CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

GEOTECHNICAL STUDY

Gunnison West Park
Gunnison, Colorado

Report Prepared for:

Ms. Ashley Hejtmanek
Design Workshop
120 East Main Street
Aspen, CO 81611

Project No. 20.6066
October 28, 2020

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Report Prepared by:

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Principal, Manager - Salida and Crested Butte

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

COMMON ABBREVIATIONS

AASHTO .... **American Association of State Highway and Transportation Officials**
ABC .... **aggregate base course**
ACI .... **American Concrete Institute**
ADA .... **Americans with Disabilities Act**
ADSC .... **Association of Drilled Contractors**
AI .... **Asphalt Institute**
APM .... **asphalt paving material**
ASCE .... **American Society of Civil Engineers**
ASTM .... **American Society for Testing and Materials**
AWWA .... **American Water Works Association**
bgs .... **below ground surface**
CDOT .... **Colorado Department of Transportation**
CBR .... **California Bearing Ratio**
CFR .... **Code of Federal Regulations**
CGS .... **Colorado Geological Survey**
CKD .... **cement of kiln dust stabilized subgrade**
CMU .... **concrete masonry unit**
CTB .... **cement treated base course**
deg .... **degree**
EDLA .... **equivalent daily load application**
e_m .... **edge moisture variation distance**
EPS .... **expanded polystyrene**
ESAL .... **equivalent single axle loads**
f'c .... **specified compressive strength of concrete at the age of 28 days**
F_a .... **seismic site coefficient**
FHWA .... **Federal Highway Administration**
FS .... **factor of safety**
F_V .... **seismic site coefficient**
GSA .... **global stability analysis**
GVW .... **gross vehicle weight**
HMA .... **hot mix asphalt**
IBC .... **International Building Code**
ICC-ES .... **International Code Council Evaluation Services, Inc.**
IRC .... **International Residential Code**
kip .... **1,000 pounds-force**
km .... **kilometer**
LTS .... **lime treated subgrade**
MDD .... **maximum dry density**
mg/L .... **milligrams per liter**
MGPEC .... **Metropolitan Government Pavement Engineers Council**
mm .... **millimeter**
Mr .... **resilient modulus**
MSE .... **mechanically stabilized earth**
mV .... **millivolts**
NAPA .... **National Asphalt Pavement Association**
N_{DESIGN} .... **design gyrations**

OSHA .... **Occupational Safety and Health Administration**
OMC .... **optimum moisture content**
OWTS .... **onsite wastewater treatment system**
PCA .... **Portland Cement Association**
PCC .... **portland cement concrete**
pcf .... **pounds per cubic foot**
pci .... **pounds per cubic inch**
pH .... **power of hydrogen**
psf .... **pounds per square foot**
psi .... **pounds per square inch**
PT .... **post-tension**
S_s .... **mapped spectral accelerations for short periods**
UBC .... **Uniform Building Code**
USGS .... **United States Geological Survey**

1. PURPOSE

1.1 GENERAL

Cesare, Inc. (Cesare) performed a geotechnical study for the proposed Gunnison West Park to be located in Gunnison, Colorado. The study was made to characterize existing subsurface conditions at the site and assist in determining design criteria for planning, site development, foundation systems, interior floor systems, exterior flatwork, surface and subsurface drainage adjacent to structures, and to present other pertinent geotechnical issues. Information gathered during the field exploration and laboratory testing is summarized in Figure 1 and Appendices A through C. Cesare's opinions and recommendations presented in this report are based on data generated during this field exploration, laboratory testing, and its experience.

1.2 SCOPE OF SERVICES

The scope of services performed is detailed in Cesare's Proposal Agreement No. SC200504 which was executed on August 18, 2020.

2. SUMMARY OF FINDINGS AND CONCLUSIONS

This section is intended as a summary only and does not include design details. The report should be read in its entirety and utilized for design.

- Soil consists of gravelly sands to sandy gravels to the full depths explored of 10 to 20 feet. Less than a foot of fill was encountered in Exploratory Boring TH-1 and the upper 3 feet of soil below the topsoil in Exploratory Boring TH-2 may be fill from a previous leach field. Groundwater was encountered at depths of 2 to 4.5 feet at the time of drilling and 31 days after drilling.
- Spread footings or pad type foundations are adequate for support of proposed structures. Slab-on-grade floors are adequate for interior floor systems.
- Good surface drainage should be established and positive drainage away from the structures, pavement, and other site improvements should be provided during construction and maintained throughout the life of the proposed structures. Below grade areas, such as basements are not recommended due to high groundwater conditions.
- The subgrade beneath proposed roadways are considered excellent for pavement support. As such, the recommended pavement section is 3 inches of APM over 6 inches of ABC.

3. SITE CONDITIONS

The site is located in Gunnison, Colorado. A vicinity map is shown in Figure 1. The site is the former property of the Lazy K Ranch. The site is bound by West Tomichi Avenue and residences to the north, residences to the east, West Gunnison Avenue to the south, and the Gunnison River to the west. There are structures associated with the Lazy K Ranch consisting of four cabins and a clubhouse/office in the northern portion of the site south of West Tomichi Avenue. The structures are accessed via gravel drives from West Tomichi Avenue. The southern portion of the site is currently vacant undeveloped land. There is evidence of previous development onsite, including abandoned wells, abandoned utility services, concrete slabs, and a foundation excavation. The foundation excavation is located at the northeastern corner of West Gunnison Avenue and 3rd Street. This excavation had cattails indicating it is at or below the groundwater table.

3rd Street bisects the site from the south to the north. 3rd Street is a gravel roadway. A series of five ponds bisect the site in a general east/west direction. The ponds had water and are interconnected by a ditch. The water in the ponds were at an elevation about 2 to 4 feet lower than the site at the time of this study. There are two pedestrian/light vehicle crossings and a culvert crossing on 3rd Street over the ditch.

The topography of the site is flat with a grade change of about 7 feet to the west. There is a shallow (less than 3 feet) depression west of the clubhouse/office building. Vegetation onsite consists of native grasses and deciduous trees. There are numerous stockpiles onsite. The origin of the material from these stockpiles is unknown, however, the stockpile located at the intersection of 3rd Street and West Gunnison Avenue was likely derived from the foundation excavation nearby. There are no bedrock outcrops onsite or near the site.

4. PROPOSED CONSTRUCTION

The proposed construction includes Phase I of a park which is about 8.2 acres and includes a restroom structure. There are two areas of residential development. One area is about 2 acres in size and exists south of West Tomichi Avenue in the vicinity of the existing structures. Another area of residential development is along West Gunnison Avenue and is about 0.75 acres in size. The exact nature of the residential development is unknown but will likely consist of a mix of multi- and single-family structures with paved access parking. The structures will likely not have basements and will be serviced by municipal water and sanitary sewer. Site grading is anticipated. Cesare anticipates grading to be less than 3 feet. A site plan showing existing features and proposed construction is shown in Figure 1.

5. GEOLOGIC CONDITIONS

The "Geologic Map of the Gunnison Quadrangle, Gunnison County, Colorado" prepared for the CGS by Stork, et al., dated 2006, indicates that surficial deposits onsite consist of:

- Alluvial deposits.

6. FIELD EXPLORATION

Subsurface conditions were explored on September 4, 2020 by drilling eight exploratory borings at the locations indicated in Figure 1. Borings were drilled 10 to 20 feet deep. Graphical logs of the subsurface conditions observed and further explanation of the exploration performed are presented in the Logs of Exploratory Borings and accompanying Key to Symbols contained in Appendix A.

Photo 1. View looking at drilling of TH-2.

7. LABORATORY TESTING

Cesare personnel returned samples obtained during field exploration to its laboratory where professional staff visually classified them and assigned testing to selected samples to evaluate pertinent engineering properties. Laboratory tests performed are listed in Table 7.1. Further discussion of laboratory testing and the laboratory test results are presented in Appendix B.

TABLE 7.1. Laboratory Testing Performed

Laboratory Test	To Evaluate
Grain size analysis	Grain size distribution for classification purposes.
Atterberg limits	Soil plasticity for classification purposes.
Water soluble sulfate content	Potential corrosivity of the soil on cementitious material.

8. SUBSURFACE CONDITIONS

Cesare's exploratory borings encountered:

- Less than a foot of fill in Exploratory Boring TH-1. In Exploratory Boring TH-2, the upper 2.5 feet of material below the topsoil may be fill, possibly associated with a leach field.
- Overburden soil consisting of gravelly sand to sandy gravel to the depths explored. The soil is silty and contains cobbles to boulders up to 14 inches in dimension.
- No bedrock was encountered to depths of 10 to 20 feet.
- Groundwater was measured at depths of 2 feet to 4.5 feet at the time of drilling.

