# Project Manual - Volume One

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### Civil, Geotech, Transportation, and Survey Engineers: DOWL HKM

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PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Protecting existing vegetation to remain.
2. Removing existing vegetation.
3. Clearing and grubbing.
4. Stripping and stockpiling topsoil.
5. Removing above- and below-grade site improvements.
6. Disconnecting, capping or sealing, and removing site utilities.

1.2 RELATED REQUIREMENTS:

1. Section 31 20 00 - Earth Moving.
2. Section 02 32 00 "Geotechnical Data" for geotechnical report and recommendations for the site.
3. Section 02 41 00 "Site Demolition" for demolition of existing site improvements.

1.3 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. Standard Specifications:

2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.
3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

C. Related Sections:

1. Section 02 32 00 "Geotechnical Data" for geotechnical report and recommendations for the site.
2. Section 02 41 00 "Site Demolition" for demolition of existing site improvements.

1.4 DEFINITIONS

A. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
B. Topsoil: Top layer of the soil profile consisting of existing native surface topsoil or existing in-place surface soil and is the zone where plant roots grow.

C. Plant-Protection Zone: Area surrounding individual trees, groups of trees, shrubs, or other vegetation to be protected during construction, and indicated on Drawings.

D. Tree-Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and as defined by landscape architect.

E. Vegetation: Trees, shrubs, groundcovers, grass, and other plants.

1.5 MATERIAL OWNERSHIP

A. Except for stripped topsoil and other materials indicated to be stockpiled or otherwise remain Owner's property, cleared materials shall become Contractor's property and shall be removed from Project site.

1.6 INFORMATIONAL SUBMITTALS

A. Existing Conditions: Documentation of existing trees and plantings, adjoining construction, and site improvements that establishes preconstruction conditions that might be misconstrued as damage caused by site clearing.

1. Use sufficiently detailed photographs or videotape.
2. Include plans and notations to indicate specific wounds and damage conditions of each tree or other plants designated to remain.

B. Record Drawings: Identifying and accurately showing locations of capped utilities and other subsurface structural, electrical, and mechanical conditions.

1.7 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during site-clearing operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Improvements on Adjoining Property: Authority for performing site clearing indicated on property adjoining Owner's property will be obtained by Contractor before performing work.

1. Do not proceed with work on adjoining property until approved by landowner.

C. Utility Locator Service: Notify One Call for area where Project is located before site clearing.

D. Do not commence site clearing operations until temporary erosion- and sedimentation-control and plant-protection measures are in place.
PART 2 - PRODUCTS

2.1 MATERIALS
   A. Satisfactory Soil Material: Requirements for satisfactory soil material are specified in Section 023200 "Geotechnical Data" within geotechnical report.
      1. Obtain approved borrow soil material off-site when satisfactory soil material is not available on-site.

PART 3 - EXECUTION

3.1 PREPARATION
   A. Protect and maintain benchmarks and survey control points from disturbance during construction.
   B. Protect existing site improvements to remain from damage during construction.
      1. Restore damaged improvements to their original condition, as acceptable to Owner.

3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL
   A. Provide temporary erosion- and sedimentation-control measures to prevent soil erosion and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways, according to erosion- and sedimentation-control Drawings and requirements of authorities having jurisdiction.
   B. Verify that flows of water redirected from construction areas or generated by construction activity do not enter or cross protection zones.
   C. Inspect, maintain, and repair erosion- and sedimentation-control measures during construction until permanent vegetation has been established.
   D. Remove erosion and sedimentation controls and restore and stabilize areas disturbed during removal.

3.3 TREE AND PLANT PROTECTION
   A. Repair or replace trees, shrubs, and other vegetation indicated to remain or be relocated that are damaged by construction operations, in a manner approved by Architect.

3.4 EXISTING UTILITIES
   A. Locate, identify, disconnect, and seal or cap utilities indicated to be removed or abandoned in place.
      1. Arrange with utility companies to shut off indicated utilities.
   B. Locate, identify, and disconnect utilities indicated to be abandoned in place.
C. Interrupting Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

1. Coordinate utility interruption with City of Bozeman personnel.

D. Excavate for and remove underground utilities indicated to be removed.

3.5 CLEARING AND GRUBBING

A. Remove obstructions, trees, shrubs, and other vegetation to permit installation of new construction.

1. Do not remove trees, shrubs, and other vegetation indicated to remain or to be relocated.
2. Grind down stumps and remove roots, obstructions, and debris to a depth of 18 inches below exposed subgrade.
3. Chip removed tree branches and dispose of off-site.

B. Fill depressions caused by clearing and grubbing operations with satisfactory soil material unless further excavation or earthwork is indicated.

1. Place fill material in horizontal layers not exceeding a loose depth of 8 inches, and compact each layer to a density equal to adjacent original ground.

3.6 TOPSOIL STRIPPING

A. Remove sod and grass before stripping topsoil.

B. Strip topsoil in a manner to prevent intermingling with underlying subsoil or other waste materials.

1. Remove subsoil and non-soil materials from topsoil, including clay lumps, gravel, and other objects more than 2 inches in diameter; trash, debris, weeds, roots, and other waste materials.

C. Stockpile topsoil away from edge of excavations without intermixing with subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust and erosion by water.

1. Limit height of topsoil stockpiles to 72 inches.
2. Stockpile surplus topsoil to allow for re-spreading deeper topsoil.

3.7 SITE IMPROVEMENTS

A. Remove existing above- and below-grade improvements as indicated and necessary to facilitate new construction.

B. Remove slabs, paving, curbs, gutters, and aggregate base as indicated.

1. Unless existing full-depth joints coincide with line of demolition, neatly saw-cut along line of existing pavement to remain before removing adjacent existing pavement. Saw-cut faces vertically.
3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Remove surplus soil material, unsuitable topsoil, obstructions, demolished materials, and waste materials including trash and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 10 00
SECTION 31 11 00 – TREE PROTECTION

PART 1 - GENERAL

1.0 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General conditions, Supplementary Conditions, apply to work of this section.

1.1 DESCRIPTION

The work in this section includes protection, trimming and maintenance of existing trees, shrubs and groundcover that are affected by execution of the Contract Documents, whether temporary or permanent construction. All proprietary products listed within this specification shall be considered as a BASIS-OF-DESIGN PRODUCT.

A. The Contractor assumes responsibility for all coordination of work within the Critical Root Zone (CRZ) of protected trees.

B. Plant protection applies to all trees to remain within the Limit of Work as well as those, which are adjacent to the Limit of work and could be affected by new construction. Work to include:

1. Protection of existing trees and indicated vegetated areas.

2. Watering of existing trees and vegetated areas to be protected.

3. Maintenance of existing and newly installed tree and vegetation protection elements including but not limited to fencing, organic bark mulch, landscape fabric, cabling, and signage.

4. Pruning of existing trees to be protected

5. Removal of pruning debris and other excess material not used. On-site chipping and re-use of pruned material is encouraged.

C. Contractor shall perform all tree protection installation and removal, and any necessary pruning work required for construction under the supervision of the Owner.

1.2 RELATED WORK DESCRIBED ELSEWHERE

A. Section 32 84 00 - Irrigation System

B. Section 32 93 00 - Landscaping

C. Section 32 92 00 – Lawns and Grass

1.3 DEFINITIONS

A. Tree Protection Zone: Area surrounding individual trees or groups of trees to remain during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

B. Drip Line: The areas encompassing the base of the tree as delineated by an imagined vertical line drawn from the farthest extent of the branches to the ground.
C. Diameter at Breast Height (DBH): Diameter at breast height as measured at four and one-half feet (4'-6") above the existing grade at the base of the tree.

D. Critical Root Zone (CRZ): An area up to one and one-half the radius of the drip line of the tree.

1.4 REFERENCED STANDARDS


D. Alex Shigo, Tree Pruning, Shigo & Tree Associates, LLC, 1989.


G. ANSI A300: Standards for Tree Care Operations, American National Standards Institute.

H. International Society of Arboriculture Best Management Practices publications


1.5 QUALITY ASSURANCE

A. Tree Service Firm Qualifications: An experienced tree service firm with a minimum of five years of experience that has successfully completed tree protection and trimming work similar to that required for this project.

B. Arborist Qualifications: An arborist certified by ISA or licensed in the jurisdiction where the project is located.


1. Owner’s representative shall be notified 24 hours in advance of all pruning, thinning and tree protection work.

D. Pre-Construction Conference: Conduct conference at project site to comply with requirements in ANSI A300 Division 1, Section “Project Management and Coordination.”

1. Before tree protection and trimming operations begin, meet with representatives of authorities having jurisdiction, Owner’s Arborist, Landscape Architect, consultants, and other concerned entities to review tree protection and trimming procedures and responsibilities.

1.6 SUBMITTALS

A. Product Data: For each type of product indicated below.
B. Product samples:
   1. Tree protection area signage.
   2. Cabling materials.
   3. Landscape fabric.
   4. Organic bark mulch.

C. Tree Pruning Schedule: Written schedule from arborist detailing scope and extent of pruning of trees to remain that are affected by construction.

D. Tree Protection Plan: Contractor shall submit a tree protection plan that confirms that use of the tree protection fencing plan provided in the Contract Documents. Contractor shall notify the Owner of all work activities within the CRZ of trees to be protected, anticipated work methods, proposed tree and root avoidance techniques, and Arborist's on-site confirmation of CRZ for each tree.

1.7 JOB CONDITIONS

A. Site Work Restrictions: In order to prevent excessive soil compaction and destruction of soil structure, no site work will be performed in cases where equipment or traffic must pass over wet soils or if wet soils must be handled or manipulated within the Tree Protection Zone in order for the work to progress. Wet soil is defined as any soil within 85 percent of field capacity (saturation).

B. Utilities
   1. Utility locates are required prior to digging and any construction activities.
   2. Coordinate work with Owner, including irrigation manager, in order to prevent damage to underground sprinkler system.

1.8 MAINTENANCE

A. Water will be available on site. Provide necessary hoses and other watering equipment required to complete work.

B. Maintain existing plantings and trees by watering, cultivating, weeding, and spraying as necessary to keep landscape in a vigorous, healthy condition.

C. Coordinate watering schedules with irrigation contractor during installation and until final acceptance. Provide deep root watering to newly installed trees.

PART 2 – PRODUCTS

2.0 MATERIALS

A. Topsoil Depth: Natural or cultivated surface-soil layer containing composted organic matter an sand, silt and clay particles; friable, pervious, and black or darker shade of brown, gray or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than two inches in diameter; and free of weeds, roots and toxic and other non-soil materials.

B. Filter Fabric: Manufacturer’s standard, non-woven, pervious, geotextile fabric of polypropylene, nylon, or polyester fibers.
C. Chain-Link Fence:
   1. Fencing shall be galvanized chain link as specified below, six feet minimum height. Plastic fencing and wood stakes, or snow fencing are not acceptable.
   2. Includes posts, braces, supports and mesh that may be salvaged materials or other used material to form a minimum six foot high enclosure.
   3. Posts shall be a minimum diameter of 1-1/2-inch steel pipe.
   4. Mesh shall be two inches by two inches by 11 gauge minimum chain link fabric.
   5. Use of concrete or metal post piers is permitted.

E. Signage: Provide weather resistant 8-1/2 inches by 11 inches fluorescent green or yellow signs that identify Tree Protection Zone and list restrictions.

F. Cabling: Cabling materials shall meet the ANSI A300 standards for cabling of trees.

G. Tree Tags: Rack track shaped aluminum engraved numbered tags.

H. Organic Mulch: Shall be free from weed seed, sawdust and splinters and shall not contain resin, tannin, wood fiber or other compounds detrimental to plant life. Bagged mulch shall have moisture content not in excess of 22%. Bulk mulch shall have a size range of ½ inch to 1-1/4 inch with a maximum of 20% passing a ½ inch screen. Re-use of organic debris generated during the project is encouraged.

I. Mycorrhizae Fungal Inoculants: “mycocgrow gel” as manufactured by Fungi Perfecti, Olympia, WA, 1-800-780-9162, or approved alternate.

J. Slow Release Fertilizer: Osmocote Plus, 15-9-12, or approved alternate.

K. Anti-Desiccant: Protective film emulsion for protection of plant surfaces during transport. Permeable to permit transpiration, as manufactured by Wilt Pruf, Inc., P.O. Box 4280, Greenwich, Connecticut, 06830, or approved alternate. Mixed and applied in accordance with manufacturer’s instructions.

L. Staking and Guying
   1. Tie Wire: 12-gauge, galvanized wire
   2. Metal posts: 8'-0” t-stakes
   3. Nylon strap: three inches wide, 12 inches long white or black nylon strap with one ½” brass grommet in each end or Landscape Architect approved equivalent.

PART 3 - EXECUTION

3.0 INSTALLATION OF TREE PROTECTION FENCING

A. Prior to the start of any construction activity install temporary fencing at the designated tree protection zones to protect existing trees and vegetation to remain from construction damage. Maintain temporary fence and remove when construction (including irrigation and planting) is complete. Owner shall approve fence installation prior to mobilization of the site.
1. Install chain-link fence according to ASTM F 567 and manufacturer's written instructions. All fencing to be locked securely and only entered with owner's permission and in consultation with the Owner's Arborist.

2. Place concrete or metal piers to minimize pedestrian and vehicle circulation and landscape impacts.

3. Provide diagonal bracing to vertical posts at corners of enclosures and wherever needed to ensure rigidity of the fencing.

4. If chain link fabric is used versus chain link panels the chain-link fabric shall be tight to grade at the bottom edge and stretched uniformly between posts. Top of fabric shall be a minimum of six feet above grade. Install fabric to form completely closed area around tree(s). Attach fabric to posts 12 inches on center with 11 gauge wire ties securely fastened, or with bolted ring clips and to top rail not over three feet on center.

B. Fencing shall be installed as follows: In the vicinity of coniferous trees, fenced area shall include an area of a radius from the trunk equal to one and one-half times the radius of the drip line of the tree. In the vicinity of deciduous trees, fenced area shall include an area of a radius from the trunk equal to one and one-half times the radius of the drip line of the tree. For areas with shrubs plants, fenced area shall include the entire edge of the planted area.

C. Area within tree protection fencing must be mulched with organic bark mulch to a depth of four inches.

D. Attach orange flag strips 12 inches long at three feet on center along the fence, five feet above grade.

E. Place tree protection signs at thirty-foot intervals along fence with a minimum of one sign if the fence is less than 30 feet in length.

3.1 FENCE MAINTENANCE AND REMOVAL

A. Maintain fence in specified location and in good condition until completion of site operations and of delivery of equipment and material, except where directed otherwise in writing by Owner's representative.

B. Fencing shall be immediately repaired when damaged.

C. Remove protection fencing at Substantial Completion.

3.2 USE OF AREA WITHIN FENCE

A. Do not use area within fence for operation, storage, vehicles, or foot traffic. Contractor shall notify Owner's representative 24 hours in advance of the need to move a tree protection fence or access inside of it.

B. Do not alter grades within the required protective fence line except as directed during the fine grading operations at the conclusion of site development.

C. Control soil moisture within the protected area. Prevent flooding, ponding, erosion, or excessive wetting of the soil and root systems caused by dewatering operations. Protect root areas from leachate, concrete, oil, fuel, lubricating oil, and from other contaminants.
3.3 USE OF AREA ADJACENT TO FENCE

A. Do not store materials potentially harmful to tree roots within 20 feet of protected areas. Potentially harmful materials include, but are not limited to petroleum products, cement and concrete materials, cement additives, lime, paints coating, waterproofing agents, from coatings, detergents, acids, and cleaning agents.

B. Notify owner’s representative of all heavy equipment work to be performed within the CRZ.
   1. Tie-back all flexible limbs and branches, which may be damaged during construction, under the direction of the Owner’s representative.
   2. Use compaction mitigation strategies such as planking, mulch, or plating as directed by the Owner’s representative.

3.4 DAMAGES FOR LOSS OR INJURY TO TREES

A. Trees removed or damaged and deemed unviable, during demolition or construction, are to be replaced following consultation with Owner’s Arborist or Owner’s representative.

B. Trees removed during demolition or construction are to be replaced following consultation with Owner’s Arborist or Owner’s Representative. Appraised values of existing trees have been determined according to industry standards and will be provided by the Owner if applicable.

C. Contractor is to replace any and every tree lost or irreparably damaged as a result of failure of the Contractor to protect or to adequately maintain existing trees. Trees that fail to fully foliate in the spring following completion of construction operations may be presumed to have been lost due to construction operations.

D. In the event of injuries to the crown, trunk or root system of any tree to remain that are the result of the Contractor’s failure to protect and/or maintain such tree, the Owner’s Representative may elect to retain the tree and hold the Contractor liable for compensation.

E. Promptly repair trees damaged by construction operations within 24 hours. Treat damaged trunks, limbs, and roots according to Owner’s Arborist’s written instructions. Work required by the Owner’s Arborist shall be performed by the Contractor at no additional cost to the Owner.

F. Trees, which are removed without authorization, shall be replaced with a tree of the same size and species. If a tree of the same size and species is not available the Owner’s Representative shall provide alternatives. If a tree cannot be replaced because the size exceeds the maximum which can be relocated using latest technology, the Contractor shall compensate the Owner at amount equal to the appraised value.

G. Should replacement work of large trees be required as a result of Contractor’s failure to protect or maintain trees, a subcontractor specializing in relocating large trees shall conduct all replacement work. Submit qualifications of tree relocation Contractor to the Owner’s Representative. The cost of the subcontractor will be at the Contractor’s expense.

H. Completely remove and dispose of any tree killed or irreparably damaged as a result of Contractor’s failure to protect or maintain trees. Remove those trees damaged or killed as a result of vandalism, natural acts or other causes. Removal and disposal shall include stumps and roots to a depth of two feet below finished grade.

3.5 PRUNING OF EXISTING TREES
A. Limbs and branches that have been broken shall be cut off cleanly above the nearest crotch in accordance with International Society of Arboriculture (ISA) standards. Cut limbs and branches greater than one-half inch in diameter. Sterilize equipment with alcohol prior and during trimming and pruning operation. All pruning of damaged trees shall be carried out to the complete satisfaction of the Owner’s Representative.

B. The Contractor shall provide a ISA certified professional to assess and recommend treatment of any damage to trunks or major limbs three inches in diameter or over.

C. All existing trees to be saved shall be limbed and pruned by a ISA certified Arborist. Limbs shall be pruned to ensure safety and promote health of the tree. Inform the Owner’s Representative prior to commencement of pruning.

3.6 EXCAVATION

A. Install shoring or other protective support systems to minimize sloping or benching of excavations.

B. Do not excavate within Tree Protection Zones, unless otherwise indicated.

C. Where excavation for new construction is required within tree protection zones, hand clear and excavate to minimize damage to root systems. Use narrow-tine spading forks and comb soil to expose roots. Work shall be performed under the supervision of the Owner’s representative.

1. Redirect roots into backfill areas where possible. If encountering large, main lateral roots, expose roots beyond excavation limits as required to bend and redirect them without breaking. If encountered immediately adjacent to location of new construction and redirection is not practical, cut roots approximately three inches back from new construction.

2. Do not allow exposed roots to dry out before placing permanent backfill. Water and maintain in a moist condition. Temporarily support and protect roots from damage until they are permanently relocated and covered with approved soil.

   a. Straw Mulch: Thoroughly wet excavated sub-grade where roots of existing trees to remain have been exposed. Apply four inches of wet organic bark mulch on horizontal area and wet burlap mats along exposed trench sides.

   b. Watering and Maintenance: Thoroughly and evenly water protected areas at a rate not to exceed two inches per hour during dry periods. Coordinate water procedures and schedules with the Owner’s Representative or the Project Manager. Maintain root protection procedures throughout the term of the Contract, as required.

D. Where utility trenches are required within tree protection zones, tunnel under or around roots by drilling, auger boring, pipe jacking, or digging by hand.

   1. Root Pruning: Do not cut roots larger than 1” without notifying Owner’s representative; Cut roots smaller than 1” in accordance with ISA standards.

3.7 POST CONSTRUCTION TREE MAINTENANCE

A. Ensure that existing trees remaining on the project site shall be in as good condition at completion of the work as at the commencement of the work. If such a condition does not exist at the completion of the work, assume responsibility to provide corrective actions or replacement with new material as directed by the Owner’s Representative.
SECTION 31 20 00 - EARTH MOVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Preparing subgrades for slabs-on-grade, walks, pavements, turf and grasses.
   2. Excavating and backfilling for buildings and structures.
   3. Drainage course for concrete slabs-on-grade.
   4. Subbase course for concrete walks and pavements.
   5. Subbase course and base course for asphalt paving.
   6. Subsurface drainage backfill for walls and trenches.
   7. Excavating and backfilling trenches for utilities and pits for buried utility structures.

1.2 RELATED REQUIREMENTS:

A. Section 23 20 00 Geotechnical Investigation
B. Section 31 10 00 - Site Clearing.
C. Section 31 63 10 – Vertically Rammed Engineered Aggregate Piers
D. Section 33 10 00 Water Distribution Piping
E. Section 33 30 00 Sanitary Sewer
F. Section 33 41 00 Strom Utility Drainage Piping
G. Section 32 12 16 Asphalt Paving
H. Section 32 13 13 Concrete Paving

1.3 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. Standard Specifications:

2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.
3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.4 DEFINITIONS

A. Backfill: Soil material or controlled low-strength material used to fill an excavation.
   1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
   2. Final Backfill: Backfill placed over initial backfill to fill a trench.

B. Base Course: Aggregate layer placed between the subbase course and hot-mix asphalt and or concrete paving.

C. Bedding Course: Aggregate layer placed over the excavated subgrade in a trench before laying pipe.

D. Borrow Soil: Satisfactory soil imported from off-site for use as fill or backfill.

E. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated.
   1. Authorized Additional Excavation: Excavation below subgrade elevations or beyond indicated lines and dimensions as directed by Architect.

F. Fill: Soil materials used to raise existing grades.

G. Rock: Rock material in beds, ledges, un-stratified masses, conglomerate deposits, and boulders of rock material 3/4 cu. yd. or more in volume that exceed a standard penetration resistance of 100 blows/2 inches when tested by a geotechnical testing agency, according to ASTM D 1586.

H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface.

I. Subbase Course: Aggregate layer placed between the subgrade and base course for hot-mix asphalt pavement, or aggregate layer placed between the subgrade and a cement concrete pavement or a cement concrete or hot-mix asphalt walk.

J. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below subbase, drainage fill, drainage course, or topsoil materials.

K. Utilities: On-site underground pipes, conduits, ducts, and cables, as well as underground services within buildings.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of the following manufactured products required:
   1. Geotextiles.
2. Controlled low-strength material, including design mixture.
3. Warning tapes.

B. Samples for Verification: For the following products, in sizes indicated below:

2. Warning Tape: 12 inches long; of each color.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified testing agency.

B. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:

1. Classification according to ASTM D 2487.
2. Laboratory compaction curve according to ASTM D 698.

C. Pre-excavation Photographs or Videotape: Show existing conditions of adjoining construction and site improvements, including finish surfaces that might be misconstrued as damage caused by earth moving operations. Submit before earth moving begins.

1.7 QUALITY ASSURANCE

A. Geotechnical Testing Agency Qualifications: Qualified according to ASTM E 329 and ASTM D 3740 for testing indicated.

1.8 PROJECT CONDITIONS

A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.

1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.

B. Utility Locator Service: Notify "Call Before You Dig" and the Campus Locates for area where Project is located before beginning earth moving operations.

C. Do not commence earth moving operations until temporary erosion- and sedimentation-control measures, specified in Section 312500 "Erosion and Sediment Control," are in place.

PART 2 - PRODUCTS

2.1 SOIL MATERIALS

A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
B. Satisfactory Soils: Obtain approval from the Architect for all fill before placing soil. Satisfactory fill material shall be free of rock or gravel larger than [3 inches (75 mm)] in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.

C. Subbase Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; 3” minus in in compliance with the Montana Public Works Standard Specifications, sixth edition (MPWSS), as amended by City of Bozeman Modifications to MPWSS, latest edition.

D. Base Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; 1.5” minus in in compliance with the Montana Public Works Standard Specifications, sixth edition (MPWSS), as amended by City of Bozeman Modifications to MPWSS, latest edition.

E. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand; Type 1 Pipe Bedding in compliance with the Montana Public Works Standard Specifications, sixth edition (MPWSS), as amended by City of Bozeman Modifications to MPWSS, latest edition.

F. Drainage Course: Narrowly graded mixture of washed crushed stone, or crushed or uncrushed gravel; ASTM D 448; coarse-aggregate grading Size 57; with 100 percent passing a 1-1/2-inch (37.5-mm) sieve and 0 to 5 percent passing a No. 8 (2.36-mm) sieve.

G. Topsoil: Topsoil shall be free of existing sod and lawn. Imported – Friable, dark loamy soil, fertile, free from rubble, stones, clay lumps, extraneous material, and plant roots and reasonably free of weeds. Physical properties as follows:

- Clay between 7-27%
- Silt between 28-50%
- Sand less than 52%

H. Sod: Sod shall be from a commercial sod farm located in Gallatin Valley. Sod shall be well-established lawn turf grasses similar to the seed mix described below:

Irrigated Grass Seed Mixture: Seed at the minimum rate of three (3) pounds per one thousand (1000) square feet (130 lbs./acre).

<table>
<thead>
<tr>
<th>Name of Grass</th>
<th>Proportion by Weight</th>
<th>Percent Purity</th>
<th>Percent Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Midnight' Kentucky bluegrass</td>
<td>25%</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>'Rugby II' Kentucky bluegrass</td>
<td>25%</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>'Ram I' Kentucky bluegrass</td>
<td>25%</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>'Delaware' Dwarf Peren. Rye Grass</td>
<td>25%</td>
<td>95%</td>
<td>85%</td>
</tr>
</tbody>
</table>

2.2 GEOTEXTILES

A. Separation Geotextile: Propex 350ST woven geotextile fabric, manufactured for separation applications, or approved equal.
2.3 CONTROLLED LOW-STRENGTH MATERIAL

A. Controlled Low-Strength Material: Self-compacting, flowable concrete material produced from the following:

1. Portland Cement: ASTM C 150, Type II or Type III.
2. Fly Ash: ASTM C 618, Class C or F.

2.4 ACCESSORIES

A. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored as follows:

2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

PART 3 - EXECUTION

3.1 PREPARATION

A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.

B. Protect and maintain erosion and sedimentation controls during earth moving operations.

C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.

3.2 DEWATERING

A. Prevent surface water and ground water from entering excavations, from ponding on prepared subgrades, and from flooding Project site and surrounding area.

B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation.

1. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
3.3 EXPLOSIVES

A. Explosives: Do not use explosives.

3.4 EXCAVATION, GENERAL

A. Unclassified Excavation: Excavate to subgrade elevations regardless of the character of surface and subsurface conditions encountered. Unclassified excavated materials may include rock, soil materials, and obstructions.

1. Earth excavation includes excavating pavements and obstructions visible on surface; underground structures, utilities, and other items indicated to be removed; together with soil, boulders, and other materials not classified as rock or unauthorized excavation.

3.5 EXCAVATION FOR STRUCTURES

A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1 inch (25 mm). If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.

1. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

2. Engineered Aggregate Pier (EAP) Foundations: Stop excavations 6 to 12 inches (150 to 300 mm) above bottom of footing before EAPs are placed. After EAPs have been installed, remove loose and displaced material. Excavate to final grade, leaving solid base to receive concrete foundations. See the EAP specification section for additional footing subgrade preparation.

3. Excavation for Underground Tanks, Basins, and Mechanical or Electrical Utility Structures: Excavate to elevations and dimensions indicated within a tolerance of plus or minus 1 inch (25 mm). Do not disturb bottom of excavations intended as bearing surfaces.

B. Excavations at Edges of Tree- and Plant-Protection Zones:

1. Excavate by hand to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.

3.6 EXCAVATION FOR WALKS AND PAVEMENTS

A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.7 EXCAVATION FOR UTILITY TRENCHES

A. Excavate trenches to indicated gradients, lines, depths, and elevations.

1. Beyond building perimeter, excavate trenches to allow installation of top of pipe below frost line.

B. Trenches in Tree- and Plant-Protection Zones:

1. Hand-excavate to indicated lines, cross sections, elevations, and subgrades. Use narrow-tine spading forks to comb soil and expose roots. Do not break, tear, or chop exposed roots. Do not use mechanical equipment that rips, tears, or pulls roots.
2. Do not cut main lateral roots or taproots; cut only smaller roots that interfere with installation of utilities.
3. Cut and protect roots according to requirements in Section 015639 "Temporary Tree and Plant Protection."

3.8 SUBGRADE INSPECTION

A. Notify Architect when excavations have reached required subgrade.

B. If Architect determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.

C. Proof-roll subgrade below the building slabs and pavements with a pneumatic-tired and loaded 10-wheel, tandem-axle dump truck weighing not less than 15 tons (13.6 tonnes) to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Completely proof-roll subgrade in one direction, repeating proof-rolling in direction perpendicular to first direction. Limit vehicle speed to 3 mph (5 km/h).
2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

3.9 STORAGE OF SOIL MATERIALS

A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent erosion and windblown dust.

1. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.10 BACKFILL

A. Place and compact backfill in excavations promptly, but not before completing the following:

1. Construction below finish grade including, where applicable, subdrainage, dampproofing, waterproofing, and perimeter insulation.
2. Surveying locations of underground utilities for Record Documents.
3. Testing and inspecting underground utilities.
4. Removing concrete formwork.
5. Removing trash and debris.
6. Removing temporary shoring and bracing, and sheeting.
7. Installing permanent or temporary horizontal bracing on horizontally supported walls.
B. Place backfill on subgrades free of mud, frost, snow, or ice.

3.11 UTILITY TRENCH BACKFILL

A. Place backfill on subgrades free of mud, frost, snow, or ice.


3.12 SOIL FILL

A. Fill to be in compliance with the Montana Public Works Standard Specifications, sixth edition (MPWSS), as amended by City of Bozeman Modifications to MPWSS, latest edition.

3.13 SOIL MOISTURE CONTROL

A. Uniformly moisten or aerate subgrade and each subsequent fill or backfill soil layer before compaction to within 2 percent of optimum moisture content.

1. Do not place backfill or soil material on surfaces that are muddy, frozen, or contain frost or ice.
2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.14 COMPACTION OF SOIL BACKFILLS AND FILLS

A. Compaction to be in compliance with the Montana Public Works Standard Specifications, sixth edition (MPWSS), as amended by City of Bozeman Modifications to MPWSS, latest edition.

B. All existing fill and deleterious material should be removed in their entirety from the proposed building footprint. All exposed subgrade surfaces should be free of mounds and depressions which could prevent uniform compaction. If unexpected fill or obstructions are encountered during site clearing or excavation, such features should be removed and the excavation should extend to the natural soils and thoroughly cleaned prior to fill placement and construction.

C. All fill and backfill should be approved by the geotechnical engineer, moisture conditioned and placed in 8-inch loose lifts. The fill and backfill should then be compacted with an appropriately sized compactor to the following minimum dry densities as determined by ASTM D698.

1. Below Foundations = 98 percent
2. Around Foundations = 95 percent
3. All Other Fill = 95 percent

D. No fill should be placed over frozen ground or in a frozen condition. All loose disturbed soil and/or fills in the base of the over-excavation should be removed from the foundation excavation prior to placement of structural fill. Footings should not be placed on either uncompacted disturbed native soils, or uncontrolled fill. Qualified personnel should observe all footing and slab subgrades to confirm subsoil conditions.
E. Imported gravel meeting the below specifications or the site soils may be used as foundation wall backfill provided proper moisture conditioning to near optimum moisture (± 2 percent) and compacted in accordance with the details presented above. If backfill is needed below foundations, only imported gravel meeting the specifications below should be used. Other imported gravel options may be used by approval of the geotechnical engineer.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3-inch</td>
<td>100</td>
</tr>
<tr>
<td>No. 4</td>
<td>25-60</td>
</tr>
<tr>
<td>No. 200</td>
<td>0 - 12</td>
</tr>
<tr>
<td></td>
<td>Liquid limits less than 25 and PI less than 6</td>
</tr>
</tbody>
</table>

F. Surface water should not be allowed to accumulate and infiltrate soils near the proposed foundations. It must be controlled and directed away from the structures. A simple means of reducing moisture changes is to prevent surface water infiltration by sloping the ground away from the foundation. The recommended minimum slope within 10 feet of the building is 1 inch vertical for 1 foot horizontal. The sloped ground should be initially constructed at a greater slope to account for settlement/consolidation of exterior backfill. Within 10 feet of the foundation, the upper 12 to 18 inches of backfill should consist of less permeable, compacted clay soils. The area around the foundation should be inspected regularly, particularly after a rain event to determine if proper drainage away from the structure has been maintained.

3.15 GRADING

A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated.

1. Provide a smooth transition between adjacent existing grades and new grades.
2. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.

B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations within the following tolerances:

1. Turf or Unpaved Areas: Plus or minus [1 inch (25 mm)].
2. Walks: Plus or minus [1 inch (25 mm)].
3. Pavements: Plus or minus [1/2 inch (13 mm)].

C. Grading inside Building Lines: Finish subgrade to a tolerance of [1/2 inch (13 mm)] when tested with a 10-foot (3-m) straightedge.
3.16 SUBBASE AND BASE COURSES UNDER PAVEMENTS AND WALKS

A. Place subbase course and base course on subgrades free of mud, frost, snow, or ice.


3.17 DRAINAGE COURSE UNDER CONCRETE SLABS-ON-GRADE

A. Place drainage course on subgrades free of mud, frost, snow, or ice.


3.18 FIELD QUALITY CONTROL

A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections:

1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
2. Determine that fill material and maximum lift thickness comply with requirements.
3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.

B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.

C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.

D. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.

E. Testing agency will test compaction of soils in place according to ASTM D 1556, ASTM D 2167, ASTM D 2922, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:

1. Paved and Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 4000 sq. ft. or less of paved area or building slab, but in no case fewer than three tests.
2. Foundation Wall Backfill: At each compacted backfill layer, at least one test for every 100 feet or less of wall length, but no fewer than two tests.
3. Trench Backfill: At each compacted initial and final backfill layer, at least one test for every 150 feet or less of trench length, but no fewer than two tests.
F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or aerate, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.

