen and thawed or wetted and dried shall not be used. Coarse aggregate shall have a percentage of wear, by Los Angeles abrasion test, of not more than 45. It shall conform to the following gradation:

Sieve Size (ASTM E11)	Percent Finer by Weight (%)
2 inches	100
1 ½ inch	70-100
¾ inch	50-85
No. 4	30-55
No. 50	8-24
No. 200	3-10

I. Sand for Concrete, Grout, and Masonry

1. Shall conform to ASTM C33 for fine aggregate.

J. Riprap

1. Shall be hard, durable angular shaped stones and conform to the following gradation limits:

Rock Size (inches)	Maximum Percent Smaller by Weight (%)
18	100
15	90
12	50
10	10

K. Filter Gravel

1. Shall conform to the following gradation requirements:
 - a. 0.25 inch $<D_{15} < 2$ inch
 - b. $D_{85} > 2$ inch
 - c. $D_{100} \leq 4$ inches
2. Filter gravel shall be utilized for the dewatering containment area and dewatering drain line outfall identified on the Contract Drawings.

L. Geotextile Filter Fabric

1. Geotextile filter fabric shall conform to the requirements specified in Specification Section 02660 – Geosynthetics.

M. Geogrid

1. Geogrids shall conform to the requirements specified in Specification Section 02660 – Geosynthetics.

N. Controlled Low-Strength Material (CLSM) Used as Fill and Backfill

1. CLSM shall consist of a mixture of Portland cement, fly ash, sand, and water and shall be placed at locations indicated on the Contract Drawings or as directed by the Authority.
2. Refer to Specification Section 03302 – Miscellaneous Cast-in-Place Concrete for acceptable materials including Sustainable Design General Requirements, Sustainable Building submittal Requirements including, but not limited to, GWP data and Mix Design Carbon Calculation.
3. The type of cement in CLSM shall be cement or a combination of cementitious materials.
4. Fine aggregate in CLSM shall be clean sand per ASTM C33. Recycled aggregate is acceptable.
5. Water in CLSM shall be potable.
6. Design and test the CLSM. The mix design shall be such as to ensure that the CLSM hardens sufficiently to support the weight of an average person in one (1) to four (4) hours after placement and support equipment weight in twenty-four (24) hours. The mixture shall be designed such that when tested in the field with the Kelly Ball apparatus per ASTM D6024, the maximum depression diameter shall be three (3) inches. CLSM shall be self-leveling and shall have an average patty diameter from 8

to 12 inches when the flow is measured in accordance with ASTM D6103.

7. The batch proportions accepted by the Authority apply only for materials from the same source and having the same characteristics as the materials used in the mix design. Materials from any other source shall be used only with the acceptance of the Authority.
8. If a change in sources of materials is proposed, a new mix design shall be developed by Contractor before the new material is used. When unsatisfactory results or other conditions make it necessary, Contractor shall develop a new mix design to get the desired results.
9. During the progress of the work, no change shall be made in the batch proportions of the ingredients without the acceptance of the Authority.

10. CLSM

- a. The initial trial mixture for CLSM shall consist of the following minimum proportions per cubic yard to provide minimum compressive strength listed below:
 - 1) Cement plus Supplementary Cementitious Materials: 300 lbs.
 - 2) Sand (SSD): 2860 lbs.
 - 3) Water: 370 lbs.
 - 4) Air Entraining admixture: 6 percent
 - 5) Minimum compressive strength at 28 days: 130 psi

O. Warning Tape

1. Warning Tape shall consist of a corrosion resistant, high visibility plastic marking tape installed above underground utilities to provide an early visual alert during excavation. The tape shall be manufactured from durable polyethylene and shall be color-coded in accordance with industry standards for utility identification. The material shall be resistant to chemicals, moisture, and environmental degradation.

PART 3 EXECUTION

3.1 PREPARATION

A. Test Pits:

1. Perform exploratory excavation work (test pits) for the purpose of verifying the

location of underground utilities and Structures and to check for unknown utilities and Structures, prior to commencing excavation work.