- Thirty-one days after drilling, groundwater was encountered at depths of 2 to 4.5 feet in Exploratory Borings TH-4, TH-5, and TH-8.
- Exploratory Borings TH-1 to TH-3, TH-6, and TH-7 caved at depths of 2 to 4 feet at the time of drilling.

The subsurface conditions encountered in Cesare's exploratory borings are reasonably consistent with those described in Section **5. GEOLOGIC CONDITIONS**. These observations represent conditions at the time of field exploration and may not be indicative of other times or other locations.

9. GROUNDWATER

Groundwater was encountered and temporary monitoring wells were installed in Exploratory Borings TH-4, TH-5, and TH-8 to monitor groundwater levels. The temporary monitoring wells consisted of 5 feet of PVC slotted pipe in the lower portion of the piezometer. Refer to Figure 2 for details of well construction. A Notice of Intent (NOI) was submitted to the Colorado Department of Water Resources (DWR) at least 3 business days prior to drilling the borings and installation of the wells. All temporary monitoring wells must be abandoned within 18 months of installation in accordance with DWR abandonment requirements, unless the wells are permitted as permanent monitoring wells. When groundwater monitoring is completed, Cesare can abandon each of the monitoring wells, when directed by the Client. Fees for abandoning the wells are not included in this study.

Cesare anticipates the groundwater levels to mimic the level of water in the ponds. Groundwater can be expected to fluctuate and can be influenced by variations in seasons, weather, precipitation, drainage, vegetation, landscaping, irrigation, leakage of water and/or wastewater systems, etc., both onsite and offsite. Discontinuous zones of perched water may exist over ice lenses during spring snowmelt. Cesare's field explorations were performed during the fall when groundwater levels are usually lowest. Groundwater levels will be higher in the spring and early summer.

10. GEOLOGIC HAZARDS

The following subsections present a cursory review of geologic publications and data gathered during this study. A detailed geologic hazards assessment is not the focus of Cesare's scope of service.

10.1 HIGH GROUNDWATER

Groundwater was encountered within 2 feet of the surface. Groundwater levels are expected to be higher during late spring and early summer when flows within the Gunnison River are higher. Groundwater will impact below grade construction, including utilities and foundations. Basements are not recommended, and any crawlspaces should be established above existing grade. Foundations should be established as high as reasonably possible.

10.2 ABANDONED MINES

No abandoned mines are known to exist below or in the vicinity of the property. Risks associated with settlement due to abandoned mines is considered nil.

10.3 RADON

The U.S. Environmental Protection Agency map of radon zones indicates that virtually all of western

Colorado, including Gunnison County, is in Zone 1 (www.epa.gov/radon/zonemap.html). Although there is no known safe level of radon, Zone 1 is the zone of highest risk for exposure to radon gas [i.e., greater than 4 picoCuries per Liter (pCi/L)]. The Colorado Geological Survey (CGS) participated in an EPA study in 1987 and 1988 to record indoor radon levels throughout Colorado residences and compiled its results in a report that related geologic setting and building construction with radon levels (CGS 1991 Open-File Report 91-4). Residences with basements had higher levels of radon than residences built on grade on the same geologic material. Radon values in alluvial and glacial valley fill were highly variable. The CGS is careful to state that radon potential can vary considerably within the same geologic unit due to the non-uniform distribution of uranium, secondary leaching, and the accumulation of uranium and other radioactive elements into other strata.

Based on levels of radon recorded in existing residences in the region and the presence of rock types that are known to produce radon, it is reasonable to assume that radon emission into buildings is occurring in the Gunnison area. The EPA, the Colorado Department of Public Health and Environment (CDPHE) Radiation Management Division, and the National Association of Home Builders (NAHB) recommend that all new residences constructed in Zone 1 include radon-resistant features. These organizations also recommend that after the building is constructed, radon should be measured and if the results are greater than 4 pCi/L, the system should be upgraded from passive to active (usually by installing a fan). In the EPA publication titled, "Building Radon Out: A Step-by-Step Guide on How to Build Radon-Resistant Homes" (USEPA Office of Air and Radiation EPA/402-K-01-002, April 2001), three practical and inexpensive alternatives for passive, sub-slab depressurization systems are presented: gravel with vents, perforated pipes, or soil gas collection mats. Recommendations for passive and active design and construction techniques for reducing radon gas can be found on the EPA radon website www.epa.gov/radon or the CDPHE radon website www.cdphe.state.co.us/hm/rad/radon.

11. FOUNDATION RECOMMENDATIONS

11.1 SPREAD FOOTINGS

The proposed structure may be founded on conventional spread footings or pad type footings bearing on the natural, undisturbed soil or on controlled, structural fill below frost depth and below any existing manmade fill in accordance with the following design recommendations:

a) A frost depth of 30 inches (City of Gunnison Building Permit Packet, April 2010).
b) The structures should be founded entirely on native soil or entirely on structural fill, but not a combination of the two.
c) The footings should be designed for a maximum allowable soil bearing pressure of 3,000 psf based on dead load plus full live load.
d) Continuous footings should have a minimum width of 16 inches and isolated pad type footings should have a minimum dimension of 18 inches. Using the soil pressure recommended above, Cesare estimates the maximum settlement for the structure will be on the order of 1 inch, with differential settlement, potentially on the order of 0.5 inches. Footings should be proportioned as much as practicable to reduce differential settlement.
e) Steel reinforcement for continuous concrete foundation walls should be designed to span localized settlements over a distance of 10 feet.
f) All soft or loose soil beneath footing areas should be redensified in place, or removed and

replaced with properly compacted structural fill, suitable flow fill, or concrete prior to placement of footing concrete.

g) Particles greater than 12 inches in dimension should be removed from exposed footing subgrade.

h) Removal of cobbles and/or boulders from the soil at the foundation elevation can result in depressions. These resulting depressions can be backfilled with compacted onsite soil or concrete.

i) All footing excavations should be observed by a Cesare representative prior to placement of concrete to determine if bearing conditions are consistent with those assumed to develop its recommendations.

12. LATERAL EARTH PRESSURES

12.1 FOUNDATION WALLS

Lateral pressures on walls depend on the type of wall, hydrostatic pressure behind the wall, type of backfill material, and allowable wall movements. Cesare recommends drain systems be constructed behind walls that are entirely above existing grade to reduce the potential for hydrostatic pressures to develop. Where anticipated/permissible wall movements are greater than 0.5% of the wall height, lateral earth pressures can be estimated for an "active" condition. Where anticipated wall movement is less than approximately 0.5% of the wall height or wall movement is constrained, lateral earth pressures should be estimated for an "at rest" condition. Recommended lateral earth pressures for onsite material are provided in Table 12.1.

The recommended values for lateral earth pressures provided in Table 12.1 are given in terms of an equivalent unit weight. The equivalent unit weight multiplied by the depth below the top of the ground surface is the horizontal pressure against the wall at that depth. The resulting pressure distribution is a triangular shape. These soil pressures are for horizontal backfill with no surcharge loading. If these criteria cannot be met, Cesare should be contacted for additional criteria.

The unfactored or ultimate coefficients of sliding resistance between concrete and bearing soil are provided in Table 12.1.

TABLE 12.1. Lateral Earth Pressures and Coefficients of Sliding Resistance for Onsite Material

Backfill Material Type	Equivalent Unit Weight (pcf)			Coefficient of Sliding Resistance
	Active	At Rest	Passive	
Onsite soil above GWT*	45	35	220	0.8
Onsite soil below GWT*	90	75	280	0.8

*groundwater table

12.2 THRUST BLOCK LOADS

The subsurface conditions at the proposed sewer and water line locations consists of gravelly sands and sandy gravels. Thrust blocks placed within the gravelly sand and sandy gravel should be designed for a maximum allowable lateral soil bearing pressure of 200 psf/feet of depth. For example, if the thrust block is placed 6 feet deep, then 200 (psf/feet) x 6 (feet) = 1,200 psf.

13. INTERIOR FLOORS

The natural sandy and gravelly soil exhibited zero swell potential. Concrete slabs placed on this material or on properly placed structural fill comprised of this material do not require special considerations for accommodating movement as a result of moisture sensitive soil.

13.1 SLAB-ON-GRADE CONSTRUCTION DETAILS

Cracking of slabs-on-grade can occur as a result of compressing of the supporting soil but also as a result of concrete curing stresses. If slab-on-grade floors are chosen, Cesare recommends that design and construction of all interior slab-on-grade floors incorporate the following considerations and precautions. These details will not reduce the amount of movement but are intended to reduce potential damage should some settlement of the supporting subgrade take place. The ACI Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.R-96)" should be consulted regarding methods/techniques to reduce the occurrence of concrete shrinkage cracks and other potential issues associated with concrete finishing and curing.

a) A vapor barrier is recommended beneath concrete slabs-on-grade that will support equipment sensitive to moisture or will be covered with wood, tile, carpet, linoleum, or other moisture sensitive or impervious coverings. Location of the vapor barrier should be in accordance with recommendations provided by ACI 302.2R-06, "Guide for Concrete Slabs that Receive Moisture-Sensitive Flooring Materials."
b) Backfill in the utility trenches beneath slabs should be compacted as specified in Section **16. STRUCTURAL FILL/BACKFILL SOIL.**
c) Plumbing and utilities that pass through the slab should be isolated from the slabs.
d) Separate slabs from foundation walls, interior columns, and utilities with a joint which allows/provides free vertical movement of the slab (i.e., floating slab construction).
e) Provide frequent control joints in the slab. Refer to ACI 302.1R-15.