3.19 PROTECTION
A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.
   1. Scarify or remove and replace soil material to depth as directed by Architect; reshape and recompact.
C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
   1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.20 DISPOSAL OF SURPLUS AND WASTE MATERIALS
A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

3.21 PLACING OF TOPSOIL AND SOD
A. All areas disturbed by construction, except surfaces occupied by paving and areas indicated to be undisturbed shall be restored with topsoil and sod.
B. Cut sod in uniformly wide strips, uniformly 1-1/2 inches thick with clean cut edges.
C. Sod shall be rolled or folded prior to lifting. Handling of sod shall be done in a manner that will prevent tearing, breaking, drying, or any other damage.
D. Sod shall be installed in place on the site not more than 24 hours after cutting.
E. Obtain ENGINEER's approval of rough grading before placing topsoil.
F. Relieve subgrade compaction using a fracturing, deep-tine aerifier, a high-pressure water injection aerifier, or other method approved by OWNER.
G. Scarify and place 9-10 inches minimum of topsoil. Uniformly spread layer of topsoil over areas that have been distributed. If quantity of on-site topsoil is insufficient, import off-site topsoil.
H. Level topsoil to eliminate water pockets and irregularities. Compact to 85 % Standard Proctor Density in planted areas.
I. Slope graded surfaces to drain surface water away from buildings; minimum slope 1/4 inch in 12 inches (2%).

J. Grade uniformly with rounded surfaces at tops and bottoms of abrupt changes in plane. Hand-grade steep slopes and areas that are inaccessible for machine work and areas around existing trees.

K. Protect graded areas from undue erosion. Repair and regrade if required. Refill and compact where settlement or erosion occurs. Provide hay bales and burlap as required to prevent erosion throughout project.

L. Grade areas to elevations and slopes indicated without depressions causing pocketing of surface water or humps, producing localized runoff and gullying. Ponding of water on-site is not allowed. Finish surfaces to be not more than 0.10 foot above or below established grade elevation.

M. Remove all lumps and clods prior to placing sod.

END OF SECTION 31 20 00
SECTION 31 25 00 – EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.1 SUMMARY

A. Contractor shall be fully responsible for the Storm Water Discharge Permit and fully comply with the Montana Department of Environmental Quality (DEQ) regulations in regards to Storm Water Discharges associated with Construction Activity including, but not limited to, any and all submittals, inspections, fees, reporting, training, and installation of Best Management Practices (BMP’s). CONTRACTOR shall sign all permits and forms and assumes all responsibility of management of the Storm Water Erosion Control Plan and any associated records or fines.

B. The CONTRACTOR is required to develop a Storm Water Pollution Prevention Plan (SWPPP) per DEQ standards. The SWPPP must clearly address the effluent limitations and the selected BMP’s to be used to manage pollutant sources and ensure appropriate protection of state surface waters as outlined in DEQ’s General Permit for Storm Water Discharges Associated with Construction Activity (called "General Permit"). In case of conflict between this specification and the General Permit, the General permit shall prevail.

C. The site is required to reach "final stabilization" before permit coverage may be terminated. In Montana's semi-arid climate, the time necessary to achieve this "final stabilization" often requires maintenance and permit coverage well beyond the Substantial Completion phase to ensure vegetation or other site stabilization measures are in-place.

1.2 RELATED REQUIREMENTS:

A. Section 31 10 00 - Site Clearing.

B. Section 31 20 00 - Earth Moving.
1.3 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. Standard Specifications:


2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.

3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.4 DEFINITIONS

A. Best Management Practices (BMPs)

1. Schedule of activities, prohibition of practices, maintenance procedures, and other management practices to prevent or reduce the pollution of state surface waters. BMP’s also include treatment requirements, operating procedures, and practices to control plant site runoff, spillage or leaks, sludge or waste disposal, or drainage from raw material storage.

B. Final stabilization

1. The time at which all soil-disturbing activities at the site have been completed, and a vegetative cover has been established with a density of at least 70% of the pre-disturbance levels, or equivalent permanent, physical erosion reduction methods have been employed. Final stabilization using vegetation must be accomplished using seeding mixtures or forbs, grasses, and shrubs that are adapted to the conditions of the site. Establishment of a vegetative cover capable of providing erosion control equivalent to pre-existing conditions at the site will be considered final stabilization.

1.5 SUBMITTALS

A. Prior to receiving a Notice to Proceed, contractor shall submit to the ENGINEER the following documentation:
1. a copy of the completed and signed NOI form;

2. a copy of the signed SWPPP as submitted to the DEQ; and

3. a copy of the Department's Confirmation Letter for receipt of the complete NOI Package.

B. In addition, the ENGINEER shall be copied on all documentation submitted to or received from the MT DEQ including but not limited to notices of noncompliance, if necessary and the Notice of Termination, when submitted.

1.6 APPLICABLE LAWS AND REGULATIONS

1.7 Per ARM 17.30.1105, CONTRACTOR shall obtain permit coverage under the General Permit for Storm Water Discharges Associated with Construction Activity (General Permit). A copy of this permit is included at the end of this section.

PART 2 - PRODUCTS – NOT USED

PART 3 - EXECUTION

3.1 GENERAL

A. Permit coverage can be obtained by the DEQ's Water Protection Bureau after receiving the following Notice of Intent (NOI) Package items by the proposed construction start date:

B. NOI form with all requested items completed. A draft copy of this form is included in the Appendix and intended as a starting point for development of the NOI. Technical data available to the ENGINEER has been included in this draft permit for the CONTRACTOR's convenience.

C. Storm Water Pollution Prevention Plan (SWPPP) addressing all requested items in the General Permit. A draft copy of the form created by the DEQ to satisfy this requirement is included in the Appendix and intended as a starting point for development of the SWPPP. Additional guidance to completing a SWPPP can be found in the General Permit and on the MT DEQ website. Technical data available to the ENGINEER has been included in this draft permit for the CONTRACTOR's convenience.

D. Application fee based on the total acres of disturbed land.
E. CONTRACTOR must read and be familiar with the General Permit to assist in the completion of the forms and submittal of the NOI Package. Note that formal signatory requirements allow only certain qualified people to sign NOI forms and other forms or reports.

F. The CONTRACTOR will be responsible for annual renewals of the permit until “final stabilization” has occurred and the Notice of Termination (NOT) can be submitted. The CONTRACTOR must submit a NOT form when the construction activity is complete and the site has achieved “final stabilization.” ENGINEER shall be notified of any inspection made for the purpose of determining if the site has achieved final stabilization.

G. SWPPP Administrator

1. Per DEQ regulations, the CONTRACTOR must specify a Primary SWPPP Administrator(s), a Secondary SWPPP Administrator(s) in the SWPPP. A SWPPP Administrator(s) is an individual or position title who is responsible for developing, implementing, maintaining, revising, and updating the SWPPP. The SWPPP Administrator(s) must address all aspects of the SWPPP, initiating with the start of construction activities, and lasting until final stabilization is achieved and the permit authorization is terminated. There can be multiple individuals and/or position titles which serve as a SWPPP Administrator; but a Primary SWPPP Administrator and Secondary SWPPP Administrator (as applicable) must be identified on the NOI Form and in the SWPPP.

2. The SWPPP Administrator(s) must have knowledge of the principles and practices of erosion and sediment controls and pollution prevention practices and possess the skills necessary to assess site conditions and determine the effectiveness of selected BMPs.

3. The SWPPP Administrator(s) must meet the authorized representative requirements as defined in Part 4.15 of the General Permit to sign inspection reports and other reports. The primary and secondary SWPPP Administrators identified in Section F of the Form NOI must meet this requirement. The SWPPP Administrator(s) must be trained as required in the General Permit.

3.2 Inspections

A. Inspections must be performed by a SWPPP Administrator. Site inspections are to be conducted according to section 2.3.4 of the General Permit. Site inspections are to be conducted during the construction project's normal working hours and the inspection schedule must be documented in the SWPPP. Site inspections must be performed in accordance with one of the two schedules listed Parts 2.3.1. or 2.3.2. of the General Permit unless subject to the schedule in Part 2.3.3. The initial SWPPP submitted with the NOI Package must specify which inspection schedule will be utilized (either Part 2.3.1. or 2.3.2.), and this inspection schedule must be used until final stabilization is achieved for all areas of the construction activity, except for any temporary reduced inspection schedule as allowed in Part 2.3.3. The CONTRACTOR cannot switch between the inspection schedule options in Parts 2.3.1. and 2.3.2. during the life of the permit authorization.

3.3 Maintenance
A. All BMPs identified in the SWPPP must be maintained in effective operating condition. If site inspections identify BMPs which are not in effective operating condition, maintenance must be performed before the next storm event. If existing BMPs need to be modified, or if additional BMPs are necessary for any reason, implementation of these additional measures must be completed before the next storm event. All changes in the design, implementation, or installation of erosion and sediment control or other BMPs must be documented where applicable in the SWPPP. SWPPP changes must also be summarized in a SWPPP Revision/Update Log as required in Part 3.12.2. of the General Permit. Prior to submitting a Notice of Termination, all temporary BMP’s should be removed.

3.4 Recordkeeping

A. At the identified site, the primary SWPPP Administrator must retain all documentation required in the General permit including but not limited to:

1. a copy of the General Permit;

2. a copy of the completed and signed NOI form;

3. a copy of the Department's Confirmation Letter for receipt of the complete NOI Package;

4. a copy of the latest up-to-date and signed SWPPP;

5. BMP installation and design standards for all BMPs installed and detailed in the SWPPP;

6. SWPPP Administrator(s) documentation under Part 3.2. of the General Permit;

7. SWPPP Administrator Delegation Form (if applicable);

8. SWPPP Revision/Update Log as required under Part 3.12.2. of the General Permit;

9. all inspection records required under Part 2.3. of the General Permit; and

10. all reports of noncompliance under Part 4 of this permit.

11. These documents are to be made available at the site immediately upon request from the ENGINEER, OWNER, a Department representative, EPA official, or local official.

END OF SECTION 31 25 00
PART 1 - GENERAL

1.1 SUMMARY

A. Section includes all equipment, material, labor, and supervision for the design, installation, and testing of the drilled/replacement, vertically rammed engineered aggregate pier (EAP) ground improvement system. The EAP system must meet the performance requirements specified in this specification and the construction documents and shall rely on subsurface information presented in the project geotechnical report. The EAP lengths shall be designed to terminate within the dense poorly graded gravel bearing layer encountered at depths ranging from approximately 17.0 to 21 feet below existing ground surface as indicated on the boring logs of the geotechnical report. It is noted that the depth to gravel layer increases to 21 feet towards the east half and northeast corner area of the building footprint.

B. Work in other Sections related to Engineered Aggregate Piers:
   1. Division 31 Section “Site Clearing.”
   2. Division 31 Section “Earth Moving.”

1.2 DESCRIPTION OF EAP SYSTEM

A. The EAP system shall be constructed by vertically ramming (compacting, with no vibration) aggregate in an excavated or drilled shaft using special high-energy impact ramming equipment. The aggregate pier elements shall be in a columnar configuration and shall be used to reinforce soils for the support of slabs and high bearing pressure footings.

B. Special high-energy impact ramming apparatus shall be used to produce the EAP ground improvement system. The ramming assembly shall include a 2,500 lb. class hydraulic break hammer, equivalent or greater, with a patented beveled rammer.

1.3 REFERENCE STANDARDS

A. Design:

B. Modulus and Uplift Testing
C. Materials and Inspection
   2. ASTM STP 399 (1966) - Dynamic Cone Penetrometer Testing
   4. ASTM D 698 - Standard Proctor Test/Aggregate Densification

D. Conflicts between Specifications and References
   1. Where specifications and reference documents conflict, the Project Structural Engineer of Record/Project Geotechnical Engineer shall make the final determination of the applicable document.

1.4 SUBMITTALS

A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.

B. EAP Designer Submittals:
   1. Submit detailed design calculations, subgrade/ground improvement construction drawings, material specifications and shop drawings, (the Design Submittal), to the Structural Engineer of Record and Project Geotechnical Engineer for review and approval at least 3 weeks prior to the beginning of construction. All EAP system design calculations and plans shall be prepared and sealed by a Professional Engineer licensed in the state of Montana. The design submittal shall consider the following:

   a. Design Considerations:
      1) The design submitted by the EAP Designer shall consider the actual service load bearing pressure and settlement of all foundations in the building, including spread footings, shearwall and retaining wall footings, and strip wall footings, and shall be in accordance with acceptable engineering practice and these specifications.
      2) The design life of the installed EAP system shall be no less than 75 years.
      3) The EAP system shall be designed to preclude significant plastic bulging deformations at the top-of-pier design stress and in the absence of tip termination upon a bearing stratum (stiff or medium dense soil) to preclude significant tip stresses as determined from end-bearing capacity analysis or the shape of the telltale test curve from telltales installed in modulus test piers. The results of the modulus test shall be used to verify the design assumptions.
      4) EAP system shall be designed in accordance with the reference design standards in Section 1.3. EAP system design shall meet the following performance criteria:
         a) Allowable service level dead load plus live load bearing pressure for footings supported by EAP reinforced subgrade shall be 5,500 psf.
         b) Estimated total long-term settlement for footings: shall be less than or equal to 1.0-inch.
         c) Estimated long-term differential settlement of adjacent footings shall be less than or equal to ½-inch.
         d) Coefficient of sliding friction applied as a uniform value across the footing bottom in contact with the EAP improved subgrade shall be a minimum of 0.45.
         e) Minimum EAP bearing stiffness (verified by modulus test) shall be 200 psi/in (pci).
         f) One-third (1/3) increase to ASD pressure permissible for short-term loading wind and/or seismic loading.
5) EAPs shall be designed and constructed to meet the combined, service level loadings and allowable settlement limits indicated in the Drawings, as provided by the project Structural Engineer of Record.

6) The size and spacing of the EAPs shall be described on the subgrade/ground improvement construction drawings. The Installer shall be responsible for delivering a system that will support the loading conditions and control settlement in accordance with these specifications. The Owner’s Representative shall approve any modifications in size and spacing of the pier elements.

C. EAP Installer Submittals:
   1. Modulus Test Requirements – A load test schedule shall be prepared by the Installer for each modulus test (based on the project requirements and in accordance with Section 3.4 of these specifications). Each proposed load test location shall be shown on the shop drawings, and must be approved by the Project Geotechnical Engineer and Project Structural Engineer of Record. The intent is to locate the load tests at locations where the most settlement and/or design load is anticipated. A report of load testing results shall be submitted to the Owner and Project Geotechnical Engineer after completion of the load tests. The report shall include a description of the installation equipment, installation records and complete test data; analysis of the test data and verification of the design parameter values based on the modulus test results. The report shall be prepared by or under the direct supervision of a registered professional engineer experienced in modulus testing, performance and analysis of the aggregate pier system.
   2. Aggregate – Material delivery tickets from the aggregate supplier shall be obtained by the EAP installer to verify that it has the appropriate rating and gradation. Approval of alternate materials shall be obtained from the Pier Designer.
   3. Minutes of EAP pre-installation conference.
   4. Daily EAP Installation Reports – Aggregate Pier Progress Report shall be completed by the installer during each day of installation, and shall consist of the following: Date of installation and summary of installation equipment and installation procedures; Pier location, length, and diameter; Final elevations of the pier top and bottom; Documentation of any unusual subsurface conditions encountered; Soil and groundwater observations, if any; The results of any field Quality Control testing or deflection monitoring done. The Installer shall immediately report any unusual conditions encountered during installation to the EAP Designer, to the Owner’s Testing Agency, and the Project Geotechnical Engineer.
   5. EAP System Record Drawings - The Installer shall furnish Record Drawings specifying the location of the installed EAPs to the Project Structural Engineer of Record, and Project Geotechnical Engineer. The record shall indicate the constructed pier location, length, average lift depth, final elevations of the base and top of piers, and the type and size of the densification equipment used. The record shall also include select graphs of the rammer deflection data and or calibrated dynamic penetration test (ASTM STP 399) data for the piers constructed.

D. Project Geotechnical Engineer Observation Report
   1. EAP Installation: A signed and sealed written observation report shall be provided by the Project Geotechnical Engineer to the General contractor, to the EAP System Designer, to the Owner’s Testing Agency, and the Project Structural Engineer of Record.
   2. Spread Foundation Construction: The Project Geotechnical Engineer shall prepare a report documenting the spread foundation construction, including verification of EAP elements required for each foundation and preparation of the foundation bottom as specified in these specifications and construction documents.


1.5 QUALITY ASSURANCE

A. EAP System Installer Qualifications: An experienced installer who has completed work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance. They shall have a minimum of 5 years of experience with the installation of EAP and shall have completed at least 25 projects of similar or larger size and scope. The Installer shall adhere to all requirements described in this Specification.

B. EAP System Designer Qualifications: EAP System Designer (Designer) shall have demonstrated experience in the design of similar size and types of projects and shall have a minimum of 5 years of experience EAP System design and shall have completed at least 25 projects of similar or larger size and scope. The Designer shall be a professional engineer who is legally qualified to practice in Montana.

C. The EAP Designer, Installer, shall have a pre-installation meeting at the site to include the General Contractor, Geotechnical Engineer and Testing Agency personnel and prepare and distribute meeting minutes in accordance with Division 1 Specification - “Administrative Requirements”.

D. The Installer shall have a full-time Quality Control (QC) representative to verify and report all QC installation procedures. The Installer shall immediately report any unusual conditions encountered during installation, to the EAP System Designer, to the Owner’s Testing Agency, and the Project Geotechnical Engineer.

E. The Owner is responsible for retaining an independent engineering testing firm to provide Quality Assurance (QA) services. The Testing Agency shall observe the modulus and uplift test(s) when modulus or uplift test(s) are to be performed. The Installer shall set up and conduct the test(s) and provide and install all dial indicators and other measuring devices. The Testing Agency shall observe the installation of EAP test elements.

F. The EAP System Designer or a qualified representative shall perform sufficient site visits as to observe excavation and installation of the EAPs. A qualified Designer representative consists of an individual with at least 2 years of construction/design experience.

PART 2 - PRODUCTS

2.1 AGGREGATE

A. Material used to form the EAP elements shall be hard and chemically inert so as to remain stable during column construction and building service life in the anticipated soil and ground water conditions. The aggregate shall consist of solid, durable, and non-friable rock; free of thin, slab-type rock fragments and conform to standards used by the EAP industry.

B. Material shall be used with a grading appropriate for compaction to form a dense column.

C. The material used to build the EAP elements shall be as specified by the EAP System Designer. The EAP System Designer shall be notified for approval, prior to use, when changes in specification or supply of the material is encountered.

PART 3 - EXECUTION
3.1 GENERAL

A. EAP system installation shall be performed following rough grading of the project site or building pad.

B. General Contractor to locate and protect underground and aboveground utilities and other structures from damage during installation of the EAP elements.

C. A working surface shall be established as needed by the General Contractor to provide wet weather protection of the subgrade and to provide access for efficient operation of the EAP system installation.

D. Ponding of water in the area of footing excavation shall not be permitted. General Contractor and EAP installer to coordinate to maintain a level, well drained surface.

E. If cave-ins occur during excavation such that the sidewalls of the shaft are deemed to be unstable, a temporary steel casing shall be used to stabilize the excavation.

F. If cave-ins occur on top of a lift of aggregate such that the volume of the caved soils is greater than 15 percent of the volume of the aggregate in the lift, then the aggregate shall be considered contaminated and shall be removed and replaced with uncontaminated aggregate.

G. After drilling of the shaft, to form the bottom bulb the rammer energy shall be applied on the first lift of aggregate in wet conditions or to the in-situ soil in dry conditions. After construction of the bottom bulb, aggregate shall be rammed in thin lifts in the shaft to the planned top elevation as shown in the drawings and/or quality control records. Aggregate shall be placed in the augered cavity in compacted lift thicknesses no greater than 24 inches or as determined by the EAP System Designer.

H. A specially-designed beveled tamper and high-energy impact densification apparatus shall be employed to densify lifts of aggregate during installation. The tamper diameter shall be at least 80% of the pre-augered hole diameter. The apparatus shall apply direct downward impact energy to each lift of aggregate.

3.2 LOCATING EAP ELEMENTS

A. The center of each pier element shall be within six inches of the plan locations indicated or specifically approved by the pier installer. The final measurement of the top of piers shall be the lowest point on the aggregate in the last rammed lift.

B. Ground elevations at each staked EAP location shall be provided in sufficient detail to estimate drilling depth elevations to within 2 inches. These shall be provided on stakes at each pier location and by data export a minimum of 1 day prior to pier installation in a given area.

C. EAP elements installed outside of the above tolerances and deemed not acceptable, except as caused by obstructions or Changed Conditions, shall be rebuilt at no additional expense to the General Contractor or Owner.

3.3 OBSTRUCTIONS

A. Should any obstruction be encountered during drilling or excavation for EAPs, the General Contractor shall be responsible for removing such obstruction, or the pier shall be relocated or abandoned as approved by the Owner’s Representative. Obstructions include, but are not limited to, boulders, timbers, concrete, bricks, debris, utility lines, etc., that prevent installing the EAPs to the required depth, or cause the aggregate pier to drift from the required locations.
B. EAP elements may be terminated short of design depths on top of partially weathered rock, or very dense gravel layers as approved by the Project Geotechnical Engineer of Record.

3.4 FIELD TESTING AND INSPECTIONS

A. The Installer shall have a full-time Quality Control representative (QCR) to report installation procedures. The QCR may be a member of the installation crew. The QCR shall immediately report any unusual conditions encountered during installation to the EAP System Design Engineer, the General Contractor, and to the Testing Agency. The quality control procedures shall include the preparation of EAP Progress Reports completed during each day of installation and containing the following:

1. EAP location;
2. EAP length and drilled diameter;
3. Planned and actual pier elevations at the top and bottom of EAP element;
4. Average lift thickness for each EAP element;
5. Depth of groundwater, if encountered;
6. Documentation of any unusual conditions encountered; and
7. Type and size of ramming equipment used.

B. The Owner shall retain an independent engineering testing firm to provide Quality Assurance (QA) services. This Testing Agency shall observe the modulus and uplift test(s) when modulus or uplift test(s) are to be performed. The Installer shall set up and conduct the test(s) and provide and install all dial indicators and other measuring devices. The Testing Agency shall observe the installation of EAP elements.

C. Prior to installing production piers, the aggregate pier designer shall establish the required energy output for the rammer and terminal rammer-blow deflection criterion for the ramming of each lift. Rammer energy output shall be confirmed by the installer prior to construction of production piers. Instrumentation used to confirm rammer-blow deflections shall be capable of recording to a precision of at least 0.001 inch per rammer stroke, and shall be capable of recording deflection accompanying each rammer blow. During pier lift construction, rammer-blow deflections shall be monitored in at least 5% of the piers for the project to confirm that the design deflection per rammer-blow is achieved. Rammer-blow deflection monitoring shall be performed randomly on installed piers to confirm that terminal rammer-blow deflections meet the established acceptance criterion.

D. EAP Modulus Load Testing

1. A minimum of one modulus test shall be performed to verify the parameter values selected for design. The test(s) shall be performed by the EAP installer at locations agreed upon by the EAP System Designer, Project Structural Engineer of Record, Project Geotechnical Engineer and the Owner’s Testing Agency. EAP modulus testing shall be performed in accordance with the requirements outlined in the EAP Design Submittal. At a minimum, the modulus testing shall include the following:
   a. EAP elements shall be tested to 150% of the maximum design stress as shown in the EAP System design submittal. Modulus Test Procedures shall utilize appropriate portions of ASTM D 1143, ASTM D 1194 and ASTM D 3689, as outlined below. The modulus tests shall be of the type and installed in a manner specified herein.
   b. The Modulus test shall be performed in and on the neat drilled diameter only, no exceptions, i.e. a footing area is not acceptable.
   c. Unless terminating upon a bearing layer as verified by testing agency, a telltale shall be installed at the bottom of the test pier so that bottom-of-pier deflections may be determined. Acceptable performance is indicated when the bottom of the pier deflection is no more than 20% of the top of pier deflection at the design stress level.
   d. ASTM D-1143 general test procedures shall be used as a guide to establishing load increments, load increment duration, and load decrements.
e. With the exception of the load increment representing approximately 115% of the design maximum EAP stress, all load increments shall be held for a minimum of 15 minutes, a maximum of 2 hours, and until the rate of deflection reduces to 0.01 inch per hour, or less.

f. The load increment that represents approximately 115% of the design maximum stress on the EAP shall be held for a minimum of 15 minutes. Loads are then maintained until the rate of deflection reduces to 0.01 inch per hour or for the maximum of 4 hours, whichever is occurs first.

g. A seating load equal to 5 percent of the total load shall be applied to the loaded steel plate prior to application of load increments and prior to measurement of deflections to compensate for surficial disturbance.

2. The results of the modulus load test shall be reported on a deflection versus stress graph. The EAP modulus shall be calculated as the design stress divided by the deflection of the top plate minus the deflection of the bottom plate at the design stress. The deflection of the top and bottom plates shall not exceed the upper zone settlement as shown in the design calculations.

3. Based on the load tests, if performance criteria specified in this specification and on construction drawings is not met, the installer shall either modify the design and/or installation to meet the performance criteria or retest to prove compliance with performance criteria at no additional charge unless the unacceptable performance is due to a change-of-condition from those revealed in the geotechnical site characterization.

3.5 FOOTING AND UTILITY EXCAVATIONS

A. Coordinate all excavations made subsequent to EAP installations so that the integrity of the EAPs are not compromised. Confirm safe excavation distances/depths with the Installer and EAP System Designer. Protect completed EAP elements during foundation preparation per Details provided in the EAP Design Drawings.

B. Footing excavation must be performed with a smooth-edged bucket (no teeth) to limit disturbance of the tops of piers at bearing elevation. Over-excavation below the bottom of the footing may be allowed, with replacement per Details provided in the EAP Design Drawings.

C. Typical installation sequencing will consist of installing the EAP from the rough graded or native ground surface above the footing subgrade elevations. The pier tops will be extended to elevations approximately 12 inches above footing subgrade. The remainder of the pier excavation will be backfilled with overburden to protect the top of piers until the footing excavation is completed. The overburden will then be excavated down to the footing subgrade using a smoothed edged excavator bucket to limit disturbance to the tops of the piers and footing subgrade. If excavation is conducted properly in a good workmanship manner the final footing subgrade with top of piers exposed should consist of a smooth level unyielding surface.

D. Before footing construction, the tops of all the EAP elements exposed in each footing excavation shall be inspected by the Geotechnical Engineer and Testing Agency. The tops of any pier elements that may have been disturbed by footing excavation and related activity shall be recompacted to a dry density equivalent to at least 97% of the maximum dry density obtainable by the ASTM compaction procedure (ASTM D 698). Mechanical tamping type compactors (not vibratory) shall be used to re-compact the pier tops as necessary to meet the requirements of the EAP design, and the requirements of the construction documents.

E. Inspect all foundations and remove all loose soil or mud and properly prepare foundation subgrade as directed by the Owner’s testing agency prior to concrete placement.

F. Foundation excavations to expose the tops of EAP elements shall be made in a workmanlike manner, and shall be protected until concrete placement, with procedures and equipment best suited to:
1. Prevent softening of the matrix soil between and around the EAP elements before pouring structural concrete, i.e. water shall not be allowed to pond in footing excavations or around tops of piers.
2. Achieve direct and firm contact between the dense, undisturbed EAP elements (or properly placed structural fill per EAP Design Details) and the concrete foundations.

G. If same day placement of foundation concrete is not possible, the Contractor shall consider the placement of a minimum 3-inch thick lean concrete seal ("mud mat") immediately after the foundation bottom is excavated and approved.

H. EAP elements designed for each footing shall be exposed at the completion of footing excavation.

I. For the purpose of this specification, the zone of influence is an envelope defined by a horizontal distance of 5 feet from the EAP edge then extending down 5 feet to a point that intersects an imaginary 1:1 sloping plane from the top of the EAP element. The zone of influence continues along the 1:1 slope to a point that corresponds to the bottom of the EAP element elevation.

J. In the event that utility excavations are required within the zone of influence, the General Contractor shall contact the EAP Designer to develop construction solutions to minimize impacts on the installed EAP.

END OF SECTION 31 63 10
SECTION 32 12 16 - ASPHALT PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Cold milling of existing asphalt pavement.
2. Hot-mix asphalt patching.
3. Hot-mix asphalt paving.
4. Hot-mix asphalt overlay.

B. Related Requirements:

1. Section 31 20 00 "Earth Moving" for subgrade preparation, fill material, unbound-aggregate subbase and base courses, and aggregate pavement shoulders.
2. Section 32 13 73 "Concrete Paving Joint Sealants" for joint sealants and fillers at pavement terminations.

1.2 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. Standard Specifications:

2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.
3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.3 PREINSTALLATION MEETINGS

A. Pre-installation Conference: Conduct conference at Project site.

1. Review methods and procedures related to hot-mix asphalt paving including, but not limited to, the following:

   a. Review proposed sources of paving materials, including capabilities and location of plant that will manufacture hot-mix asphalt.
   b. Review requirements for protecting paving work, including restriction of traffic during installation period and for remainder of construction period.
1.4 ACTION SUBMITTALS
   A. Product Data: For each type of product.
      1. Include technical data and tested physical and performance properties.
      2. Job-Mix Designs: For each job mix proposed for the Work.

1.5 INFORMATIONAL SUBMITTALS
   A. Qualification Data: For testing agency.
   B. Material Test Reports: For each paving material, by a qualified testing agency.
   C. Field quality-control reports.

1.6 QUALITY ASSURANCE
   A. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.

1.7 FIELD CONDITIONS
   A. Environmental Limitations: Do not apply asphalt materials if subgrade is wet or excessively damp, if rain is imminent or expected before time required for adequate cure, or if the following conditions are not met:

      1. Asphalt Base Course: Minimum surface temperature of 40 deg F (4.4 deg C) and rising at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES
   A. General: Use materials and gradations that have performed satisfactorily in previous installations.
   B. Aggregate shall meet Type B requirements of the Montana Public Works Standard Specifications, sixth edition (MPWSS).

2.2 ASPHALT MATERIALS
   B. Tack Coat: ASTM D 977 or AASHTO M 140 emulsified asphalt, or ASTM D 2397 or AASHTO M 208 cationic emulsified asphalt, slow setting, diluted in water, of suitable grade and consistency for application.
   C. Water: Potable.
2.3 AUXILIARY MATERIALS


2.4 MIXES

A. Hot-Mix Asphalt: Dense-graded, hot-laid, hot-mix asphalt plant mixes; designed according to procedures in Al MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:


PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that subgrade is dry and in suitable condition to begin paving.

B. Proof-roll subgrade below pavements with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

   1. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Architect, and replace with compacted backfill or fill as directed.

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

3.2 PATCHING

A. Asphalt Pavement: Saw cut perimeter of patch and excavate existing pavement section to sound base. Excavate rectangular or trapezoidal patches, extending 12 inches (300 mm) into perimeter of adjacent sound pavement, unless otherwise indicated. Cut excavation faces vertically. Remove excavated material. Re-compact existing unbound-aggregate base course to form new subgrade.

B. Placing Patch Material: Fill excavated pavement areas with hot-mix asphalt base mix for full thickness of patch and, while still hot, compact flush with adjacent surface.

C. Placing Patch Material: Partially fill excavated pavements with hot-mix asphalt base mix and, while still hot, compact. Cover asphalt base course with compacted, hot-mix surface layer finished flush with adjacent surfaces.
3.3 SURFACE PREPARATION

A. General: Immediately before placing asphalt materials, remove loose and deleterious material from substrate surfaces. Ensure that prepared subgrade is ready to receive paving.

3.4 PLACING HOT-MIX ASPHALT

A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand in areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.

1. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
2. Place hot mix in compliance with Montana Public Works Standard Specifications, sixth edition (MPWSS), as amended by City of Bozeman Modifications to MPWSS, latest edition

3.5 COMPACTION

A. General: Begin compaction as soon as placed hot-mix paving will bear roller weight without excessive displacement. Compact hot-mix paving with hot, hand tampers or with vibratory-plate compactors in areas inaccessible to rollers.

1. Complete compaction before mix temperature cools to 185 deg F (85 deg C).

B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.

C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Density: 92 percent of reference maximum theoretical density according to ASTM D 2041

D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.

E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.

F. Repairs: Remove paved areas that are defective or contaminated with foreign materials and replace with fresh, hot-mix asphalt. Compact by rolling to specified density and surface smoothness.

G. Protection: After final rolling, do not permit vehicular traffic on pavement until it has cooled and hardened.

H. Erect barricades to protect paving from traffic until mixture has cooled enough not to become marked.
3.6 INSTALLATION TOLERANCES

A. Pavement Thickness: Compact each course to produce the thickness indicated within the following tolerances:

1. Base Course: Plus or minus 1/2 inch (13 mm).
2. Surface Course: Plus 1/4 inch (6 mm), no minus.

B. Pavement Surface Smoothness: Compact each course to produce a surface smoothness within the following tolerances as determined by using a 10-foot (3-m) straightedge applied transversely or longitudinally to paved areas:

1. Surface Course: 1/8 inch (3 mm).
2. Crowned Surfaces: Test with crowned template centered and at right angle to crown. Maximum allowable variance from template is 1/4 inch (6 mm).

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Thickness: In-place compacted thickness of hot-mix asphalt courses will be determined according to ASTM D 3549.

C. Surface Smoothness: Finished surface of each hot-mix asphalt course will be tested for compliance with smoothness tolerances.

D. In-Place Density: Testing agency will take samples of un-compacted paving mixtures and compacted pavement according to ASTM D 979 or AASHTO T 168.

1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D 2041, and compacted according to job-mix specifications.
2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D 1188 or ASTM D 2726.

a. Two tests will be taken for every 4000 sq. yd. or less of installed pavement, with no fewer than three cores taken.

b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D 2950 and correlated with ASTM D 1188 or ASTM D 2726.

E. Replace and compact hot-mix asphalt where core tests were taken.

F. Remove and replace or install additional hot-mix asphalt where test results or measurements indicate that it does not comply with specified requirements.

END OF SECTION 32 12 16
SECTION 32 13 13 - CONCRETE PAVING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Driveways.
   2. Roadways.
   3. Parking lots.
   4. Curbs and gutters.
   5. Walks.