2. Perform test pits for the purpose of compaction testing, as earthwork progresses. Pause operations and provide safe access to testing personnel.
 3. Test pits shall be backfilled and compacted as soon as the desired information has been obtained. Backfilled surfaces shall be stabilized in accordance with erosion and sedimentation control plans submitted by the Contractor and approved by the Authority.
- B. Geotechnical instrumentation shall be installed in accordance with Specification Section 02495 – Geotechnical Instrumentation.
- C. Clearing and Stripping. The ground surface beneath planned Structures and in areas requiring excavation or filling shall initially be cleared and stripped of organic material and debris. These materials shall not be reused as on-site fill material; they shall be removed from the site and disposed of. Strip to a minimum depth of six (6) inches.

3.2 DEWATERING AND DRAINAGE

- A. Dewatering and drainage systems shall be in accordance with Specification Section 02240 – Construction Dewatering and Groundwater Control.
- B. Runoff or groundwater seepage that would interfere with the work shall be controlled during construction.
- C. Temporary dewatering and drainage systems shall be in place and operational prior to commencing excavation work.
- D. The groundwater shall be verified to be at the level required in the approved dewatering and drainage submittal prior to excavation.
- E. Dewatering shall be accomplished by methods which preserve the undisturbed state of Subgrade soils. Dewatering shall be such as to prevent boiling, detrimental under-seepage, or disturbance at the base of the excavation.
- F. Observe groundwater level inside the excavation visually and ensure the excavation is always dry.

3.3 SUPPORT OF EXCAVATION

- A. Support of excavation shall be in accordance with Specification Section 02311 – Support of Excavation.

- B. Temporary excavation slopes shall be constructed per the requirements of OSHA excavation safety standards and the reviewed Shop Drawings.

3.4 EXCAVATION

- A. Excavation shall include material of every description and of whatever substance encountered. Pavement shall be cut with a saw, wheel or pneumatic chisel along straight lines before excavating.
- B. In general, furnish all equipment necessary to excavate all on-site soils including, but not limited to, dense soils, boulders, and obstructions. In no case shall the earth be ploughed, scraped, or dug with machinery so near to the finished Subgrade as to result in excavation of, or disturbance of material below grade.
- C. Excavations shall be made to the grade indicated on the Contract Drawings and in widths sufficient for laying the pipe, construction of the structure, bracing and for dewatering and drainage facilities. Excavations for Structures shall be suitably wide for construction of the Structures, including excavation supports, dewatering, and drainage systems and working clearances.
- D. Excavation shall be performed In-the-Dry and shall be accomplished by methods which preserve the natural undisturbed condition of the Subgrade soils.
- E. Moisture-Sensitive Soils are particularly susceptible to disturbance due to construction operations. When excavation is to end in such soils, use a smooth-edge bucket to excavate the last one (1) foot of depth.
- F. If the bottom of any excavation is taken out below the limits shown on the Contract Drawings or as specified for convenience or by mistake of the Contractor, or as a result of disturbance from the Contractor's activities, it shall be refilled at no additional cost to the Authority with Structural Fill, CLSM, or other material satisfactory to the Authority.
- G. When excavation has reached prescribed depths, including any allowances for working mats or base materials, prior to the placement of working mats or base materials, notify the Authority to observe the conditions and notify the soil testing laboratory to verify the suitability of the existing Subgrade soils for the anticipated foundation and structural loadings. If materials and conditions are not satisfactory to the Authority, the Authority will issue instructions as to the corrective procedures. The Authority will be the sole judge as to whether the work has been accomplished satisfactorily.
- H. Perform Over-excavation as specified herein or at the request of the Authority to remove Unsuitable Soil, Objectionable Material, or other materials as determined by the Authority to such depth and width as the Authority may direct and replace with

suitable material as directed by the Authority. Remove loose or soft material from the Subgrade immediately prior to placing the lean concrete working mat.