13.2 STRUCTURALLY SUPPORTED FLOORS

A floor system that is supported by the foundation system and has an air or void space (typically a crawlspace) below the floor so that it is not in contact with the underlying soil/bedrock material is considered a structurally supported or structurally suspended floor. If potential movement of slab-on-grade floors and associated cracking/distress are not considered tolerable by the owner, developer, architect, or structural engineer for any reason, a structurally supported floor should be provided.

There are design and construction issues associated with structurally supported floors that must be considered, such as ventilation and lateral loads. Where structurally supported floors are installed, the minimum required air space depends on the material used to construct the floor. Building codes require a clearance space of at least 18 inches above exposed earth if untreated wood floor components are used. Where other support material is used, a minimum clearance space of 8 inches is recommended. This minimum clearance space should be maintained between any point on the underside of the floor system (including beams and plumbing) and the surface of the exposed earth. The minimum clearance between the crawlspace ground surface and the structural floor members and suspended plumbing should be constructed to meet minimum code or recommended clearances.

Where structurally supported floors are used, utility connections, including water, gas, air duct, and exhaust stack connections to floor supported appliances should be capable of absorbing some deflection of the floor. Plumbing that passes through the floor should ideally be hung from the underside of structural floor and not lay on the bottom of the excavation. This configuration may not be achievable for some parts of the installation. It is prudent to maintain the minimum clearance space below all plumbing lines. If trenching below the lines is necessary, Cesare recommends sloping these trenches so they discharge to the foundation drain. Penetrations through the foundation wall should allow for at least 1 inch of clearance and be provided with flexible connections. The ground surface below the structurally supported floor should be sloped to the perimeter drain.

Control of humidity in crawlspaces is important for indoor air quality and performance of wood floor systems. An engineering professional with expertise in the design and construction of crawlspace humidity control should be contacted.

14. EXTERIOR FLATWORK

Flatwork supported on foundation wall backfill may settle and crack if the backfill is not properly moisture conditioned and compacted.

Exterior flatwork should be isolated from the structures. Exterior flatwork should be expected to move, although measures can be incorporated into construction to limit the movement or effects of the movement. Cesare recommends flatwork not be doweled into structure foundations, but rather supported on a haunch to limit settlement. The haunch should extend the full length of the slab.

Exterior flatwork, such as driveways and sidewalks, are normally constructed as slabs-on-grade. Porches and patios are increasingly constructed as structurally supported slabs, which in Cesare’s opinion, is the most positive means of keeping slabs from moving and adversely affecting the operation of doors or means of egress. Cesare recommends that landings and slabs at egress doors, as well as porches and patios, be constructed as structurally supported elements if potential movement cannot be tolerated.

Simple decks that are not integral to the structure and can tolerate foundation movement can be constructed with less substantial foundations. A short pier or footing bottomed below frost depth can be used if movement is acceptable and if acceptable by local building requirements. Use of deeper foundation elements can reduce potential movement. Footings or short piers should not be underlain by wall backfill, due to risk of settlement. Inner edges of decks may be constructed on haunches and detailed such that movement of the deck foundations will not cause distress to the structure.

14.1 OVERHANGING ROOFS

Porches, patios, or decks with overhanging roofs that are integral to the structure, such that foundation movement cannot be tolerated, should be constructed with the same foundation type as the structure.

15. EXCAVATIONS

Conventional earthmoving equipment should be adequate to excavate the onsite soil. Groundwater should be expected in all excavations, especially during irrigation season. The gravelly sands and sandy gravels will flow below the groundwater table. Below grade construction below the groundwater table will require temporary dewatering. All excavations should be properly sloped and/or braced, and local and federal safety codes should be observed. Slopes and other areas void of vegetation should be protected against erosion. If temporary shoring is required, a contractor specializing in design and construction of shoring should be contacted.

It is the contractor's responsibility to provide safe working conditions and comply with the regulations in OSHA Standards-Excavations, 29 CFR Part 1926. The following guidelines are provided for planning purposes. Sloping and shoring requirements must be evaluated at the time of construction by the contractor's competent person as defined by OSHA. OSHA classifications for various material types and the steepest allowable slope configuration corresponding to those classifications are shown in Table 15.1.

TABLE 15.1. Allowable Slope Configuration for Onsite Material

Material Type	OSHA Classification	Steepest Allowable Slope Configuration*
All soils	Type C	1-1/2:1

* Units horizontal to units vertical. The values shown apply to excavation less than 20 feet in height. Conditions can change and evaluation is the contractor's responsibility.

The classifications and slope configurations in Table 15.1 assume that excavations are above the groundwater table, there is no standing water in the excavations, and there is no seepage from the slope into the excavations, unless otherwise specified. The above classifications and slope configurations assume that the material in the excavations is not fractured, adversely bedded, jointed, nor left open to desiccate, crack, or slough, and is protected from surface runoff. There are other considerations regarding allowable slope configurations that the contractor is responsible for, including proximity of equipment, stockpiles, and other surcharge loads to the excavation. The contractor's competent person is responsible for all decisions regarding slope configuration and safety conditions for excavations.

Excavations should not undermine existing foundation systems of structures or infrastructure unless they are adequately protected. At a minimum, new excavations should not intersect a line drawn on a 34 degree angle down and away from the bottom edge of the existing foundation systems or bottom edge of infrastructure. If this condition cannot be met, shoring or staged excavations may be required. If shoring is required, a condition survey of the adjacent structures is recommended before construction starts and upon completion of construction. In Cesare's experience, condition surveys include, but may not be limited to, photographs of any distress to adjacent structures.

Permanent slopes should be no steeper than 2:1 and should be revegetated or otherwise protected from erosion.

16. STRUCTURAL FILL/BACKFILL SOIL

Where fill/backfill soil is necessary, the suitable onsite inorganic soil may be used below, around, and above the structure. At this site, unsuitable material is defined as topsoil, organics, trash, ash, frozen material, hard lumps, and clods, and particles that are larger than 3 inches. Existing onsite fill material can be reused for structural fill/backfill, provided it is free of unsuitable material. If unsuitable material is encountered in the existing fill, it cannot be reused as fill/backfill. Recommendations for fill/backfill placement are:

a) Fill/backfill material should be placed in loose lifts and compacted in accordance with Table 16.1
b) Maximum loose lift thickness shall be 8 inches, depending on the type of equipment used to apply compactive effort, and shall be reduced if the specified compaction cannot be obtained with the equipment used.
c) Fill/backfill should not be placed if material is frozen or if the surface upon which fill/backfill is to be placed is frozen.
d) Fill/backfill material should be placed and spread in horizontal lifts of uniform thickness in a manner that avoids segregation.
e) Placement surface should be kept free of standing water, debris, and unsuitable material during placement and compaction of fill/backfill material.
f) Fill/backfill maximum allowable particle size is 3 inches. Do not incorporate oversize material in the fill/backfill that is incapable of being broken down by the equipment and methods being employed to process and compact the fill/backfill. Process and compact material in the lift, as necessary, to produce the specified fill/backfill characteristics. If oversize particles remain in the lift after processing and compacting, remove oversize material to produce a fill/backfill within specified requirements.
g) Overlot fill placement beneath structures and pavements and compaction should be observed and tested on a full-time basis by a representative of Cesare. At a minimum, utility trench backfill should be tested in accordance with jurisdictional requirements.

TABLE 16.1 Compaction Specifications

Material Type (General)	AASHTO Classification	Material Thickness* (ft)	Moisture Content (%)	Relative Compaction (%)	Compaction Standard
Granular material that is clean to silty	A-1, A-2-4, A-2-5, A-3, A-4, A-5	<15	+2% of OMC	>95%	Standard Proctor (ASTM D698)
Fine grained material and granular material with plastic fines	A-2-6, A-2-7 A-6 A-7	<15	+2% of OMC	>95%	Standard Proctor (ASTM D698)

* If fill thickness greater than 15 feet is planned, additional requirements may apply.

16.1 IMPORT FILL

Material imported for structural fill should be tested and approved for use onsite by the project geotechnical engineer prior to hauling to the site. Proctor and classification tests should be conducted to determine if the fill meets required specifications. Fill material should be well graded meeting the specifications in Table 16.2.