1.2 RELATED REQUIREMENTS:

1. Section 03 30 00 "Cast-in-Place Concrete" for general building applications of concrete.
2. Section 32 13 16 "Decorative Concrete Paving" for stamped concrete other than detectable warnings.
3. Section 32 13 73 "Concrete Paving Joint Sealants" for joint sealants in expansion and contraction joints within concrete paving and in joints between concrete paving and asphalt paving or adjacent construction.
4. Section 31 20 00 Earth Moving

1.3 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. Standard Specifications:

2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.
3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.4 DEFINITIONS

A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.
1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Other Action Submittals:

1. Design Mixtures: For each concrete paving mixture. Include alternate design mixtures when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.

1.6 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified ready-mix concrete manufacturer and testing agency.

B. Material Certificates: For the following, from manufacturer:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

C. Contractor shall provide control sample for colored concrete.

D. Field quality-control reports.

1.7 QUALITY ASSURANCE

A. Ready-Mix-Concrete Manufacturer Qualifications: A firm experienced in manufacturing ready-mixed concrete products and that complies with ASTM C 94/C 94M requirements for production facilities and equipment.

B. Testing Agency Qualifications: Qualified according to ASTM C 1077 and ASTM E 329 for testing indicated.

C. Concrete Testing Service: Engage a qualified testing agency to perform material evaluation tests and to design concrete mixtures.

D. ACI Publications: Comply with ACI 301 (ACI 301M) unless otherwise indicated.

E. Pre-installation Conference: Conduct conference at Project site.

1.8 PROJECT CONDITIONS

A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.
PART 2 - PRODUCTS

2.1 FORMS

A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, and smooth exposed surfaces.

1. Use flexible or uniformly curved forms for curves with a radius of 100 feet (30.5 m) or less. Do not use notched and bent forms.

B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and that will not impair subsequent treatments of concrete surfaces.

2.2 STEEL REINFORCEMENT

A. Plain-Steel Welded Wire Reinforcement: ASTM A 185/A 185M, fabricated from as-drawn steel wire into flat sheets.


D. Reinforcing Bars: ASTM A 615/A 615M, Grade 60 (Grade 420); deformed.

E. Galvanized Reinforcing Bars: ASTM A 767/A 767M, Class II zinc coated, hot-dip galvanized after fabrication and bending; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

F. Epoxy-Coated Reinforcing Bars: ASTM A 775/A 775M or ASTM A 934/A 934M; with ASTM A 615/A 615M, Grade 60 (Grade 420) deformed bars.

G. Steel Bar Mats: ASTM A 184/A 184M; with ASTM A 615/A 615M, Grade 60 (Grade 420), deformed bars; assembled with clips.

H. Plain-Steel Wire: ASTM A 82/A 82M, as drawn.

I. Deformed-Steel Wire: ASTM A 496/A 496M.

J. Tie Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.

K. Hook Bolts: ASTM A 307, Grade A (ASTM F 568M, Property Class 4.6), internally and externally threaded. Design hook-bolt joint assembly to hold coupling against paving form and in position during concreting operations, and to permit removal without damage to concrete or hook bolt.

L. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcing bars, welded wire reinforcement, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete of greater compressive strength than concrete specified, and as follows:

1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
2. For epoxy-coated reinforcement, use epoxy-coated or other dielectric-polymer-coated wire bar supports.

M. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating, compatible with epoxy coating on reinforcement.

N. Zinc Repair Material: ASTM A 780.

2.3 CONCRETE MATERIALS

A. Cementitious Material: Use the following cementitious materials, of same type, brand, and source throughout Project:
   1. Portland Cement: ASTM C 150, gray portland cement Type I.

B. Normal-Weight Aggregates: ASTM C 33, uniformly graded. Provide aggregates from a single source.
   1. Maximum Coarse-Aggregate Size: 1 inch (25 mm) nominal.
   2. Fine Aggregate: Free of materials with deleterious reactivity to alkali in cement.

C. Water: Potable and complying with ASTM C 94/C 94M.


E. Chemical Admixtures: Admixtures certified by manufacturer to be compatible with other admixtures and to contain no more than 0.1 percent water-soluble chloride ions by mass of cementitious material.
   1. Water-Reducing Admixture: ASTM C 494/C 494M, Type A.
   2. Retarding Admixture: ASTM C 494/C 494M, Type B.
   3. Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type D.
   4. High-Range, Water-Reducing Admixture: ASTM C 494/C 494M, Type F.
   5. High-Range, Water-Reducing and Retarding Admixture: ASTM C 494/C 494M, Type G.
   6. Plasticizing and Retarding Admixture: ASTM C 1017/C 1017M, Type II.

2.4 FIBER REINFORCEMENT

A. Synthetic Fiber: Monofilament or fibrillated polypropylene fibers engineered and designed for use in concrete paving, complying with ASTM C 1116/C 1116M, Type III, [1/2 to 1-1/2 inches (13 to 38 mm)] long.

B. Fiber reinforcement required in all exterior Portland cement sidewalks and paving.

2.5 CURING MATERIALS

A. Moisture-Retaining Cover: ASTM C 171, polyethylene film or white burlap-polyethylene sheet.

B. Water: Potable.

C. Evaporation Retarder: Waterborne, monomolecular, film forming, manufactured for application to fresh concrete.
D. Clear, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B, dissipating.

E. White, Waterborne, Membrane-Forming Curing Compound: ASTM C 309, Type 2, Class B, dissipating.

2.6 CONCRETE MIXTURES

A. Prepare design mixtures, proportioned according to ACI 301 (ACI 301M), for each type and strength of normal-weight concrete, and as determined by either laboratory trial mixtures or field experience.

1. Use a qualified independent testing agency for preparing and reporting proposed concrete design mixtures for the trial batch method.

2. When automatic machine placement is used, determine design mixtures and obtain laboratory test results that meet or exceed requirements.

B. Proportion mixtures to provide normal-weight concrete with the following properties:

1. Compressive Strength (28 Days): 4000 psi (27.6 MPa).

2. Maximum Water-Cementitious Materials Ratio at Point of Placement: 0.45.

3. Slump Limit: 4 inches (100 mm), plus or minus 1 inch (25 mm).

C. Add air-entraining admixture at manufacturer's prescribed rate to result in normal-weight concrete at point of placement having an air content as follows:

1. Air Content: 6 percent plus or minus 1.5 percent for 1-inch (25-mm) nominal maximum aggregate size.

D. Chemical Admixtures: Use admixtures according to manufacturer's written instructions.

E. Synthetic Fiber: Uniformly disperse in concrete mixture at manufacturer's recommended rate, but not less than 1.0 lb/cu. yd. (0.60 kg/cu. m).

F. Color Pigment: Add color pigment to concrete mixture according to manufacturer's written instructions and to result in hardened concrete color consistent with approved mockup.

2.7 CONCRETE MIXING

A. Ready-Mixed Concrete: Measure, batch, and mix concrete materials and concrete according to ASTM C 94/C 94M[ and ASTM C 1116/C 1116M]. Furnish batch certificates for each batch discharged and used in the Work.

1. When air temperature is between 85 and 90 deg F (30 and 32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.
PART 3 - EXECUTION

3.1 EXAMINATION
   A. Examine exposed subgrades and subbase surfaces for compliance with requirements for dimensional, grading, and elevation tolerances.
   B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION
   A. Remove loose material from compacted subbase surface immediately before placing concrete.

3.3 EDGE FORMS AND SCREED CONSTRUCTION
   A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides to required lines, grades, and elevations. Install forms to allow continuous progress of work and so forms can remain in place at least 24 hours after concrete placement.
   B. Clean forms after each use and coat with form-release agent to ensure separation from concrete without damage.

3.4 STEEL REINFORCEMENT
   A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
   B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
   C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
   D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.

3.5 JOINTS
   A. General: Form construction, isolation, and contraction joints and tool edges true to line, with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline unless otherwise indicated.
      1. When joining existing paving, place transverse joints to align with previously placed joints unless otherwise indicated.
   B. Construction Joints: Set construction joints at side and end terminations of paving and at locations where paving operations are stopped for more than one-half hour unless paving terminates at isolation joints.
C. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, other fixed objects, and where indicated.

1. Locate expansion joints at intervals of 50 feet (15.25 m) unless otherwise indicated.
2. Extend joint fillers full width and depth of joint.
3. Terminate joint filler not less than 1/2 inch (13 mm) or more than 1 inch (25 mm) below finished surface if joint sealant is indicated.
4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
6. During concrete placement, protect top edge of joint filler with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.

D. Contraction Joints: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of the concrete thickness, as follows, to match jointing of existing adjacent concrete paving:

1. Sawed Joints: Form contraction joints with power saws equipped with shatterproof abrasive or diamond-rimmed blades. Cut 1/8-inch- (3-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks.

3.6 CONCRETE PLACEMENT

A. Before placing concrete, inspect and complete formwork installation, steel reinforcement, and items to be embedded or cast-in.

B. Remove snow, ice, or frost from subbase surface and steel reinforcement before placing concrete. Do not place concrete on frozen surfaces.

C. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.

D. Comply with ACI 301 (ACI 301M) requirements for measuring, mixing, transporting, and placing concrete.

E. Do not add water to concrete during delivery or at Project site. Do not add water to fresh concrete after testing.

F. Deposit and spread concrete in a continuous operation between transverse joints. Do not push or drag concrete into place or use vibrators to move concrete into place.

G. Consolidate concrete according to ACI 301 (ACI 301M) by mechanical vibrating equipment supplemented by hand spading, rodding, or tamping.

H. Screed paving surface with a straightedge and strike off.

I. Commence initial floating using bull floats or darbies to impart an open-textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.

J. Curbs and Gutters: Use design mixture for automatic machine placement. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing.
K. Slip-Form Paving: Use design mixture for automatic machine placement. Produce paving to required thickness, lines, grades, finish, and jointing.
   1. Compact subbase and prepare subgrade of sufficient width to prevent displacement of slip-form paving machine during operations.

L. Cold-Weather Placement: Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing, or low temperatures. Comply with ACI 306.1 and the following:
   1. When air temperature has fallen to or is expected to fall below 40 degree F (4.4 degree C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 degree F (10 degree C) and not more than 80 degree F (27 degree C) at point of placement.
   2. Do not use frozen materials or materials containing ice or snow.
   3. Do not use calcium chloride, salt, or other materials containing antifreeze agents or chemical accelerators unless otherwise specified and approved in design mixtures.

M. Hot-Weather Placement: Comply with ACI 301 (ACI 301M) and as follows when hot-weather conditions exist:
   1. Cool ingredients before mixing to maintain concrete temperature below 90 degree F (32 degree C) at time of placement. Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated in total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
   2. Cover steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.

3.7 FLOAT FINISHING
A. General: Do not add water to concrete surfaces during finishing operations.
B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations. Float surface with power-driven floats or by hand floating if area is small or inaccessible to power units. Finish surfaces to true planes. Cut down high spots and fill low spots. Refloat surface immediately to uniform granular texture.
   1. Burlap Finish: Drag a seamless strip of damp burlap across float-finished concrete, perpendicular to line of traffic, to provide a uniform, gritty texture.
   2. Medium-to-Fine-Textured Broom Finish: Draw a soft-bristle broom across float-finished concrete surface perpendicular to line of traffic to provide a uniform, fine-line texture.
   3. Medium-to-Coarse-Textured Broom Finish: Provide a coarse finish by striating float-finished concrete surface 1/16 to 1/8 inch (1.6 to 3 mm) deep with a stiff-bristled broom, perpendicular to line of traffic.

3.8 CONCRETE PROTECTION AND CURING
A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
B. Comply with ACI 306.1 for cold-weather protection.
C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete but before float finishing.

D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

E. Curing Methods: Cure concrete by curing compound as follows:

1. Curing Compound: Apply uniformly in continuous operation by power spray or roller according to manufacturer's written instructions. Reccoat areas that have been subjected to heavy rainfall within three hours after initial application. Maintain continuity of coating, and repair damage during curing period.

3.9 PAVING TOLERANCES

A. Comply with tolerances in ACI 117 and as follows:

1. Elevation: 3/4 inch (19 mm).
2. Thickness: Plus 3/8 inch (10 mm), minus 1/4 inch (6 mm).
3. Surface: Gap below 10-foot (3-m-) long, unlevelled straightedge not to exceed 1/2 inch (13 mm).
4. Alignment of Tie-Bar End Relative to Line Perpendicular to Paving Edge: 1/2 inch per 12 inches (13 mm per 300 mm) of tie bar.
5. Lateral Alignment and Spacing of Dowels: 1 inch (25 mm).
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Paving Edge: 1/4 inch per 12 inches (6 mm per 300 mm) of dowel.
8. Joint Spacing: 3 inches (75 mm).
9. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
10. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.10 FIELD QUALITY CONTROL

A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.

B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain at least one composite sample for each 25 cu. yd. or fraction thereof of each concrete mixture placed each day.

   a. When frequency of testing will provide fewer than five compressive-strength tests for each concrete mixture, testing shall be conducted from at least five randomly selected batches or from each batch if fewer than five are used.

2. Slump: ASTM C 143/C 143M; one test at point of placement for each composite sample, but not less than one test for each day's pour of each concrete mixture. Perform additional tests when concrete consistency appears to change.

3. Air Content: ASTM C 231, pressure method; one test for each composite sample, but not less than one test for each day's pour of each concrete mixture.
4. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when it is 80 deg F (27 deg C) and above, and one test for each composite sample.

5. Compression Test Specimens: ASTM C 31/C 31M; cast and laboratory cure one set of three standard cylinder specimens for each composite sample.

6. Compressive-Strength Tests: ASTM C 39/C 39M; test one specimen at seven days and two specimens at 28 days.

   a. A compressive-strength test shall be the average compressive strength from two specimens obtained from same composite sample and tested at 28 days.

C. Strength of each concrete mixture will be satisfactory if average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.

D. Test results shall be reported in writing to Architect, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain Project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.

E. Nondestructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Architect but will not be used as sole basis for approval or rejection of concrete.

F. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Architect.

G. Concrete paving will be considered defective if it does not pass tests and inspections.

H. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.

I. Prepare test and inspection reports.

3.11 REPAIRS AND PROTECTION

A. Remove and replace concrete paving that is broken, damaged, or defective or that does not comply with requirements in this Section. Remove work in complete sections from joint to joint unless otherwise approved by Architect.

B. Drill test cores, where directed by Architect, when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory paving areas with portland cement concrete bonded to paving with epoxy adhesive.

C. Protect concrete paving from damage. Exclude traffic from paving for at least 14 days after placement. When construction traffic is permitted, maintain paving as clean as possible by removing surface stains and spillage of materials as they occur.

D. Maintain concrete paving free of stains, discoloration, dirt, and other foreign material. Sweep paving not more than two days before date scheduled for Substantial Completion inspections.
END OF SECTION 32 13 13
SECTION 32 13 73 - CONCRETE PAVING JOINT SEALANTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Cold-applied joint sealants.
   2. Cold-applied, jet-fuel-resistant joint sealants.
   3. Hot-applied joint sealants.

1.2 RELATED REQUIREMENTS:

   1. Section 32 12 16 "Asphalt Paving" for constructing joints between concrete and asphalt pavement.
   2. Section 32 13 13 "Concrete Paving" for constructing joints in concrete pavement.

1.3 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. Standard Specifications:

       2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.
       3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.4 ACTION SUBMITTALS

   A. Product Data: For each joint-sealant product indicated.
   B. Samples for Verification: For each kind and color of joint sealant required, provide Samples with joint sealants in 1/2-inch- (13-mm-) wide joints formed between two 6-inch- (150-mm-) long strips of material matching the appearance of exposed surfaces adjacent to joint sealants.
   C. Pavement-Joint-Sealant Schedule: Include the following information:

       1. Joint-sealant application, joint location, and designation.
2. Joint-sealant manufacturer and product name.

1.5 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified Installer testing agency.
B. Product Certificates: For each type of joint sealant and accessory, from manufacturer.
C. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for joint sealants.

1.6 QUALITY ASSURANCE

A. Installer Qualifications: Manufacturer's authorized representative who is trained and approved for installation of units required for this Project.
B. Source Limitations: Obtain each type of joint sealant from single source from single manufacturer.

1.7 PROJECT CONDITIONS

A. Do not proceed with installation of joint sealants under the following conditions:
   1. When ambient and substrate temperature conditions are outside limits permitted by joint-sealant manufacturer [or are below 40 degrees F (5 degrees C)].
   2. When joint substrates are wet.
   3. Where joint widths are less than those allowed by joint-sealant manufacturer for applications indicated.
   4. Where contaminants capable of interfering with adhesion have not yet been removed from joint substrates.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Compatibility: Provide joint sealants, backing materials, and other related materials that are compatible with one another and with joint substrates under conditions of service and application, as demonstrated by joint-sealant manufacturer based on testing and field experience.
B. Colors of Exposed Joint Sealants: As selected by Architect from manufacturer's full range.

2.2 COLD-APPLIED JOINT SEALANTS

A. Single-Component, Nonsag, Silicone Joint Sealant for Concrete: ASTM D 5893, Type NS.
B. Single-Component, Self-Leveling, Silicone Joint Sealant for Concrete: ASTM D 5893, Type SL.
C. Multicomponent, Pourable, Traffic-Grade, Urethane Joint Sealant for Concrete: ASTM C 920, Type M, Grade P, Class 25, for Use T.

2.3 HOT-APPLIED JOINT SEALANTS


2.4 JOINT-SEALANT BACKER MATERIALS

A. General: Provide joint-sealant backer materials that are non-staining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.
B. Round Backer Rods for Cold- and Hot-Applied Joint Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

2.5 PRIMERS

A. Primers: Product recommended by joint-sealant manufacturer where required for adhesion of sealant to joint substrates indicated, as determined from preconstruction joint-sealant-substrate tests and field tests.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Examine joints indicated to receive joint sealants, with Installer present, for compliance with requirements for joint configuration, installation tolerances, and other conditions affecting joint-sealant performance.
B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

A. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions.
B. Joint Priming: Prime joint substrates where indicated or where recommended in writing by joint-sealant manufacturer, based on preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
3.3 INSTALLATION OF JOINT SEALANTS

A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated unless more stringent requirements apply.

B. Joint-Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.

C. Install joint-sealant backings of kind indicated to support joint sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.

1. Do not leave gaps between ends of joint-sealant backings.
2. Do not stretch, twist, puncture, or tear joint-sealant backings.
3. Remove absorbent joint-sealant backings that have become wet before sealant application and replace them with dry materials.

D. Install joint sealants using proven techniques that comply with the following and at the same time backings are installed:

1. Place joint sealants so they directly contact and fully wet joint substrates.
2. Completely fill recesses in each joint configuration.
3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.

E. Tooling of Nonsag Joint Sealants: Immediately after joint-sealant application and before skinning or curing begins, tool sealants according to the following requirements to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint:

1. Remove excess joint sealant from surfaces adjacent to joints.
2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.

F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions unless otherwise indicated.

3.4 CLEANING

A. Clean off excess joint sealant or sealant smears adjacent to joints as the Work progresses, by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.

3.5 PROTECTION

A. Protect joint sealants, during and after curing period, from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations in repaired areas are indistinguishable from the original work.
END OF SECTION 32 13 73
SECTION 32 17 23 - PAVEMENT MARKINGS

1.1 GENERAL SUMMARY

A. Section includes painted markings applied to asphalt and concrete pavement.

1.2 RELATED REQUIREMENTS:

1. Section 32 12 16 Asphalt Paving
2. Section 32 13 13 Concrete Paving

1.3 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. Standard Specifications:

2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.
3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include technical data and tested physical and performance properties.

1.5 FIELD CONDITIONS

A. Environmental Limitations: Proceed with pavement marking only on clean, dry surfaces and at a minimum ambient or surface temperature of [40 degrees F (4.4 degrees C) for alkyd materials] [55 degrees F (12.8 degrees C) for water-based materials], and not exceeding 95 degrees F (35 degrees C).
PART 2 - PRODUCTS

2.1 Products to comply with Montana Public Works Standard Specifications, sixth edition (MPWSS), as amended by City of Bozeman Modifications to MPWSS, latest edition.

2.2 PAVEMENT-MARKING PAINT

   A. To comply with Montana Public Works Standard Specifications, sixth edition (MPWSS), as amended by City of Bozeman Modifications to MPWSS, latest edition.

PART 3 - EXECUTION

3.1 EXAMINATION

   A. Verify that pavement is dry and in suitable condition to begin pavement marking according to manufacturer's written instructions.

   B. Proceed with pavement marking only after unsatisfactory conditions have been corrected.

3.2 PAVEMENT MARKING

   A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.

   B. Sweep and clean surface to eliminate loose material and dust.

3.3 PROTECTING AND CLEANING

   A. Protect pavement markings from damage and wear during remainder of construction period.

   B. Clean spillage and soiling from adjacent construction using cleaning agents and procedures recommended by manufacturer of affected construction.

END OF SECTION 32 17 23
SECTION 32 84 00 – IRRIGATION SYSTEM

PART 1 – GENERAL

1.01 RELATED DOCUMENTS

Drawings and general provisions of each Contract, including General Conditions and Supplementary Conditions, apply to work of this section.

1.02 DESCRIPTION

The work of this section consists of all items necessary to install the proposed irrigation system as indicated on the plans, and the protection and splicing required to maintain all parts of the existing irrigation system in operation, with the exception of those parts designated to be removed or abandoned. This includes required sleeves for pipe and wire, back-flow prevention devices, reconnections, and miscellaneous modifications to the existing irrigation distribution lines including, but not limited to:

A. Automatic controller and remote control valves.
B. Lawn and planting beds sprinkler system.
C. Connection to proposed irrigation water source and power supply.

All proprietary products listed within this specification shall be considered as a BASIS-OF-DESIGN PRODUCT.

1.03 RELATED WORK DESCRIBED ELSEWHERE

A. Landscaping Section 32 93 00
B. Lawns and Grass Section 32 92 00

1.04 QUALITY ASSURANCE

A. Qualifications of Installer

Provide at least one person who shall be present at all times during execution of this portion of the work and who shall be thoroughly familiar with the type of materials of installation and who shall direct all work performed under this section. All work of this section and related work listed above shall be performed by the same CONTRACTOR.

B. Codes and Standards

1. In addition to complying with all pertinent codes and regulations, comply with the latest rules of the National Electrical Code for all electrical work and materials.
2. Comply with National Plumbing code at all connections to potable water systems.
3. Where provisions of pertinent codes and standards conflict with the requirements of this section of these Specifications, the more stringent provisions shall govern.

1.05 SUBMITTALS
A. Material List

Before any irrigation system materials are delivered to the job site, submit to the ENGINEER a complete list of all irrigation system materials to be furnished and installed.

1. Show manufacturer’s name and catalog number for each item, furnish complete catalog cuts and technical data, and furnish the manufacturer’s recommendations as to method of installation. Where materials proposed differ from those specified, furnish complete shop drawings and design calculations to demonstrate equivalent performance of the proposed installation.

2. Do not permit any irrigation system component to be brought onto the job site without prior approval by the ENGINEER. Provide one sample of each element of the system to the ENGINEER for approval (sprinkler heads, valves, couplings, etc.). These samples will be returned to the CONTRACTOR, and if approved, may be used in the project.

B. Shop Drawings

CONTRACTOR shall submit Five (5) copies of the proposed sprinkler layout in a schematic form to the ENGINEER for approval. Any modifications to these proposed drawings will be returned to the CONTRACTOR for the preparation of five (5) copies of the final revised layout. The material list will be coordinated with the final shop drawings by the CONTRACTOR. Show all sleeve locations.

C. Field Verification

CONTRACTOR shall field verify all dimensions, existing and proposed conditions, and as required to provide one complete and operable system. Proposed system shall be laid out above ground using locate flags to show location of all sprinkler heads, valves, and sleeve locations. This layout shall be signed off on by MSU Irrigation Manager before any excavation shall begin.

D. As-built Drawings

Provide a complete set of Mylar reproducible as-built shop drawings to the ENGINEER for approval prior to final payment.

1.06 PRODUCT HANDLING

A. Protection

Use all means necessary to protect irrigation system materials before, during, and after installation and to protect the installed work and materials of all other trades.

B. Replacements

In the event of damage, immediately make all repairs and replacements necessary to the approval of the ENGINEER and at no additional cost to the OWNER.

1.07 PERFORMANCE REQUIREMENTS

A. Minimum Requirements

The following shall be the minimum requirements of the system. They are not intended to limit the overall intent, which is to obtain a fully operational and completely automatic sprinkler system. Specific requirements of this project manual shall apply to all elements typically. Conflicts between the drawings and the project manual or between specific and general performance of material
requirements shall be assumed to be the most expensive.

B. Project Zones

Refer to the drawings for the general zones to be served by this system.

1. Irrigation layout must be adaptable to the future modification of the system to smaller heads, more intense head arrays and minimal spraying over the sidewalks. This should be accomplished by running the laterals near sidewalk edges whenever possible, and by positioning the mains with this future intent.

2. CONTRACTOR will advise himself of all existing and proposed site conditions and related planting and grading as required to coordinate and schedule with the work of other contractors.

3. Heads shall be positioned to prevent damage from spraying on the building envelope and/or causing inside flooding in any and all cases.

4. Organize zones to allow walking across the area on dry sidewalk while the irrigation system is on.

PART 2 - MATERIALS

2.01 PIPE

A. Plastic Pipe

1. Plastic pipe shall be rigid non-plasticized Schedule 40 PVC IPS solvent-welded conforming to ASTM D-1784 and D-2241 standard specifications for PVC plastic pipe. The pipe shall be homogeneous throughout and free from visible cracks, holes, foreign materials, blisters, deleterious material, wrinkles, and dents.

2. All pipes shall be continuously and permanently marked with the following information:
   Manufacturer’s name or trademark, size, schedule and type of pipe, working pressure at 73 deg. F and National Sanitation Foundation (N.S.F.) approval.

3. All main lines shall be a minimum of two inches (2”) in diameter.

4. All lateral lines shall be a minimum of one and one-half inches (1-½”) in diameter.

5. All plastic pipe fittings to be installed shall be molded fittings manufactured of the same material as the pipe, rated as a pressure fitting (no DWV fittings shall be allowed) and shall be suitable for solvent weld, slip joint ring-tite seal, or screwed connections. All pipe six inches (6”) in diameter and above shall be Schedule 40 PVC IPS gasket end. All smaller pipes shall be Schedule 40 PVC IPS solvent-welded.

6. Slip fitting socket taper shall be so sized that a dry unsoftened pipe end, conforming to these specifications, can be inserted no more than halfway into the socket. Plastic saddle and flange fittings will not be permitted. Only schedule 80 pipe may be threaded.

7. When connection is plastic to metal, plastic male adapters shall be used. The male adapter shall be hand tightened, plus one turn with a strap wrench. Joint compound shall be Teflon Tape on Water Based Teflon Paste.
8. All mainline pipes shall be traceable via purple or blue-colored 14 gauge single strand direct burial wire attached to the pipe. The tracer wire shall surface at and be secured to the controller. This is not necessary for lateral pipelines with irrigation heads attached.

B. Pipe Sleeves

Pipe sleeves shall be Schedule 40 PVC pipe, six-inch (6") diameter unless noted otherwise, or equal approved by ENGINEER.

1. Installation

Provide empty sleeves along all pathways as noted on the drawings or every 100 feet. Extend sleeves at least one foot (1') beyond pavement on both sides. Sleeves shall be installed 18 inches below finished grade. Cap ends of empty sleeves with duct tape.

2. Sleeve Location Marking

   a. New Pavement

      The location of each sleeve must be marked along both of the extreme edges of any new pavement installed over the sleeve. This shall be accomplished by pressing the end section of a two-inch (2") pipe into the uncured pavement surface to make an imprint.

   b. Existing Pavement

      For sleeves pushed under existing pavement, sleeve locations shall be marked along the extreme edges of the pavement on both sides where the sleeve emerges from under the pavement. Markings shall consist of scoring the surface of the existing pavement with a 2” O.D. core drill just enough to make the impression of a circle in the pavement surface.

2.02 RISERS/SWING JOINTS

A. Flexible Risers

Stationary Pop-up and Surface Sprinkler Heads shall be installed using “funny pipe” or four-piece swing joints. Sprinkler Heads with one-half inch (1/2") and/or three-quarter inch (3/4") inlets shall connect with “funny pipe” exclusively, in lengths no longer than three feet (3’). Sprinkler Heads with one-inch (1") inlets shall connect with four-piece swing joints only.

1. Installation with “funny pipe”, which is one-half inch (1/2") low density, polyethylene pipe, rated 80 PSI at 100 deg. F, must use Teflon-taped barbed street ells. Use of flexible pipe such as “funny pipe” is limited to connecting laterals to irrigation heads.

2. Four-piece swing joints shall consist of an assembly using three (3) one inch (1") Marlex street elbows, with a 1” SCH 80 Nipple of required length to set head at grade.

B. Rigid Risers

All risers for shrub spray heads, bubblers, etc., that are in shrub or flowerbed areas and planters, shall be schedule 80 PVC plastic pipe, unless otherwise specified or shown on the plans. The risers shall be of sufficient height so as not to cause any interruption of the stream from the sprinkler nozzle when the plant material has reached its optimum growth.

2.03 VALVES
A. Ball Valves
   1. All manual ball valves, sizes 1-1/2" inches and smaller, shall be all bronze double with integral taper seats and with rising stem.
   2. All valves 2" and larger shall be gate valves.
   3. All ball valves shall be full port, with chromium or stainless ball with Teflon seats 150 PSI rated, Hammond, or approved equal.

B. Pressure Reducing Valves

   Provide pressure-reducing valves on main lines only, Watts, Series U5, U5B ½" to 2" Standard Capacity, or approved equal.

C. Gate Valves

   1. All manual gate valves, sizes four-inch (4") and smaller, shall be made in the U.S.A., brass body, threaded, non-rising stem, full port, 200 PSI/13.8 bar non-shock cold working pressure up to 180 deg. F./82 deg. C., NSF/ANSI 61-8 compliant: NIBCO model TI-8 or approved equal.
   2. All gate valves of 6-inch (6") size or larger shall be at least 150 PSI rated, AWWA-C509 resilient wedge gate valve, made in the U.S.A., featuring non-rising stem, iron body, epoxy coated interior, mechanical joint with appropriate size gaskets for corresponding pipe as per drawing.

D. Quick-Coupler Valves

   Provide Rain Bird #3 DNP Quick Coupler valves.

E. Automatic Remote Control Valves

   Automatic control valves shall consist of:

   1. Rain Bird PESB Series, 24 volt, contamination resistant valve with a pressure operating range of 20-200 psi and at 0.25 to 200 gpm flow range. Glass-filled nylon construction, one-piece solenoid with captured plunger, flow control handle adjusts, manual internal and external bleeds, nylon screen scrubber and purple flow control handles for easy identification of non-potable water systems or approved equal.

F. Back-Flow Preventers

   Back-flow on potable systems only shall be Rain Bird Model DCA2–0-OR or approved equal.

2.04 VALVE BOXES

   All remote control valves, pressure regulating valves, manual control valves, zone shut-off valves, gate valves or globe valve filters and drains, unless otherwise indicated, shall be installed in a valve access box of proper size as required for easy access to the valve. Valve box to be Carson, with round, locking green cover ten inches (10") in diameter for quick coupler valves, and 10" x 15" standard for all others unless described otherwise in the contract drawings, or approved equal. All round valve boxes shall be supported underneath the bottom edges with two bricks (minimum). All rectangular valve boxes shall be supported underneath the bottom edges with three bricks (minimum).

2.05 AUTOMATIC IRRIGATION CONTROLLER
A. Controller Type

The automatic controller shall be 120 volt input, soft-wired, 26.5 volt output, with the number of valve stations and in the type and model number indicated on the plans, and shall be a Rain Bird ESP SAT LS or ESP SAT LW. Wall or pedestal mount type must be pre-approved by the ENGINEER and OWNER for the site situation. Controller station size and quantity specified per drawing. Station wiring and timing schedule specified per drawing. All station wiring must be terminated in a Rain Bird ESPSATOB24 mounted in the pedestal or wall mounted wire trough. All controllers must be equipped with a Rain Bird RMK450NARR with a University licensed and authorized frequency, hooked to a Rain Bird Maxilink Ant 01 or Antenex Directional Yagi Model Y4503/Y4505 or University approved substitute.

B. Electrical Power

Power for the controllers shall be the responsibility of the sprinkler installer. Meet all electrical specifications for installation of controllers and power to the controllers. The controllers must be wired to the power source in the pedestal or wall via an Isobar Ultra 4 surge protector and a two-receptacle Ground Fault Interrupter (GFI) outlet. A pigtail that can reach from the controller to the outlet is required. Power source must be pre-approved by Owner prior to connection.

C. Sleeves

1. Provide minimum of six inches (6") diameter sleeves under paved areas as necessary to run all control wiring and piping for sprinkler zones. Coordinate with concrete work prior to forms being set.

2. No sleeving shall be put in tunnel walls. All main lines fed from the tunnel shall be cored, and sized to fit link seals for that pipe size. Each mainline shall be sealed using 2 link seals, one on the inner wall and one on the outer wall. No fittings allowed within 3'-0" of outer tunnel wall.

D. Location

After pre-approval by the ENGINEER and OWNER, locate controllers on outside walls of buildings or on pedestals at locations that will maximize the view of the zones serviced by each controller. Verify locations with the ENGINEER to avoid compromising buildings systems and/or appearance concerns.

Pedestal controllers must be mounted to a concrete slab of dimensions 1.5' x 1.5' x 0.33'. Each pedestal slab shall have a minimum of 2 electrical sweep 90's poured into it. First; one 1" sweep shall hold 120V direct bury power wires, second, one 2" sweep shall hold valve control and flow meter wires- additional or larger sweeps shall be installed as needed to avoid wire damage. Two bollards consisting of three inch (3") steel pipe filled with concrete and anchored in concrete shall be installed against the edge of the slab in front and in back of the controller. The bollards shall be primed and painted with a black, epoxy-based paint. The concrete at the top of the pipe must be domed and finished to a smooth, even surface, without concrete residue on the outside surface of the pipe.

E. Flow Meter

A MaxiCom-compatible flow meter must be installed at every point of connection. This may be either a Rain Bird Brass Insert Sensor (FS350B) for pipe three inches or larger, or a Rain Bird PVC Tee Sensor of the appropriate size: FS150P for 1-1/2" pipe, FS200P for 2' pipe, and FS300P for 3" pipe. The flow meter must be directly connected to the controller using PE43 communication cable (the blue/blue white wire pair must be used for the flow meter/pulse transmitter connection) and a PT 322.
pulse transmitter. All splices using this type of cable must meet Rain Bird MaxiCom standards. Programming and hook up of the PT322 shall be completed by MSU Irrigation Employee.

