

Appendix D

Geotechnical Report

Geotechnical Report

Shandin Hills MHRC
4164 N. 4th Avenue
San Bernardino, California

Prepared for:

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July 28, 2023

Mr. Abe Tress
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**Geotechnical Report
Shandin Hills MHRC
4164 N. 4th Avenue
San Bernardino, California
*LCI Report No.: LP23116***

Dear Mr. Tress:

As per your request, ***LandMark Consultants, Inc.*** is providing the following geotechnical report for the proposed private mental health center project located at 4164 N. 4th Avenue in the city of San Bernardino, California. The proposed development will consist of a new 72,000 sq-ft building on approximately 5.93 acres west of the existing mental health rehabilitation complex. This new structure is planned to be single tory, wood/metal-framed, with shallow reinforced concrete foundations and slab-on-grade.

Purpose of Work

The purpose of this study was to investigate the upper 41.5 feet of subsurface soil at selected locations within the site for evaluation of physical/engineering properties. From the analysis of the field and laboratory data, professional opinions were developed and are provided in this report regarding geotechnical conditions at this site and the effect on design and construction.

Authorization

Mr. John Tanori provided authorization by written agreement to proceed with our work on May 24, 2023. We conducted our work in general accordance with our written proposal dated May 18, 2023.

Field Exploration

Subsurface exploration was performed on June 22, 2023, using 2R Drilling of Ontario, California to advance five (5) borings to depths of 21.5 to 41.5 feet below existing ground surface. The borings were advanced with a truck-mounted, CME 75 drill rig using 8-inch diameter, hollow-stem, continuous-flight augers. The approximate boring locations were established in the field and plotted on the site map by sighting to discernible site features. The boring locations are shown on the Site and Exploration Plan (Plate A-2).

A geo-technician observed the drilling operations and maintained logs of the soil encountered with sampling depths. Soils were classified during drilling according to the Unified Soil Classification System using the visual-manual procedure in accordance with ASTM D2488. Relatively undisturbed and bulk samples of the subsurface materials were obtained at selected intervals. The relatively undisturbed soil samples were retrieved using a 2-inch outside diameter (OD) split-spoon sampler or a 3-inch OD Modified California Split-Barrel (ring) sampler lined with 6-inch stainless-steel sleeves.

In addition, Standard Penetration Tests (SPT) were performed in accordance with ASTM D1586 and ASTM D6066. The samples were obtained by driving the samplers ahead of the auger tip at selected depths using a 140-pound CME automatic hammer with a 30-inch drop. The number of blows required to drive the samplers the last 12 inches of an 18-inch drive depth into the soil is recorded on the boring logs as “blows per foot”. Blow counts (N values) reported on the boring logs represent the field blow counts. No corrections have been applied to the blow counts shown on the boring logs for effects of overburden pressure, automatic hammer drive energy, drill rod lengths, liners, and sampler diameter.

After logging and sampling the soil, the exploratory borings were backfilled with the excavated material. The backfill was loosely placed and was not compacted to the requirements specified for engineered fill.

The subsurface logs are presented on Plates B-1 through B-5 in Appendix B. A key to the log symbols is presented on Plate B-6. The stratification lines shown on the subsurface logs represent the approximate boundaries between the various strata. However, the transition from one stratum to another may be gradual over some range of depth.

Laboratory Testing

Laboratory tests were conducted on selected bulk soil samples to aid in classification and evaluation of selected properties of the site soils. The tests were conducted in general conformance to the procedures of the American Society for Testing and Materials (ASTM) or other standardized methods as referenced below. The laboratory testing program consisted of the following tests:

- ▶ Particle Size Analyses (ASTM D6913/D7928)
- ▶ Unit Dry Densities (ASTM D2937)
- ▶ Moisture Contents (ASTM D2216)
- ▶ Moisture-Density Relationship (ASTM D1557)
- ▶ Chemical Analyses (soluble sulfates & chlorides, pH, and resistivity) (Caltrans Methods)

The laboratory test results are presented on the subsurface logs (Appendix B) and in Appendix C. Engineering parameters of soil strength, compressibility, and relative density utilized for developing design criteria provided within this report were extrapolated from data obtained from the field and laboratory testing program.