TABLE 16.2. Import Fill Specifications

Soil Parameter	Specification
Maximum particle size	3 inch
Percent finer than No. 200 sieve	Maximum 20%
Liquid limit	Maximum 30%
Plasticity index	Maximum 15%

17. SUBSURFACE DRAINAGE

Due to the existence of high groundwater conditions, Cesare recommends that no basements be planned. Crawlspaces and lowest floor elevations should be founded as high as reasonably possible.

Cesare recommends that crawlspaces constructed above existing grade be provided with an exterior perimeter subsurface drainage system. The system shall be sloped to drain to a suitable gravity outlet or a sump. A pump shall be installed if a sump is used. The drainage system shall consist of perforated, machine slotted, or equivalent rigid plastic pipe placed around the perimeter of the crawlspace foundation. Pipes with a smooth interior are recommended. Pipes that are corrugated on the interior can become obstructed more easily than pipes with smooth interiors and may be more difficult to clean.

Cesare recommends exterior perimeter drains rather than interior perimeter drains for most conditions because for water to reach interior perimeter drains, it must first pass beneath the foundations. This increases the risk of wetting the soil beneath the foundations, which increases the risk for foundation movement. It is difficult to quantify the increase in risk associated with using interior rather than exterior perimeter drains, but foundation movement can cause distress to structures, such as cracking of walls, slabs, and finishes, and out-of-plumb doors and windows.

18. SURFACE DRAINAGE

Good drainage and surface water management is important. Performance of site improvements, such as foundations, floors, hardscape, and pavement are often adversely affected by failing to establish and/or maintain good site drainage. Grades must be adjusted to provide positive drainage away from the structure, pavement, and other site improvements during construction and maintained throughout the life of the proposed facility. The following drainage precautions are recommended:

a) The ground surface around the perimeter foundation walls should be sloped to drain away from the structure in all directions. Current building codes require a minimum slope of 6 inches in the first 10 feet of the structure (5%). At the completion of construction, Cesare recommends a continuous slope away from foundations of 12 inches in the first 10 feet (10%), where site constraints permit. Cesare recommends that concrete and pavement adjacent to structures slope at a rate of at least 2% away from the structure or as otherwise required by ADA criteria. Maximum grades practical should be used for paving and flatwork to prevent areas where water can pond.
b) Joints that occur at locations where paving or flatwork abuts the structure should be properly sealed with flexible sealants and maintained.
c) The ground surface should be sloped so that water will not pond between or adjacent to structures and other site improvements. Curbs, sidewalks, paths, plants, or other

improvements should not block, impede, or otherwise disrupt surface runoff. Use of chases and weep holes to promote drainage is encouraged. Landscape edging should be perforated or otherwise constructed in a manner to prevent ponding of surface water, especially in the vicinity of the backfill soil.

d) Drainage swales should be located as far away from the foundation as practicable.
e) If site constraints do not allow for the recommended slopes, the project civil engineer shall provide a method for drainage that is equivalent to the recommendations herein. Water should not be allowed to pond adjacent to or near foundations, flatwork, or other improvements.
f) Roof downspouts and other water collection systems should discharge onto pavements or extend away from the structure well beyond the limits of the backfill zone using downspout extensions, appropriately sized splash blocks, or other means. Buried downspout extensions are discouraged as they can be difficult to monitor and maintain.
g) Irrigation directly adjacent to the structure is discouraged and should be minimized. Sprinkler lines, zone control boxes, and sprinkler drains shall be located outside the limits of the foundation backfill. Sprinkler systems should be placed so that the spray from the heads, under full pressure, does not fall within 5 feet of the foundation walls.
h) Plants, vegetation, and trees that require moderate to high water usage are discouraged and should not be located within 3 feet of foundation walls.
i) Plantings that are desired within 5 feet of the foundation should be placed in watertight planters/containers.
j) The project civil engineer shall perform measurements to document that positive drainage, as described in this section or as otherwise designed by the project civil engineer, is achieved. Maintenance of surface drainage is imperative subsequent to construction and is the responsibility of the owner and/or tenant.

18. PAVEMENT RECOMMENDATIONS

18.1 DESIGN CRITERIA

The pavement recommendations contained in this report are based on the Colorado Department of Transportation (CDOT) pavement Design Manual, 2012 and the design parameters indicated in Table 18.1.

TABLE 18.1. Pavement Design Parameters

Design Parameter	Value
Design period (years)	20
Initial serviceability (ρ_s)	4.5
Terminal serviceability (ρ_t) (local/collector)	2.0/2.5
Serviceability loss, (ρ_s-ρ_t) (local/collector)	2.5/2.0
Reliability, Z_r (%)	80
Overall standard deviation, S_o (APM)	0.44
Total 18 kip ESAL's • Local • Collector (3rd Street)	 60,000 150,000
Subgrade strength • R-value (estimated gravelly sand/sandy gravel)	 45

Deviation from the parameters shown in Table 18.1 will require a revision to the recommended pavement section thicknesses. If the subgrade becomes saturated, the pavement is not properly maintained, and/or the actual traffic is greater than the values used in the design, the design service life will be reduced.

18.2 PAVEMENT THICKNESSES

The shallow subgrade soil consists of the gravelly sands and sandy gravels. According to FHWA-RD-97-083 *Design Pamphlet for the Determination of Design Subgrade in Support of the 1993 AASHTO Guide for the Design of Pavement Structures*, dated September 1997, this material is considered excellent for pavement subgrade. The recommended pavement sections are shown on Table 18.2.

TABLE 18.2. Recommended Pavement Section Thicknesses

Traffic Area	Alternate	APM (in)	ABC (in)	Total Thickness (in)
Local	APM	3.0	6.0	9.0
Collector	APM	3.0	6.0	9.0

18.3 SUBGRADE PREPARATION AND PAVEMENT CONSTRUCTION

18.3.1 Pavement Subgrade

The entire subgrade should be proof rolled a maximum of 24 hours prior to placement of ABC with a heavy rubber tired vehicle (GVW of 50,000 pounds with 18 kip per axle at tire pressures of 90 psi) to detect any soft or loose areas. All areas exhibiting unstable subgrade conditions, such as rutting, pumping, or excessive movement should be overexcavated to a firm soil layer or to a maximum depth of 2 feet, whichever is shallowest, and replaced with suitable compacted fill. If unstable subgrade conditions persist, Cesare should be contacted for consultation. Soft spots should be stabilized prior to placement of pavement sections. Positive drainage off paved surfaces should be provided.

18.3.2 Subbase and Aggregate Base Course

Subbase and ABC should meet the following requirements:

- ABC material should be approved prior to construction and should subsequently be tested as the material is being placed.
- ABC should have a minimum R-value of 70.
- ABC material should be compacted to a minimum of 95% of the MDD as determined by the modified Proctor test, ASTM D1557.

18.3.3 Pavement

Pavement construction shall be in accordance with the following recommendations and criteria:

- APM shall meet the requirements in the latest edition of CDOT *Standard Specifications for Road and Bridge Construction*, Section 400.
- Asphalt binder grade shall be PG 58-28, N_{Design} of 50 (Local) or 75 (Collector).
- Approved APM material should be placed in the lifts indicated on Table 18.3.

TABLE 18.3. Pavement Section Lift Thickness Recommendations

Grade	Lift Thickness (in)
S	2 to 4-1/4
SX	1-1/2 to 2-1/2

Per MGPEC 2019.

- APM shall be compacted to 92% to 96% of the maximum theoretical density within 0.3% of the optimum asphalt content as determined by ASTM D2041.
- APM placement specifications should follow CDOT specifications and industry standards as recommended by the NAPA and the AI.
- Portland cement concrete should be obtained from an approved mixture design with minimum properties meeting a CDOT Class D mixture.
- Portland cement concrete placement specifications should follow industry standards as recommended by the ACI and the PCA.
- Positive drainage off paved surfaces should be provided.
- Construction material should be approved prior to use and should subsequently be tested as this material is being placed.

19. SOIL CHEMICAL TESTING

19.1 SULFATE EXPOSURE

Water soluble sulfate contents of 0.02% were measured on samples collected in Exploratory Boring B-5 at a depth of 5 feet. Results are summarized in Appendix B. The PCA publication titled *Design and Control of Concrete Mixtures* 2002 and the ACI publication titled *Building Code Requirements for Structural Concrete and Commentary* consider this range negligible for water soluble sulfate exposure.

20. GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical study. The primary reason for this is that the analytical methods used by geotechnical engineers are generally empirical and must be tempered by engineering judgment and experience, therefore, the solutions or recommendations presented in any geotechnical study should not be considered risk free, and more importantly, are not a guarantee that the interaction between the soil and the proposed construction will perform as predicted, desired, or intended. The engineering recommendations presented in the preceding sections constitute Cesare's best estimate of those measures that are necessary to help the structures/pavements perform in a satisfactory manner based on the information generated during this study, training, and experience in working with these conditions.