- I. Excavation for pipelines beneath Structures and excavation for footings shall be carried out with the excavating equipment operating from the Subgrade for the structure. The excavation shall be carried out "In-the-Dry" and in a manner which will preserve the undisturbed state of the Subgrade soils.
- J. If intact rock with a minimum volume of one (1) cubic yard, requiring systematic drilling or jack hammering in the opinion of the Authority, is encountered during excavation, the Contractor shall expose the rock and notify the Authority prior to any breaking or removal. The Authority shall document the conditions before work proceeds. Removal of intact rock shall be performed only as directed and approved by the Authority.
- K. Remove, relocate, or otherwise manage obstructions encountered during earthwork operations as required to achieve the specified lines, grades, and compaction requirements. Work shall be performed using methods approved by the Authority and in a manner that does not endanger adjacent structures, utilities, or completed work.
- L. If rock below the design subgrade is shattered, disturbed, or otherwise unsuitable to support the subgrade, remove the affected material and replace it with Structural Fill or CLSM, as directed by the Authority, at no additional cost to the Authority. Blasting is strictly prohibited.
- M. Prevent displacement, settlement, or damage to areas outside the approved excavation limits.
- N. After obstruction removal, backfill, compact, and restore the excavation to the required lines and grades using Structural Fill as directed by the Authority.

3.5 SUBGRADE PREPARATION

- A. Maintain the excavated Subgrade In-the-Dry.
- B. Prior to placement of fill, remove Objectionable Material which shall include, but not be limited to, pavement, topsoil, organic matter, contaminated soil, construction debris, perishable materials, snow, ice, frozen earth, rocks and lumps of cemented soils over six (6) inches in maximum dimension.
- C. For Subgrades consisting of granular soils, proof compact the final Subgrade using at least four (4) Coverages of a vibrator plate compactor.
- D. Protect all cohesive subgrade from disturbance, rutting, pumping, or softening. If necessary to maintain stability, an approved working mat consisting of Granular Material, Crushed Stone, or other suitable material shall be placed and maintained at

no additional cost to the Authority.

- E. Soft Subgrades or Unsuitable Material shall be removed and replaced with compacted Structural Fill.
- F. Subgrade soils that have become soft, loose, "quick", or otherwise unsatisfactory as a result of inadequate excavation, dewatering or other construction methods, in the opinion of the Authority, shall be removed and replaced with Structural Fill or CLSM as acceptable to the Authority and at no additional cost to the Authority.
- G. Exposed Subgrades for foundations shall be proof rolled with at least four (4) overlapping Coverages of a vibratory drum roller with a minimum of a 10-ton static drum weight. Proof-rolling in confined areas may be accomplished with hand operated vibratory equipment approved by the Authority. Proof-rolling shall be conducted in the presence of the Authority. The Authority shall waive this requirement if, in its opinion, the Subgrade will be rendered Unsuitable by such proof rolling.
- H. During wet or freezing weather, or in areas where the exposed Subgrade consists of Moisture-Sensitive Soils, take measures to protect foundation excavations once they have been approved by the Authority. These measures shall include, but are not limited to, placing insulation blankets, placing a layer of Granular Material, Crushed Stone, or CLSM on the exposed Subgrade, or covering the exposed Subgrade with a plastic tent. Provide additional over-excavation if required because the Subgrade was not protected against wet or freezing weather at no additional cost to the Authority.
- I. Notify the Authority to observe the Subgrade following Subgrade preparation and prior to fill placement. If the existing Subgrade soils are determined to be Unsuitable, directions will be provided by the Authority regarding removal and replacement with suitable materials.

3.6 FILLING PLACEMENT AND COMPACTION PROCEDURES

- A. Fill and backfill materials shall be placed in lifts to suit the specified compaction requirements to the lines and grades required, making allowances for settlement and placement of cover materials (i.e., topsoil, sod, etc.). Soft spots or uncompacted areas shall be corrected.
- B. Fill and backfill shall not be placed and compacted when the materials are too wet to properly compact (i.e., the in-place moisture content of the soil at that time is no more than three (3) percentage points above the Optimum Moisture Content of that soil as determined by the laboratory test of the moisture-density relation appropriate to the specified level of compaction).
- C. Structural Fill and Common Fill shall be placed in level lifts not exceeding 8 inches in

loose thickness and compacting the entire lift to a minimum 95 Percent Compaction of maximum dry density (ASTM D1557).