F. Certified Installation

All MaxiCom components must be ordered and installed by a MaxiCom-certified installer.

2.06 IRRIGATION HEADS

A. Rotary Sprinklers

Rotary sprinkler heads shall be Model I-20 R Series, manufactured by Hunter Industries, San Marcos, California; or Rain Bird 5000 Series PLPCSAMNP, 5505 NP; or 8005NP Series, manufactured by Rain Bird Sprinkler Mfg. Corp., Glendora California or approved equal. Height specified should be reflective of height of vegetation irrigated.

B. Spray Heads

Spray head sprinklers shall be Rain Bird Model Nos. 1800 Series SAM or with variable arc nozzles (VAN) or MPR nozzles, manufactured by Rain Bird Sprinkler Mfg. Corp., Glendora California or approved equal. Height specified should be reflective of height of vegetation irrigated.

C. Bubblers

All bubbler zones must be controlled by a Rain Bird PESB Series Valve incorporating a Rain Bird PRS regulator. There must be a Rain Bird WYE Filter System installed directly downstream of the valve, located inside the valve box in a manner that allows easy maintenance. The bubbler heads must be Rain Bird 1300A-F Series mounted on Rain Bird 1804 SAM Spray Bodies or approved equal.

D. Drip Irrigation

No drip irrigation systems are allowed at Montana State University.

2.07 CONTROL CABLE

A. Type

All electrical control and ground wire shall be Baron irrigation control cable or approved equal, 14-gauge unless otherwise indicated on the drawings. All wiring to be used for connecting the automatic remote control valve to the automatic controllers shall be Type “UF”, 600 volt, solid copper, single conductor wire with PVC or polyethylene insulation and bear UL approval for direct underground burial feeder cable.

B. Insulation

Insulation shall be four-sixty-fourths inch (4/64”) thick minimum covering of ICC-100 compound for positive waterproofing protection. All control or “hot” wires shall be red and all common or “ground” wires shall be white. A black extra wire shall be included in the wiring run for every four (4) wires installed.

C. Code Compliance

Verification of wire types and installation procedures shall be checked to conform to local codes.
D. Splices

All splices are to be completed within valve boxes using one-piece, jelly-filled, water-proof wire connectors with 20 expansion coils per splice, allowing work to be completed at ground level. All splices shall be located on as-built drawings.

E. Trench Installation

1. Tape and bundle all wiring at ten-foot (10’) intervals.
2. Attach tracer wire to main line pipe only at ten-foot (10’) intervals.
3. All 120 volt wiring shall be in conduit with marker tape installed in the ditch six inches (6”) above the conduit.
4. All wiring under pavement and through sleeves shall be in conduit.
5. Tie a loose twenty-inch (20”) loop in wiring at all changes in direction greater than 30 degrees. Untie all loops after making connections.

2.08 VAULTS

A. Water Service Connection

A vault shall be installed at domestic water service connection. Vault shall house domestic water back-flow preventers, blowout assembly and isolation valves. Vault must comply with applicable code(s).

B. Location

Review location of vault with ENGINEER prior to installation.

2.09 OTHER MATERIALS

A. Tools To Be Furnished

1. Supply as part of this contract the following tools:
   a. Two keys for each automatic controller
   b. Two quick-coupler keys, Rain Bird Model 33K with matching hose swivels.
2. The above equipment shall be turned over the OWNER at the conclusion of the project. Before final inspection can occur, evidence that the OWNER has received materials must be shown to the ENGINEER.

B. Concrete

Provide and coordinate installation of all concrete thrust blocks. Refer to Division 3 for concrete requirements. Provide thrust blocks for all lines larger than 3-inch diameter, at all tees and ells.

C. Other Materials

All other materials not specifically described but required for a complete and proper irrigation system
installation, shall be new, first quality of their respective kinds, and subject to the approval of the ENGINEER.

PART 3-EXECUTION

3.01 SURFACE CONDITIONS

A. Inspection

1. Prior to all work of this section, carefully inspect the installed work of all other trades and verify that such work is complete to the point where this installation may properly commence.

2. Verify that irrigation system may be installed in strict accordance with all pertinent codes and regulations, the original design, the referenced standards, and the manufacturer’s recommendations.

B. Discrepancies

1. In the event of discrepancy, immediately notify the ENGINEER.

2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.02 FIELD MEASUREMENTS

Make all necessary measurements in the field to ensure precise fit of items in accordance with the original design.

3.03 TRENCHING AND BACKFILLING

A. General

1. Perform all trenching required for the installation of items where the trenching is not specifically described in other sections of these specifications.

2. Make all trenches in accordance with OSHA Requirements with sufficient width to provide free working space at both sides of the trench and around the installed item as required for gluing, joining, backfilling, and compacting while minimizing width of trenches.

3. The CONTRACTOR will be required to conduct his work so that trenches will remain open a minimum possible time.

B. Depth

1. Trench as required to provide the elevations shown on the Plans.

2. Trench to sufficient depth to give a minimum of eighteen inches (18") of fill above the top of the pipe measured from the adjacent finished grade under driveways and sidewalks.

3. All mainline and control cables shall have a minimum cover of eighteen inches (18") above the pipe or wire. All laterals shall have a minimum cover of twelve inches (12") above the pipe.

4. All sleeves shall be installed at a depth on line and grade with existing or proposed irrigation lines. Sleeves with excessive or shallow invert depth will be rejected.
C. Correction of Faulty Grades

Where trench excavation is inadvertently carried below proper elevations, backfill with material approved by the ENGINEER and then compact to provide a firm and unyielding sub grade to the approval of the ENGINEER and at no additional cost to the OWNER.

D. Trench Bracing

1. Properly support all trenches in strict accordance with all pertinent rules and regulations.
2. Brace, sheet, and support trench walls in such a manner that they will be safe and that the ground alongside the excavation will not slide or settle, and that all existing improvements of every kind will be fully protected from damage.
3. In the event of damage to such improvements, immediately make all repairs and replacements necessary to the approval of the ENGINEER and at no additional cost to the OWNER.
4. Arrange all bracing, sheeting, and shoring so as to not place stress on any portion of the completed work until the general construction thereof has proceeded far enough to proved sufficient strength.

E. Removal of Trench Bracing

Exercise care in the driving and removal of sheeting, shoring, bracing, and timbering to prevent collapse or caving of the excavation faces being supported.

F. Grading and Stockpiling Trenched Material

1. Control the stockpiling of trenched material in a manner to prevent water from running into the excavation.
2. Do not obstruct surface drainage but provide means whereby storm and wastewater are diverted into existing gutters, other surface drains, or temporary drains.

G. Methods

1. All trench excavation shall be made by open cut. During excavation, material suitable for backfilling shall be piled in an orderly manner, a sufficient distance from the banks of the trench to avoid overloading, and to prevent slides or cave-ins. All material not required for backfill or not suitable for backfill shall be removed from the site by the CONTRACTOR. Banks of trenches shall be kept as nearly vertical as possible, and shall be properly sheeted and braced as may be necessary to prevent caving.
2. The CONTRACTOR shall provide, place and maintain all necessary barricades, warning signs, and other safety devices to prevent pedestrians from falling in open trenches.
3. Trench widths in paved streets or in areas where proximity to other structures requires vertical cuts, shall not be wider than is required for proper handling, jointing and bedding of the pipe.
4. The bottom of the trenches shall be accurately graded to line and grade, and provide uniform bearing and support for each section of the pipe on undisturbed soil, at every point along its entire length. Depressions for joints shall be dug after the trench bottom has been graded, and shall be only of such length, depth, and width as required for properly making the particular type joint. Care shall be taken not to excavate below the depths indicated.
5. Where rock occurs in trench excavation, the rock shall be removed to a depth of six inches (6") below the established grade line, and to a width of twelve inches (12") greater than the outside diameter of the pipe to be installed in the trench.

6. No water shall be permitted to rise or stand in trenches not yet backfilled until after the pipe has been placed, tested and covered with backfill for a depth of at least ten inches (10"). Any pipe having its alignment or grade changed as a result of a flooded trench shall be removed and re-laid after the trench is graded once again at not additional cost to the OWNER.

H. Pavement Removal

1. Where excavation of trenches requires the removal of pavement, the pavement shall be cut in a straight line along the edge of the excavation by use of a spade-bit air hammer, concrete saw or similar approved equipment to obtain straight, square and clean break. After backfilling and sub grade preparations are completed, the pavement section and surfacing shall be replaced.

2. Excess material, including rock, broken concrete, bituminous materials, debris, or other materials not suitable for backfill, shall be removed from the site and disposed of by the CONTRACTOR.

3.04 BORING

A. Locations

Boring shall be used to route pipe, wiring, or both under structures such as walks or curbs where trenching is impractical. Sleeves shall be installed in all bored holes.

B. Method

Boring shall be accomplished with a drill, auger, water jet, or any other instrument approved by the ENGINEER capable of producing a precise hole. Boring shall not disturb overlaying structures or cause settlement and damage to those structures.

3.05 SLEEVES

A. Locations

Sleeves shall be installed wherever routing of a pipe, wiring, or both crosses a paved area or passes through a bored hole.

B. Methods

1. Sleeves laid in open trenches shall be uniformly and evenly supported by undisturbed soil on the trench bottom. Backfill shall conform to standards hereinafter specified.

2. Sleeves installed in borings shall be forced through and shall have a snug fit throughout the length of the bored hole. Sleeves cracked or broken shall not be accepted.

3.06 BACKFILL

A. Material

Backfill material shall be free of clods, lumps of frozen material, or stones larger than one-inch (1") in their maximum dimension. The bedding and select material under, around and six inches (6") above the top of the pipe shall be placed by hand in maximum layers of six inches (6") and carefully compacted in a manner which will not displace the pipe. Compaction of the select backfill shall be at

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least ninety percent (90%) of the maximum density as determined by AASHTO T-180. Water settling will not be allowed.

B. Inspection

The trenches shall not be backfilled until inspection has been completed and the pipe installation, including the grade, alignment and jointing has been found to be in compliance with the requirements of the plans and specifications.

C. Around and Over the Pipe

1. Select backfill material consisting of sand, fine gravel or select earth, free of large lumps or rocks larger than three-quarters of an inch (¾”) shall be used in backfilling around and over the installed pipe.

2. The select material shall be obtained from the excavation material removed from the trench and shall be processed by screening, sifting, or selective sorting, so as to produce the type of backfill herein specified. The CONTRACTOR may at his option and expense provide an acceptable imported material.

3. This backfill material shall be carefully deposited around and over the pipe in layers not more than six inches (6”) thick, loose measurement, unless otherwise permitted by the ENGINEER, wetted to optimum moisture content and uniformly compacted to at least ninety-five percent (95%) of the maximum density obtainable at optimum moisture content as determined by ASTM D698 (latest revision), until the pipe has a cover depth of at least one foot (1’).

D. Remainder of Trench Backfill

1. The remaining depth of the trench shall be backfilled with excavation material removed from the trench, which shall be wetted or dried to near optimum moisture content.

2. This material shall be carefully deposited in layers not to exceed six inches (6”) in compacted thickness and compacted to at least ninety-five percent (95%) of the maximum density as determined by ASTM D698 (latest revision). The method of compaction selected by the CONTRACTOR shall not cause damage of any nature to the installed pipe. Replace topsoil on trench fill and compact to eighty-five percent (85%) of maximum density at optimum moisture.

3. The use of water settlement for this portion of the trench backfilling is permissible if the specified density can be obtained and the backfill material is suitable for this type of trench compaction.

3.07 INSTALLATION OF PIPING

A. General

1. Layout the piping system in strict accordance with the Plans.

2. Where piping is shown on the Plans to be under paved areas but running parallel and adjacent to planted areas, the intention is to install the piping in the planted areas.

B. Line Clearance

1. All lines shall have a minimum clearance of four inches (4”) from each other, and six inches (6”) from lines of other trades, except through pipe sleeves.

2. Parallel lines shall not be installed directly over one another.
C. Inspection of Pipe and Fittings

   Carefully inspect all pipe and fittings before installation, removing all dirt, scale, and butts and reaming as required; install all pipe with stamped markings oriented up to allow visual inspection and verification.

D. Plastic Pipe

   1. Plastic pipe shall be installed in a manner so as to provide for expansion and contraction as recommended by the manufacturer.

   2. All plastic pipe joints shall be solvent-weld joints or gasket fit joints. Only the solvent cement recommended by the pipe manufacturer shall be used and it must be a two-part system consisting of primer and cement. No single part cement system shall be used. All plastic pipe and fittings shall be installed as outlined and instructed by the pipe manufacturer and it shall be the CONTRACTOR's responsibility to make arrangements with the pipe manufacturer for any field assistance that may be necessary. The CONTRACTOR shall assume full responsibility for the correct installation.

   3. All plastic (PVC) to metal joints shall be made with plastic threaded male adaptors into metal threaded female fittings.

   4. The solvent-weld joints shall be made on dry pipe.

   5. The solvent-weld joints shall be allowed to set at least 24 hours before pressure is applied to the system on PVC pipe.

E. Copper Pipe

   Direct buried copper pipe connections shall be made using silver solder.

F. Thrust Blocks

   Provide concrete thrust blocks for all pipes as shown on the plans. All thrust blocks shall bear directly on undisturbed earth. Center the pipe in the middle of the thrust block.

3.08 INSTALLATION OF EQUIPMENT

A. General

   1. All fittings, valves, etc., shall be carefully placed in the trenches with concrete thrust blocks, placed where required.

   2. All sprinklers, having adjustable nozzles, shall be adjusted for proper and adequate distribution of the water over the coverage pattern of the sprinkler.

   3. All nozzles on stationary pop-up sprinklers or stationary spray heads shall be tightened after installation. All sprinklers having an adjusting screw, adjusting stem or adjusting friction collars shall be adjusted as required for the proper arc of coverage, radius, diameter and/or discharge.

   4. All control wires shall be clearly labeled by station, using weatherproof material, at the controller and at the valve ends. Mark the underside of all valve box covers, indicating the valve controller station number. All markings shall be made in a neat and legible manner using white enamel paint.
5. All control or "hot" wires shall be red and all common or "ground" wires shall be white. A black extra wire shall be included in the wiring run for every four (4) wires installed.

B. Sprinkler Heads

1. Install lawn sprinkler heads where indicated on the plans and in strict accordance with the manufacturer's recommendations and as necessary to provide complete uniform coverage and precipitation.

2. Upon completion of installation, reset all lawn sprinkler heads flush with grade and firmly anchored with soil.

C. Master Automatic Control Valves

A master automatic control valve shall be installed at the point of connection to the main for any remotely controlled portion of the irrigation system. In cases where there are multiple points of connection, a master valve shall be installed for each, with no more than three points of connection allowed.

3.09 TESTING AND INSPECTION

A. Covering or Enclosing Work Prior to Inspection

Do not allow or cause any of the work in this section to be covered up or enclosed until it has been inspected, tested, and approved by the OWNER’s Representative.

B. Flushing

Before backfilling the mainline, and with all control valves in place, but before lateral pipes are connected, completely flush and test the mainline and repair for all leaks; flush out each section of lateral pipe before sprinkler heads are attached.

C. Testing

1. Make all necessary provisions for thoroughly bleeding the line of air and debris.

2. After valves have been installed, test all live water lines hydrostatically for leaks at a pressure of one hundred fifty (150) psi for a period of two (2) hours, with all couplings exposed and with all pipe sections center loaded.

3. Furnish all necessary testing equipment and personnel.

4. Correct all leaks and retest until acceptance by the ENGINEER.

D. Final Inspection

1. Thoroughly clean, adjust, and balance all systems.

2. Demonstrate the entire system to the ENGINEER and OWNER, proving that all remote control valves are opening and closing on command, that all heads are properly adjusted for radius and arc of coverage, that all emitters are functioning, and that the installed system is workable, clean, and efficient.
3. Existing irrigation system(s) or portions of systems which have had their performance altered by any of the work related to this project shall be repaired or adjusted using materials and installation methods in accordance with this specification and in a manner to restore head-to-head sprinkler coverage, uniform precipitation rates, control zone integrity, and elimination of the spraying of water on building walls and sidewalks.

3.10 PAVEMENT REPLACEMENT

Pavement replacement shall utilize the same materials and design as the original pavement.

3.11 CLEANUP

Upon completion of the work, the entire site shall be cleared of all debris, and ground surfaces shall be finished to smooth, uniform slopes and shall present a neat and workmanlike appearance. Cleanup shall be considered an incidental item, and no additional payment shall be made for any cleanup item. All improvements or other obstructions removed during construction shall be replaced in a condition at least equal to their existing condition.

3.12 MAINTENANCE

A. The CONTRACTOR shall, for a period of one (1) year after completion and final acceptance of the work, maintain and repair any trench or boring settlement which may occur, and shall make suitable repairs to any pavements, or other structures which may become damaged as a result of settlement. All such maintenance and repair shall be at the CONTRACTOR's expense.

B. The CONTRACTOR shall inform the OWNER of the location and the nature of all damage done to the existing irrigation system not slated for demolition within eight hours of the occurrence of the damage.

C. The CONTRACTOR shall maintain the existing and proposed irrigation system in operation during the construction period. Upon completion of the proposed irrigation work the CONTRACTOR shall balance and adjust the entire (new and existing) system.

3.13 AS-BUILT DRAWINGS, CHARTS AND EQUIPMENT MANUALS

A. Record Drawings

1. Record accurately on one set of black and white prints of the site plan all installed work including both pressure and non-pressure lines.

2. Upon completion of each increment of work, transfer all such information and dimensions to the print. The dimensions shall be recorded in a legible and workmanlike manner.

3. Dimension from two permanent points of reference (buildings, monuments, sidewalks, curbs, pavement, etc.). Locations shown on as-built drawings shall be kept day-to-day as the project is being installed. All dimensions noted on drawings shall be one-eighth-inch (1/8") in size (minimum).

4. Show locations and depths of the following items:
   - Point of connection
   - Routing of pressure lines (max. dimension=one hundred feet (100') along lines)
   - Gate valves
   - Sprinkler control valves
Quick coupling valves
Routing of control wires
Sprinkler heads
Other related equipment

5. Maintain as-built drawings on site at all times.

6. Make all notes on drawings in pencil (no ball point pen).

B. Controller Charts

1. ENGINEER must approve as-built drawings before charts are prepared.

2. Provide one controller chart for each controller supplied showing the area covered by automatic controller, of the maximum size controller door will allow.

3. The chart is to be a reduced drawing of the actual as-built system.

4. Chart shall be black line print and different colored shading used to show area of coverage for each station.

5. When completed and approved, the chart shall be hermetically sealed between two pieces of plastic.

6. The chart shall be mounted using Velcro or equal type of semi-permanent fastening device.

7. These charts must be completed and approved prior to final acceptance of the irrigation system by the OWNER.

C. Operation and Maintenance Manuals

1. Prepare and deliver to the ENGINEER within ten calendar days prior to completion of construction, all required and necessary descriptive material in complete detail and sufficient quantity, properly prepared in two (2) individually bound copies of the operations and maintenance manual. The manual shall describe the material installed and shall be in sufficient detail to permit operating personnel to understand, operate and maintain all equipment. Spare parts lists and related manufacturer information shall be included for each equipment item installed. Each complete, bound manual shall include the following information:

   a. Index sheet stating CONTRACTOR’s address and telephone number, duration of guarantees period, list of equipment with names and addresses of local manufacturer representatives.

   b. Complete operating and maintenance instructions on all major equipment.

   c. System start-up and shut down instructions.

2. In addition to the above maintenance manuals, provide the maintenance personnel with instructions for system operation and show written evidence to the OWNER at the conclusion of the project that this service has been rendered.

3.14 GUARANTEE

A. Warranty
1. The entire irrigation and water system shall be guaranteed to give satisfactory service for a period of one year from the date of acceptance by the OWNER.

2. Should any trouble develop within the time specified above due to inferior or faulty materials or workmanship, the trouble shall be corrected at no expense to the OWNER.

3. Any and all damages resulting from faulty materials or workmanship shall be repaired by the CONTRACTOR to the satisfaction of the OWNER, at no cost to the OWNER.

End of Section 32 84 00
SECTION 32 92 00 – LAWNS COMPREHENSIVE

PART 1 - GENERAL

1.0 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General conditions, Supplementary Conditions, apply to work of this section.

1.1 DESCRIPTION

A. Work in this section includes:
   1. Furnishing all plants, labor, equipment;
   2. Performing all operations to finish grade topsoil;
   3. Prepare seed and sod beds;
   4. Sod all lawn areas; and
   5. Maintenance and protection of all sodded and seeded areas.

B. All areas within the contract limits, except surfaces occupied by paving and areas indicated to be undisturbed shall be hydroseeded or sodded as shown on Plans. Areas repaired due to Contractor damage shall be hydroseeded.

C. All proprietary products listed within this specification shall be considered as a BASIS-OF-DESIGN PRODUCT.

1.2 RELATED WORK DESCRIBED ELSEWHERE

A. Section 32 84 00 - Irrigation System

B. Section 32 93 00 - Landscaping

The Montana Department of Transportation Standard Specification for road and bridge construction, 1987 Edition, Section 610, roadside development shall govern the work as if bound herein. Where provisions of this section and the referenced standard conflict, this section shall govern.

1.3 QUALITY ASSURANCE

A. Qualification of Workmen

Provide at least one person who shall be present at all times during execution of this portion of the work and who shall be thoroughly familiar with the type of materials being installed and the best methods for their installation and who shall direct all work performed under this section.

B. Contractor Qualifications

The Contractor shall have at least two (2) years of weed control spraying experience. Proof of experience will be required. The Contractor must have a valid Montana Commercial Herbicide Applicator’s License.

C. Chemical Registration

All weed control chemicals must be registered with the Environmental Protection Agency and the State of Montana.
D. Equipment Requirements

The Contractor shall furnish, operate, and maintain suitable and adequate equipment necessary to perform the above operations in an approved and workman-like manner without delays. Spray nozzles shall be raindrop or similar drift control type.

E. Liability and Contractor's Responsibilities

Weather conditions must be such that no damage outside the sprayed area will occur and the Contractor will cease spraying whenever the application of spray could cause such damage.

The Contractor agrees to hold harmless the Owner and Landscape Architect and/or Engineer against any and all claims for damage arising from operations covered in this proposal.

F. Time of Application

Because of varied climatic conditions, it will be the Contractor's responsibility to coordinate spraying activities to achieve the best results. To avoid possible chemical exposure and general alarm among campus users, time of application must not coincide with other nearby outside campus activities. If nearby activity encroaches during spraying operations, spraying must cease immediately until people leave the area.

1.4 PRODUCT HANDLING

A. Protection

1. Use all means necessary to protect and maintain materials before, during, and after installation and to protect the installed work and materials of all other trades.

2. All seed shall be delivered in the original bags certifying purity, germination, common, and botanical name for each species, and percent weed seed. Owner shall inspect all seed prior to application. Untagged seed bags shall be rejected. Immediately make all replacements necessary to the approval of the Owner's Representative and at no additional cost to the Owner.

3. Deliver chemical fertilizers and herbicides, as specified, to site in original, sealed containers bearing manufacturer's guaranteed statement of analysis

B. Storage

Seed, fertilizer, herbicide, hydromulch, and tackifer shall be kept in dry storage away from contaminants, at a weatherproof location.

C. Notice to Proceed

The Contractor shall not proceed with seeding or sodding operations until the irrigation system has been tested and approved by the Owner's Representative.

D. Schedules

Install lawn seed mixes during the specified time periods. If special conditions exist that may warrant a variance in the specified plant dates or conditions, a written request shall be submitted to the Owner's Representative stating the special conditions and proposed variance.
The Contractor shall provide a weed control plan and schedule prior to bed preparation, for approval of the Owner’s Representative.

E. Substitutions

Requests for substitutions shall be submitted in writing to the Owner’s Representative prior to award of contract.

1.5 SPECIAL LANDSCAPE PROVISIONS

A. Water

Water will be available on site. Provide necessary hoses and other watering equipment required to complete work.

B. Maintenance

Until final acceptance, and until as approved stand of grass is achieved, maintain plantings by watering, cultivating, mowing, weeding, spraying, cleaning and replacing as necessary to keep lawns in a vigorous, healthy condition.

Watering: Water as necessary to keep top two inches of soil moist. Coordinate with Irrigation Contractor.

Mowing: Mow newly planted grass area weekly after initial growth reaches 2-½ inches.

Weeding: Remove weeds and foreign grasses in planted areas at least once per week. Herbicides may be used only when approved by the Owner’s Representative.

Fencing: Provide four (4’) foot tall orange plastic snow fencing and metal tee fence post spaced at a maximum of eight (8’) feet apart around all walks at seeded and sodded areas. Maintain until lawn is accepted.

1.6 CONDITION OF SURFACES

Lawn areas will be left at ± 0.1 feet of finish grade as shown on plans.

1.7 ACCEPTANCE

The work will be accepted when a completed stand of grass at the three-leaf stage or beyond is achieved and all provisions of Section 3.5.C, “Performance” have been met as approved by the Owner and Owner’s Representative.

PART 2 - MATERIALS

2.1 GRASS SEED

A. General

1. All seed shall be:

   a. Free from noxious weed seeds, and re-cleaned;

   b. Grade A recent crop seed;
c. Treated with appropriate fungicide;
d. Delivered to the site in sealed containers with dealer's guaranteed analysis.

B. Irrigated Grass Seed Mixture: Seed at the minimum rate of three (3) pounds per one thousand (1000) square feet (130 lbs./acre).

<table>
<thead>
<tr>
<th>Name of Grass</th>
<th>Proportion by Weight</th>
<th>Percent Purity</th>
<th>Percent Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>'Midnight' Kentucky bluegrass</td>
<td>16%</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>'Rugby II' Kentucky bluegrass</td>
<td>16%</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>'Ram I' Kentucky bluegrass</td>
<td>18%</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>Fine Fescue</td>
<td>25%</td>
<td>95%</td>
<td>85%</td>
</tr>
<tr>
<td>'Delaware' Dwarf Peren. Rye Grass</td>
<td>25%</td>
<td>95%</td>
<td>85%</td>
</tr>
</tbody>
</table>

C. Non-irrigated Grass Seed Mixture: must be ‘Kitty Hawk’ turf-type tall fescue seeded at three (3) pounds per thousand (1000) square feet (130 lbs./acre).

D. Dryland Grass Seed Mixture: Seed at the minimum rate of 25 pounds per acre.

<table>
<thead>
<tr>
<th>Name of Grass</th>
<th>Proportion by Weight</th>
<th>Percent Purity</th>
<th>Percent Germination</th>
</tr>
</thead>
<tbody>
<tr>
<td>Western Wheatgrass</td>
<td>45%</td>
<td>95%</td>
<td>90%</td>
</tr>
<tr>
<td>Thickspike Wheatgrass</td>
<td>17%</td>
<td>95%</td>
<td>90%</td>
</tr>
<tr>
<td>Green Needlegrass</td>
<td>17%</td>
<td>95%</td>
<td>90%</td>
</tr>
<tr>
<td>Blue Grama</td>
<td>5%</td>
<td>95%</td>
<td>90%</td>
</tr>
<tr>
<td>Needle and Thread</td>
<td>16%</td>
<td>95%</td>
<td>90%</td>
</tr>
</tbody>
</table>

2.2 SOD

A. General

1. Sod all areas where site is substantially disturbed.

2. Sod shall be from a commercial sod farm located in the Gallatin Valley.

3. Sod type, condition and source shall be approved by the Owner’s Representative.

B. Sod Characteristics

Sod shall be well-established lawn turf grasses similar to the seed mix described in 2.1 B.

Sod shall be vigorous, well-rooted, healthy turf, well hydrated and possessing excellent color.

Sod shall be free from disease, insect pests, weeds, other grasses, stones, and any other harmful or deleterious matter.

C. Sod Handling

Cut sod in uniformly wide strips, uniformly 1-1/2 inches thick with clean cut edges.

Sod shall be rolled or folded prior to lifting. Handling of sod shall be done in a manner that will prevent tearing, breaking, drying, or any other damage.
Sod shall be installed in place on the site not more than 24 hours after cutting.

2.3 FERTILIZER

A. Soil Testing

1. Verify fertilization needs by sampling and testing soil prior to purchasing fertilizer. The test sample shall be obtained by sampling six different locations at the project site. Soil from sampled locations shall be mixed in equal parts to provide a compiled sample for testing.

Testing by an approved laboratory shall include:

   a. A test for soil pH,
   
   b. A test for electrical conductivity (EC),
   
   c. A test for the amount of nitrogen, phosphorus and potassium present (NPK),
   
   d. A test to determine the amount of organic matter present (OM).

2. Results of tests shall be reviewed by the Owner and Engineer prior to purchase of fertilizer. If tests results are typical for the general campus area, fertilization operations may commence as specified. If test results are not typical for the general campus area, Owner will provide modified formulation and application rate specifications by Change Order.

B. Formulation

1. Fertilizer shall be manufactured by Anderson ProTurf, or equal approved by the Owner. Application rates shall be in accordance with manufacturer recommendations. Fertilizer shall be complete, uniform in composition, dry and free flowing. The fertilizer shall be delivered to the site in the original waterproof containers, each bearing the manufacturer's statement of analysis.

2. Fertilizer to be spread on areas to be seeded shall be commercially prepared by Anderson ProTurf or an equal product pre-approved by the Owner. Fertilizer shall be a slow release, Poly-S urea, and shall contain the following percentages by weight:

   10% Nitrogen
   20% Phosphorus
   10% Potassium
   12% Sulfur

3. Grow-in Fertilizer shall be a slow-release, Poly-S urea, and shall be formulated as 25-3-4-Fe-2% and commercially prepared by Anderson ProTurf or equal approved by the Owner.

C. Special Protection

   If stored at the site, protect fertilizer from the elements at all times.

2.4 Mulch

Wood cellulose fiber for hydromulch – Weyerhauser, Conweb, or approved equal.
2.5 Mulch Tackifier

Mulch tackifier must be natural, non-asphaltic, vegetable gum with gelling and hardening agents, Terra Tack or approved equal.

2.6 Water

Water shall be clean irrigation quality water.

2.7 Pre-Planting Herbicide

Roundup, provide compatible surfactant and drift control agents as required.

2.8 Post-Emergent Herbicide

"TRIMEC" 2.4.D.M.C.P.P. DICAMBA (BANVIL) manufactured by P.B.I. Gordon 816-421-4070 distributed by Wilbur Ellis Company (406)-248-1176 or West Chemical Agricultural Chemicals, Inc., (406)-252-3834, or other appropriate control which best fits the weed problem and necessary applications.

2.9 Native Topsoil

Refer to Montana Standard Specifications Subsections 203.80 Topsoil Salvaging and placing, 610.00 Topsoiling and 713.06 Topsoil Material.

2.10 Imported Topsoil

In the event sufficient quantities of native topsoil cannot be salvaged from the site, the Contractor shall provide imported topsoil to supplement the project requirements. The Contractor shall provide topsoil that meets or exceeds the quality of the native topsoil material available on site. Contractor shall provide source and analysis information to the Owner's Representative, for his approval, prior to delivery. The Contractor shall incorporate into the topsoil, amendments necessary to provide topsoil fertility and quality, equal to or exceeding the characteristics of the native topsoil.

PART 3 - EXECUTION

3.1 SURFACE CONDITIONS

A. Inspection

Prior to all work of this section, carefully inspect the installed work of all other trades and verify that all such work is complete to the point where this installation may properly commence.

Verify that seeding may be completed in accordance with the original design and the reference standards.

B. Discrepancies

1. In case of discrepancy, immediately notify the Owner's Representative.

2. Do not proceed with installation in areas of discrepancy until all such discrepancies have been fully resolved.

3.2 FINISHING

A. Preparation
1. **General Seeding Areas:** For areas of general seeding, contractor shall provide a 6" minimum compacted, depth of topsoil on all lawn areas. Topsoil shall be graded smoothly and evenly. Lawn area sub grade shall be roughed and scarified 6" minimum depth to except and bind with the finish layer of topsoil. Topsoil shall be spread in a non-muddy, unfrozen condition. Surface finish shall be +/- 0.1 foot. Compaction of the topsoil layer shall be ±85% maximum dry density. Refer to Montana Department of Highways Standard Specifications Subsections 610.00 Topsoiling.203.08 Topsoil Salvaging and Placing, 713.06 topsoil material.

2. **Reclaimed Areas:** For areas reclaimed from pavement, contractor shall provide a 6" minimum compacted, depth of topsoil on all lawn areas. Topsoil shall be graded smoothly and evenly. Lawn area sub grade shall be roughed and scarified 12" minimum depth, or to a sufficient depth to loosen sub grade as directed by the Owner's Representative, to prevent a hardpan and bind with the finish layer of topsoil. Topsoil shall be spread in a non-muddy, unfrozen condition. Surface finish shall be +/- 0.1 foot. Compaction of the topsoil layer shall be ±85% maximum dry density. Refer to Montana Department of Highways Standard Specifications Subsections 610.00 Topsoiling.203.08 Topsoil Salvaging and Placing, 713.06 topsoil material.

**B. Finish Grading**

Grade lawn areas to finish grades, filling as needed or removing surplus dirt and floating areas to a smooth uniform grade. All lawn areas shall slope to drain minimum 2% slope. Where no grades are shown, surfaces shall have a smooth and continual grade between existing or fixed controls (such as walks, curbs, catch basins, and elevations at steps or building). Loosen and fine rake areas to receive seed or sod to break up lumps and produce a smooth, even grade, free from unsightly variations, ridges, or depressions. Remove stones one inch or larger, sticks, roots or other debris exposed during this operation. All finish grades shall meet the approval of the Owner's Representative before grass seed is sown or sod is placed.

**C. Weed Control**

1. Prior to application of seed or sod, the bed shall be roughed up to a depth of 1/8th inch.

2. Moisten the seedbed to a depth of 1" to promote germination of any seeds contained in the topsoil. If rhizomatous grasses, field bindweed (morning glory) or noxious weeds are evident, the Contractor shall be required to eliminate those undesirable plants prior to seeding or sodding, at the discretion and direction of the Owner's Representative.

3. Spray areas showing weed growth with approved herbicides, mow, and remove clippings prior to final grading. Seeding and sodding shall be executed 72 hours following Roundup application.