Site Conditions

The project site is roughly rectangular shaped in plan view, elongated in the east-west direction, and is relatively flat-lying. The project site is currently occupied by the existing mental rehabilitation building in the southeast corner of the site. Adjacent properties are flat-lying and are approximately at the same elevation as this site. Single family residences are located surrounding the site. The project site is bounded on the east by N. 4th Avenue.

The project site lies at an elevation of approximately 1400 feet above mean sea level (AMSL) in the Inland Empire region of Southern California. Annual rainfall in this arid region is less than 4 inches per year with four months of average summertime temperatures above 100 °F. Winter temperatures are mild, seldom reaching freezing.

Geologic Setting

The project site is located within the eastern portion of the San Bernardino Basin or San Bernardino Valley Block. The valley is situated between the Transverse Range (San Bernardino Mountains) and the San Andreas Fault zone to the northeast, the Peninsular Range (San Jacinto Mountains) and the San Jacinto Fault zone to the southwest and the Perris Block further to the south-southwest.

The San Bernardino Mountains are the loftiest range within the Transverse Range province, with the highest peak, Mount San Gorgonio at 11,502 feet (3,508 m). The San Bernardino Mountains are about 65 miles (105 km) long, with a maximum width of 40 miles (65 km). They are bounded on the west and southwest by the Cajon Pass and the San Andreas Fault, on the north by the Mojave Desert, on the east by Twentynine Palms Valley, and on the southeast by Morongo and Coachella Valleys.

The San Andreas Fault Zone is located along the southern flanks of the San Bernardino Mountains, which have been uplifted along its trace (Norris & Webb, 1990). The flanks of the range are cut by deep, narrow canyons and are drained by several permanent streams. The Santa Ana River, located to the north of the site, has the largest drainage basin in southern California. It drains both the San Bernardino and eastern San Gabriel Mountains, and the northern Peninsular Ranges (Norris & Webb, 1990).

Subsurface Soils

Subsurface soils encountered during the field exploration conducted on June 22, 2023, consist of silty sand (SM), sand (SP-SM) and sand (SP). The near surface soils are non-expansive in nature. The subsurface logs (Plates B-1 through B-5) depict the stratigraphic relationships of the various soil types.

Groundwater

Groundwater was not encountered in the boring during the time of exploration. Based on available information from the Western Municipal Water District Cooperative Well Measuring Program, the nearest groundwater well with data (Well No. 01N04W21B002S) is located less than 1-mile southwest of the project site. The most recent measurement was recorded approximately 140-feet bgs.

There is uncertainty in the accuracy of short-term water level measurements. Groundwater levels may fluctuate with precipitation, irrigation of adjacent properties, drainage, and site grading. The groundwater level noted should not be interpreted to represent an accurate or permanent condition. Based on the regional topography, groundwater flow is assumed to be generally towards the south within the site area. Flow directions may vary locally in the vicinity of the site.

Faulting

The project site is located within the seismically active San Bernardino Valley of southern California and is considered likely to be subjected strong ground motion from earthquakes in the region. We have performed a computer-aided search of known faults or seismic zones that lie within a 36-mile radius of the project site (Table 1).

A fault map illustrating known active faults relative to the site is presented on Figure 1, *Regional Fault Map*. Figure 2 shows the project site in relation to local faults. The criterion for fault classification adopted by the California Geological Survey defines Earthquake Fault Zones along Holocene-active or pre-Holocene faults (CGS, 2023b). Earthquake Fault Zones are regulatory zones that address the hazard of surface fault rupture. A Holocene-active fault is one that has ruptured during Holocene time (within the last 11,700 years). A pre-Holocene fault is a fault that has not ruptured in the last 11,700 years. Pre-Holocene faults may still be capable of surface rupture in the future, but are not regulated by the Alquist-Priolo Act (AP).