21. LIMITATIONS

This document has been prepared as an instrument of service for the exclusive use of Design Workshop for the specific application to the project as discussed herein and has been prepared in accordance with geotechnical engineering practices generally accepted in the state of Colorado at the date of its preparation. No warranties, either expressed or implied, are intended or made. This document should not be assumed to contain information for other parties or other purposes.

The findings of this study are valid as of the date its preparation. Changes in the conditions of a property can occur with the passage of time, whether due to natural processes or the works of people on this or adjacent properties. Standards of practice evolve in engineering and changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this study may be invalidated wholly or partially by changes outside of Cesare's control, therefore, this study is subject to review and should not be relied upon without such review after a period of 3 years.

In the event that changes, including but not limited to, the nature, type, design, size, elevation, or location of the project or project elements as outlined in this report are made, the conclusions and recommendations contained in this report shall not be considered valid unless Cesare reviews the changes and either confirms or modifies the conclusions of this report in writing.

Cesare should be retained to review final plans and specifications that are developed for proposed construction to judge whether the recommendations presented in this report and any addenda have been appropriately interpreted and incorporated in the project plans and specifications as intended.

The exploration locations for this study were selected to obtain a reasonably accurate depiction of underground conditions for design purposes and these locations are often modified based on accessibility and the presence of underground or overhead utility conflicts. Variations from the soil conditions encountered are possible. These variations may necessitate modifications to Cesare's design recommendations, therefore, Cesare should be retained to observe subsurface conditions, once exposed, to evaluate whether they are consistent with the conditions encountered during Cesare's exploration and that the recommendations of this study remain valid. If parties other than Cesare perform these observations and judgements, they must accept responsibility to judge whether the recommendations in this report remain appropriate.

Cesare's scope of services for this report did not include either specifically, or by implication, any environmental assessment of the site or identification of contaminated or hazardous material or conditions. Additionally, none of the services performed in connection with this study were designed or conducted for the purpose of mold prevention. Proper implementation of the recommendations conveyed in this report will not, of itself, be enough to prevent mold from growing in or on the structures involved.

At a minimum, Cesare should be retained during construction to observe and/or test the following:

- completed excavations.
- placement and compaction of fill.
- proposed import or onsite fill material.
- placement and compaction of pavement subgrade, subbase, base course and asphalt.

Cesare offers many other construction observations, materials engineering, and testing services and can be contacted to discuss further.
acted to discuss further.

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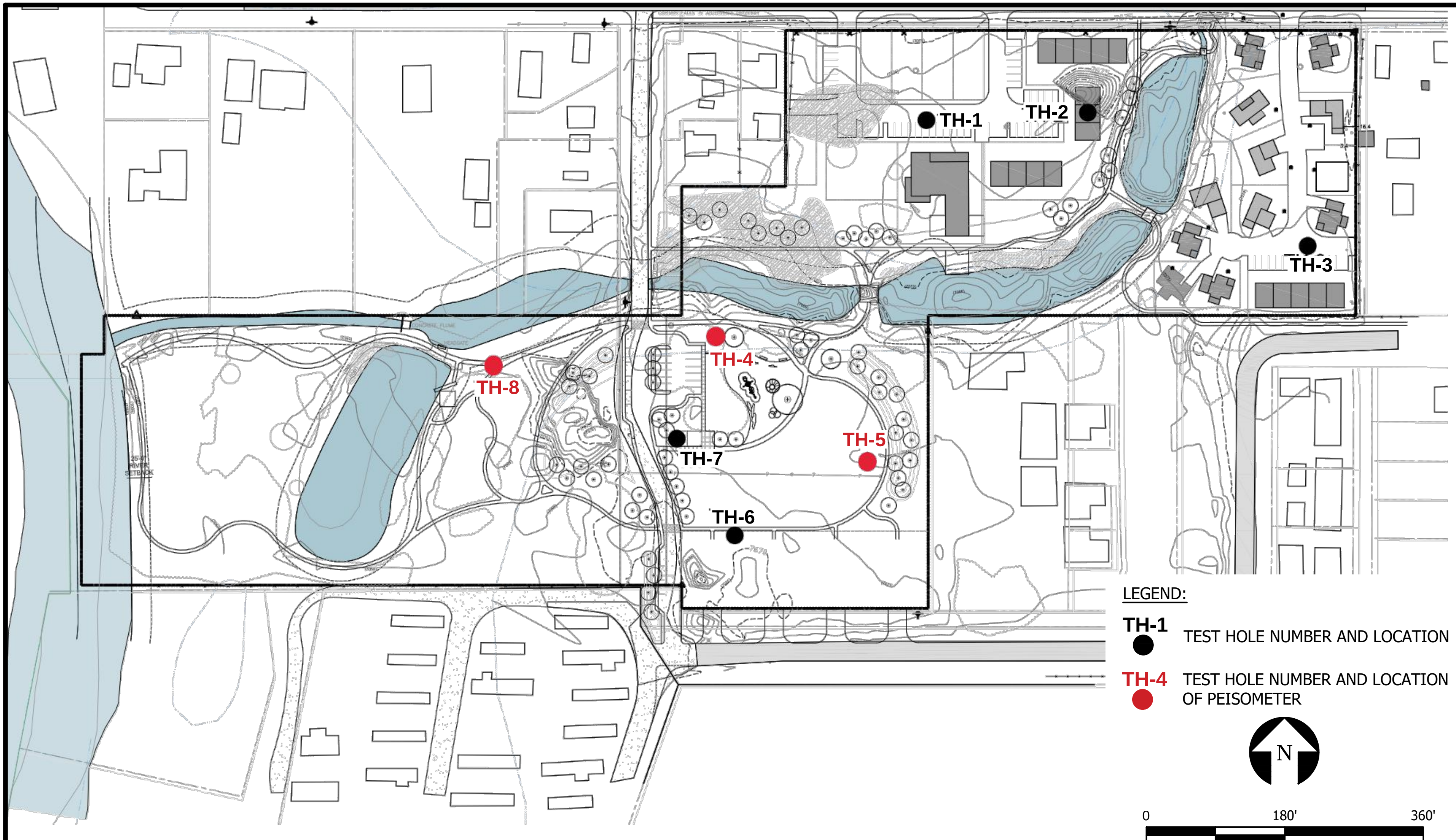