- D. Structural Fill shall be constructed to the lines and grades required, making allowances for settlement and placement of cover materials (i.e. topsoil, sod, etc.). Soft spots or uncompacted areas shall be corrected.
- E. Fill materials shall not be placed on frozen surfaces, or surfaces covered by snow or ice. Fill material shall be free of snow, ice and frozen earth.
- F. Structure water-tightness tests and damp-proofing/water-proofing shall be completed prior to placing fill or backfill around Structures.
- G. If the Subgrade slopes more than ten (10) percent, the Subgrade shall be stepped to produce a stable, horizontal surface for the placement of fill materials. The existing Subgrade slope shall then be scarified to a depth of at least six (6) inches.
- H. Fill slopes should be compacted by slope rolling and trimming or should be overfilled and trimmed back to plan grade to expose a firm, smooth surface free of loose material.
- I. Fill lifts shall not contain stones with a dimension larger than 2/3 of the specified loose measure lift thickness.
- J. Compaction in open areas where compaction can be performed without physical restrictions on equipment movement or operator access, may be accomplished by any of the following methods: compaction equipment, fully loaded ten-wheel trucks or front-end loaders, tractor dozers weighing at least 30,000 pounds or heavy vibratory rollers. Compaction in confined areas (including areas within a 45-degree angle extending upward and outward from the base of a wall) and in areas where the use of large equipment is impractical, shall be accomplished by hand operated vibratory equipment or mechanical tampers. Lift thickness shall not exceed six (6) inches measured before compaction when hand operated equipment is used.
- K. Relatively lightweight compaction equipment (i.e., plate compactors, walk-behind vibratory rollers, jumping jacks, etc.) shall be used in the vicinity of manholes and concrete pipes and other sensitive utilities. Reduced lift thicknesses of no more than six (6) inches shall be used where such equipment is required.
- L. Fill material shall be moisture conditioned prior to placement, unless in-place moisture conditioning methods that can achieve the required moisture content are demonstrated to the Authority.
- M. Compaction of each specified lift of Structural Fill and Common Fill shall be conducted by a minimum of four (4) passes with acceptable compaction equipment to a specified density which is expressed as a percentage of the maximum dry density as determined

by ASTM D1557, unless specified otherwise by the Authority.

- N. For compaction of Crushed Stone in confined areas, use hand-guided compaction equipment. Place the material in loose lifts not exceeding eight (8) inches thick. In larger open areas, and when large compaction equipment is used, lifts shall not exceed 12 inches thick. Each lift shall be compacted with at least four (4) complete coverages using appropriate compaction equipment.
- O. When using Crushed Stone as subgrade protection in wet silty and clayey soils, place stone in lifts no greater than 10 to 12 inches thick followed by compacting the lift with four (4) passes with a plate compactor. A non-woven filter fabric shall be used between the surrounding soils and the open stone. Subgrades shall be hand excavated or with an excavator equipped with a smooth-edge bucket. Subgrades shall be firm and stable prior to placement of fabric and stone.
- P. Fill required beneath foundations or slabs on grade (except sidewalks) shall be Structural Fill. Place and compact Structural Fill in even lifts having a maximum thickness (measured before compaction) of eight (8) inches.
- Q. Fill and backfill material placed immediately adjacent to and within ten (10) feet of Structures, excluding utilities, shall be Structural Fill. All structure water-tightness tests and damp-proofing/water-proofing shall be completed prior to placing fill or backfill around Structures. Place and compact Structural Fill in even lifts having a maximum thickness (measured before compaction) of 8-inches uniformly around the Structure.
- R. Common Fill may be used in areas beyond those designated for Structural Fill, unless shown or specified otherwise by the Authority. Common Fill shall be placed in even lifts having a maximum thickness (measured before compaction) of 12-inches.