**3.3 PLANTING**

**A. Preparation**

1. Contractor shall provide a 6" minimum compacted, depth of topsoil on all lawn areas. Topsoil shall be graded smoothly and evenly. Lawn area sub grade shall be roughed and scarified 6" minimum depth to except and bind with the finish layer of topsoil. Topsoil shall be spread in a non-muddy, unfrozen condition. Surface finish shall be +/- 0.1 foot. Compaction of the topsoil layer shall be ±85% maximum dry density. Refer to Montana Department of Highways Standard Specifications Subsections 610.00 Topsoiling.203.08 Topsoil Salvaging and Placing, 713.06 topsoil material.
2. Hydroseed bed preparation shall pertain to the preparation of the surface of the ground to receive the seed. The ground shall be hand or machine raked to remove all debris, clods, rocks, and other material larger than 1 inch, to a depth of 4 inches. Such debris, clods, rocks, and other material so removed shall be disposed of off the immediate property. Hydroseed bed preparation shall not commence until the moisture conditions make the ground area and soil friable.

3. If there has been a time lapse following the placement of the topsoil to allow it to become settled and compacted on the surface, the areas to be seeded shall be thoroughly worked to a depth of 3 to 4 inches so as to provide a surface of such condition that it will allow application of the seed in compliance with these specifications.

4. Hydroseed beds shall be permitted to settle or firmed by rolling before seeding.

5. Initial application of fertilizer shall be applied evenly at the rate of 600 lbs. of material per Acre prior to seeding and incorporate into the prepared seedbed ½” deep by light raking.

B. Sowing

1. Immediately prior to the application of the seed, the soil shall be loose to a depth of at least 1 inch and free from all material as specified. If soil is too loose or dry for good handling, it should be moistened and rolled lightly.

2. Hydroseed all irrigated areas as shown on the plans. Irrigated areas may be seeded any time between April 15 and June 1, and August 10 and September 10, provided the irrigation system is operational. Hydroseed all dry land areas as shown on the plans. Seed to overlap limits of irrigated lawn by one half the distance between sprinkler head and limits of coverage between April 1 and May 15, and September 20 and October 30.

3. Lawn grass shall be sown at 3 pounds per 1000 square feet, (130 lbs./acre) using approved methods that allow for the even precise hydroseeding and incorporation of the seed into the top ½-inch of the prepared seedbed. If seed can be drilled, reduce rate to 60 pounds per acre. A drill type seeder with spacing greater than 3½” is not acceptable. When seed is drilled and the surface is unduly loose, the seedbed shall be compacted by an agricultural roller, cultipacker, or compactor not more than 24 hours after seeding.

4. Apply tackifier on all slopes greater than 4 to 1 at a rate of 100 pounds per acre.

5. Seed and mulch shall be applied in separate and distinct operations except that a minimal amount of mulch may be added to the seed slurry as a visual aid during the seeding process. Mulch applied with seed shall not exceed of mulch for each five (5) gallons of water. This mulch shall be deducted from the total quantity to be applied. The application of the seed slurry shall be made with the equipment having a built-in agitation system and operating capacity sufficient to agitate, suspend, and homogeneously mix slurry containing water, seed, and mulch. The slurry shall be sprayed over the soil in a uniform coat. Wherever practical, the slurry shall be applied normal to the surface being treated to effectively drill the seed in to the seedbed. Hydromulch application shall follow seeding as soon as practical, with consideration for minimal soil erosion through washing. All seeded areas shall be mulched before work is terminated on any day.

C. Mulching

1. Mulch all hydroseeded areas. Topsoil or seed that washes out for reasons attributable to the Contractor’s activities or failure to take proper precautions shall be replaced at the Contractor’s expense.
2. All structures shall be protected from hydraulic application of mulch material. Any material deposited on walks, streets, inlets, or other structures, shall be removed.

1. Mulch shall not be applied in the presence of free surface water, but may be applied on damp ground.

2. Organic mulch shall be mixed with water at a rate of one pound of mulch (dry weight) to one gallon of water, hydraulically applied as per manufacturer's recommendations at a rate of 2000 pounds per acre.

D. Tackifier

Mulch tackifiers shall be mixed with water at a rate specifically by the manufacturer and shall be applied at a minimum rate of 40 pounds per acre.

3.4 SOD INSTALLATION

A. Preparation

Contractor shall provide a 6” minimum compacted, depth of topsoil on all lawn areas. Topsoil shall be graded smoothly and evenly. Lawn area sub grade shall be roughed and scarified 6” minimum depth to except and bind with the finish layer of topsoil. Topsoil shall be spread in a non-muddy, unfrozen condition. Surface finish shall be +/- 0.1 foot. Compaction of the topsoil layer shall be ±85% maximum dry density. Refer to Montana Department of Highways Standard Specifications Subsections 610.00 Topsoiling, 203.08 Topsoil Salvaging and Placing, 713.06 topsoil material.

B. Application

1. Sod may be placed at any time when the ground is not frozen.

2. A string or line of boards may be used as a guide for setting the first course of sod across the area. Each course is matched against the edge of this course, staggering successive courses. All work should be done on boards laid on top of the sod to avoid footprints or other injuries to the surface.

3. All sod is to be laid on topsoiled areas. The joints shall be butting.

4. Lay sod across slope.

5. Roll or lightly tamp, with suitable wooden or metal tamper, all new sod sufficiently to set or press sod into underlying soil.

6. Before sod is laid, apply fertilizer specified, at the rate of six (6) pounds per 1000 square feet.

7. After sod installation is completed, clean up and thoroughly moisten areas of newly laid sod.

3.5 STAKING AND FENCING

A. General

All newly sodded or seeded areas are to be fenced so as to prevent trampling by foot or vehicular traffic. Fencing shall be removed by Contractor when Owner has determined that the lawn area is successfully established, as dictated in this section.
B. Materials

1. Posts to be five-foot minimum, six foot maximum green steel t-posts.

2. Fencing to be four-foot Tenax in guardian orange, length variable. Color substitutions allowed only with the direction and approval of the Project Manager.

C. Performance

1. Staking shall not be performed without prior identification of underground utilities, including but not limited to irrigation.

2. Stakes shall be installed every 16 feet or less, using a t-post driver.

3. Fencing to be attached to posts with nylon fence ties, zip ties or flexible wire.

3.6 MAINTENANCE

A. General

Maintain original grades of all lawn areas after commencement of planting and during maintenance period until final acceptance of the job, but in no case less than forty-five (45) days.

B. Work Included

1. All irrigated areas shall be watered as required to establish a mature stand of grass.

2. All areas shall be watched closely so that they are not permitted to dry out or to form puddles of water, or to be washed by over-application.

3. Mow all seeded lawn at 2½" each time its height reaches 3½". Maintain through a minimum of three mowings to provide an even stand over the entire seeded area, until final inspection and acceptance.

4. Provide a "grow-in" fertilizer, as specified, for all irrigated lawns. Apply six weeks after seed germination. In the case of fall seeding, apply prior to May 1, the following year.

5. Apply post emergence herbicide per the manufacturer's recommendations and application rates, whenever and wherever weed growth jeopardizes or inhibits the development of a mature grass lawn. Apply herbicide in late spring or early summer. Apply only when mean high temperatures are between 60° and 85° F with wind velocities less than five (5) miles per hour. Prior to application, Contractor shall notify Owner, in writing, of the proposed schedule for applying herbicides. Written notice shall include the following items:

a. Date of proposed application
b. Specific area of proposed application
c. Proposed herbicide for application
d. Proposed concentration and application rate.

The application area must be signed with Owner-approved signs informing the public of the application and duration of restricted use.

C. Performance
1. Establish a dense lawn of permanent grasses, free from lumps and depressions. Any part failing to show uniform cover and grades free from lumps and depressions shall be redone, and such replacement shall continue until a dense lawn is established. Scattered bare spots will not be allowed. Adequate germination shall equate to 11 to 15 seedlings per square foot over 95 percent of area seeded for native grass areas.

2. Finish grades at the edges of sidewalks, curbs or other hard surface boundaries must be at a level such that the established turf surface will be one (1) inch below the plane of the hard surface for a minimum distance of six (6) feet from the edge.

3. Maintain entire lawn area until the above performance is achieved throughout the project.

D. Replacements

1. Any area that fails to produce an adequate stand of grass shall be re-sodded or reseeded by the Contractor at no additional expense to the Owner.

2. Replacements required because of vandalism or other causes beyond the control of the Contractor are not part of the Contract.

3. For acceptance, the established grass will be judged by the stand's fullness, health, maturity and number of weeds present. Determination and acceptance of grass areas shall be made by the Owner's Representative.

E. Extension of Maintenance Period

Continue the maintenance period at no additional cost to the Owner until all previously noted deficiencies have been corrected, at which time the final inspection shall be made.

3.7 CLEAN-UP

Keep premises neat and orderly including organization of storage areas. Remove trash and debris resulting from lawn preparation from site daily as work progresses. Leave paved areas in a broom clean condition by sweeping or hosing.

END OF SECTION 32 92 00
SECTION 32 93 00 – LANDSCAPING

PART 1 - GENERAL

1.0 RELATED DOCUMENTS

Drawings and general provisions of the Contract, including General conditions, Supplementary Conditions, apply to work of this section.

1.1 DESCRIPTION

A. The work in this section includes landscape construction, protection of existing site and landscape conditions and landscape maintenance during construction.

B. See drawings for extent of landscaping.

C. All proprietary products listed within this specification shall be considered as a BASIS-OF-DESIGN PRODUCT.

1.2 RELATED WORK DESCRIBED ELSEWHERE

A. Section 31 11 00 – Tree Protection

B. Section 32 84 00 - Irrigation System

C. Section 32 92 00 – Lawns and Grass

1.3 QUALITY ASSURANCE

A. Comply with applicable Federal, state and local regulations governing landscape materials and work.

B. Owner’s representative reserves right to review and reject materials at growing site and as delivered to site.

C. Observation at growing site does not preclude right of rejection at job site. Remove rejected materials from site immediately.

D. Personnel: Employ only qualified personnel familiar with required work.

E. Contractor’s Responsibilities: Landscape Contractor to coordinate activities with all other trades. Landscape Contractor to also secure utility locates prior to commencing work involving excavation or digging.

1.4 REFERENCED STANDARDS


D. Alex Shigo, Tree Pruning, Shigo & Tree Associates, LLC, 1989.


J. International Society of Arboriculture (ISA) Best Management Practices publications

### 1.5 SUBMITTALS

A. File Certificates of Inspection of plant material by Federal, State and local authorities with Landscape Architect, if required.

B. Submit within 30 days after award of contract, complete list of materials to be furnished under this section and confirmed sources for materials.

C. Requests for substitutions shall be submitted in writing to the Landscape Architect prior to award of contract.

D. Provide and pay for material testing. Submit the following materials certification and text report.

1. Topsoil
   a. pH factor
   b. Mechanical analysis
   c. Percentage of organic content
   d. Recommendations on type and quantity of additives required to establish satisfactory pH factor and supply of nutrients to bring topsoil to satisfactory level for planting.
   e. Identify source location of topsoil proposed for use on the project if imported from off-site.

2. Organic Additives
   a. Loss of weight by ignition
   b. Moisture absorption capacity
   c. Percentage of organic matter
d. pH factor

E. Submit the following material samples, in a size within reason to evaluate material thoroughly:

1. Mulch
2. Erosion control fabric
3. Edging

1.6 PRODUCT PREPARATION, DELIVERY, AND STORAGE

A. Preparation and Protection

1. Balled and Burlapped (B&B) Plants: Dig and prepare shipment in a manner that will not damage roots, branches, shape, and future development.

2. Container Grown Plants: Deliver plants in container sufficiently rigid to hold ball shape and protect root mass.

3. Use all means necessary to protect and maintain materials before, during and after installation and to protect the installed work and materials of all other trades.

4. All seed shall be delivered in the original bags certifying purity, germination, common, and botanical name for each species, and percent weed seed. Owner's representative shall inspect all seed prior to application. Untagged seed bags shall be rejected. Immediately make all replacements necessary to the approval of the Owner's representative and at no additional cost to the Owner.

5. Deliver all products, as specified, to site in original, sealed containers bearing manufacturer's guaranteed statement of analysis.

B. Delivery

1. Deliver packaged materials in sealed containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery and while stored on site.

2. Deliver only plant materials that can be planted in one day unless adequate storage and watering facilities are available on job site.

3. Protect root balls by heeling in with mulch if not planted within 24 hours of delivery.

4. Protect during delivery to prevent damage to roots at all times. Cover all materials during transport.

5. Notify Land Owner's representative of delivery schedule 48 hours in advance so plant material may be observed upon arrival at job site and can be inspected immediately after being unloaded at site.

6. Remove rejected plant material immediately from site.

7. Do not lift, move, adjust to plumb, or otherwise manipulate plants by trunk or stems. Avoid damage or stress by proper handling. Plant material dropped on the ground, rather than gently placed into the storage area or planting bed, will be rejected.
C. Storage

1. Plant material shall be stored in a shady and secure location, and shall be watered regularly prior to planting to prevent drying out of the rootball.

2. Seed, fertilizer, herbicide, hydromulch, and tackifier shall be kept in dry storage away from contaminants, at a weatherproof location.

1.7 JOB CONDITIONS

A. Site and Plant Protection

1. Care must be exercised to minimize disturbance or compaction of areas adjacent to any project. Trees shall be protected as specified in the project manual. (Section 02210 – Tree Protection)

2. In order to prevent excessive soil compaction and destruction of soil structure, no site work will be performed in cases where equipment or traffic must pass over wet soils or if wet soils must be handled or manipulated in order for the work to progress. Wet soil is defined as any soil within 90 percent of field capacity (saturation).

3. Do not move equipment over existing landscape or newly placed structures without approval of the Owner or Owner’s Representative.

4. Provide board roading as required to protect paving. Protect other improvements from damage, with protection boards, ramps and protective sheeting.

B. Planting Restrictions

1. Perform actual planting per referenced standards.

2. Owner’s representative must approve all bedding plants and ground covers.

3. Plant materials must be installed with spacings that allow, at maturity, a maximum of 30 percent canopy overlap or inter-fingering. This does not apply to species of widely disparate mature sizes, such as between a large tree and understory shrubs, because their canopies do not grow together.

4. Trees that are medium and small at maturity must be planted no closer than fifteen feet to any building, sidewalk or paved surface unless otherwise indicated on the drawings. Trees that are large at maturity cannot be placed closer than 20 feet to any building, sidewalk or paved surface unless otherwise indicated on the drawings. Owner must approve exceptions to these requirements.

C. Utilities

1. Utility locates are required prior to digging and any construction activities.

2. Coordinate work with Owner, including irrigation manager, in order to prevent damage to underground sprinkler system.

1.8 WARRANTY

A. Warranty plant material for one year after final acceptance. Replace dead or dying materials not in vigorous, thriving condition as soon as weather permits and on notification by Owner’s representative.
Replace plants, including trees, which in opinion of Owner’s representative have partially died, thereby compromising shape, size or symmetry.

B. Replace plants with same kind and size as originally planted, at no cost to Owner. Provide one-year warranty on replacement plants. Trees should be replaced at start of next planting or digging season. In such cases, remove dead trees immediately. Protect irrigation system and other piping conduit or other work during replacement. Repair damage immediately.

C. Warranty excludes replacement of plants after final acceptance because of injury by storm, drought, drowning, hail, freeze, insects, or disease. Materials damaged by "Acts of God" prior to final acceptance are responsibility of Contractor.

D. At end of warranty period, remove staking and guying materials from the site.

1.9 MAINTENANCE

A. Water will be available on site. Provide necessary hoses and other watering equipment required to complete work.

B. Maintain plantings and trees by watering, cultivating, weeding, spraying, cleaning, and replacing as necessary to keep landscape in a vigorous, healthy condition.

C. Coordinate watering schedules with irrigation contractor or Owner’s representative during installation and until final acceptance. Provide deep root watering to newly installed trees.

D. Mowing: Mow newly planted grass area weekly after initial growth reaches two and one-half inches.

E. Weeding: Remove weeds and foreign grasses in planted areas at least once per week. Herbicides may be used only when approved by the Owner’s Representative.

F. Fencing: Provide four (4') foot tall orange plastic snow fencing and metal tee fence post spaced at a maximum of eight (8’) feet apart around all walks at seeded areas. Maintain until lawn is accepted.

G. Tree Replacement

Trees removed during demolition or construction are to be replaced following consultation with Owner’s Arborist or Owner’s Representative. Appraised values of existing trees have been determined according to industry standards and will be provided by the Owner if applicable.

PART 2 – PRODUCTS

2.0 PLANTS

A. General

Plant quality must be equal to well formed No. 1 grade nursery stock. Listed plant heights are from tops of root balls to nominal tops of plants. Plants shall be specimen quality, typical of their species or variety.

B. Shrubs and Ground Covers

Plants shall be nursery grown, healthy and vigorous, of normal habit of growth for the species, free from disease, insect eggs, and larvae. Specified sizes are before pruning and measured with branches in normal position. Plants shall be well rooted and established in the container.
C. Ornamental and Shade Trees

Trees shall be healthy, vigorous, full-branched, well-shaped, trunk diameter, and height requirements as specified. Root balls shall be firm, neat and slightly tapered and well burlapped. Trees with loose or damaged root balls at time of planting shall be rejected. Root balls should meet the American Standard for Nursery Stock, Edition approved 1985 by American National Standards Institute, Inc. (Z60.1) standard.

D. Special Requirements

Shade trees are to be procured a minimum of 30 days prior to scheduled installations. Trees to be shipped in enclosed truck or the branches/leaves protected by appropriate fabric during shipping. Trees are to be healed in at job site or at Contractor’s holding facility and maintained until site is ready. Owner’s representative will review trees at holding area prior to planting.

E. Collected Trees

Direct planting from the collection site is preferred. Coordinate with Owner for utility locates and scheduling of sidewalk closures or other logistical issues. If necessary, spray field grown trees immediately prior to digging with anti-desiccant. Insure adequate coverage to trunks, branches and foliage.

2.1 SOIL PREPARATION MATERIALS

A. Soil Amendments: Soil amendments are not to be used unless approved by Owner.

B. Topsoil

1. Friable, fertile, dark, loamy soil, free of clay lumps, stones and other extraneous material and reasonably free of weeds and foreign grasses, with a pH of 5.0 to 8.0.

2. Organic matter shall be four to 12 percent total dry weight.

3. Provide tests for certification.

C. Sharp Sand

Sharp sand shall be clean, washed and fine aggregate and shall meet ASTM C33 standards.

D. Peat Moss

Peat moss shall be commercially produced, sterilized, reed-sedge peat, equivalent to Martins Peat, Big Fork, Montana. Peat must have a pH between five and seven and organic matter content not less than 90 percent.

E. Fertilizer

1. Type A – as recommended by testing agency.

2. Type B – Scotts “Osmocote” at a 14-14-14 ratio, incorporated into the soil according to instructions on the bag.

2.2 MISCELLANEOUS MATERIALS

A. Edging
As indicated on drawings.

B. Mulch
   1. Shredded, medium grade, Douglas fir bark with a chip size of one and one-half inch to two and one-half inch average, free of wood chips and sawdust, as manufactured by Model Log Homes, 75777 Gallatin Road, Gallatin Gateway, Montana, 59730 (or approved equal).
   2. One and one-half inch round, native, washed, river rock.
   3. Owner’s representative approved equal.

C. Landscape Fabric
   Heavy, professional grade, spun-bonded nylon landscape fabric with six-inch anchoring pins. Woven fabric is unacceptable.

D. Anti-Desiccant
   1. Protective film emulsion for protection of plant surfaces during transport. Permeable to permit transpiration, as manufactured by Wilt Pruf, Inc., P.O. Box 4280, Greenwich, Connecticut, 06830. Mixed and applied in accordance with manufacturer’s instructions.
   2. Owner’s representative approved equal.

E. Staking and Guying
   1. Tie Wire: 12-gauge, galvanized wire
   2. Metal posts: 8’-0” t-stakes
   3. Nylon strap: three inches wide, 12 inches long white or black nylon strap with one ½” brass grommet in each end or Landscape Architect approved equivalent.

F. Drainage Fill
   No drainage without Owner’s written permission.

G. Native Topsoil
   Refer to Montana Standard Specifications Subsections 203.80 Topsoil Salvaging and placing, 610.00 Topsoiling and 713.06 Topsoil Material.

H. Imported Topsoil
   In the event sufficient quantities of native topsoil cannot be salvaged from the site, the Contractor shall provide imported topsoil to supplement the project requirements. The Contractor shall provide topsoil that meets or exceeds the quality of the native topsoil material available on site. Contractor shall provide source and analysis information to the Owner’s Representative, for his approval, prior to delivery. The Contractor shall incorporate into the topsoil, amendments necessary to provide topsoil fertility and quality, equal to or exceeding the characteristics of the native topsoil.

PART 3 - EXECUTION
3.0 INSPECTION

Examine sub-grade and verify conditions under which work is to be performed. Notify General Contractor and Owner’s representative of unsatisfactory conditions.

3.1 BED PREPARATION

A. Scarify all sub-grade of bed areas to six inches, all areas.
B. Contractor shall spread topsoil evenly throughout bed after thoroughly mixing soil, amendments and fertilizer together on site.
C. Remove any debris and rocks larger than one inch.

3.2 SHRUB AND GROUNDCOVER PLANTING

A. Provide one-foot deep top soil in all shrub beds.
B. Place plants in a position on bed areas before removal from containers. Obtain approval from Owner’s representative of plant layout in the field. Owner’s representative reserves the right to shift locations of plants prior to planting.
C. Remove all materials (burlap, twine, wire, etc.) from entire root ball on all B&B plants.
D. Plant all plants as located, setting plants with the root flare even with the tops of bed grades. Backfill with native soil and compact soil carefully around each plant ball. Water thoroughly to eliminate air pockets. Carefully prune plants to remove dead or broken branches and hand-rake bed areas to smooth even surfaces.

3.3 TREE PLANTING

A. Ornamental Trees and Shrubs
   1. Stake locations for approval by Owner’s representative.
   2. Plant in pits two times wider than ball for trees and shrubs.
   3. Fill material should be the native soil removed from the hole. No planting mix or soil amendments should be used.
   4. Glazed sides of mechanically dug holes should be roughened or scarified to allow root penetration.
   5. Remove all materials (burlap, twine, wire, etc) from entire root ball.
   6. Carefully settle by watering to prevent pockets.
   7. Root collar shall not be planted below finish grade level.
B. Root Balls
   1. Root balls shall be properly located in relationship to adjacent soil as required by referenced standards.
2. Balls set too deep or too shallow shall be carefully removed and replanted as required by the Owner's representative.

3.4 TREE MOVING AND TRANSPLANTING

A. Tree moving and transplanting shall be done in accordance with standards outlined in ANSI A300: Standards for Tree Care Operations, American National Standards Institute.

B. All tree moving and/or transplanting operations shall be coordinated with the Owner prior to commencement of work.

C. All removal and receiving areas shall have a comprehensive utility locate done according to current standards prior to commencement of work.

3.5 PERENNIAL PLANTING

A. Prepare planting beds as indicated on drawings. Provide one foot of thoroughly mixed and prepared soil consisting of 50 percent sand loam topsoil; 25 percent coarse pumice, 3/8 inch size; and 25 percent peat moss. Thoroughly mix in 20 pounds of Scott, Ortho or Lilly-Miller nitrogen fertilizer per cubic yard with formulation of 10-20-10.

B. Replace existing soil with planting mix.

C. Space plants as indicated on drawings. Obtain approval of plant layout from Owner's representative before planting. Owner's representative reserves the right to change the location of plants prior to planting.

3.6 LANDSCAPE FABRIC

After planting has been completed and approved by the Owner's representative, install landscape fabric across planting beds. Sheets of fabric should have a minimum six-inch overlap. At the bed margins, fabric should be installed under the bottom of the edging. Fabric lapping outside the edging should be trimmed to below grade and buried when the edging is backfilled. Fabric should be well anchored with 6 inch staples pounded flush with the grade. Plant openings must be large enough to allow for future growth.

3.7 TOP DRESSING

After landscape fabric has been installed and accepted by the Owner's representative, top dress bed areas with mulch, as indicated on drawings, a minimum of three inches deep. Fabric must not be exposed or protrude above the mulch or edging. Mulch should be clean, whether organic or mineral mulch, and should be free of debris and soil.

3.8 TREE WRAPPING

Tree wrapping will not be accepted.

3.9 PRUNING OF NEW TREES

A. Follow referenced standards and prune material as directed by Owner's representative.

B. Do not cut back terminal branches. Properly remove sucker growth from the base and badly broken or bruised branches. Thin native trees more heavily than nursery grown plants.
3.10 TREE SAUCERS

Form a four inch high saucer around each new tree for deep watering. Contractor is responsible for deep watering until final acceptance.

3.11 TREE GUYING AND STAKING

A. Stake and guy trees immediately following planting operation. Take precautions during guying operation to prevent damage or injury to branches and roots. Orient all stakes within each cluster or row of trees in the same direction or as directed by Owner’s representative.

B. Trees of over one inch caliper must be staked with woven nylon straps and wire. Tension on ties should be adequate to support tree, but slack enough to permit movement and the development of reaction wood. Ties cannot be fastened tightly to trunks; free movement or slack equal to at least twice the caliper must be allowed.

3.12 PLANTING BED EDGING

Install edging per manufacturer’s directions. Set edging as indicated in true lines as designed with top of edging one inch above finish grade.

3.13 CLEANUP

A. Keep premises neat and orderly including organization of storage areas. Remove trash and debris from excavated planting areas, preparing beds, or planting plants from site daily as work progresses. Keep paved areas clean by sweeping or hosing.

B. Repair all damage caused by landscape operations.

END OF SECTION 32 93 00
SECTION 33 10 00 - WATER DISTRIBUTION PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes water-distribution piping and related components outside the building for combined water service and fire-service mains.

1.2 RELATED REQUIREMENTS:

A. Section 31 10 00 - Site Clearing.

B. Section 31 20 00 - Earth Moving.

1.3 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. Standard Specifications:
   2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.
   3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.4 DEFINITIONS

A. DI Ductile Iron

B. PE: Polyethylene plastic.

C. PP: Polypropylene plastic.

D. PVC: Polyvinyl chloride plastic.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product, pipe, fitting and miscellaneous fitting indicated.
1.6 INFORMATIONAL SUBMITTALS
A. Field quality-control test reports.

1.7 CLOSEOUT SUBMITTALS
A. Operation and Maintenance Data: For water valves and specialties to include in emergency, operation, and maintenance manuals.

1.8 QUALITY ASSURANCE
A. Regulatory Requirements:
   1. Comply with requirements of utility company supplying water. Include tapping of water mains and backflow prevention.
   2. Comply with standards of authorities having jurisdiction for potable-water-service piping, including materials, installation, testing, and disinfection.
   3. Comply with standards of authorities having jurisdiction for fire-suppression water-service piping, including materials, hose threads, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.


D. NFPA Compliance: Comply with NFPA 24 for materials, installations, tests, flushing, and valve and hydrant supervision for fire-service-main piping for fire suppression.

1.9 DELIVERY, STORAGE, AND HANDLING
A. Preparation for Transport: Prepare valves, including fire hydrants, according to the following:
   1. Ensure that valves are dry and internally protected against rust and corrosion.
   2. Protect valves against damage to threaded ends and flange faces.
   3. Set valves in best position for handling. Set valves closed to prevent rattling.

B. During Storage: Use precautions for valves, including fire hydrants, according to the following:
   1. Do not remove end protectors unless necessary for inspection; then reinstall for storage.
   2. Protect from weather. Store indoors and maintain temperature higher than ambient dew-point temperature. Support off the ground or pavement in watertight enclosures when outdoor storage is necessary.

C. Handling: Use sling to handle valves and fire hydrants if size requires handling by crane or lift. Rig valves to avoid damage to exposed parts. Do not use hand-wheels or stems as lifting or rigging points.

D. Deliver piping with factory-applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe-end damage and to prevent entrance of dirt, debris, and moisture.
E. Protect stored piping from moisture and dirt. Elevate above grade. Do not exceed structural capacity of floor when storing inside.

F. Protect flanges, fittings, and specialties from moisture and dirt.

G. Store plastic piping protected from direct sunlight. Support to prevent sagging and bending.

1.10 PROJECT CONDITIONS

A. Interruption of Existing Water-Distribution 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 water-distribution service according to requirements indicated:

1. Notify Architect no fewer than two 2 days in advance of proposed interruption of service.
2. Do not proceed with interruption of water-distribution service without Architect's written permission.

1.11 COORDINATION

A. Coordinate connection to water main with utility company.

PART 2 - PRODUCTS

2.1 WATER MAINS, SERVICES, VALVES AND FITTINGS


2.2 CORROSION-PROTECTION PIPING ENCASEMENT


2.3 FIRE HYDRANTS


PART 3 - EXECUTION

3.1 GENERAL

A. Refer to Section 31 20 00 "Earth Moving" for excavating, trenching, and backfilling.

END OF SECTION 33 10 00
SECTION 33 30 00 - SANITARY SEWERS

PART 1 - GENERAL

1.1 SUMMARY

A. This Section includes waste water-collection piping and related components outside the building.

1.2 RELATED REQUIREMENTS:

A. Section 31 10 00 - Site Clearing.

B. Section 31 20 00 - Earth Moving.

1.3 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. Standard Specifications:


2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.

3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.4 DEFINITIONS

A. PVC: Polyvinyl chloride plastic.

1.5 ACTION SUBMITTALS

A. Product Data: For each type of product, pipe, fitting and miscellaneous fitting indicated.

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

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.
1.7 QUALITY ASSURANCE

A. Regulatory Requirements:

2. Comply with standards of authorities having jurisdiction for waste water-service piping, including materials, installation, and testing.

B. Piping materials shall bear label, stamp, or other markings of specified testing agency.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic manholes, pipe, and fittings in direct sunlight.
B. Protect pipe, pipe fittings, and seals from dirt and damage.
C. Handle manholes according to manufacturer's written rigging instructions.

PART 2 - PRODUCTS

2.1 MAINS, MANHOLES, CLEANOUTS, FRAMES, COVERS AND FITTINGS


PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavating, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION


3.3 MANHOLE AND CLEANOUT INSTALLATION


3.4 FIELD QUALITY CONTROL

3.5 CLEANING

A. Clean dirt and superfluous material from interior of piping.

END OF SECTION 33 30 00
SECTION 33 41 00 - STORM UTILITY DRAINAGE PIPING

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
   1. Pipe and fittings.
   2. Manholes.
   3. Catch basins.
   4. Stormwater inlets.
   5. Stormwater detention structures.
   6. Pipe outlets.
   7. Oils sand separators

1.2 RELATED REQUIREMENTS:

A. Section 31 10 00 - Site Clearing.
B. Section 31 20 00 - Earth Moving.

1.3 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. Standard Specifications:
   2. Except as specifically noted otherwise in the contract documents, all work shall be performed in accordance with the Standard Specifications.
   3. The information in these project specifications shall take precedence in the event of any discrepancies. Any discrepancies discovered by the Contractor shall be brought to the attention of the Engineer before performing the associated work.

1.4 DEFINITIONS

A. PVC: Polyvinyl chloride plastic.
B. RCP: Reinforced concrete pipe.
C. CMP: corrugated metal pipe
1.5 ACTION SUBMITTALS

A. Product Data: For each type of product indicated.

B. Shop Drawings:
   1. Manholes: Include plans, elevations, sections, details, frames, and covers.
   2. Catch basins and stormwater inlets. Include plans, elevations, sections, details, frames, covers, and grates.
   3. Stormwater Detention Structures: Include plans, elevations, sections, details, frames, covers, design calculations, and concrete design-mix reports.

1.6 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Do not store plastic pipe, and fittings in direct sunlight.

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

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

D. Handle manholes, catch basins and stormwater inlets according to manufacturer's written rigging instructions.

PART 2 - PRODUCTS

2.1 PIPE, MANHOLES, CATCHBASINS, INLETS, OIL SAND SEPARATORS AND MISCELLANOUS FITTINGS


PART 3 - EXECUTION

3.1 EARTHWORK

A. Excavation, trenching, and backfilling are specified in Section 312000 "Earth Moving."

3.2 PIPING INSTALLATION

3.3 FIELD QUALITY CONTROL


3.4 CLEANING

A. Clean interior of piping of dirt and superfluous materials. Flush with water.

END OF SECTION 33 41 00
March 8, 2016
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Mr. Dusty Eaton, AIA, LEED AP, Principal
608 N. 29th St.
Billings, MT 59701

RE: Final Geotechnical Report
Norm Asbjornson Innovation Center
Montana State University – Bozeman, MT

Dear Mr. Eaton:

We are pleased to present this final geotechnical report for the proposed Norm Asbjornson Innovation Center located at Montana State University in Bozeman, Montana. The enclosed report describes site conditions and presents geotechnical related conclusions and recommendations for final design and planning of the facility. We are available to answer any questions that may come up as the design progresses.

Please contact DOWL if you have any questions in regard to this report.

Respectfully submitted,

DOWL

[Signature]

Gregory Underhill, P.E.
Senior Geotechnical Engineer
GEOTECHNICAL REPORT

PROPOSED NORM ASBJORNSON INNOVATION CENTER
MONTANA STATE UNIVERSITY
BOZEMAN, MONTANA

Prepared for:

A&E ARCHITECTS
Mr. Dusty Eaton, AIA, LEED AP, Principal
608 N. 29th St.
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Prepared by:

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Review: David Barrick, P.E.

March 8, 2015
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Appendix D  Screw Pile Information
1.0 SUMMARY

DOWL has completed a final geotechnical evaluation for the proposed new Norm Asbjornson Innovation Center (NAIC) at the Montana State University Bozeman, Montana. A preliminary investigation report was submitted on January 13, 2014. This final investigation consisted of advancement of four additional borings within the proposed engineering building footprint. This final report incorporates findings from the preliminary investigation as well as information obtained from the additional borings. This investigation report provides final geotechnical related recommendations pertinent for project final design and planning.

The proposed site is located on the northeast corner of West Grant and South 7th avenue within the current pay parking lot and band practice field east of the Health and PE complex (see Figure 1). The preliminary investigation included advancing four borings (Borings B-1 through B-4) at locations that also encompassed the proposed adjacent parking garage. Additional borings were advanced during May 2015 within the proposed parking garage site (Borings B-5 through B-8). Borings B-9 through B-12 were then advanced within the proposed NAIC engineering building footprint during December 2015. This final investigation report includes information from borings advanced directly within the engineering building footprint as well as adjacent boring information, additional laboratory testing and final analysis recommendations.