Review of the current Alquist-Priolo Earthquake Fault Zone maps (CGS, 2023a) indicates that the nearest mapped Earthquake Fault Zone is the San Andreas – San Bernardino (south) fault located approximately 1.7 miles north of the project site.

General Ground Motion Analysis

The project site is considered likely to be subjected to moderate to strong ground motion from earthquakes in the region. Ground motions are dependent primarily on the earthquake magnitude and distance to the seismogenic (rupture) zone. Acceleration magnitudes also are dependent upon attenuation by rock and soil deposits, direction of rupture and type of fault; therefore, ground motions may vary considerably in the same general area.

2022 CBC General Ground Motion Parameters: The California Building Code (CBC) requires that a site-specific ground motion hazard analysis be performed in accordance with ASCE 7-16 Section 11.4.8 (ASCE, 2016) for structures on Site Class D with S_1 greater than or equal to 0.2 and Site Class E sites with S_s greater than or equal to 1.0 (CBC, 2019). **This project site has been classified as Site Class C which would require a site-specific ground motion hazard analysis.**

The 2022 CBC general ground motion parameters are based on the Risk-Targeted Maximum Considered Earthquake (MCE_R). The Structural Engineers Association of California (SEAOC) and Office of Statewide Health Planning and Development (OSHPD) Seismic Design Maps Web Application (SEAOC, 2020) was used to obtain the site coefficients and adjusted maximum considered earthquake spectral response acceleration parameters. Design spectral response acceleration parameters are defined as the earthquake ground motions that are two-thirds (2/3) of the corresponding MCE_R ground motions. The Maximum Considered Earthquake Geometric Mean (MCE_G) peak ground acceleration adjusted for soil site class effects (PGAM) value to be used for liquefaction and seismic settlement analysis in accordance with 2022 CBC Section 1803.5.12.2 is estimated at 1.2g for the project site. ***Design earthquake ground motion parameters are provided in Table 2.***

Seismic and Other Hazards

► **Groundshaking.** The primary seismic hazard at the project site is the potential for strong groundshaking during earthquakes along the Cucamonga, San Jacinto, San Andreas and other nearby faults. A further discussion of groundshaking mentioned above.

► **Surface Rupture.** The project site does not lie within a State of California, Alquist-Priolo Earthquake Fault Zone or County of San Bernardino Fault Zone. Surface fault rupture is considered to be unlikely at the project site because of the well-delineated fault lines through the San Bernardino Valley as shown on USGS and CDMG maps.

However, because of the high tectonic activity and deep alluvium of the region, we cannot preclude the potential for surface rupture on undiscovered or new faults that may underlie the site.

► **Liquefaction.** Liquefaction is unlikely to be a potential hazard at the site, due to groundwater deeper than 50 feet (the maximum depth that liquefaction is known to occur).

Other Potential Geologic Hazards.

► **Landsliding.** The hazard of landsliding is unlikely due to the regional planar topography. No ancient landslides are shown on geologic maps of the region and no indications of landslides were observed during our site investigation.

► **Volcanic hazards.** The site is not located in proximity to any known volcanically active area and the risk of volcanic hazards is considered very low.

► **Tsunamis, sieches, and flooding.** The site does not lie near any large bodies of water, so the threat of tsunami, sieches, or other seismically-induced flooding is unlikely.

► **Expansive soil.** The near surface soils at the project site consist of sands which are non-expansive.

Hydroconsolidation

In arid climatic regions, granular soils have a potential to collapse upon wetting. This collapse (hydro-consolidation) phenomena is the result of the lubrication of soluble cements (carbonates) in the soil matrix causing the soil to densify from its loose configuration during deposition. Based on our experience in the vicinity of the project site, there is a slight risk of collapse upon inundation from at the site. Therefore, development of building foundation is not required to include provisions for mitigating the hydro-consolidation caused by soil saturation from landscape irrigation or broken utility lines.