3.7 COMPACTION REQUIREMENTS

- A. Perform in place testing of compacted fill lifts to measure in-place density and water content per ASTM D6938.
- B. Beneath foundations and slabs on grade (except sidewalks): Compact the top 12-inches of existing Subgrade (and each layer of fill if applicable) to a minimum of 95 percent maximum dry density per ASTM D1557 at or near its Optimum Moisture Content (minus two (2) to plus three (3) percent).
- C. Pipeline bedding shall be compacted to not less than 95 percent of maximum dry density per ASTM D1557 (Modified Proctor), at or near its Optimum Moisture Content (minus two (2) to plus three (3) percent).
- D. Ten (10) feet around Structures: Compact each layer of fill or backfill to a minimum of 95 percent maximum dry density per ASTM D1557 at or near its Optimum Moisture

Content (minus two (2) to plus three (3) percent).

- E. Embankments (except under roadways and within reinforced slope), lawn or unimproved areas: Compact each layer of fill or backfill to a minimum of 90 percent maximum dry density per ASTM D1557 at or near its Optimum Moisture Content (minus one (1) to plus four (4) percent).
- F. Sidewalks and reinforced slope and embankment: Compact each layer of fill to a minimum of 95 percent modified proctor per ASTM D1557 at or near its Optimum Moisture Content (minus two (2) to plus three (3) percent).
- G. Roads, paved areas and roadway embankments: Compact each layer of fill or backfill to a minimum of 95 percent maximum dry density per ASTM D1557 at or near its Optimum Moisture Content (minus two (2) to plus three (3) percent).

3.8 Controlled Low Strength Material (CLSM) Fill

- A. CLSM shall not be placed on frozen ground. Batching, mixing, and placing of CLSM may be started when weather conditions are favorable and when the temperature is at least 34°F and rising. At time of placement of CLSM the temperature shall be at least 40°F. Mixing and placing shall stop when the temperature is 38°F (3.3°C) and falling. Each filling stage shall be as continuous an operation as is practicable.
- B. CLSM shall be discharged from the mixer by an acceptable procedure into the area to be filled. Place CLSM to limits indicated on the Contract Drawings. Mixing CLSM with in-situ soil shall be avoided.
- C. When CLSM is placed as backfill against Structures, the fill shall be placed in lifts of 2 to 3 feet, and the next lift shall not be placed until the previous lift can support the weight of workers without indenting the surface and at least 16 hours have elapsed from the end of placement. Reduce lift thickness as necessary to prevent floatation of the Structure.
- D. When CLSM is placed over culverts or pipelines, they shall be anchored to prevent flotation during the placement of CLSM. Unless otherwise required, place CLSM to one (1) foot below the finished grade elevation if the finished grade elevation is not more than five (5) feet over the top of the culvert or pipe. If the finished grade is more than 5 feet over the top of the culvert or pipe, place CLSM to an elevation two (2) feet over the top of the culvert or pipe, and backfill the remainder with the specified backfill or as indicated on the Contract Drawings.

3.9 HANDLING AND DISPOSAL OF MATERIALS

- A. Unsuitable Soil, Objectionable Material, removed obstructions, and waste and surplus excavated material shall be removed and disposed of off-site or permanently stockpiled

within the work site if designated on the Contract Drawings. Materials may be temporarily stockpiled in an area within the limits of construction that does not disrupt construction activities, create any nuisances or safety hazards, or otherwise restrict access to the work site. Refer to the Specification Section 02226 - Excavated Material Handling and Disposal for the materials handling and disposal requirements.

- B. Stockpile materials only within the limits of disturbance shown on the Contract Drawings, and locate stockpiles so as not to impose surcharge loads on any excavation
- C. Excavated materials can be reused if they meet the Contract Documents requirements.
- D. Topsoil or loam, if any, excavated under this Section may be salvaged for convenience for use as specified under Specification Section 02900 – Restoration and Landscaping as approved by the Authority.

3.10 GRADING

- A. Perform grading to the lines and grades shown on the Contract Drawings. Remove and dispose of Objectionable Material encountered within the limits indicated. Subgrades shall be completely and continuously drained and dewatered throughout the grading process. Perform dewatering in accordance with Specification Section 02240 – Construction Dewatering and Groundwater Control to intercept or divert surface water which may affect the execution or condition of grading work.
- B. If at the time of grading it is not possible to place any material in its proper section of the Work, it shall be stockpiled in approved areas for later use. Stockpiling or double handling of excavated material will be provided at no additional cost to the Authority.