BACKGROUND IMAGE FROM DESIGNWORKSHOP

PROJECT NO:	20.6066		
PROJECT NAME:	Gunnison West Park		
DRAWN BY:	KNZ	CHECKED BY:	DRD
DWG DATE:	10.02.20	REV. DATE:	--

FIGURE 1
Site Plan and Location of Exploratory Borings and Piezometers

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APPENDIX A

Field Exploration

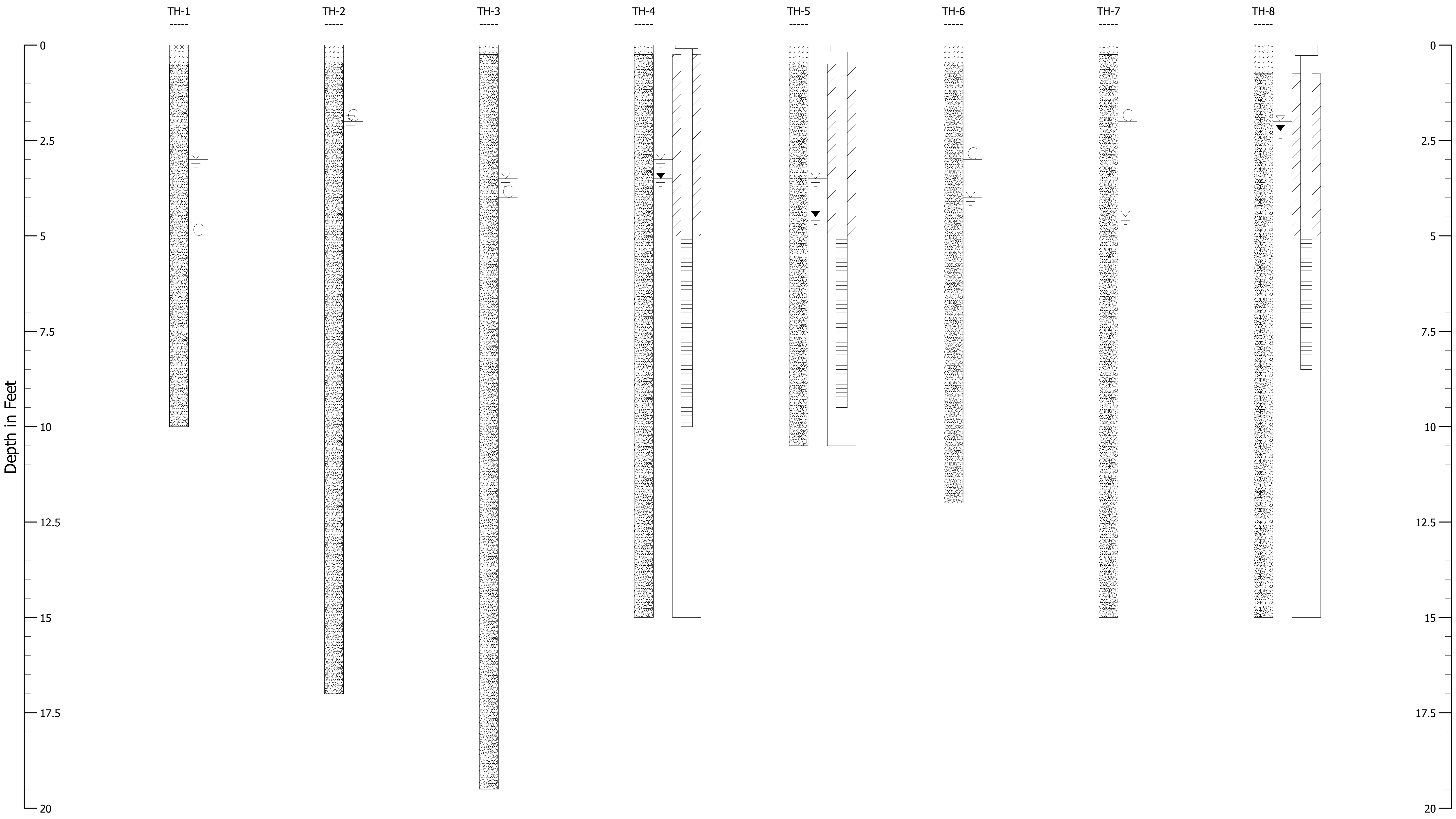
FIELD EXPLORATION

Bulk samples were collected from cuttings generated during drilling when present. Due to the high groundwater conditions, bulk samples typically were not present from drilling operations.

Cesare installed temporary monitoring wells in Exploratory Borings TH-4, TH-5, and TH-8. Groundwater level measurements within the temporary monitoring wells are included in Section **8. SUBSURFACE CONDITIONS**. Groundwater can be expected to fluctuate with variations in seasons, flow in the Gunnison River, drainage, site vegetation, irrigation, or weather conditions.

Monitoring wells were constructed using 2 inch diameter PVC pipe consisting of a slotted and solid intervals. Refer to the boring logs for well completion details specific to each boring. The monitor well pipe was terminated above the ground surface.

Temporary monitoring wells must be abandoned within 18 months of installation in accordance with the State of Colorado's Division of Water Resources abandonment requirements, unless the wells are permitted as permanent monitoring wells. If requested by the Client, Cesare can assist with well abandonment and/or the process of converting the monitoring wells from temporary to permanent.



PROJECT NO:	20.6066
PROJECT NAME:	Gunnison West Park
DWG DATE:	10/27/2020

LOGS OF EXPLORATORY BORINGS

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KEY TO SYMBOLS

Symbol	Description
	Strata symbols
	FILL, sand with gravel, slightly moist, brown (SM, A-2-4).
	Topsoil
	GRAVEL, sandy to SAND, gravelly, with cobbles and boulders (up to 14 inches in dimension) in a silty matrix, subrounded, poorly to well graded, moist to wet, light brown to brown (SM, GM, GW and GP; A-1-a to A-2-6).
	Misc. Symbols
	Water level during drilling
	Depth to caving
	Water level 31 days after drilling
	Monitor Well Details
	Covered riser
	Assorted cuttings

Symbol	Description
	Slotted pipe
	End of well installation

Notes:

1. Exploratory test holes were drilled on September 4, 2020, using a CME-55 track mounted drill rig equipped with a 4-inch continous flight solid stem auger.

2. Relative elevations were determined from a site plan provided by Design Workshop.

3. Groundwater was encountered at depths of 2 and 4 feet below ground surface at the time of drilling. Groundwater was encountered at depths of 2 and 4.5 feet below ground surface in test holes TH-4, TH-5 and TH-8 31 days after drilling. For safety purposes, borings were backfilled at completion of the study. Monitoring wells were installed in test holes TH-4, TH-5 and TH-8.

4. Contacts between soil units are approximate and may be gradational.

5. These logs are subject to the limitations, conclusions, and recommendations in this report.

Project No. 20.6066.

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APPENDIX B

Laboratory Testing

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SUMMARY OF LABORATORY TEST RESULTS
Gunnison West Park
Project No. 20.6066

Sample Location		Water Soluble Sulfates (%)	Gradation			Atterberg Limits		Material Type
Location	Depth (feet)		Gravel (%)	Sand (%)	Silt/ Clay (%)	Liquid Limit (%)	Plasticity Index (%)	
TH-6 Stockpile	NA		47	42	11	28	3	(GW-GM) Well graded gravel with silt and sand; A-1-a
TH-1 Stockpile	NA		55	34	11	NV	NP	(GP-GM) Poorly graded gravel with silt and sand; A-1-a
3rd Street Stockpile	NA	0.02	36	44	20	28	11	(SM) Silty sand with gravel; A-2-6(0)
TH-2	0.5 to 3		46	41	13	NV	NP	(GM) Silty gravel with sand; A-1-a

NP = non plastic
NV = no value

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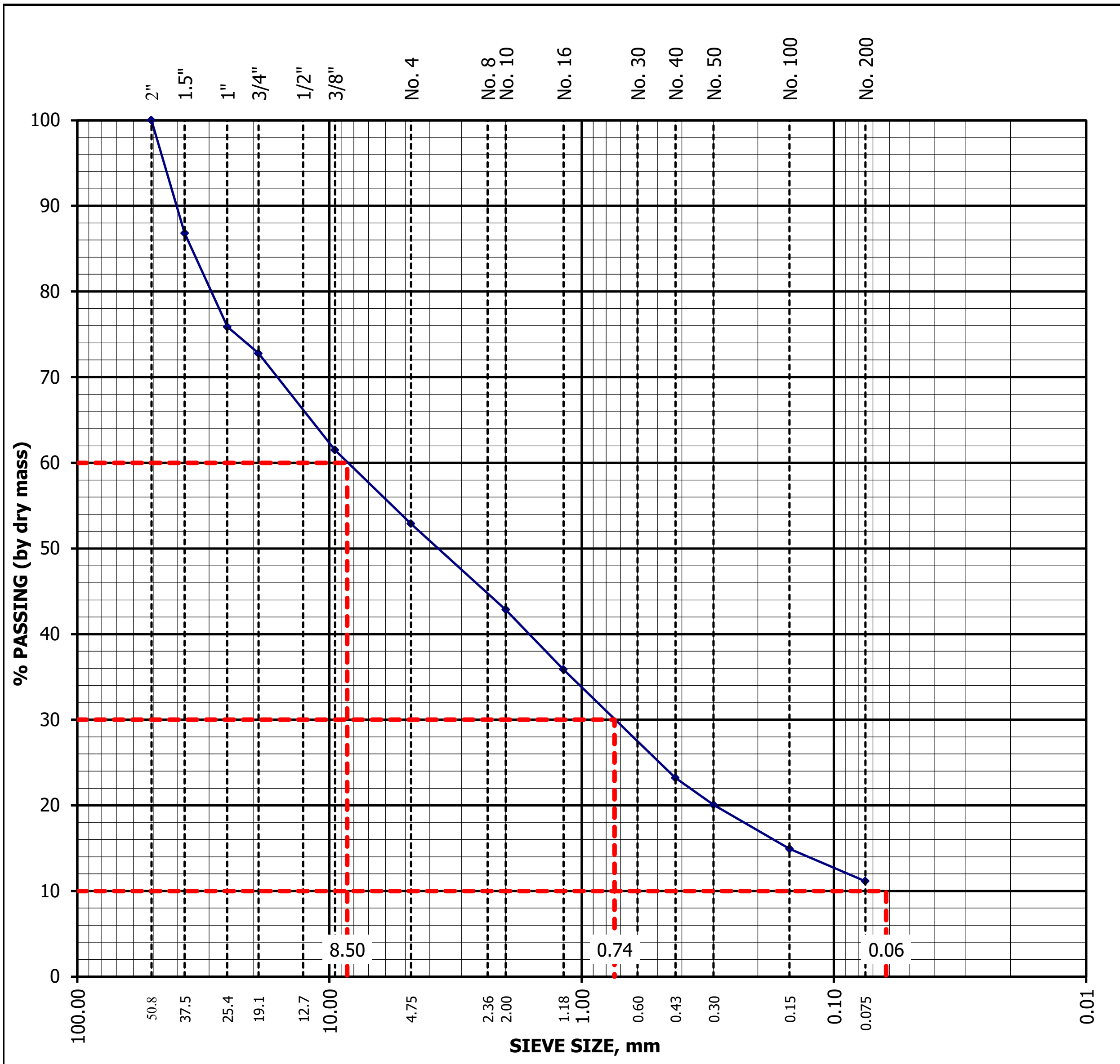
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	20.6066, Design Workshop	Date:	15-Sep-20
Project Name:	West Gunnison Park	Technician:	K. Frazier
Lab ID Number:	SC202058	Reviewer:	D. Duran
Sample Location:	TH-1 stockpile		
Visual Description:	GRAVEL, sandy with silt, brown		