Soil Infiltration Rate

A total of two (2) infiltration tests were conducted on July 10, 2023, at these proposed locations for the on-site storm-water retention basin as shown on the Site and Exploration Plan (Plate A-2). The infiltration tests were performed to the guideline from Design Handbook for Low Impact Development Best Management Practices, prepared by State Water Conservation District, Appendix A, Section 2.3, dated September 2011.

The tests were performed using 6-inch perforated pipe inside an 8-inch diameter flight auger borehole made to depths of approximately 5.0 feet below the existing ground surface, corresponding to the anticipated bottom depth of the stormwater retention basin. The pipes were filled with water and successive readings of drops in water levels were made every 10 minutes for a total elapsed time of 60 minutes, until a stabilization drop was recorded.

The test results indicate that the stabilized soil infiltration rate for the soil ranges from 2.2 to 2.5 inches per hour. A maximum soil infiltration rate of 2.2 inches per hour may be used for the on-site storm-water retention basin design. An oil/water separator should be installed at inlets to the stormwater retention basin to prevent sealing of the basin bottom with silt and oil residues. The field and conversion calculation worksheets are included in Appendix D.

We recommend additional testing should be performed after the completion of rough grading operations, to verify the soil infiltration rate.

Site Preparation

Pre-grade Meeting: Prior to site preparation, a meeting should be held at the site with as a minimum, the owner's representative, grading contractor and geotechnical engineer in attendance.

Clearing and Grubbing: Any surface improvements, debris or vegetation including grass, trees, and weeds on the site at the time of construction should be removed from the construction area. Root balls should be completely excavated. Organic stripping should be hauled from the site and not used as fill. *Any trash, construction debris, concrete slabs, old pavement, landfill, and buried obstructions such as old foundations, un-controlled fills and utility lines exposed during rough grading should be traced to the limits of the foreign material by the grading contractor and removed under our supervision.* Any excavations resulting from site clearing should be dish-shaped to the lowest depth of disturbance and backfilled under the observation of the geotechnical engineer's representative.

Building Pad Preparation: The existing surface soil within the proposed building pad areas should be removed to 48 inches below the original grade or 24 inches below the lowest foundation grade (whichever deeper), extending five feet beyond all exterior wall/column lines (including adjacent concrete areas). Exposed sub-grade should be scarified to a depth of 6 to 8 inches, uniformly moisture conditioned to at least 2% over optimum moisture content, and re-compacted to a minimum of 90% of the maximum density determined in accordance with ASTM D1557 methods.

Auxiliary Structures Foundation Preparation: Auxiliary structures such as free standing or retaining walls should have footings extended to a minimum of 18 inches below grade. The existing soil beneath the structure foundation prepared in the manner described for the house pad except the preparation needs only to extend 18 inches below and beyond the footing.

Sidewalk and Concrete Hardscape Areas: In areas other than the building pad which are to receive concrete slabs, the ground surface should be over-excavated to a depth of 8 to 12 inches, uniformly moisture conditioned to at least 2% over optimum moisture, and re-compacted to at least 90% of ASTM D1557 maximum density.

Street Subgrade Preparation: The native soils in street areas should be removed and recompacted to 12 inches below the design subgrade elevation. Engineered fill in street areas should be uniformly moisture conditioned to at least 2% over optimum moisture, placed in layers not more than 6 to 8 inches in thickness and mechanically compacted to a minimum of 90% of the ASTM D1557 maximum dry density.

The on-site soils are suitable for use as compacted fill and utility trench backfill. Imported fill soil (if required) should be like onsite soil or non-expansive, granular soil meeting the USCS classifications of SM, SP-SM, or SW-SM with a maximum rock size of 6 inches and no less than 5% passing the No. 200 sieve. *The geotechnical engineer should approve imported fill soil sources before hauling material to the site.* Native and imported materials should be placed in lifts no greater than 8 inches in loose thickness, uniformly moisture conditioned to at least 2% over optimum moisture, and re-compacted to at least 90% of ASTM D1557 maximum density.