The soil profiles encountered in the additional borings B-9 through B-12 are relatively consistent with the soil profiles indicated in borings B-1 through B-4. The soil profiles consist of topsoil or pavement surfacing overlaying native lean clay deposits that overlay layers of medium to very dense gravel deposits. Medium dense to very dense silty sand and or sandy silt deposits underlay the gravel and transition to siltstone or sandstone bedrock at depth. The siltstone and sandstone deposits are poorly indurated and are considered to be relatively soft or weak in consistency. The siltstone and sandstone deposits extend to the greatest depth drilled.

Groundwater was encountered in all of the borings at depths ranging from approximately 19.7 to 20.0 feet during the time of the investigations.

Based on the investigation boring and laboratory testing information the surficial native clay soils typically exhibit moderate to low bearing strength and high compressibility. Settlements in excess of two (2) inches could occur from heavily loaded footings placed on the native clay soils and the potential for excessive differential settlements is significant. It is therefore recommended to utilize deep foundations to support the new facilities. Options for engineered aggregate piers, drilled piers, driven piling or screw piles are provided.

It is our opinion that the native clay soils are suitable to support interior slab on-grade floors provided the clay subgrade soils are partially over-excavated from beneath the floor areas and subgrade preparation and structural fill placement is performed as specified under Section 5.2.3.
Recommendations in this report are contingent upon DOWL’s involvement during the planning, design and construction stages of the project. If any unexpected soils or conditions are revealed during construction, this office should be notified immediately to survey the conditions and make necessary modifications.
2.0 PLANNED CONSTRUCTION

The new Norm Asbjornson Innovation Center (NAIC) project includes an engineering building and parking garage. The project area is located on the corner of West Grant and South 7th avenue within the current pay parking lot and band practice field immediately east of the Health and PE complex. The proposed facility locations are presented in Figure 2. The parking garage structure is currently under construction and is located within the southwest corner area of the site primarily within the southern end of the current band practice field. The proposed Norm Asbjornson Innovation Center will be located within the northern portion of the site which is currently utilized as a pay parking lot and band practice field. The NAIC building will consist of a three story structure with slab-on-grade floor with perimeter frost wall and partial basement. The structural system will include a steel frame with columns and an exterior, non-bearing wall “skin” and associated wall/strip footing. It is our understanding that laboratory facilities will be located on the first floor which will require concrete pavements designed to accommodate truck loadings. The partial basement will be connected to the existing steam tunnel alignment that is located along Grant Street.

3.0 INVESTIGATION PROCEDURE

3.1 INVESTIGATIONS

A preliminary geotechnical evaluation and report was completed at the general site of Norm Asbjornson Innovation Center during November, 2014. The preliminary investigation consisted of advancement of four geotechnical borings (B-1 through B-4), laboratory testing, preliminary engineering analysis and a Preliminary Geotechnical Report which was submitted on January 13, 2015. The preliminary investigation included advancing four borings (Borings B-1 through B-4) at locations that also encompassed the proposed adjacent parking garage. Additional borings were advanced during May 2015 within the proposed parking garage site (Borings B-5 through B-8). Borings B-9 through B-12 were then advanced within the proposed NAIC engineering building foot print during December 2015.

3.2 FIELD INVESTIGATION

The final field investigation for the NAIC building was performed on December 18, 2015. The field investigation consisted of a geologic review, site observations and advancement of an additional four (4) soil borings (Borings B-9 through B-12). The borings were advanced utilizing a truck-mounted Mobile B-61 drilling rig equipped with 8¼ inch O.D. hollow stem augers. The drilling was performed under the direction of a DOWL Geotechnical Engineer. The locations of the borings as well as all previous borings are presented in the Geotechnical Investigation Boring Location Site Map (Figure 2). Borings B-9 through B-12 were advanced to depths ranging from approximately 20.3 to 26.5 feet.
Horizontal locations of the borings were determined by measuring from existing building and sidewalk corners. Vertical elevations of the exploration borings were determined by interpolation from topographic map contours.

At each boring location, Standard Penetration Test (SPT) sampling was performed using a 2-inch outside diameter split-spoon sampler in accordance with ASTM D 1586. The tests were performed utilizing an “Automatic Hammer” which simulates driving the sampler into the soil utilizing a series of drops of a 140 lb. weight falling 30 inches for a total penetration of 18 inches into the soil. The number of blows required for each 6 inches of penetration was recorded. The Standard Penetration Resistance ("N-value") of the soil was then calculated as the number of blows required for the final 12 inches of penetration. If 50 blows were recorded within a single 6-inch interval, the test was terminated and the blow count was recorded as 50 blows for the number of inches of penetration. This resistance, or N-value, provides a measure of the relative density of granular soils and the relative consistency of cohesive soils.

During the drilling, pertinent information including soil sample depths, stratigraphy, soil engineering characteristics and groundwater occurrence were noted. Soil samples were collected while advancing the soil borings using split-spoon sampler. Disturbed bulk samples were obtained from drill cuttings at intervals selected by the field engineer. Relatively undisturbed samples were obtained by hydraulically pushing Shelby tube sample collectors into the subgrade soils. These samples were then transported to the DOWL soils laboratory where engineering property and strength tests were conducted. This information was recorded and is presented on the logs of exploration borings in Appendix A.

The soil descriptions shown on the boring logs are based on field and laboratory testing in accordance with ASTM Standards D 2487 or D 2488. The boring logs contain both factual and interpretive information. On the logs, horizontal lines, designating the interface between differing materials encountered, represent approximate boundaries. The actual transitions may be more gradual or abrupt. The soil and groundwater conditions depicted are only for the specific dates and locations reported, and therefore, are not necessarily representative of other locations and times.

### 3.3 LABORATORY TESTING

Disturbed split-spoon and bulk samples along with relatively undisturbed Shelby tube samples were collected during the field investigation and submitted for testing. Laboratory testing was completed on select soil samples to assist in soil classification and to characterize soil engineering properties. Laboratory testing included the following:
<table>
<thead>
<tr>
<th>Test</th>
<th>Purpose of Test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Moisture Content (ASTM D 2216)</td>
<td>Provides a measure of natural (in-situ) water content.</td>
</tr>
<tr>
<td>Atterberg Limits (ASTM D 4318)</td>
<td>Provides an indicator of the consistency and swell potential of fine grained soils.</td>
</tr>
<tr>
<td>Particle-Size Distribution (ASTM D 422)</td>
<td>Provides a measure of grain sizes of the soils for classification and identification of physical characteristics.</td>
</tr>
<tr>
<td>Moisture-Density Relationship (ASTM D 698)</td>
<td>Provides a measure of the relationship of water content to the density of soil during compaction.</td>
</tr>
<tr>
<td>One dimensional Consolidation (ASTM D 2435)</td>
<td>To determine the amount and rate at which a soil will compress when loaded.</td>
</tr>
<tr>
<td>Unconfined Compression (ASTM 2166)</td>
<td>To determine general soil or rock shear strength properties.</td>
</tr>
<tr>
<td>Direct Shear (ASTM D 3080)</td>
<td>To determine general soil or rock shear strength properties.</td>
</tr>
<tr>
<td>Corrosion Tests (pH, Resistivity, and Sulfates)</td>
<td>To determine the potential for corrosive interaction of soils with concrete and metal</td>
</tr>
</tbody>
</table>
4.0 SITE CONDITIONS

4.1 LOCAL GEOLOGIC CONDITIONS

The Gallatin valley is an intermountain basin in the Rocky Mountains bounded by the Bridger and Gallatin Ranges to the East and South. The Gallatin Mountain Range has provided material for vast coalescing alluvial fans deposited upon the valley floor from the South and East valley limits, sloping rather steeply to the North. These alluvial/fluviatile deposits range from Tertiary to Quaternary in age. The project site is located on the MSU campus south of downtown Bozeman which is situated in the southeast extremity of the Gallatin Valley on Quaternary alluvial fan deposits known as the Bozeman Fan. The alluvial fan deposits typically consist of varying thickness depositional clays, sands and gravels. Tertiary age fluviatile and soft bedrock strata underlay the alluvial fan deposits at varying depths and locations.

4.2 SITE DESCRIPTION

A site map is presented in Figure 2. The proposed site is located on the northeast corner of West Grant and South 7th avenue within the current pay parking lot and band practice field. The new NAIC building will be situated primarily on the paved parking area with the western portion of the building extending onto the grassed band practice field. Various buried utilities exist within the site. The topography of the site area is essentially flat sloping gently at an approximate one percent grade to the north. Photographs of the site are presented in Appendix C.

4.3 SOILS

In summary, the soil profiles encountered in borings B-9, through B-12 are relatively consistent and very similar to the conditions revealed in the preliminary exploration borings B-1 through B-4 and borings B-5 through B-8 which advanced for the parking garage. The following borings were advanced within or close to the perimeter of the proposed NAIC building: B-2, B-4, B-9, B-10, B-11, and B-12. The soil profiles consist of topsoil or pavement surfacing overlying native lean clay deposits that overlie layers of medium to very dense gravel deposits. Medium dense to very dense silty sand and or sandy silt deposits underlay the gravel and transition to siltstone or sandstone bedrock at depth. The siltstone and sandstone deposits are poorly indurated and are considered to be relatively soft or weak in consistency. The siltstone and sandstone deposits extend to the greatest depth drilled.

The soil profiles are presented in detail in the exploration boring logs in Appendix A. At the NAIC building location the lean clay deposits extend from the surface to depths ranging from 16.3 (B-2) to 20.5 feet (B-4) feet in depth at which depths gravel was encountered. The gravel layer extends to depths ranging from approximately 23.0 feet (B-2) to 27.0 feet (B-4) at which depths medium dense to dense silty sand/sandy silt and poorly graded sand deposits are encountered. These deposits transition to siltstone or sandstone at depth. The following sections summarize the soils encountered at the NAIC
building site:

4.3.1 Asphalt Surfacing

The asphalt surfacing section at the student parking lot ranged from consisted of approximately three and one half (3.5) to five (5) inches of asphalt and five (5) to nine (9) inches of road base.

4.3.2 Topsoil

Topsoil was encountered in Borings B-2 and B-12. The topsoil was approximately 8 inches in thickness. It is noted that topsoil thickness can vary across the site and may be thicker at other locations.

4.3.3 Clay

Native lean and or sandy lean clay was encountered near surface in all borings. In general, the clay ranged from soft to stiff and as an average is medium stiff in consistency and standard penetration (N) values generally ranged from 5 to 19 blows per foot. Moisture content of the clay ranged from 19.3 to 29 percent from depths ranging between 2.5 to 19 feet. Liquid limits and plasticity indices ranged from 30 to 43 percent and 11 to 20 respectively. Results from unconfined compression tests from samples indicate that the clay exhibits unconfined compressive strengths ranging from 1.0 to 3.3 kips per square foot with corresponding undrained shear strengths of .500 to 1.65 kips per square foot; in place unit dry unit weights of the clay ranged from 86.6 to 96.6 pounds per cubic foot (pcf). Results from unconfined compression tests from samples of clay taken at depths of 3, 6 and 16 feet in Borings B-1, B-3 and B-4 respectively indicated that the clay exhibited unconfined compressive strengths ranging from 2.9 to 2.0 kips per square foot with corresponding undrained shear strengths of 1.45 to 1.0 kips per square foot; in place unit dry unit weights of the clay ranged from 98 to 103 pounds per cubic foot (pcf). Standard penetration tests taken in Borings B-9 through B-12 were similar to those in Borings B-1 through B-4.

In general, the clay deposits exhibit moderate to low bearing strength, moderate to high compressibility and are generally high in natural moisture.

4.3.4 Gravel

Gravel was encountered in all borings at depths ranging from 16.3 feet (B-2) to 20.5 feet (B-4). The gravel can be generally classified as poorly graded gravel with sand and cobbles. The gravel ranged from dense to very dense in consistency. Standard penetration (N) values ranged from 33 to greater than 84 blows per foot. The gravel was at or below the water table and saturated. The gravel layer thickness ranges from approximately 7 to 9.5 feet and averages approximately 8.6 feet in thickness across the parking garage site based on the borings advanced.

The gravel deposits exhibit high bearing strength and low compressibility.
4.3.5  Silty Sand / Sandy Silt

Silty sand/sandy silt underlays the gravel deposits at all boring locations. These deposits transition between sand and silt at random depth intervals but are predominantly silty sand. The deposits ranged from coarse to fine grained. The deposits extended to depths ranging from 35 feet (B-2) to 45 feet (B-5) at which depths the soils transitioned to sandstone and siltstone. The silty sand and sandy silt ranged from medium dense to dense in consistency. Standard penetration (N) values generally ranged from 18 to 43 blows per foot and averaged 27 blows per foot in the medium dense intervals. Isolated layers of poorly graded sand and fine gravel were encountered within the sand and silt deposits. The sand and silt was below the water table and saturated.

The sand deposits exhibit moderate to high bearing strength and moderate to low compressibility.

4.3.6  Poorly graded sand

Poorly graded sand with widely scattered fine gravel was encountered between the depths of 38.0 to 45.0 feet in boring-7. These deposits transitioned to very weak slightly indurated sandstone at approximately 45 feet in B-7. The deposits ranged from coarse to fine grained. The sand ranged was dense to very dense in consistency. Standard penetration (N) values generally ranged from 54 to 66 blows per foot. This deposit did exhibit sensitivity to differential hydrostatic pressure indicated by heaving sand in the augers during drilling.

The sand deposits exhibit high bearing strength and low compressibility.

4.3.7  Sandstone and Siltstone Bedrock

Sandstone and siltstone bedrock was encountered underlying the sand and silt deposits at depths ranging from 35 to 49.5 feet. In general the bedrock formations are considered moderately indurated or soft rock. It was possible to auger into the formations with some difficulty. Auger refusal was encountered in the sandstone in boring B-3 at a depth of 42 feet. Standard penetration tests ranged from 39 within a “soft layer” to greater than 80 blows per foot. Based on our experience, bedrock undelaying the campus area can be variable in consistency and may contain soft zones.

The bedrock formations generally exhibit high bearing strength and low compressibility.

4.4  GROUNDWATER

Groundwater was encountered in all of the borings at depths ranging from 19.7 to 20.0 feet during the time of the investigations. Table 4-1 presents the approximate depths to the ground water table observed at the time of the investigations. Note B-2 and B-4 were advanced during November of 2014. The groundwater generally flows within the gravel layer.
Table 4-1
Approximate Depth to Ground Water (Nov 3, 2014 and Dec 18, 2015)

<table>
<thead>
<tr>
<th>Boring</th>
<th>Surface Elevation</th>
<th>Depth to Ground Water (ft)</th>
<th>Ground Water Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-2</td>
<td>4921.1</td>
<td>*20.2</td>
<td>*4900.9</td>
</tr>
<tr>
<td>B-4</td>
<td>4920.2</td>
<td>*20.0</td>
<td>*4900.2</td>
</tr>
<tr>
<td>B-9</td>
<td>4922.4</td>
<td>**20.8</td>
<td>**4901.6</td>
</tr>
<tr>
<td>B-10</td>
<td>4921.9</td>
<td>**20.3</td>
<td>**4901.6</td>
</tr>
<tr>
<td>B-11</td>
<td>4921.3</td>
<td>**19.8</td>
<td>**4901.5</td>
</tr>
<tr>
<td>B-12</td>
<td>4920.9</td>
<td>**19.7</td>
<td>**4901.6</td>
</tr>
</tbody>
</table>

*Measured 11/3/2014
**Measured 12/18/2015

Fluctuations of groundwater occur due to seasonal moisture conditions, irrigation practices, changes in land use, and many other factors. Form our experience groundwater elevations can fluctuate significantly within the MSU campus dependent upon location. Groundwater conditions may vary from those encountered at the time of the field investigation depending upon the influence of these factors. Perched water tables have been encountered at various locations within the MSU campus.

4.5 EARTHQUAKES AND SEISMICITY

The project site is generally within an area of high seismicity. The USGS database presents spectral response acceleration data in bedrock for short (0.2 sec) periods (Ss) and for long (1 sec) periods (S1) for similar probability and 50-year return periods. According to USGS design procedures, this data is then adjusted depending on the soil classification to reflect magnification effects as the earthquake wave energies pass from bedrock into soil. The values are then reduced by a factor that accounts for partial damping of the wave energy by the structure. The final values obtained (known as SDS and SD1) become the basis for the structural design and in this case at the proposed site are estimated at 0.533 g (SDS) and 0.223 g (SD1).

The methods of ASCE/SEI 7-05 require that the properties of the soil at the proposed building site be classified as one of several site classes. The seismic design parameters for this site include a seismic zone soil profile type of (D), in accordance with the above referenced standard. Site Class D corresponds to a stiff soil profile. We have based this classification on the laboratory test data and exploration information.

5.0 ENGINEERING ANALYSIS AND RECOMMENDATIONS

Based on the planned construction and soils encountered at the site, the following recommendations are provided at this time.
5.1 GENERAL

The Center will consist of a three story building with slab-on-grade floor with perimeter frost wall and partial basement. The structural system will include a steel frame with columns and an exterior, non-bearing wall “skin” and associated wall/strip footing. It is our understanding that laboratory facilities will be located on the first floor which will require concrete pavements designed to accommodate truck loadings. The partial basement will be connected to the existing steam tunnel alignment that is located along Grant Street. Morrison and Maierle has provided the following range of preliminary service level combined loading reactions for the MSU NAIC building foundations, split up by the various differing areas throughout the footprint:

1. 3 story with basement or mechanical penthouse column foundation reactions:
   - Combined gravity loads (dead, live, snow): 200-400 kips vertical load
   - Seismic loads at moment frames: 200-300 kip-ft overturning moment load, 10-30 kip overturning vertical load, 15-35 kip horizontal load

2. 3-story column foundation reactions:
   - Combined Gravity loads (dead, live, snow): 100-300 kips vertical load
   - Seismic loads at moment frames: 200-300 kip-ft overturning moment load, 10-30 kip overturning vertical load, 10-30kip horizontal load

3. Single story column foundation reactions (i.e. north classroom extension, southeast heavy lab/maker spaces, bridge to parking garage):
   - Combined gravity loads (dead, live, snow): 20-50 kips vertical load
   - Seismic loads at moment frames: 50-100 kip-ft overturning moment load, 5-10 kip overturning vertical load, 5-10 kip horizontal load

4. Exterior non-bearing foundation wall reactions:
   - Combined gravity loads (dead, live, snow): 5-7 klf vertical loads

Engineering considerations associated with design and construction of the proposed facilities will include foundation options to support column and wall loads, basement considerations, interior concrete floor slabs, surface drainage and site earthwork. Recommendations for these topics are presented in detail in the following sections.

5.2 FOUNDATIONS

5.2.1 Foundation Options/Recommendations

As discussed previously, the near surface soils at the site consist of native lean clay deposits. Based on the investigation, boring and laboratory testing information, the surficial native clay soils typically exhibit moderate to low bearing strength and high compressibility. Settlements in excess of two (2) inches could occur from heavily loaded footings placed on the native clay soils and the potential for excessive
differential settlements is significant. It is therefore recommended to utilize deep foundations or soil improvement methods to support the new facilities. Options for engineered aggregate piers (EAPs), drilled piers, driven piling or screw piles are provided.

It is our opinion that the native clay soils are suitable to support interior slab on-grade floors provided the clay subgrade soils are partially over-excavated from beneath the floor areas and subgrade preparation and structural fill placement is performed as specified under Section 5.2.3.

As discussed previously an approximate eight (8) foot thick dense gravel layer is encountered at depths of 16 to approximately 20 feet. The depth to the gravel layer increases in the northeasterly direction across the site with the greatest depth recorded in boring B-4. The gravel layer overlays medium dense to dense silty sand and/or sandy silt. Weak bedrock is encountered at depths ranging from 35 to 45 feet.

Groundwater was encountered during the time of investigations at depths ranging from approximately 19.7 to 20.0 feet between the approximate elevation ranges from 4900.2 to 4901.6.

Given the potentially heavy column and footing loads, it is recommended that the deep foundations bear within the bedrock deposits below the gravel layer or soil improvement methods (engineered aggregate piers (EAPs)) are utilized for the upper clay layer. Table 5-1 presents the approximate depth to the gravel layer at borings advanced within the garage footprint area. It is noted that the elevation of the gravel layer varies across the NAIC site. Table 5-2 presents the approximate depth to the bedrock bearing layer. It is noted the elevation of the weak bedrock contact varies by approximately 8 feet.

### Table 5-1
Approximate Depth to Gravel Layer

<table>
<thead>
<tr>
<th>Boring</th>
<th>Surface Elevation</th>
<th>Depth to Gravel Layer (ft)</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-2</td>
<td>4921.1</td>
<td>16.3</td>
<td>4904.8</td>
</tr>
<tr>
<td>B-4</td>
<td>4920.2</td>
<td>20.0</td>
<td>4899.7</td>
</tr>
<tr>
<td>B-9</td>
<td>4922.4</td>
<td>16.4</td>
<td>4906.0</td>
</tr>
<tr>
<td>B-10</td>
<td>4921.9</td>
<td>19.0</td>
<td>4902.9</td>
</tr>
<tr>
<td>B-11</td>
<td>4921.3</td>
<td>16.5</td>
<td>4904.8</td>
</tr>
<tr>
<td>B-12</td>
<td>4920.9</td>
<td>17.0</td>
<td>4903.9</td>
</tr>
</tbody>
</table>

### Table 5-2
Approximate Depth to Weak Bedrock

<table>
<thead>
<tr>
<th>Boring</th>
<th>Surface Elevation</th>
<th>Depth to Bedrock (ft)</th>
<th>Elevation</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-2</td>
<td>4921.1</td>
<td>35.0</td>
<td>4886.1</td>
</tr>
<tr>
<td>B-4</td>
<td>4920.2</td>
<td>40.0</td>
<td>4880.2</td>
</tr>
<tr>
<td>B-3</td>
<td>4922.9</td>
<td>40.0</td>
<td>4882.9</td>
</tr>
<tr>
<td>B-5</td>
<td>4921.2</td>
<td>45.0</td>
<td>4881.2</td>
</tr>
<tr>
<td>B-6</td>
<td>4922.3</td>
<td>43.5</td>
<td>4878.8</td>
</tr>
</tbody>
</table>
All exterior foundation walls should be placed at a minimum depth of 4.0 feet below final exterior grade for frost protection.

**Preparation of construction working surface:** After the topsoil and pavement fills are excavated to the first floor slab elevation, lean clay subgrade soil will be exposed during construction of the foundation elements. The lean clay is moisture sensitive and will become soft and unstable during wet weather periods. Excessive disturbance of the clay subgrade during wet weather will compromise the subgrade in areas where concrete slabs are to be installed and subsequently require additional over-excavation and replacement of unstable soils. The Contractor should be made aware of this potential and schedule his operations accordingly or construct a suitable wet weather platform (placement of gravel and or stabilization fabric) so as not to compromise the clay subgrade during construction.

5.2.1.1 **Engineered Aggregate Piers**

The structure could be supported by engineered aggregate piers (EAP). The piers are constructed by augering 24- to 36-inch diameter holes to typical depths of ranging from 8 to 25 feet below the base of the footings and backfilling the excavations with thin lifts of compacted (engineered) aggregate. Compaction densifies the aggregate and increases lateral stress in the soil matrix. The system serves to reduce settlement and increase bearing capacity by replacing compressible soils (clay) soils in the upper 16 to 20 feet (depth to the dense gravel layer) below the footing with a “stiffer” composite soil matrix. The piers are constructed in a grid pattern either under footings and or fill areas. Engineered aggregate pier elements typically cover approximately 30 percent of the footing footprint area. Gravel is typically not placed between the piers and individual footings. The piers are typically constructed a minimum distance of 12 inches above the bottom of footing elevation. The top of the pier is then “scraped off” to footing subgrade using a smooth lipped excavator bucket. The top of the pier is then inspected to ensure it is well compacted and undisturbed at footing subgrade elevation. The building foundation is then designed utilizing conventional spread footings.

During the adjacent parking garage investigation /planning phase DOWL discussed the project with Mr. John Martin of Geotech Foundation Company-West (GTFC-WEST), who designs and installs engineered aggregate piers, in regard to the applicability of using engineered aggregate piers for the parking garage. Engineered aggregate piers were evaluated for feasibility and cost and were ultimately utilized for the parking garage project. Based on structural loads provided to date for the NAIC building, and subgrade conditions, engineered aggregate piers are a viable foundation alternative for this project. For the parking garage GTFC-WEST recommended that footings placed on EAP improved foundation soils could be designed for an allowable bearing capacity of 5,500 pounds per square foot. Estimated settlement for footings designed accordingly would be total settlements of less than 1 inch and ½ inch or less differential settlement. As foundation conditions are similar at the NAIC building it is anticipated that similar bearing pressures may be utilized; however, GTFC- WEST must be contacted in regard to their
recommendations specific to the NAIC project. It is recommended that the piers be designed to bear on the gravel deposits which are encountered at depths ranging from 16 to 20 feet.

**Seismic Design Methodology for Engineered Aggregate Piers:** Unlike drilled piers or driven piling engineered aggregate piers are not considered part of the foundation system for seismic design. Lateral load resistance is required for drilled piers and driven piling foundations because they are structurally connected to the foundation elements. Engineered aggregate piers are used to improve (reinforce) the foundation soils in order to increase bearing capacity, minimize settlements and mitigate liquefaction potential if needed. Engineered aggregate piers have been utilized in Seattle for many building projects to mitigate liquefaction potential conditions. Seismic foundation design for foundation soils improved by engineered aggregate piers treat the foundation as a spread footing condition where seismic resistance is provided by sliding resistance between the top of the engineered aggregate pier and concrete footing and passive pressure resistance provided by the backfill material or floor slabs.

**Design /Build Process:** Engineered aggregate pier design/installation is a proven technology and has been used extensively for many projects in the United States. Engineered aggregate piers are incorporated into a specific project under a design/build contractual process. That is, the current industry consists of established engineered aggregate pier companies that provide design, installation and warranty service. Geotechnical and structural information is provided to the engineered aggregate pier companies. They then utilize the information to develop an appropriate engineered aggregate pier design for the project. The company then installs the piers complying with an extensive quality assurance program which monitors compaction and placement of the engineered aggregate pier. Test piers are installed to confirm the stiffness moduli used for design. A representative of the project geotechnical engineer is also onsite to observe and confirm that the engineered aggregate pier company complies with the submitted quality assurance program.

**Engineered Aggregate Pier Considerations:**

1. The piers should extend to the dense gravel layer which is encountered at the approximate depths ranging from 16 to 20 feet.

2. Allowable bearing pressure for the EAP design must be confirmed by the EAP design firm. Based on EAP design utilized for the parking garage project an allowable bearing pressure of 5,500 pounds per square foot was utilized. Estimated settlement for footings designed accordingly were total settlements of less than 1 inch and ½ inch or less differential settlement.

3. Footings placed on the piers may be designed to resist sliding using a coefficient of friction of 0.45.

4. The EAP designer installer should submit a quality control/assurance plan prior to mobilizing to the site.
5. A representative of the project geotechnical engineer must be onsite to observe and confirm that the engineered aggregate pier company complies with the submitted quality assurance program.

6. The tops of all aggregate piers must be inspected for compactness (density) prior to placement of footings.

7. A minimum of one demonstration pier should be installed with the EAP Contractor standard procedures and load tested to confirm the stiffness modulus. The EAP contractor is responsible for setting up and recording test results. The test will also be observed and recorded by the project geotechnical engineer.

5.2.1.2 Drilled Piers

The proposed structures may be supported on drilled piers end bearing in the siltstone and sandstone bedrock which are encountered at depths ranging from approximately 35 to 45 feet below existing ground. Because of the relatively thin dense gravel layer with underlying medium dense sand and silty layers it is recommended to extend the drilled piers through these layers into the bedrock. The allowable bearing capacities have been determined by assuming contribution of end bearing and skin friction and using the “Beta” Analysis Method. A safety factor of 3 has been used to determine allowable end bearing and contributing skin friction. Anticipated total settlement for this type of foundation is estimated to be 1/4-inch. The drilled piers should extend a minimum distance of 4 feet into the siltstone and sandstone bedrock. Therefore, based on the information from four borings, the pier lengths will vary from approximately 39 to 49 feet below existing ground.

<table>
<thead>
<tr>
<th>Pier Diameter (Feet)</th>
<th>Downward Capacity (Tons)</th>
<th>*Uplift Capacity (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>85</td>
<td>40</td>
</tr>
<tr>
<td>3</td>
<td>155</td>
<td>63</td>
</tr>
<tr>
<td>4</td>
<td>233</td>
<td>80</td>
</tr>
</tbody>
</table>

*Plus the weight of the pier. Uplift capacities shown assume reinforcement within the entire pier length and a factor of safety of 3 for allowable side resistance.

A minimum diameter of 24 inches is recommended to facilitate proper cleaning and inspection of the pier excavations.

Pier spacing should be not less than 3.0 pier diameters measured from outside edge to outside edge of the piers. For pier spacing less than 3.0 pier diameters, piers will behave as a group and individual pier
capacities may be reduced. Capacity reduction will depend upon pier spacing and the numbers of piers within the group. If closer spacings are required, DOWL should be notified so that appropriate reduction factors can be provided based on actual pier/pile layout.

**Drilled Pier Considerations:**

1. The drilled piers should be constructed in accordance to ACI 360.1

2. Concrete placed in pier excavations using the wet method of installation should be a fluid mix with a minimum slump of 6 to 8 to prevent voids from forming around the reinforcing steel inches, while at the same time maintaining minimum 28-day-4000 psi strength requirements.

3. The geotechnical engineer must confirm drilled pier embedment depths and end bearing foundation conditions during construction.

4. A minimum of three load tests should be conducted on select piers using the dynamic load testing method to confirm capacities.

5. A project survey benchmark should be established and used to confirm pier end bearing elevations.

6. Groundwater will be encountered at depth of 20 feet and possibly higher. Temporary casing of the drilled pier holes will be required to prevent sloughing of the boring walls or the alternate slurry method of installation may be used.

7. The bearing soils for the drilled piers will consist of bedrock deposits. It is imperative that all loose slough should be removed from the bottom of the pier boring. Loose material in the bottom of the hole will be compressible and may cause excessive settlement of the pier if not removed. The pier installation contractor shall utilize the appropriate cleaning bit to achieve a clean, slough free bottom.

8. It is noted that heaving sand conditions were encountered in some of the exploration borings. Temporary casing of the drilled pier excavations will likely be required.

9. The drilled pier installer should be equipped with appropriate drilling equipment and be prepared for any difficulties resulting from drilling into and through dense to very dense gravels as well as sloughing of granular soil. Pre-submittals by the contractor indicating means and methods and equipment to be used should be required.

10. Pumping directly from the drilled pier excavations for dewatering purposes should not be used. Dewatering in this manner may compromise the integrity of the relatively soft bedrock in the bottom of the excavations from differential hydrostatic pressures and will affect the pier end
bearing conditions. Water, Polymer additives or the slurry method may be utilized to prevent caving of the pier excavation walls and during advancement.

11. Casing should be withdrawn as the concrete is tremmied while maintaining the casing bottom below the top of the concrete.

12. It is suggested that this project be reviewed with an experienced drilled pier installation contractor to discuss the drilled pier installation considerations.

5.2.1.3 Driven Piling

Steel H-piles fitted with driving points driven to required capacities in the sandstone and siltstone bedrock may be used to support the structural loads. The piles will have to be driven through the dense gravel layer and medium dense to dense sand and silt deposits into the underlying bedrock.

It is noted that that driven H-Piles were used for the MSU Engineering and Physical Science building which was constructed in July of 1994 located on the southeast corner of South 7th Avenue and Grant Street. Subgrade conditions were similar to those encountered at this project site. The pilings used were HP-12x74 and HP 10x57. A static load test was conducted on a HP 12x74 test pile which indicated an ultimate capacity greater than 360 tons could be achieved. The recommended design working load for these piles was 130 tons. Based on review of pile driving records it is noted that the installed pile embedment lengths varied considerably and ranged from 31 feet to greater than 51 feet. This is because the bedrock consistency varies and also the recommended design capacities for the piles are considered quite high given the relatively soft bedrock conditions. The variance in pile embedment lengths could be an issue in regard to contractor bidding and payments. We are therefore recommending somewhat lower pile capacities than those used for the Engineering and Physical Science building.

For estimating purposes, it is assumed that the piles will be driven into the bedrock approximately seven feet. If weathered bedrock zones are encountered, these penetration depths may be greater. The lengths of pile may vary depending on the elevation from where they are driven, weathered bedrock zones or elevation variations of the bedrock. Steel H-piles can be spliced to reduce waste caused by variable lengths.

Also to be considered with driven piling is that considerable vibrations will be induced into the surrounding soils and possibly into the adjacent structures. The vibrations could cause settlements or other damage to the older buildings in the vicinity of the new buildings.

Allowable Capacities: The axial capacities have been determined based on soil boring information, laboratory test results, static analysis using the DRIVEN Software program and review of previous pile installations at MSU. The following table may be used when evaluating steel H-piles for design.
considerations. It is assumed the piling would be driven seven feet into the siltstone and sandstone bedrock. Anticipated settlements are less ¼ inch.

<table>
<thead>
<tr>
<th>*Pile Section</th>
<th>Allowable Axial Load (Tons)</th>
<th>Allowable Uplift (Tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP 10x57</td>
<td>80</td>
<td>14</td>
</tr>
<tr>
<td>HP 12x74</td>
<td>100</td>
<td>20</td>
</tr>
</tbody>
</table>

* Piles should consist of 50 ksi steel

2. The contractor should select a driving hammer and cushion combination capable of installing the selected piling without overstressing the pile material. The contractor should submit the pile-driving plan and the pile hammer-cushion combination to the geotechnical engineer for evaluation of the driving stresses well in advance of pile installation.

3. A static load test should be conducted on one test pile to confirm capacity.

4. The pile-driving system should be analyzed using the wave equation to evaluate the potential for overstressing of the pile materials during driving.

5. It is recommended the Pile Driving Analyzer (PDA) testing be conducted on a minimum of ten (10) production piles at various locations within the building footprints to ensure capacities are being achieved. These piles should be designated as test piles. Test piles are typically driven five (5) feet below the anticipated final pile tip elevations to further confirm capacities. This requirement could be adjusted based on the results of the PDA testing during pile installation.

6. We recommend pile spacing of equal to or greater than three pile diameters. For driven piles with spacing of greater than three pile diameters, the axial load capacity for a group will be the sum of the individual capacities.