AASHTO M 145 Classification: A-1-a Group Index: (0)
Unified Soil Classification System (ASTM D 2487): (GW-GM) Well graded gravel with silt and sand



Sieve Size	% Passing
2"	100
1.5"	87
1"	76
3/4"	73
1/2"	
3/8"	61
#4	53
#8	
#10	43
#16	36
#30	
#40	23
#50	20
#100	15
#200	11.1

Moisture (M) & Density (D)	
M, %:	1.1
D, pcf:	

LL	28
PL	25
PI	3

D_{60}	8.50
D_{30}	0.74
D_{10}	0.06
Cu	**137.10**
Cc	**1.04**

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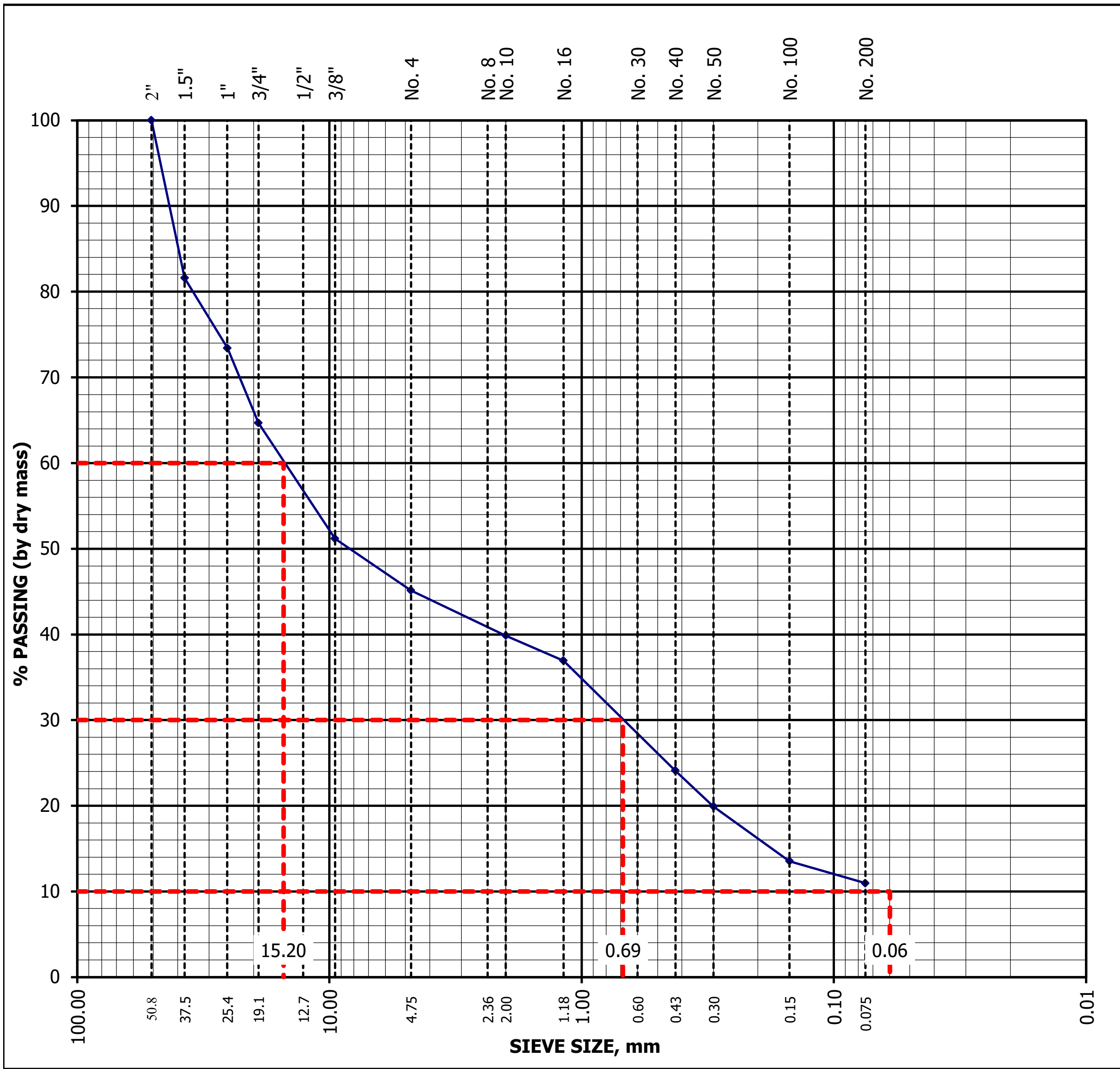
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	20.6066, Design Workshop	Date:	15-Sep-20
Project Name:	West Gunnison Park	Technician:	K. Frazier
Lab ID Number:	SC202059	Reviewer:	D. Duran
Sample Location:	TH-6 stockpile		
Visual Description:	GRAVEL, sandy with silt, light brown		

AASHTO M 145 Classification: **A-1-a** **Group Index:** **0**

Unified Soil Classification System (ASTM D 2487): **(GP-GM) Poorly graded gravel with silt and sand**



Sieve Size	% Passing
2"	100
1.5"	82
1"	73
3/4"	65
1/2"	
3/8"	51
#4	45
#8	
#10	40
#16	37
#30	
#40	24
#50	20
#100	14
#200	11.0

Moisture (M) & Density (D)	
M, %:	1.0
D, pcf:	

LL	NV
PL	NP
PI	NP

D_{60}	15.20
D_{30}	0.69
D_{10}	0.06
Cu	**253.33**
Cc	**0.52**

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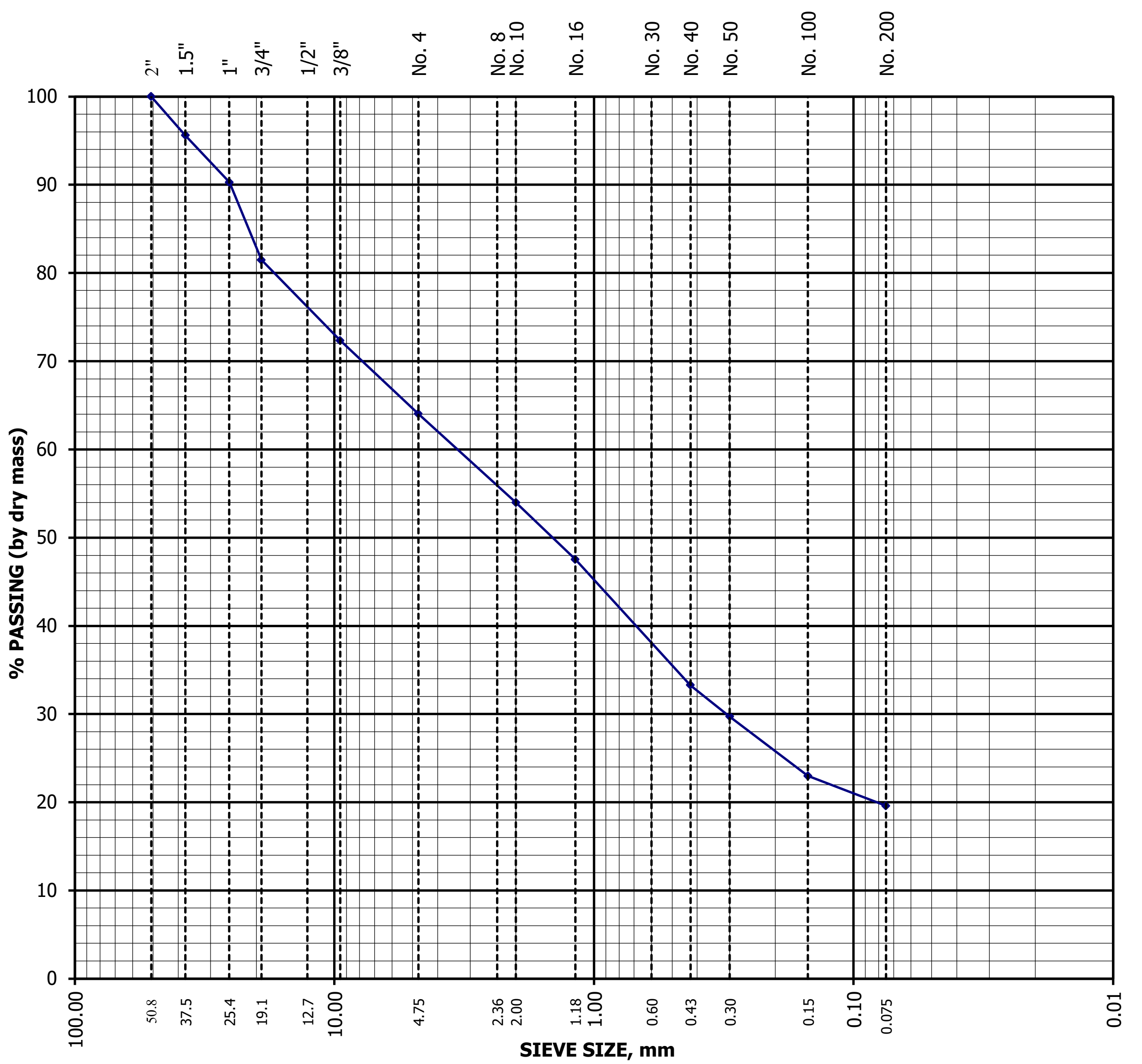
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	20.6066, Design Workshop	Date:	15-Sep-20
Project Name:	West Gunnison Park	Technician:	K. Frazier
Lab ID Number:	SC202060	Reviewer:	D. Duran
Sample Location:	3rd Street stockpile		
Visual Description:	SAND, gravelly with silt, brown		