Moisture Control and Drainage: The moisture condition of the house pad should be maintained during trenching and utility installation until concrete is placed or should be rewetted before initiating delayed construction. Adequate site drainage is essential to the future performance of the project. Infiltration of excess irrigation water and stormwaters can adversely affect the performance of the subsurface soil at the site. Positive drainage should be maintained away from all structures (5% for 10 feet minimum across unpaved areas) to prevent ponding and subsequent saturation of the native soil. Gutters and downspouts may be considered as a means to convey water away from foundations. If landscape irrigation is allowed next to the building, drip irrigation systems or lined planter boxes should be used. The subgrade soil should be maintained in a moist, but not saturated state, and not allowed to dry out. Drainage should be maintained without ponding.

Utility Trench Backfill

On-site soil free of debris, vegetation, and other deleterious matter may be suitable for use as utility trench backfill. Backfill within roadways should be placed in layers not more than 6 to 8 inches in thickness, uniformly moisture conditioned to at least 2% over optimum moisture and mechanically compacted to a minimum of 90% of the ASTM D1557 maximum dry density except for the top 12 inches of the trench which shall be compacted to at least 95%. Native backfill should only be placed and compacted after encapsulating buried pipes with suitable bedding and pipe envelope material. Pipe envelope/bedding should be clean sand (Sand Equivalent SE>30). Precautions should be taken in the compaction of the backfill to avoid damage to the pipes and structures.

Soil Bearing Values and Lateral Loads

Shallow column footings and continuous wall footings are suitable to support the structures provided they are founded on a layer of properly prepared and compacted soil as described above. The foundations may be designed using an allowable soil bearing pressure of 1,800 psf. The allowable soil pressure may be increased by 20% for each foot of embedment depth more than 18 inches and by one-third for short term loads induced by winds or seismic events. The maximum allowable soil pressure at increased embedment depths shall not exceed 2,800 psf.

All exterior and interior foundations should be embedded a minimum of 18 inches below the building support pad or lowest adjacent final grade, whichever is deeper. Continuous wall footings should have a minimum width of 12 inches. Isolated column footings should have a minimum width of 24 inches. *Recommended concrete reinforcement and sizing for all footings should be provided by the structural engineer.*

Resistance to horizontal loads will be developed by passive earth pressure on the sides of footings and frictional resistance developed along the bases of footings and concrete slabs. Passive resistance to lateral earth pressure may be calculated using an equivalent fluid pressure of 300 pcf to resist lateral loadings. The top one foot of embedment should not be considered in computing passive resistance unless the adjacent area is confined by a slab or pavement. An allowable friction coefficient of 0.35 may also be used at the base of the footings to resist lateral loading.

Foundation movement under the estimated static (non-seismic) loadings and static site conditions are estimated to not exceed $\frac{3}{4}$ inch with differential movement of about two-thirds of total movement for the loading assumptions stated above when the subgrade preparation guidelines given above are followed.

Slabs-on-Grade

Concrete slabs and flatwork should be a minimum of 5 inches thick. The concrete floor slabs may either be monolithically placed with the foundation or dowelled after footing placement. The concrete slabs may be placed on granular subgrade that has been compacted at least 90% relative compaction (ASTM D1557). *Slab thickness and steel reinforcement should be determined by the design engineer.*

American Concrete Institute (ACI) guidelines (ACI 302.1R-15 Chapter 5, Section 5.2.3) provide recommendations regarding the use of moisture barriers beneath concrete slabs. The concrete floor slabs should be underlain by a 10-mil polyethylene vapor retarder that works as a capillary break to reduce moisture migration into the slab section.

All laps and seams should be overlapped 6-inches or as recommended by the manufacturer. The vapor retarder should be protected from puncture. The joints and penetrations should be sealed with the manufacturer's recommended adhesive, pressure-sensitive tape, or both. The vapor retarder should extend a minimum of 12 inches into the footing excavations. The vapor retarder may lie directly on the granular fill with 2 inches of clean sand cover. Placing sand over the vapor retarder may increase moisture transmission through the slab, because it provides a reservoir for bleed water from the concrete to collect. The sand placed over the vapor retarder may also move and mound prior to concrete placement, resulting in an irregular slab thickness.