7. During driving of the pile sections, Pile Driving Analyzer (PDA) monitoring should be performed to ensure that the existing structures and equipment within the area are not subjected to vibration damage.

8. A representative of the geotechnical engineer should observe pile-driving operations on a full-time basis. Each pile should be observed and checked for buckling, crimping, and alignment; penetration resistance, depth of penetration, and general pile driving operations should be recorded.

9. Driven piles should be designed to resist lateral loads using a modulus of horizontal subgrade reaction of 5 tcf (tons per cubic foot) for the clay soils, subgrade reaction of 40 tons per cubic foot (tcf) for the medium dense to dense natural sand and gravel.
5.2.1.4 Screw Piles

Screw piles consist of 5.5 to 9 inch diameter pipe piles with helixes welded on. The piles consist of 85ksi steel (usually ½ inch thick). All helix welds conform to AWS and ASTM standards. The piles are installed by large tracked excavators with torque converters. Capacities are confirmed by relating installation torque to bearing capacities. Screw piles have been used for many building and parking garage projects and are a proven technology. Screw Piles were utilized for foundation support for the Gallatin County Detention Center which was constructed in 2005. Foundation conditions at the detention center are somewhat similar to conditions at the proposed Innovation Center. A static load test was conducted on a screw pile during the Gallatin County Project to confirm capacities and indicated that ultimate capacity of 325 kips was achieved for a 5.5 inch diameter pile with two helixes. We have discussed the project foundation conditions with Mr. Mike Oliveira of Alpine Site Services Inc. Denver Co., who oversaw installation of the Screw Piles at the Detention Center Project. Based on his review of the foundation conditions at the Innovation center site Mr. Oliveira is confident that Screw Piles are a feasible foundation alternative for the Innovation Project. DOWL also believes that Screw Piles may be a cost effective option. DOWL observed the static load test for the Screw Pile at the Detention Center and installation of several of the piles. Information in regard to Screw Piles is included in Appendix D.

Based on conversations with Mr. Olivia, and the testing that was conducted for the detention center, the following allowable capacity may be used for project planning purposes. Larger capacities may be achieved with larger pipe diameters. The Screw Piles should bear within the siltstone and sandstone bedrock deposits.

<table>
<thead>
<tr>
<th>*Pile Section</th>
<th>Allowable Axial Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.5 inch diameter Screw Pile</td>
<td>70 tons</td>
</tr>
</tbody>
</table>

**Table 5-5**

Screw Pile Allowable Axial Capacities

*Piles to consist of 85 ksi steel

1. Screw Piles should be designed in coordination with Alpine Site Services Inc. or other experienced qualified Screw Pile design /installer.

2. Static load tests should be conducted multiple piles at various locations to confirm capacities.

All exterior foundation walls should be placed at a minimum depth of 4 feet below final exterior grade for frost protection.

A 1/3 increase in the allowable bearing pressure may be assumed for transient loadings.
5.2.2 Lateral Pressures

The following values may be utilized for resistance to soil lateral loads on foundation walls, grade beams and footings,

<table>
<thead>
<tr>
<th>Condition</th>
<th>Coefficient of Earth Pressure</th>
<th>γK (equivalent fluid pressure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level Backfill</td>
<td>Ko = 0.64</td>
<td>*79 pcf</td>
</tr>
<tr>
<td></td>
<td>Ka = 0.47</td>
<td>*58 pcf</td>
</tr>
<tr>
<td></td>
<td>Kp = 2.1</td>
<td>**260 pcf</td>
</tr>
</tbody>
</table>

*These recommendations are based on the assumption that no hydrostatic pressures exist.

**neglecting the first foot of backfill depth.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Coefficient of Earth Pressure</th>
<th>γK (equivalent fluid pressure)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Condition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level Backfill</td>
<td>Ko = 0.41</td>
<td>*59 pcf</td>
</tr>
<tr>
<td></td>
<td>Ka = 0.25</td>
<td>*36 pcf</td>
</tr>
<tr>
<td></td>
<td>Kp = 3.5</td>
<td>**400 pcf</td>
</tr>
</tbody>
</table>

*These recommendations are based on the assumption that no hydrostatic pressures exist.

**neglecting the first foot of backfill depth.

- Coefficient of friction between concrete and clay δ = 0.25
- Coefficient of friction between concrete and gravel δ = 0.45

5.2.3 Interior Slab on Grade Floor

The existing native clay subgrade is suitable for support of standard light load bearing interior concrete floor slabs provided a minimum of 12-inches of ¾-inch minus base gravel is utilized under the slab and proper subgrade compaction and preparation are performed as discussed below. It is our understanding that laboratory facilities will be located on the first floor which will require concrete pavements designed to accommodate truck loadings. A minimum of 20 inches of ¾ inch minus base gravel will be required under the slab for these areas.

Light traffic pavement /slab on-grade thickness placed on 12 inches of road base gravel may be designed assuming a modulus of subgrade reaction (k) equal to 140 pounds per cubic inch. Heavy traffic pavement slab on-grade thickness placed at the laboratory locations placed on the 20 inches of road base gravel may be designed assuming a modulus of subgrade reaction (k) equal to 200 pounds per cubic inch. A geotextile stabilization fabric should be placed between the prepared subgrade under the heavy pavement sections. The geotextile fabric should be Geotex 350ST woven as manufactured by Propex or equal.
Fill areas when encountered should be evaluated for compaction by proof rolling and compacting to required densities. Areas that cannot be compacted should be over-excavated a minimum of 12-inches and replaced with compacted base gravel. A geotextile stabilization fabric should be placed between the prepared subgrade. The geotextile fabric should be Geotex 350ST woven as manufactured by Propex or equal. The clay subgrade soils are also moisture sensitive and will become excessively soft if saturated by rainfall events and excessive tracking from construction equipment.

All concrete slab subgrade soil should be evaluated during construction by proof-rolling with heavy equipment and compacting as specified.

The granular base gravel fill should be compacted to not less than 95% of maximum dry density at plus or minus two percentage points of optimum moisture according to ASTM D 698. The soils should be placed in loose lifts not exceeding 8 inches to ensure uniform compaction is achieved.

After excavation to the required subgrade elevation the clay subgrade soils should be moisture conditioned and compacted to not less than 95% of maximum dry density at plus or minus 2% of optimum moisture as determined by ASTM D 698 prior placement of stabilization fabric imported granular fill placement.

5.2.4 Basement Considerations

It is our understanding that a partial basement is proposed to be located in the northwest corner area of the NAIC building. The basement will connect to the existing steam tunnel alignment that is located along Grant Street. The prosed depth of the basement is approximately 15 feet with an approximate top of slab elevation of 4906.3. The top of basement slab elevation (assuming 4906.3) is approximately 2 feet below the invert elevation (4908.5) of the branch steam tunnel. It is noted that the native dense gravel layer is located at elevations ranging from 4899.7 (B-4) to 4904.8 (B-11) and the basement floor elevation may approximate the gravel elevation at some locations. Additionally a thin layer of clay may remain between the gravel layer and floor excavation elevation. Groundwater elevation approximates the top to the gravel layer (elevation 4900.2) at Boring B-4 location. Groundwater was encountered during the time of the investigation at approximate elevations ranging from 4900.2 (B-4) to 4901.6 (B-10) and could fluctuate to higher elevations. Given this information it is recommended to waterproof the basement. A mat type foundation for the basement may be desirable which would be more resistant to hydrostatic pressures.

Dependent upon groundwater elevations at the time of construction heaving of the clay layer may occur. Dependent upon conditions during construction, the clay layer should be monitored for heave prior to placement of the floor slab.

Review of the branch steam tunnel plans to which the basement will be connected indicates that 12 inches of washed gravel has been placed under the tunnel and a perforated drain pipe placed within the gravel. A
filter fabric was placed between the excavation bottom and drain gravel. A similar drainage system should be utilized for the basement and tied into the drain gravel and pipe at the branch steam tunnel location. Drain gravel should extend partially up the sidewalls of the basement at least above the footing/stem wall contact area and above the branch tunnel base elevation (4908.4). A perimeter drain pipe should be installed around the basement stem wall/footing elevation and tied into the branch tunnel gravel. Drainage pipes should be considered under the basement floor slab to minimize the potential for hydrostatic uplift should groundwater elevations approach the slab elevation.

Clay soils are elevated in natural moisture at the basement floor/drain gravel excavation depth. The clay soils should not be disturbed during excavation. A smooth lipped excavation bucket should be used. A filter fabric should be placed between the clay subgrade and drain gravel. The filter fabric should be a non-woven high survivability fabric.

Dewatering may be required for construction depending upon excavation depths and groundwater conditions at the time. Excavation wall stability will be a concern considering the relatively deep excavation required (See Section 5.3.3).

5.2.5 Corrosion Considerations

The clay surface soils at the site exhibit high corrosion potential to buried metal. A minimum resistivity value of 1650 to 1950 ohm-cm and pH of 7.6 was recorded from test results on a sample of the lean clay.

All buried metal pipes and appurtenances should be protected for severe corrosive conditions.

The clay soils exhibit low corrosivity potential to concrete. A percent soluble sulfate value less than 0.1 percent was recorded from test results on a sample of the lean clay.

Type I-II Portland cement is recommended for all project concrete.

5.3 EARTHWORK

5.3.1 Site Grading and Drainage

The following criteria should be used for site preparation purposes and when preparing construction and project documents.

- All existing fill and deleterious material should be removed in their entirety from the proposed building footprint. All exposed subgrade surfaces should be free of mounds and depressions which could prevent uniform compaction. If unexpected fill or obstructions are encountered
during site clearing or excavation, such features should be removed and the excavation should extend to the natural soils and thoroughly cleaned prior to fill placement and construction.

- All fill and backfill should be approved by the geotechnical engineer, moisture conditioned and placed in 8-inch loose lifts. The fill and backfill should then be compacted with an appropriately sized compactor to the following minimum dry densities as determined by ASTM D698.

  o Below Foundations = 98 percent
  o Around Foundations = 95 percent
  o All Other Fill = 95 percent

- No fill should be placed over frozen ground or in a frozen condition. All loose disturbed soil and/or fills in the base of the over-excavation should be removed from the foundation excavation prior to placement of structural fill. Footings should not be placed on either uncompacted disturbed native soils, or uncontrolled fill. Qualified personnel should observe all footing and slab subgrades to confirm subsoil conditions.

- Imported gravel meeting the below specifications or the site soils may be used as foundation wall backfill provided proper moisture conditioning to near optimum moisture (± 2 percent) and compacted in accordance with the details presented above. If backfill is needed below foundations, only imported gravel meeting the specifications below should be used. Other imported gravel options may be used by approval of the geotechnical engineer.

<table>
<thead>
<tr>
<th>Table 5-8 Imported Gravel Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sieve Size</strong></td>
</tr>
<tr>
<td>3-inch</td>
</tr>
<tr>
<td>No. 4</td>
</tr>
<tr>
<td>No. 200</td>
</tr>
<tr>
<td>Liquid limits less than 25 and PI less than 6</td>
</tr>
</tbody>
</table>

- Surface water should not be allowed to accumulate and infiltrate soils near the proposed foundations. It must be controlled and directed away from the structures. A simple means of reducing moisture changes is to prevent surface water infiltration by sloping the ground away from the foundation. The recommended minimum slope within 10 feet of the building is 1 inch vertical for 1 foot horizontal. The sloped ground should be initially constructed at a greater slope
to account for settlement/consolidation of exterior backfill. Within 10 feet of the foundation, the upper 12 to 18 inches of backfill should consist of less permeable, compacted clay soils. The area around the foundation should be inspected regularly, particularly after a rain event to determine if proper drainage away from the structure has been maintained.

- Roof downspouts and drains should discharge at least 10 feet beyond the limits of all foundation wall backfill.

5.3.2 Construction on Moisture Sensitive Subgrade Soils

After the topsoil and pavement fills are excavated to the first floor slab elevation, lean clay subgrade soil will be exposed during construction of the foundation elements. The lean clay is moisture sensitive and will become soft and unstable during wet weather periods. Excessive disturbance of the clay subgrade during wet weather will compromise the subgrade in areas where concrete slabs are to be installed and subsequently require additional over-excavation and replacement of unstable soils. Additional operation of construction equipment on excessively wet clay soils could be problematic. The Contractor should be made aware of this potential and schedule his operations accordingly or construct a suitable wet weather platform (placement of gravel and or stabilization fabric) so as not to compromise the clay subgrade during construction.

5.3.3 Excavation

Based on the soils encountered, conventional earthmoving equipment should be capable of excavating the site soils. All excavations should be approved by a qualified observer prior to backfill placement.

All excavations must conform to OSHA Standards for Excavations, 29 CFR Part 1926.652 Appendix B to Subpart P. Based on field observations and laboratory tests, the majority of the soils at the site are classified as Type C using OSHA classification system. Type C soils require excavation slope angles not to exceed 1.5 H: 1 V (horizontal to vertical). Soil and moisture conditions should be continually evaluated at the time of construction to ensure compliance with OSHA requirements. The contractor should have a designated safety officer familiar with soils to monitor trench wall conditions during construction. Trench wall stability and compliance with OSHA requirements is the Contractor’s responsibility.
6.0 LIMITATIONS

The conclusions and recommendations presented in this report assume that site conditions are not substantially different than those exposed by the explorations. If during construction, subsurface conditions are observed or appear to be present that are different from those encountered in the explorations, DOWL geotechnical staff should be advised promptly so that those conditions can be reviewed and recommendations reevaluated, where necessary.

If there is a substantial lapse of time between submission of this report and the start of work, and if conditions have changed due to natural causes or construction operations, DOWL should review this report to determine the applicability of the conclusions and recommendations considering the changed conditions.

This report was prepared for use by the owner and their representatives. It should be made available to prospective contractors for information on factual data only and not as a warranty of subsurface conditions.

These services have been performed in a manner consistent with the level of care and skill ordinarily exercised by members of the profession currently practicing in this area under similar conditions. No warranty is made or implied.
Appendix A

Boring Logs
### SOIL CLASSIFICATION/LEGEND

#### Unified Soil Classification System

<table>
<thead>
<tr>
<th>Criteria for Assigning Group Symbols and Names</th>
<th>Soil Classification Generalized Group Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>COARSE-GRAINED SOILS</td>
<td>CLEAN GRAVELS</td>
</tr>
<tr>
<td>More than 50% of coarse fraction retained on No. 200 sieve</td>
<td>Less than 5% fines</td>
</tr>
<tr>
<td>Sands</td>
<td>CLEAN SANDS</td>
</tr>
<tr>
<td>50% or more of coarse fraction passes No. 4 sieve</td>
<td>Less than 5% fines</td>
</tr>
<tr>
<td>Sands with FINES</td>
<td>SANDS WITH FINES</td>
</tr>
<tr>
<td>More than 12% fines</td>
<td>More than 12% fines</td>
</tr>
<tr>
<td>Sands</td>
<td>SANDS</td>
</tr>
<tr>
<td>50% or more passes the No. 200 sieve</td>
<td>SANDS WITH FINES</td>
</tr>
<tr>
<td>FINE-GRAINED SOILS</td>
<td>INORGANIC</td>
</tr>
<tr>
<td>Liquid limit less than 50</td>
<td>Non-plastic and low-plastic clays</td>
</tr>
<tr>
<td>Liquid limit greater than 50</td>
<td>Non-plastic and low-plastic organic clays</td>
</tr>
<tr>
<td></td>
<td>Non-plastic and low-plastic organic silts</td>
</tr>
<tr>
<td>HIGHLY ORGANIC SOILS</td>
<td>ORGANIC</td>
</tr>
<tr>
<td>Primarily organic matter, dark in color and has an organic odor</td>
<td>High-plasticity clays</td>
</tr>
<tr>
<td></td>
<td>ORGANIC</td>
</tr>
<tr>
<td>Primarily organic matter, dark in color and has an organic odor</td>
<td>High-plasticity organic clays</td>
</tr>
<tr>
<td></td>
<td>ORGANIC</td>
</tr>
<tr>
<td>Primarily organic matter, dark in color and has an organic odor</td>
<td>High-plasticity organic soils</td>
</tr>
</tbody>
</table>

#### Component Definitions By Gradation

<table>
<thead>
<tr>
<th>Component</th>
<th>Size Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boulders</td>
<td>Greater than 12-in.</td>
</tr>
<tr>
<td>Cobble</td>
<td>3-in. to 12-in.</td>
</tr>
<tr>
<td>Gravel</td>
<td>3-in. to No. 4 (4.75 mm)</td>
</tr>
<tr>
<td>Coarse sand</td>
<td>No. 4 (4.75 mm) to No. 10 (2.0 mm)</td>
</tr>
<tr>
<td>Medium sand</td>
<td>No. 10 (2.0 mm) to No. 40 (0.425 mm)</td>
</tr>
<tr>
<td>Fine sand</td>
<td>No. 40 (0.425 mm) to No. 200 (0.074 mm)</td>
</tr>
<tr>
<td>Silt and Clay</td>
<td>Smaller than No. 200 (0.075 mm)</td>
</tr>
</tbody>
</table>

#### Silt and Clay Descriptions

<table>
<thead>
<tr>
<th>Description</th>
<th>Typical Unified Designation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silt</td>
<td>ML (non-plastic)</td>
</tr>
<tr>
<td>Clayey Silt</td>
<td>CL (low plasticity)</td>
</tr>
<tr>
<td>Silty Clay, Lean Clay</td>
<td>OL, CH</td>
</tr>
<tr>
<td>Clay, Fat Clay</td>
<td>MH, CL</td>
</tr>
<tr>
<td>Plastic Silt</td>
<td>OH, CH</td>
</tr>
<tr>
<td>Organic Soils</td>
<td>Pt, CH</td>
</tr>
</tbody>
</table>

#### Relative Density or Consistency

<table>
<thead>
<tr>
<th>Cohesionless Soils</th>
<th>Cohesive Soils</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Density</strong></td>
<td><strong>Relative Density (%)</strong></td>
</tr>
<tr>
<td>Very loose</td>
<td>0 to 4</td>
</tr>
<tr>
<td>Loose</td>
<td>5 to 10</td>
</tr>
<tr>
<td>Med. Dense</td>
<td>11 to 29</td>
</tr>
<tr>
<td>Dense</td>
<td>30 to 49</td>
</tr>
<tr>
<td>Very Dense</td>
<td>Over 50</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(a) Soils consisting of gravel, sand and silt, either separately or in combination, possessing no characteristics of plasticity and exhibiting drained behavior.
(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.
(c) Undrained shear strength = ½ unconfined compressive strength.
(d) Øp - Denotes pocket penetrometer field measurement (tons per square foot) approximation to unconfined compressive strength.

#### Descriptive Terminology Denoting Components Proportions

<table>
<thead>
<tr>
<th>Descriptive Terms</th>
<th>Range of Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trace or Scattered</td>
<td>0 - 5%</td>
</tr>
<tr>
<td>Few</td>
<td>5 - 10%</td>
</tr>
<tr>
<td>Some or Adjective</td>
<td>15 - 30%</td>
</tr>
<tr>
<td>And</td>
<td>30 - 50%</td>
</tr>
</tbody>
</table>

(a) Use gravelly, sandy or silty as appropriate.

#### Groundwater Elevation

- Water Elevation Noted During Drilling
- Water Elevation Recorded After Drilling Complete

#### Soil Moisture

<table>
<thead>
<tr>
<th>Moisture</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dry</td>
<td>No sign of water dry to the touch</td>
</tr>
<tr>
<td>Slightly Moist</td>
<td>Dry of the optimum moisture content.</td>
</tr>
<tr>
<td>Moist</td>
<td>Approximately at optimum moisture</td>
</tr>
<tr>
<td>Very Moist</td>
<td>Moisture content above optimum but below saturated</td>
</tr>
<tr>
<td>Wet</td>
<td>Wet of optimum to saturated</td>
</tr>
</tbody>
</table>

#### Groundwater Elevation

- Water Elevation Noted During Drilling
- Water Elevation Recorded After Drilling Complete

#### Samples

- Split Spoon Sampler (2.0'' OD)
- Ring Sampler (3.0'' OD)
- Shelby Tube Sampler (3.0'' OD)
- Bulk Sample (auger cuttings)
- Core Barrel

Unless otherwise noted, drive samples advanced with 140-lb. hammer and 30-in. drop.

---

6/9/2015
MATERIAL DESCRIPTION

8" +/- Topsoil, very moist, black, organics
0.7
Fill, Silty Sand, SM; very moist, medium dense, black, organics, brick fragments
1.3
Sandy Lean Clay, CL; very moist to moist, stiff, tan, fine grained sand, silty in part
12.0
Lean Clay, CL; moist, stiff, light brown
16.3
Poorly Graded Gravel with Clay and Sand, GP-GC; moist to very moist, very dense, brown to multi-colored, rounded to sub angular gravel, fine to coarse grained sand
20.2
Groundwater observed at 20.2 feet
23.0
Poorly Graded Gravel with Sand, GP; wet, very dense, dark brown to multi-colored, rounded to sub angular gravel, fine to coarse grained sand
21.3
Silty Sand/Sandy Silt, SM/ML; very moist to wet, medium dense to very dense/very stiff to hard, light brown, fine grained sand
28.0

ADDITIONAL DATA/REMARKS

Slow and rough drilling through gravel
California sampler pushed
Siltstone, Sandy Silt, ML; wet to very moist, hard, brown, clayey in part

Sandstone, Silty Sand, SM; wet to very moist, very dense, brown, fine to coarse grained sand

Boring terminated at 50.1 feet

Groundwater observed at 20.2 feet

Severe sand heave observed at 35.0 feet

End of drilling for 11/4/2014

Slow smooth drilling with full weight on bit

Boring terminated at 50.1 feet
### MATERIAL DESCRIPTION

<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>Elevation</th>
<th>Graphic Log</th>
<th>Rock</th>
<th>Boring Number</th>
<th>N.B. Recovered</th>
<th>N. Borehole</th>
</tr>
</thead>
<tbody>
<tr>
<td>32.0</td>
<td>4892</td>
<td>3</td>
<td>13</td>
<td>18</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>36.0</td>
<td>4888</td>
<td>4</td>
<td>13</td>
<td>18</td>
<td>24</td>
<td>13</td>
</tr>
<tr>
<td>40.0</td>
<td>4884</td>
<td>5</td>
<td>34</td>
<td>50/3</td>
<td>50/3</td>
<td>14</td>
</tr>
<tr>
<td>42.0</td>
<td>4880</td>
<td>6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Surface Elevation: 4922.95**

- **Siltstone, Sandy Silt, ML:** wet to very moist, hard, brown, with fine to coarse grained sand, clayey in part (very soft rock)
- **Sandstone, Poorly Graded Sand with Silt, SP-SM:** wet, very dense, brown
- **Boring terminated due to auger refusal at 42.0 feet**
- **Groundwater observed at 20.8 feet**

**Additional Data/Remarks:**
- California sampler pushed
- Rough and very slow drilling at 41.0 feet

---

**LOG OF BOREHOLE B-3**

**Client:** A&E Architects

**Project:** MSU Norm Asbjornson Innovation Center

**Boring Location:** South Central Portion of Innovation Center

**Site:** Montana State University

**Drill Co.:** HazTech

**Driller:** Paul Bray

**Hammer:** Auto

**Logged By:** D. Barrick

**Founded By:** G. Underhill

**Started:** 11/5/2014

**Finished:** 11/5/2014

---

**Tests:**

- **N Value (blows/ft):**
  - 10: 43
  - 20: 12
  - 30: 13
  - 40: 13

---

**Dowel Hkm**

2090 Stadium Drive
Bozeman, Montana 59715
Telephone: (406) 586-8834
www.dowlhk.com
## MATERIAL DESCRIPTION

### Surface Elevation: 4920.16

<table>
<thead>
<tr>
<th>Depth (ft.)</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>4&quot; Asphalt Pavement, black</td>
</tr>
<tr>
<td>0.3</td>
<td>5&quot; Road Base, Well Graded Gravel with Sand, GW; moist, brown, sub angular gravel, fine to coarse grained sand</td>
</tr>
<tr>
<td>0.8</td>
<td>Fill, Lean Clay with Sand, CL; moist, medium stiff, black, fine grained sand</td>
</tr>
<tr>
<td>1.8</td>
<td>Sandy Lean Clay, CL; moist, medium stiff, brown, fine grained sand, silty in part</td>
</tr>
<tr>
<td>-10.0</td>
<td>Lean Clay, CL; slightly moist, soft to stiff, tan to cream white</td>
</tr>
</tbody>
</table>

Groundwater observed at 20.0 feet

Poorly Graded Gravel with Sand, GP; wet, very dense, brown to dark brown, angular to sub rounded gravel, fine to coarse grained sand

Silty Sand/Sandy Silt, SM/ML; very moist to wet, medium dense to very dense/very stiff to hard, brown, fine to medium grained sand, clayey in part

---

### Tests

<table>
<thead>
<tr>
<th>BLOWS/FT</th>
<th>M.C.</th>
<th>LL</th>
</tr>
</thead>
<tbody>
<tr>
<td>9/18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13/24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13/18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18/24</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20/18</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/3.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Lab #29904
Consolidation Cc=0.09
Unconfined qu=2.27 ksf
Cohesion (qu/2)=1.14 ksf
Dry Unit Weight=101.3 pcf
Nat. Moisture=21.1%

Lab #7125
Liquid Limit=35
Plasticity Index=19

- Slow and rough drilling through gravel
- Smooth and slow drilling
**LOG OF BOREHOLE B-4**

**MATERIAL DESCRIPTION**

Surface Elevation: 4920.16

- **36.0 ft**
  - 2" thick fine to coarse grained sand and rounded gravel lenses observed at 36.3 feet

- **40.0 ft**
  - Siltstone, Sandy Silt, ML; wet to very moist, hard, brown

- **45.0 ft**
  - Becoming more competent with depth

- **54.0 ft**
  - Sandstone, Silty Sand, SM; wet to very moist, very dense, brown, fine to coarse grained sand

- **60.3 ft**
  - Boring terminated at 60.3 feet
  - Groundwater observed at 20.0 feet

**ADDITIONAL DATA/REMARKS**

- Rough to smooth drilling at 36.5 feet
- Smooth drilling on siltstone at 43.0 feet

---

**PROJECT**

MSU Norm Asbjornson Innovation Center

**SITE**

Montana State University

**BORING LOCATION**

Northeast Corner of Innovation Center

---

**CLIENT**

A&E Architects

---

**LOGGED BY**

D. Barrick

---

**APPROVED BY**

G. Underhill

---

**STARTED** 11/3/2014

**FINISHED** 11/3/2014

**DOWL HKM**

2090 Stadium Drive
Bozeman, Montana 59715
Telephone: (406) 586-8834
www.dowlhk.com
### LOG OF BOREHOLE B-5

**Project No.: 4522.11447.01**  
**Sheet 1 of 2**

**CLIENT:** A&E Architects  
**PROJECT:** MSU NAIC Parking Garage  
**SITE:** Montana State University

**Boring Location:** Northwest Corner of Parking Garage

---

<table>
<thead>
<tr>
<th>Depth (ft)</th>
<th>Material Description</th>
<th>Graphic Log</th>
<th>Elevations (ft)</th>
<th>BULK SAMPLES</th>
<th>Driven/Push Blows per 6&quot;</th>
<th>Pocket Penetrometer, TSF</th>
<th>M.C.</th>
<th>Additional Data/Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.5&quot; +/- Topsoil, moist, dark brown, organics, Lean Clay, CL; moist to slightly moist, medium stiff to stiff, light brown, intermittent sand layers</td>
<td>4920.72</td>
<td>4918.5</td>
<td>2</td>
<td>8</td>
<td>1/18 50%</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>0.5</td>
<td></td>
<td></td>
<td>4914</td>
<td>4</td>
<td>4</td>
<td>14/18 78%</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>9.5</td>
<td>Poorly Graded Gravel with Cobbles and Clay, GP-GC; slightly moist, medium dense to dense, gray to multi-colored, sub rounded to well rounded</td>
<td>4907.19</td>
<td>4905.5</td>
<td>9</td>
<td>18</td>
<td>44/18 89%</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>13.9</td>
<td>Groundwater observed at 18.5 feet</td>
<td>4900.5</td>
<td>4893.5</td>
<td>21</td>
<td>13</td>
<td>7/18 78%</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>18.0</td>
<td>Silty Sand, SM; wet, medium dense to dense, light brown, slightly to non-plastic</td>
<td>4900.19</td>
<td>4891.5</td>
<td>10</td>
<td>14</td>
<td>6/18 106%</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>21.0</td>
<td></td>
<td>4896</td>
<td>4891.5</td>
<td>9</td>
<td>9</td>
<td>23/18 111%</td>
<td>[ ]</td>
<td></td>
</tr>
<tr>
<td>22.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27.0</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**DOWL**  
130 North Main St.  
Butte, Montana 59701  
Telephone: (406) 723-8213  
www.dowl.com

**DRILL CO.:** HazTech  
**DRILL RIG:** Longyear BK-81  
**DRILLER:** Paul Bray  
**HAMMER:** Auto  
**LOGGED BY:** J. Potts  
**APPROVED BY:** G. Underhill

**STARTED:** 5/20/2015  
**FINISHED:** 5/21/2015
<table>
<thead>
<tr>
<th>DEPTH (FT)</th>
<th>MATERIAL DESCRIPTION</th>
<th>GRAPHIC LOG</th>
<th>ELEVATION (FT)</th>
<th>BULK DENSITY</th>
<th>GRAVITY BLOW / PER 6&quot;</th>
<th>NUMBER</th>
<th>IN. COVERED / IN. RECOVERED</th>
<th>POCKET PENETROMETER, TSF</th>
<th>M.C.</th>
<th>LL</th>
<th>ADDITIONAL DATA / REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>36</td>
<td>Silty Sand, SM; wet, dense to very dense, light yellow brown</td>
<td>4887</td>
<td>4881.18</td>
<td>12</td>
<td>23</td>
<td>19</td>
<td>8</td>
<td>18/18</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>40.5</td>
<td>Silty Sand, SM; very moist, very dense, light yellow brown</td>
<td>4882.5</td>
<td>4878.5</td>
<td>22</td>
<td>76</td>
<td>34</td>
<td>9</td>
<td>18/18</td>
<td>100%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45.0</td>
<td>Siltstone (Silty Sand, SM); very moist, very dense, light yellow brown</td>
<td>4876.18</td>
<td>4873.5</td>
<td>16</td>
<td>48</td>
<td>34</td>
<td>10</td>
<td>17/18</td>
<td>94%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>49.5</td>
<td>Poorly Graded Gravel with Cobbles and Sand, GP; wet, very dense, gray, minor clay observed</td>
<td>4869.78</td>
<td>4869</td>
<td>28</td>
<td>50</td>
<td>4&quot;</td>
<td>11</td>
<td>11/10</td>
<td>110%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>54</td>
<td>Siltstone, (Silty Sand, SM); very moist to wet, very dense, light gray, sub rounded, medium grained sand, poorly cemented</td>
<td>4867.86</td>
<td>4864.68</td>
<td>50/50</td>
<td>50</td>
<td>4&quot;</td>
<td>12</td>
<td>5/4</td>
<td>125%</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Boring terminated at 56.5 feet
No groundwater observed
# LOG OF BOREHOLE B-6

**PROJECT**
MSU NAIC Parking Garage

**BORING LOCATION**
Northeast Corner of Parking Garage

**SITE**
Montana State University

<table>
<thead>
<tr>
<th>DEPTH (FT.)</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3&quot; Asphalt Pavement, black</td>
</tr>
<tr>
<td>0.2</td>
<td>Road Base, Well Graded Gravel with Sand, GW; moist, brown, angular to sub angular, fine to coarse grained sand</td>
</tr>
<tr>
<td>1.0</td>
<td>Lean Clay, CL; moist to slightly moist, medium stiff to stiff, light brown, trace sand and silt, medium plasticity</td>
</tr>
<tr>
<td>4.5</td>
<td>Poorly Graded Gravel with Clay, GP-GC; moist, very dense to dense, multi-colored to light gray, sub angular to rounded</td>
</tr>
<tr>
<td>16.2</td>
<td>Groundwater observed at 21.1 feet</td>
</tr>
<tr>
<td>22.5</td>
<td>Silty Sand, SM; wet, dense, light brown to multi-colored, medium to fine grained sand, trace clay</td>
</tr>
<tr>
<td>27</td>
<td></td>
</tr>
<tr>
<td>31.5</td>
<td></td>
</tr>
</tbody>
</table>

**TESTS**

- USCS=CL
- Plasticity Index=11
- Consolidation Cc=0.12
- Unconfined (qu)=1.507 ksf
- Cohesion (qu/2)=0.754 ksf
- Dry Unit Weight=93.3 pcf
- Nat. Moisture=22.3%

**LOGGED BY** 
J. Potts

**APPROVED BY** 
G. Underhill

**STARTED** 
5/21/2015

**FINISHED** 
5/21/2015
Poorly Graded Sand, SP; wet, medium dense, yellow brown

Siltstone, (Silty Sand, SM); wet to very moist, very dense, brown, fine grained sand

Boring terminated at 45.2 feet

Groundwater observed at 45.2 feet
### MATERIAL DESCRIPTION

**Surface Elevation: 4922.4**

<table>
<thead>
<tr>
<th>DEPTH (FT.)</th>
<th>MATERIAL DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>3.5” Asphalt Pavement, black</td>
</tr>
<tr>
<td>0.8</td>
<td>5.5” Road Base, Well Graded Gravel with Sand, GW; moist, dark brown to black, sub rounded gravel, fine to coarse grained sand, 1” minus</td>
</tr>
<tr>
<td>4.5</td>
<td>Lean Clay, CL; moist, medium stiff, light brown, silty in part, trace sand stiff at 5.0 feet</td>
</tr>
<tr>
<td>4.9</td>
<td>very stiff at 15.0 feet</td>
</tr>
<tr>
<td>16.4</td>
<td>Poorly Graded Gravel with Clay and Sand, GP-GC; moist, very dense, brown to multi-colored, sub rounded to sub angular gravel, fine to coarse grained sand</td>
</tr>
<tr>
<td>18.0</td>
<td>Groundwater observed at 20.8 feet</td>
</tr>
<tr>
<td>24.0</td>
<td>Silty Sand, SM; wet, medium dense, dark brown to multi-colored, fine to medium grained sand</td>
</tr>
<tr>
<td>26.5</td>
<td>Boring terminated at 26.5 feet</td>
</tr>
<tr>
<td>27.0</td>
<td>Groundwater observed at 20.8 feet</td>
</tr>
</tbody>
</table>