AASHTO M 145 Classification: **A-2-6** **Group Index:** **(0)**
Unified Soil Classification System (ASTM D 2487): **(SM)** **Silty sand with gravel**



Sieve Size	% Passing
2"	100
1.5"	96
1"	90
3/4"	81
1/2"	
3/8"	72
#4	64
#8	
#10	54
#16	48
#30	
#40	33
#50	30
#100	23
#200	19.6

Moisture (M) & Density (D)	
M, %:	1.2
D, pcf:	

LL	28
PL	17
PI	11

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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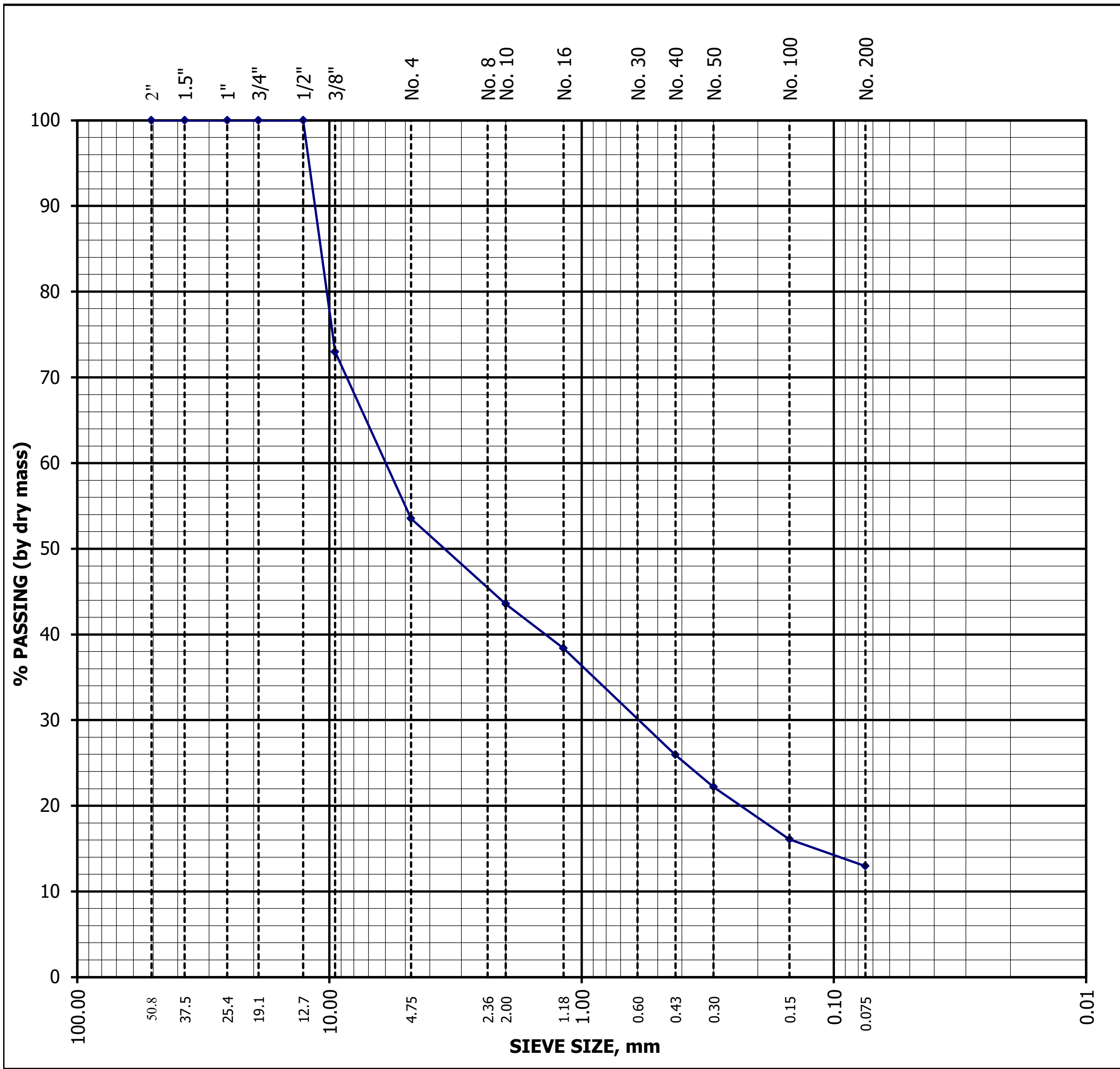
GRADATION PLOT - SOIL & AGGREGATE

Project Number:	20.6066, Design Workshop	Date:	15-Sep-20
Project Name:	West Gunnison Park	Technician:	K. Frazier
Lab ID Number:	SC202061	Reviewer:	D. Duran
Sample Location:	TH-2 at 0.5' to 3'		
Visual Description:	SAND, with gravel and silt, dark brown		

AASHTO M 145 Classification: **A-1-a** **Group Index:** **0**

Unified Soil Classification System (ASTM D 2487): **(GM)** **Silty gravel with sand**



Sieve Size	% Passing
2"	
1.5"	
1"	
3/4"	100
1/2"	
3/8"	73
#4	54
#8	
#10	44
#16	38
#30	
#40	26
#50	22
#100	16
#200	13.0

Moisture (M) & Density (D)	
M, %:	11.2
D, pcf:	

LL	NV
PL	NP
PI	NP

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

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APPENDIX C

Vapor Barriers

VAPOR BARRIERS

If it is determined that a vapor retarder/barrier is warranted, Cesare recommends that the vapor barrier comply with ASTM E1745, and if moisture sensitive flooring will be utilized, have a permeance below 0.01 perms before and after mandatory conditioning testing. The vapor retarder/barrier should be installed per ASTM E1643 and the design professional should consider project specific requirements in specification verbiage. See the ACI Committee 302, "Guide for Concrete Floor and Slab Construction (ACI 302.R-96)" for additional discussion and guidance regarding the use of vapor retarders/barriers beneath floor slabs.

The 2018 IBC, Section 1805.2 Dampproofing states that where hydrostatic pressure will not occur, as determined by Section 18-03.5.4, floors shall be dampproofed in accordance with this section.

Section 1805.2 Floors, states,

> "*Dampproofing materials for floors shall be installed between the floor and the base course required by Section 1805.4.1, except where a separate floor is provided above a concrete slab. Where installed beneath the slab, dampproofing shall consist of not less than 6-mil (0.006 inch; 0.152 mm) polyethylene with joints lapped not less than 6 inches (152 mm), or other approved methods or materials. Where permitted to be installed on top of the slab, damp proofing shall consist of mopped-on bitumen, not less than 4-mil; (0.004 inch; 0.102 mm) polyethylene, or other approved methods or materials. Joints in the membrane shall be lapped and sealed in accordance with the manufacturer's installation instructions*".

Section 1805.4.1 Floor Base Course, states,

> *"Floors of basements, except as provided for in Section 1805.1.1 shall be placed over a floor base course not less than 4 inches (102 mm) in thickness that consists of gravel or crushed stone containing no more than 10 percent of material that passes through a No. 4 (4.75mm) sieve."*

Cesare recommends a 4 inch layer of free draining gravel to provide a leveling course and moisture break beneath the floor slab.