3.11 RIPRAP PLACEMENT

- A. Carry out the placement of Riprap in coordination with the construction activities. Proceed with Riprap installation with only the minimal necessary delay, ensuring that the timing of placement allows for the proper construction of the specific sections that the Riprap is intended to protect. This approach is critical to maintain the integrity of both the Charles River embankment and the Riprap protection, preventing any unintended mixing of the slope materials with the Riprap. Only sufficient lag in the placement of the Riprap protection shall be permitted, and this delay shall occur solely as required to facilitate the correct construction process for the protected portions of the outfall and the slope. In no case shall the elevation of the slope be greater than 5 feet above the elevation of the Riprap material.
- B. Subgrade and Slope Preparation
 - 1. Prepare the slope surface by grading and trimming to produce a smooth, firm surface conforming to the design slope. Remove loose soil, debris, and vegetation

that may prevent proper seating of the Riprap.

2. Compact earth slope as required by in this section, generally to a uniform surface free of irregularities.
3. Provide adequate dewatering to prepare a firm and stable Subgrade.

C. Riprap Placing

1. Place Riprap immediately upon an approved Subgrade (Filter Gravel or Geotextile), to the lines and grades shown on the plans and as directed by the Authority.
2. Place Riprap on the prepared Filter Gravel or Geotextile starting at the toe of the slope and proceeding upward.
3. Place Riprap to full specified thickness in one operation unless otherwise directed by the Authority.
4. Do not place Riprap in a manner that causes segregation of sizes or damages the underlying surface.
5. Mechanical equipment may be used to place Riprap; however, hand or mechanical redistribution of stones may be required to fill voids and reduce segregation.
6. Riprap shall be seated to form a dense, interlocking mass with the least practicable percentage of voids. Avoid excessive down pressure from equipment to prevent mixing Riprap and Filter Gravel or damage to Geotextile.
7. Backfill voids within the installed Riprap with smaller rock or filter stone to ensure full coverage and minimize soil migration, preferential drainage paths and attracting animals.

D. Protection of Work During Construction

1. Prevent vehicles and equipment from operating on the placed Riprap, unless approved otherwise by the Authority.
2. Repair any displacement, slumping, or damage to the Riprap or Geotextile promptly and at no additional cost to the Authority.
3. Take note of the 100-year flood elevation and provide temporary protection below this level of the Charles River embankment if a flood event is forecasted and at no additional cost to the Authority.

E. Final Grading and Acceptance

1. Slope face shall be finished to reasonably smooth contour, with uniform distribution of stones, without large pockets of segregated stone sizes or exposed Geotextile.
2. Riprap thickness, slope coverage, and surface quality shall be inspected and accepted by the Authority before final payment.

3.12 FILTER GRAVEL PLACEMENT

A. Subgrade and Slope Preparation

1. Prepare the Subgrade by grading and trimming to produce a smooth, firm surface conforming to the design slopes and elevation. Remove loose soil, debris, and vegetation.
2. Compact earth slope as required by earthwork specifications, generally to a uniform surface free of irregularities.
3. Provide adequate dewatering to prepare a firm and stable Subgrade.

B. Filter Gravel Placing

1. Place Filter Gravel immediately upon an approved Subgrade (immediately following placement of Geotextile), to the lines and grades shown on the Contract Drawings and as directed by the Authority.
2. Place Filter Gravel on Geotextile starting at the toe of the slope and proceeding upward.
3. Place Filter Gravel to full specified thickness in one operation unless otherwise directed by the Authority.
4. Do not place Filter Gravel in a manner that causes segregation of sizes or damages the underlying surface.
5. Stones shall be seated to form a dense, interlocking mass with the least practicable percentage of voids. Avoid excessive down pressure from equipment to prevent damage to Geotextile.

**** END OF SECTION ****