**Topographic Log:**

<table>
<thead>
<tr>
<th>DEPTH (FT.)</th>
<th>BLOCK</th>
<th>BLOW PENS/PUSH IN.</th>
<th>N BLOWS/FT.</th>
<th>NUMBER IN. RECOVERED</th>
<th>N BLOWS/FT.</th>
<th>N VALUE</th>
<th>ADDITIONAL DATA/REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>Surface Elevation: 4922.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.8</td>
<td>13/18</td>
<td>72%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Lab #8376</td>
</tr>
<tr>
<td>4.5</td>
<td>6/18</td>
<td>33%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>USCS=CL</td>
</tr>
<tr>
<td>4.9</td>
<td>4/18</td>
<td>78%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Gravel=3%</td>
</tr>
<tr>
<td>16.4</td>
<td>22/24</td>
<td>92%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Sand=9%</td>
</tr>
<tr>
<td>18.0</td>
<td>18/18</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fines=88%</td>
</tr>
<tr>
<td>24.0</td>
<td>18/18</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Liquid Limit=35</td>
</tr>
<tr>
<td>26.5</td>
<td>18/18</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Plasticity Index=14</td>
</tr>
<tr>
<td>27.0</td>
<td>18/18</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Max Dry Unit Weight=105.9 pcf</td>
</tr>
<tr>
<td>27.0</td>
<td>18/18</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Opt. Moisture=17.6%</td>
</tr>
<tr>
<td>27.0</td>
<td>18/18</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Nat. Moisture=21.3%</td>
</tr>
</tbody>
</table>

**Sample Tests:**

- Lab #8376
- Nat. Moisture=24.3%
### MATERIAL DESCRIPTION

<table>
<thead>
<tr>
<th>Depth (FT)</th>
<th>Material Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.4</td>
<td>5&quot; Asphalt Pavement, black</td>
</tr>
<tr>
<td>1.2</td>
<td>9&quot; Road Base, Well Graded Gravel with Sand, moist, brown to black, sub rounded gravel, fine to coarse sand, 1&quot; minus</td>
</tr>
<tr>
<td>4.5</td>
<td>Lean Clay, CL; moist, stiff, dark brown to black, silty in part at 3.6 feet</td>
</tr>
<tr>
<td>6.0</td>
<td>medium stiff at 6.0 feet</td>
</tr>
<tr>
<td>9.0</td>
<td>stiff at 17.5 feet</td>
</tr>
<tr>
<td>18.0</td>
<td>Poorly Graded Gravel with Clay and Sand, GP-GC; very moist, very dense, brown to multi-colored, sub rounded to sub angular gravel, fine to coarse grained sand Groundwater observed at 20.3 feet</td>
</tr>
<tr>
<td>26.5</td>
<td>Boring terminated at 26.5 feet</td>
</tr>
<tr>
<td>27</td>
<td>Groundwater observed at 20.3 feet</td>
</tr>
</tbody>
</table>

### Additional Data

- **Lab #31120**
  - USCS=CL
  - Sand=96.1%
  - Liquid Limit=30
  - Plasticity Index=12
  - Unconfined (qu)=1.01 ksf
  - Cohesion (qu/2)=0.51 ksf
  - Dry Unit Weight=96.5 pcf
  - Nat. Moisture=21.0%

- **Lab #31121**
  - USCS=CL
  - Sand=9.3%
  - Liquid Limit=38
  - Plasticity Index=20
  - Consolidation=0.29
  - Unconfined (qu)=3.359 ksf
  - Cohesion (qu/2)=1.680 ksf
  - Dry Unit Weight=100.3 pcf
  - Nat. Moisture=22.7%

- **Lab #8378**
  - Nat. Moisture=28.9%
LOG OF BOREHOLE B-11

MATERIAL DESCRIPTION

Surface Elevation: 4921.3

0
- 4" Asphalt Pavement, black
- 6.5" Road Base, Well Graded Gravel with Sand, moist, dark brown to black, sub rounded gravel, fine to coarse grained sand, 1" minus
- Lean Clay, CL; moist, medium stiff, light brown, silty in part, trace sand

0.3

0.9

4.5

9.0

9.5

13.5

18

22.5

27

24.0

Groundwater observed at 19.8 feet

Boring terminated at 24.0 feet

Lab #31122
Nat. Moisture=28.4%

Lab #8379
Nat. Moisture=22.9%

Lean Clay with Sand, CL; moist, medium stiff, light brown, fine grained sand, silty in part

very stiff at 12.5 feet

stiff at 15.0 feet

Poorly Graded Gravel with Clay and Sand, GP-GC; moist, very dense, brown to multi-colored, sub rounded gravel, fine to coarse grained sand

Groundwater observed at 19.8 feet
<table>
<thead>
<tr>
<th>DEPTH (FT.)</th>
<th>MATERIAL DESCRIPTION</th>
<th>GRAPHIC LOG</th>
<th>ELEVATION (FT.)</th>
<th>BLOWS/PUSH</th>
<th>N VALUE</th>
<th>PL</th>
<th>LL</th>
<th>ADDITIONAL DATA/REMARKS</th>
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<tbody>
<tr>
<td>0</td>
<td>8&quot; +/- Topsoil, very moist, black, organics</td>
<td></td>
<td>4920.9</td>
<td>11</td>
<td>13/18</td>
<td>72%</td>
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<td></td>
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<tr>
<td>0.7</td>
<td>Lean Clay, CL; moist, stiff, light brown, silty in part, trace sand</td>
<td></td>
<td>4918.5</td>
<td>2</td>
<td>12/12</td>
<td></td>
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<tr>
<td>4.5</td>
<td>medium stiff at 3.0 feet</td>
<td></td>
<td>4914</td>
<td>5</td>
<td>13/18</td>
<td>72%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.0</td>
<td>stiff at 5.0 feet</td>
<td></td>
<td>4914</td>
<td>5</td>
<td>14/18</td>
<td>78%</td>
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</tr>
<tr>
<td>9.0</td>
<td>medium stiff at 9.0 feet</td>
<td></td>
<td>4909.5</td>
<td>2</td>
<td>10/12</td>
<td>83%</td>
<td></td>
<td>Lab #31123 Nat. Moisture=26.5%</td>
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<tr>
<td>10.5</td>
<td>stiff at 10.5 feet</td>
<td></td>
<td>4909.5</td>
<td>6</td>
<td>14/18</td>
<td>78%</td>
<td></td>
<td></td>
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<tr>
<td>12.5</td>
<td>Lean Clay with Sand, CL; moist, stiff, light brown to brownish orange, fine grained sand</td>
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<td>4908.4</td>
<td>3</td>
<td>16/18</td>
<td>89%</td>
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<td>Poorly Graded Gravel with Clay and Sand, GP-GC; moist, very dense, brown to multicolored, sub rounded gravel, fine to coarse grained sand</td>
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<td>4903.5</td>
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<td>4900.6</td>
<td>10</td>
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Appendix B

Laboratory Testing
<table>
<thead>
<tr>
<th>LAB NUMBER</th>
<th>LOCATION</th>
<th>DEPTH RANGE (feet)</th>
<th>CLASSIFICATION SYMBOL</th>
<th>FINESS SMALLER THAN 0.075 mm</th>
<th>SAND NO. 200(0.075 mm) TO NO. 4(4.76 mm)</th>
<th>GRAVEL NO. 4(4.76 mm) TO 3 IN.(76.2 mm)</th>
<th>LIQUID LIMIT - %</th>
<th>PLASTICITY INDEX - %</th>
<th>MAXIMUM DRY UNIT WEIGHT(D698) - PCF</th>
<th>OPTIMUM MOISTURE CONTENT - %</th>
<th>CONSOLIDATION - Pc - KSF</th>
<th>CONSOLIDATION - Cc</th>
<th>CONSOLIDATION - Cs</th>
<th>UNCONFINED, qu - KSF</th>
<th>COHESION, qu/2 - KSF</th>
<th>UNIT WT. (CONSOL) - DRY PCF</th>
<th>UNIT WT. (UNCONF) - DRY PCF</th>
<th>DIRECT SHEAR - DEGREES</th>
<th>NATURAL MOISTURE - %</th>
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<tr>
<td>29901</td>
<td>B-3</td>
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<td>CL</td>
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<tr>
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<td>B-9</td>
<td>12.5'-14.0'</td>
<td>CL</td>
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<td>4</td>
<td>30</td>
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<td>21.3</td>
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<td>38</td>
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<td>105.9</td>
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<td>21.3</td>
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<tr>
<td>31122</td>
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<td>38</td>
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<td>17.6</td>
<td>21.3</td>
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<tr>
<td>8379</td>
<td>B-11</td>
<td>12.5'-14.0'</td>
<td>CL</td>
<td>91</td>
<td>9</td>
<td>38</td>
<td>105.9</td>
<td>17.6</td>
<td>21.3</td>
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<tr>
<td>31123</td>
<td>B-12</td>
<td>8.0-9.0'</td>
<td>CL</td>
<td>91</td>
<td>9</td>
<td>38</td>
<td>105.9</td>
<td>17.6</td>
<td>21.3</td>
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**UNCONFINED COMPRESSION TEST**

### Sample Unit Load - KSF

<table>
<thead>
<tr>
<th>LAB NO.:</th>
<th>29897</th>
<th>LAB NO.:</th>
<th>29901</th>
<th>LAB NO.:</th>
<th>29904</th>
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</thead>
<tbody>
<tr>
<td>RATIO:</td>
<td>2.00</td>
<td>RATIO:</td>
<td>2.08</td>
<td>RATIO:</td>
<td>1.39</td>
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<tr>
<td>LOCATION:</td>
<td>B-1</td>
<td>LOCATION:</td>
<td>B-3</td>
<td>LOCATION:</td>
<td>B-4</td>
</tr>
<tr>
<td>DEPTH:</td>
<td>2.5-4.5'</td>
<td>DEPTH:</td>
<td>5.0-6.9'</td>
<td>DEPTH:</td>
<td>15.0-17.0'</td>
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</tbody>
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<table>
<thead>
<tr>
<th>TYPE OF BREAK</th>
<th>TYPE OF BREAK</th>
<th>TYPE OF BREAK</th>
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<tr>
<td><img src="image" alt="Y Type" /></td>
<td><img src="image" alt="Linear" /></td>
<td><img src="image" alt="Triangular" /></td>
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<table>
<thead>
<tr>
<th>% MOISTURE</th>
<th>19.8 %</th>
<th>% MOISTURE</th>
<th>21.3 %</th>
<th>% MOISTURE</th>
<th>21.5 %</th>
</tr>
</thead>
<tbody>
<tr>
<td>WET UNIT WT.</td>
<td>123.5 PCF</td>
<td>WET UNIT WT.</td>
<td>118.9 PCF</td>
<td>WET UNIT WT.</td>
<td>123.0 PCF</td>
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<td>DRY UNIT WT.</td>
<td>103.1 PCF</td>
<td>DRY UNIT WT.</td>
<td>98.0 PCF</td>
<td>DRY UNIT WT.</td>
<td>101.3 PCF</td>
</tr>
<tr>
<td>U.C. STRENGTH, qu</td>
<td>2.90 KSF</td>
<td>U.C. STRENGTH, qu</td>
<td>2.01 KSF</td>
<td>U.C. STRENGTH, qu</td>
<td>2.27 KSF</td>
</tr>
<tr>
<td>COHESION (qu/2)</td>
<td>1.45 KSF</td>
<td>COHESION (qu/2)</td>
<td>1.01 KSF</td>
<td>COHESION (qu/2)</td>
<td>1.14 KSF</td>
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</table>

**PROJECT:** MSU NAIC  
**SAMPLED BY:** DOWL HKM  
**PROJECT NO.:** 4522.11447.01  
**DATE SAMPLED:** 11/3/2014  

**DOWL HKM**
LIQUID AND PLASTIC LIMITS TEST REPORT

Dashed line indicates the approximate upper limit boundary for natural soils.

WATER CONTENT

LIQUID LIMIT

NUMBER OF BLOWS

MATERIAL DESCRIPTION

lean clay with sand
BULK SAMPLE

LL  PL  PI  %<#40  %<#200  USCS

35  16  19  94.4  75.5  CL

Project No.  4522.11447  Client: A&E ARCHITECTS
Project: MSU NAIC ENGINEERING BUILDING
Location: B-1  Sample Number: 7124  Depth: 2'-8'

Remarks:

Figure #  7124B

Tested By: TJM  Checked By: CEP
CONSOLIDATION TEST REPORT

<table>
<thead>
<tr>
<th>Natural Sat.</th>
<th>Moist. %</th>
<th>Dry Dens. (pcf)</th>
<th>LL</th>
<th>PI</th>
<th>Sp. Gr.</th>
<th>Overburden (ksf)</th>
<th>P_C (ksf)</th>
<th>C_C</th>
<th>C_S</th>
<th>Swell Press. (ksf)</th>
<th>Clipse. %</th>
<th>e_0</th>
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</thead>
<tbody>
<tr>
<td>82.5 %</td>
<td>26.5 %</td>
<td>89.9</td>
<td>36</td>
<td>13</td>
<td>2.68</td>
<td>0.534</td>
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MATERIAL DESCRIPTION

Project No.: 4522.11447.01  Client: A&E Architects
Project: MSU NAIC Engineering Building
Location: B-3 5.0-6.9'  Depth: 5.0-6.9'  Sample Number: 29901
Remarks: Sample No.29901
Sampled By: DOWL HKM

Figure 02
### CONSOLIDATION TEST REPORT

<table>
<thead>
<tr>
<th>Water Added</th>
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<table>
<thead>
<tr>
<th>Percent Strain</th>
<th>Applied Pressure - ksf</th>
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<tbody>
<tr>
<td>-3.6</td>
<td>0.1</td>
</tr>
<tr>
<td>-3.2</td>
<td>1</td>
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<td>-2.8</td>
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<td>-2.4</td>
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<tr>
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<td>0.0</td>
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<td>0.4</td>
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</thead>
<tbody>
<tr>
<td>77.5 %</td>
<td>21.1 %</td>
<td>96.6</td>
<td>2.68</td>
<td>1.546</td>
<td>2.99</td>
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<td>1.60</td>
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</tbody>
</table>

### MATERIAL DESCRIPTION

**USCS**

**AASHTO**

**Remarks:**
- Sample No. 29904
- Sampled By: DOWL HKM

**Project No.** 4522.11447.01  **Client:** A&E Architects
**Project:** MSU NAIC Engineering Building
**Location:** B-4 15.0-17.0'
**Depth:** 15.0-17.0'
**Sample Number:** 29904

**Figure 03**

Tested By:  
Checked By: MC
LIQUID AND PLASTIC LIMITS TEST REPORT

Dashed line indicates the approximate upper limit boundary for natural soils.

<table>
<thead>
<tr>
<th>Project No.</th>
<th>Client: A&amp;E ARCHITECTS</th>
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<tr>
<td>4522.11447</td>
<td>MSU NAIC ENGINEERING BUILDING</td>
</tr>
</tbody>
</table>

| Location: B-4 |
| Sample Number: 7125 |
| Depth: 17'-18.5' |

MATERIAL DESCRIPTION | LL | PL | PI | %<#40 | %<#200 | USCS |
<table>
<thead>
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Tested By: TJM  Checked By: CEP

Figure # 7125B
LIQUID AND PLASTIC LIMITS TEST REPORT

Dashed line indicates the approximate upper limit boundary for natural soils.

SOIL DATA

<table>
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<tr>
<th>SYMBOL</th>
<th>SOURCE</th>
<th>SAMPLE NO.</th>
<th>DEPTH</th>
<th>NATURAL WATER CONTENT (%)</th>
<th>PLASTIC LIMIT (%)</th>
<th>LIQUID LIMIT (%)</th>
<th>PLASTICITY INDEX (%)</th>
<th>USCS</th>
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<tbody>
<tr>
<td></td>
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<td>8376</td>
<td>1'-6'</td>
<td>21.3</td>
<td>21</td>
<td>35</td>
<td>14</td>
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</table>

Client: MT Dept of A & E  
Project: NAIC Phase 330  
Project No.: 4522.11447  
LAB #: 8376B
## Particle Size Distribution Report

### Test Results (ASTM C136 & ASTM C117)

<table>
<thead>
<tr>
<th>Opening Size</th>
<th>Percent Finer</th>
<th>Spec.* (Percent)</th>
<th>Pass? (X=Fail)</th>
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</tr>
<tr>
<td>1/2&quot;</td>
<td>99</td>
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<td>3/8&quot;</td>
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<td>#4</td>
<td>97</td>
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<td>#10</td>
<td>95</td>
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<tr>
<td>#20</td>
<td>94</td>
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</tbody>
</table>

### Material Description

- **Bulk Sample 
  - lean clay**

### Atterberg Limits (ASTM D 4318)

- PL = 21
- LL = 35
- PI = 14

### Classification

- USCS (D 2487) = CL
- AASHTO (M 145) = A-6(12)

### Coefficients

- \( D_{90} = 0.1084 \)
- \( D_{85} = \)
- \( D_{60} = \)
- \( D_{50} = \)
- \( D_{30} = \)
- \( D_{15} = \)
- \( D_{10} = \)
- \( C_u = \)
- \( C_c = \)

### Remarks

- (no specification provided)

### Date Received: 12/18/15  
**Date Sampled:** 12/18/15

### Tested By: CS  
**Checked By:** C Paulson

### Title: Materials Lab Manager

---

**Location:** B-9  
**Sample Number:** 8376  
**Depth:** 1'-6'

**Client:** MT Dept of A & E  
**Project:** NAIC Phase 330

**Project No:** 4522.11447  
**LAB #** 8376
Dry density, pcf

<table>
<thead>
<tr>
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<th>95</th>
<th>100</th>
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<td>15</td>
<td>17</td>
<td>19</td>
<td>21</td>
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</tbody>
</table>

Maximum dry density = 105.9 pcf
Optimum moisture = 17.6%

<table>
<thead>
<tr>
<th>Elev/Depth</th>
<th>Classification</th>
<th>Nat. Moist.</th>
<th>Sp.G.</th>
<th>LL</th>
<th>PI</th>
<th>% &gt; #4</th>
<th>% &lt; No.200</th>
</tr>
</thead>
<tbody>
<tr>
<td>1'-6'</td>
<td>CL</td>
<td>A-6(12)</td>
<td>21.3</td>
<td>2.65</td>
<td>35</td>
<td>14</td>
<td>3</td>
</tr>
</tbody>
</table>

TEST RESULTS

MATERIAL DESCRIPTION

Bulk Sample
lean clay

Project No.: 4522.11447  Client: MT Dept of A & E
Project: NAIC Phase 330
Location: B-9  Sample Number: 8376

Tested By: CS  Checked By: CEP
# Particle Size Distribution Report

## Material Description

*lean clay*

## Atterberg Limits (ASTM D 4318)

<table>
<thead>
<tr>
<th>Classification</th>
<th>PL</th>
<th>LL</th>
<th>PI</th>
</tr>
</thead>
<tbody>
<tr>
<td>AASHTO (M 145)</td>
<td>18</td>
<td>30</td>
<td>12</td>
</tr>
</tbody>
</table>

## USCS (D 2487) Classification

- CL

## Coefficients

- \( D_{90} = \) 
- \( D_{50} = \) 
- \( D_{30} = \) 
- \( D_{15} = \) 
- \( D_{10} = \) 
- \( C_u = \) 
- \( C_c = \)

## Remarks

- Sampled By: DOWL
- F.M. = 0.01

## Test Results

<table>
<thead>
<tr>
<th>Opening Size</th>
<th>Percent Finer</th>
<th>Spec. ( * ) (Percent)</th>
<th>Pass?</th>
<th>X=Fail</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#10</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#20</td>
<td>100.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#40</td>
<td>99.9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#80</td>
<td>99.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#100</td>
<td>99.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>#200</td>
<td>96.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* (no specification provided)

## Location

- Location: B-10
- Sample Number: 31120
- Depth: 4.0-6.0'

## Client

- Montana Department of Administration

## Project

- Norm Asbjornson Innovation Center

## Project No.

- 4522.11447.01

## Date

- Date Received: 12/18/15
- Date Tested: 
- Tested By: JM
- Checked By: MC
- Title: Lab Manager

## Date Sampled

- 12/18/15

## Figure

- 01
## Soil Description

- **Source of Sample:** B-10
- **Depth:** 13.0'-15.0'
- **Sample Number:** 31121
- **Date:** 12-18-15

### Grain Size Distribution

<table>
<thead>
<tr>
<th>SIEVE SIZE</th>
<th>PERCENT FINER</th>
<th>SPEC. *</th>
<th>PASS? (X=NO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>#10</td>
<td>100.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#20</td>
<td>99.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#40</td>
<td>99.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#80</td>
<td>97.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>#200</td>
<td>90.7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Atterberg Limits

- **PL:** 18
- **LL:** 38
- **Pl:** 20

### Coefficients

- **D_{90}**
- **D_{50}**
- **D_{10}**
- **C_{u}**
- **C_{c}**

### Classification

- **USCS:** CL
- **AASHTO:** A-6(18)

### Remarks

**Lean CLAY**

---

**Tetra Tech**

**Billings, MT**

**Client:** Montana Department of Administration

**Project:** Norm Asbjornson Innovation Center

**Project No:** 4522.11447.01-Phase

**Figure**
**UNCONFINED COMPRESSION TEST**

**SAMPLE UNIT LOAD - KSF**

<table>
<thead>
<tr>
<th>Compressive Stress, kips/ft²</th>
<th>Vertical Strain</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>0.010</td>
<td>0.020</td>
</tr>
<tr>
<td>0.020</td>
<td>0.030</td>
</tr>
<tr>
<td>0.030</td>
<td>0.040</td>
</tr>
<tr>
<td>0.040</td>
<td>0.050</td>
</tr>
<tr>
<td>0.050</td>
<td>0.060</td>
</tr>
<tr>
<td>0.060</td>
<td>0.070</td>
</tr>
<tr>
<td>0.070</td>
<td>0.600</td>
</tr>
</tbody>
</table>

---

**TYPE OF BREAK**

<table>
<thead>
<tr>
<th>SIEVE</th>
<th>% PASSING</th>
<th>LIQUID LIMIT</th>
<th>PLASTIC LIMIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4</td>
<td>100</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>20</td>
<td>100</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>40</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>200</td>
<td>96.1</td>
<td></td>
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</tr>
</tbody>
</table>

**CLASSIFICATION**

<table>
<thead>
<tr>
<th>USCS</th>
<th>AASHTO</th>
<th>DESCRIPTION</th>
<th>SPECIFIC GRAVITY</th>
</tr>
</thead>
<tbody>
<tr>
<td>CL</td>
<td>A-6(11)</td>
<td>LEAN CLAY</td>
<td></td>
</tr>
</tbody>
</table>

**% MOISTURE**

21.0%

**WET UNIT WT.**

116.8 PCF

**DRY UNIT WT.**

96.5 PCF

**U.C. STRENGTH, qu**

1.01 KSF

**COHESION (qu/2)**

0.51 KSF

**PROJECT:** Norm Asbjornson Center  
**LAB NO.:** 31120

**PROJECT NO.:** 4522.11447.01  
**SAMPLED BY:** DOWL

**LOCATION:** BH-10  
**DATE SAMPLED:** 12/18/2015

**DEPTH:** 4.0-6.0’  
**DATE TESTED:** 1/12/2016

**RATIO:** 2.09  
**PLATE NO.:** 01

---

**DOHL**
CONSOLIDATION TEST REPORT

Percent Strain

Applied Pressure - ksf

Water Added

<table>
<thead>
<tr>
<th>Natural</th>
<th>Dry Dens. (pcf)</th>
<th>LL</th>
<th>PI</th>
<th>Sp. Gr.</th>
<th>P_c (ksf)</th>
<th>C_c</th>
<th>Initial Void Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturation</td>
<td>Moisture</td>
<td>71.2 %</td>
<td>23.0 %</td>
<td>90.0</td>
<td>38</td>
<td>20</td>
<td>2.70</td>
</tr>
</tbody>
</table>

MATERIAL DESCRIPTION

Lean CLAY

USCS AASHTO

CL A-6(18)

Project No. 4522.11447.01- Client: Montana Department of Administration
Project: Norm Asbjornson Innovation Center
Source of Sample: B-10 Depth: 13.0'-15.0' Sample Number: 31121
Tetra Tech
Billings, MT

Remarks:

Figure
Sample Type: Undisturbed
Description: Lean CLAY
Specific Gravity: 2.70
Remarks:

Client: Montana Department of Administration
Project: Norm Asbjornson Innovation Center

Source of Sample: B-10  Depth: 13.0’-15.0’
Sample Number: 31121  Date Sampled: 12-18-15
UNCONFINED COMPRESSION TEST

Sample No. 1

Unconfined strength, ksf 3.359
Undrained shear strength, ksf 1.680
Failure strain, % 2.9
Strain rate, in./min. 0.060
Water content, % 22.7
Wet density, pcf 123.0
Dry density, pcf 100.3
Saturation, % 90.1
Void ratio 0.6811
Specimen diameter, in. 2.875
Specimen height, in. 6.000
Height/diameter ratio 2.09

Description: Lean CLAY

LL = 38 PL = 18 PI = 20 GS = 2.70 Type: Undisturbed

Project No.: 4522.11447.01-Phase 330
Date Sampled: 12-18-15
Remarks:

Client: Montana Department of Administration
Project: Norm Asbjornson Innovation Center
Source of Sample: B-10 Depth: 13.0'-15.0'
Sample Number: 31121
Appendix C

Photographs
Boring B-2 – View Northwest – Northwest Corner of Innovation Center Site

Boring B-2 – View Northeast – Northwest Corner of Innovation Center Site
Boring B-3 – View Northeast – South Central Portion of Innovation Center

Boring B-3 – View Northwest – South Central Portion of Innovation Center
Boring B-4 – View North – Northeast Corner of Innovation Center

Boring B-4 – View South – Northeast Corner of Innovation Center
View Southwest – Drilling Boring B-9

View West – Drilling Boring B-9
View Northwest – Drilling Boring B-11

View West – Drilling Boring B-11
View Northwest – Drilling Boring B-12

View West – Drilling Boring B-12
Appendix D

Screw Pile Information
Greg,
Thanks for contacting Alpine Site Services about using our screw pile foundation system as an alternate for the MSU Innovation Center project in Bozeman, MT. We appreciate your interest and do feel our system will work very well (again) for the project site soils and expected loads. As you remembered, Alpine does provide a thorough package documenting our piles and conducts load testing on all projects to ASTM standards.

I've attached our engineer's letter from the Gallatin Co. Detention Center project in '09 showing that our screw piles achieved 140kip compressive service loads, along with an almost 20kip lateral load (when installed with the concrete cap specified), with a safety factor of 2 and 2.6 respectively. Also, I've attached our Alpine brochure and some other information as you requested. As you said, screw piles would be a viable foundation given the lighter sand layers involved here, with the strong advantages of faster installation and verified loading provided by our load testing.

Alpine has completed several large parking garage structures throughout the Rocky Mountain region, including one in Jackson Hole, WY and one in Glenwood Springs, CO. Our screw pile system has proven capabilities on commercial, educational and industrial projects for over 12 years in all kinds of soils conditions, and with strict loading parameters. In fact, we've completed 6 major buildings for the Mesa State campus in Grand Junction, CO and many other private and public educational buildings in Colorado.

Thanks again for your interest and for thinking of Alpine for this project. Please contact me with any requests for further information, and please let us know about this project moving forward. I'll be sure and keep in touch with Martel Construction, as it was a pleasure working with them on the detention center project.

Mike Oliveira
(303) 994-3131 mobile

Alpine Site Services
10875 Dover Street, Suite 1100
Westminster, CO 80021
(303) 420-0048 office
ADVANTAGES

Save Valuable Time

- Engineered Screw piles are four times faster than drilled piers, caissons, and driven piles. With multiple machines, reduce your installation time even further.
- Because our machines easily access difficult sites and require far less space during installation than other methods, the rest of the site can be working at the same time.
- Our Screw piles work in virtually any weather. Your site keeps working while others are having a “snow day.”

Control Cost & Save Money

- All the costs for our Engineered Screw piles are presented up-front. Prices won’t change after the job is completed. You won’t experience “sticker shock” over post completion charges for extra length, casing or rock.
- Because of their design and installation process, Engineered Screw piles will always save you money over other deep foundation systems.

Proven Reliability

- Alpine’s Engineered Screw piles are load tested for verified performance you can rely on.
- Our patent pending torque monitoring system ensures consistency during installation.
- Throughout the process, data and charting output is provided for engineer’s verification and review.

Simple Change-Over

- Pre-engineered details/drawings make change-over a snap with rapid turn around on custom detailing and designs.

WHEN SHOULD YOU USE ENGINEERED SCREW PILES

- IF THE OVER-EXCAVATION DEPTH IS GREATER THAN 3’
- IF THE BEARING PSF IS 2500 OR LESS
- WHEN THE EXPECTED CAISSON, DRILLED PIER OR DRIVEN PILE DEPTH IS GREATER THAN 20’
- FOR DENSE MATERIAL OR SOIL, STONE, COBBLE AND BOULDERS
Typical Steps to Screwpile Engineering Integration

Structural Engineer of Record responsibilities:
1. Provide all project loading information (axial, tension and lateral loads)
2. Provide background drawings for Screwpile engineer to design pile layout
3. Coordinate pile location placement, with assistance from Screwpile Engineer
4. Review Screwpile shop drawings and Load Test provided by Alpine

Geotechnical Engineer responsibilities:
1. Provide Soils Report (Borings), consult with Alpine on difficult sites
2. Observe Pile characteristics and Load Testing
3. Inspect Installs for Depth & Torque, provide inspection logs

Screwpile Engineer responsibilities:
1. Design Pile & Pile Connection
2. Design Pile Layout
3. Review Load Test & Determine torque requirements
4. Review install logs & write project completion documents
March 6, 2009

Attn: Bernie Gochis
Alpine Site Services
5990 Kipling Parkway, Suite 001
Arvada, CO 80004

Re: Gallatin County Detention Center Lateral Load Test
Bozeman, MT
AEI Project #080251

Test Date: March 4, 2009

Dear Mr. Gochis,

At your request, a representative from our office has observed an in situ lateral load test and reviewed the results to verify that the intended pile and pile cap design is appropriate for the site. The test was performed using a built up assembly anchored with a single vertical pile and a single battered pile tied together with a steel plate and a high capacity hydraulic load cell to apply lateral load to the test pile and pile cap. The test generally followed the requirements of ASTM D1143.

The purpose of our test was to determine if the pile, pile cap, and backfill material will have sufficient lateral capacity to resist a seismic lateral load of 18,000 pounds as specified by the project Engineer of Record. A test pile, comprised of a single five and one-half inch outside diameter screw pile, 0.360 inch wall thickness, and two ¼ inch thick helices, was installed to a depth of 19'-0" from existing grade. The first helix was 12" in diameter and located approximately six inches from the tip of the pile. The second helix was 14" in diameter and located approximately 1'-4" above the first helix. The installation torque achieved at bearing depth was approximately 49,000 lb-ft. A 3'-4"x3'-4"x3'-0" deep concrete cap reinforced as indicated on the project documents was placed with the test pile cap plate embedded 6 inches into the base per the preliminary shop drawings provided by our office and cured to a final tested compression strength of approximately 3,200 psi. Backfill material was placed around the test assembly and compacted in 6 inch lifts as required for the site backfill per the geotechnical recommendations to a height approximately equal to the top of the concrete pile cap.

A lateral design load of 18,000 pounds was applied with a recorded deflection of 0.021 inches after a load rest duration of fifteen minutes. The loading was then increased to a load of 42,000 pounds with an additional load rest duration time of ten minutes where a relaxation occurred to a final proof load of 40,800 pounds with an associated final measured deflection of 0.071 inches. In the hope of determining a failure point, the lateral force was increased to a maximum load of 50,000 pounds. Over the course of a 22 minute loading rest, a relaxation of approximately 3,000 pounds occurred to a minimum maintained load of 47,000 pounds with an associated total final deflection of 0.113 inches. Although no failure was observed and the service level deflection limit had still not been reached, the load test was concluded. The pile and pile cap assembly rebounded as the test load was released to a deflection of 0.062 under zero load, indicating that the pile behaved in a linear elastic manner, with an acceptable total lateral movement. It is likely the remaining deflection is due to the friction force between the concrete cap and surrounding soil at this deflection point had become greater than the force exerted by the pile shaft returning to the original un-deflected shape.

This test established that the pile and pile cap foundation system will have sufficient lateral capacity with the controlled structural fill specified in the geotechnical report to resist the seismic lateral loading provided by the Engineer of Record. Although a deflection limit of 3/8 inch was set for the service level load of 18,000 pounds, this deflection was not achieved even at an ultimate proof load of 47,000 pounds. Based on the lateral load test
information detailed above, the pile and concrete pile cap are sufficient to provide 18,000 pounds of lateral resistance with negligible deflection and a minimum safety factor of 2.6. Piles shall be placed such that there is adequate concrete cover provided (2” minimum), and no more than 3” out of dimensioned location. Piles placed singly, or in pairs, such that they support a discrete column load, shall be evaluated on a case-by-case basis considering the actual service load so that an allowable tolerance may be established.

Pile Material Test Specimens:

Pile test samples will be taken from the pile fabrication yard at Alpine Site Services, as well as from the project site during installation. The samples are to be collected and delivered to a material testing company for testing. The pile sections will be tested to verify the structural properties of the pipe material. For the 140 kip pile, the minimum f_y for the steel must meet or exceed 70 ksi, and the minimum nominal material thickness must be 0.360 inches for the pipe shaft wall thickness. Samples shall be taken for testing from the site at the rate of one sample per 200 sections or portions thereof of piling installed.

Installation Torque Logs:

Installation Torque Logs will be reviewed as they become available during production pile installation. Review of the logs will verify that minimum required torques per the compression load test documentation were achieved, and/or that satisfactory steps were taken to correct any piers that did not achieve specified torque. Special Inspection reports provided by the geotechnical engineer will also be reviewed to verify that minimum installation depths are achieved, or that acceptance was provided for any piers that did not meet the minimum depth requirement.

Should questions arise, or if further information is required, please contact our office.

Sincerely,
Anchor Engineering & Inspection, Inc.

Reviewed by,

Richard M. Schauppner, P.E.
Project Manager

Eric A. Hanson, P.E.
Principal