For areas with moisture sensitive flooring materials, ACI recommends that concrete slabs be placed without a sand cover directly over the vapor retarder, provided that the concrete mix uses a low-water cement ratio and concrete curing methods are employed to compensate for release of bleed water through the top of the slab. The vapor retarder should have a minimum thickness of 15-mil (Stego-Wrap or equivalent).

All independent concrete flatwork should be underlain by 12 inches of moisture conditioned and compacted soils. All flatworks should be jointed in square patterns and at irregularities in shape at a maximum spacing of 10 feet or the least width of the sidewalk.

Concrete Mixes and Corrosivity

Selected chemical analyses for corrosivity were conducted on bulk samples of the near surface soil from the project site (Plate C-2). The native soils have low levels of sulfate and low to moderate levels of chloride ion concentrations. Resistivity determinations on the soil indicate a moderate potential for metal loss because of electrochemical corrosion processes. A minimum of 2,500 psi concrete of Type II Portland Cement with a maximum water/cement ratio of 0.60 (by weight) should be used for concrete placed in contact with native soil on this project (sitework including sidewalks, driveways, patios, and foundations).

Landmark does not practice corrosion engineering. We recommend that a qualified corrosion engineer evaluate the corrosion potential on metal construction materials and concrete at the site.

Excavations

All site excavations should conform to CalOSHA requirements for Type C soil. The contractor is solely responsible for the safety of workers entering trenches. Temporary excavations with depths of 4 feet or less may be cut nearly vertical for short duration. Temporary slopes should be no steeper than 1.5:1 (horizontal:vertical). Sandy soil slopes should be kept moist, but not saturated, to reduce the potential of raveling or sloughing. Excavations deeper than 4 feet will require shoring or slope inclinations in conformance to CAL/OSHA regulations for Type C soil. Surcharge loads of stockpiled soil or construction materials should be set back from the top of the slope a minimum distance equal to the height of the slope. All permanent slopes should not be steeper than 3:1 to reduce wind and rain erosion. Protected slopes with ground cover may be as steep as 2:1. However, maintenance with motorized equipment may not be possible at this inclination.

Lateral Earth Pressures

Earth retaining structures, such as retaining walls, should be designed to resist the soil pressure imposed by the retained soil mass. Walls with granular drained backfill may be designed for an assumed static earth pressure equivalent to that exerted by a fluid weighing 30 pcf for unrestrained (active) conditions (able to rotate 0.1% of wall height), and 50 pcf for restrained (at-rest) conditions. These values should be verified at the actual wall locations during construction. When applicable seismic earth pressure on walls may be assumed to exert a uniform pressure distribution of $7.5H$ psf against the back of the wall, where H is the height of the backfill. The total seismic load is assumed to act as a point load at $0.6H$ above the base of the wall.

Surcharge loads should be considered if loads are applied within a zone between the face of the wall and a plane projected behind the wall 45 degrees upward from the base of the wall. The increase in lateral earth pressure acting uniformly against the back of the wall should be taken as 50% of the surcharge load within this zone. Areas of the retaining wall subjected to traffic loads should be designed for a uniform surcharge load equivalent to two feet of native soil.

Walls should be provided with back drains to reduce the potential for the buildup of hydrostatic pressure. The drainage system should consist of a composite HDPE drainage panel or a 2-foot-wide zone of free draining crushed rock placed adjacent to the wall and extending $\frac{2}{3}$ the height of the wall. The gravel should be completely enclosed in an approved filter fabric to separate the gravel and backfill soil. A perforated pipe should be placed perforations down at the base of the permeable material at least six inches below finished floor elevations.

The pipe should be sloped to drain to an appropriate outlet that is protected against erosion. Walls should be properly waterproofed. The project geotechnical engineer should approve any alternative drain system.

Pavements

Pavements should be designed according to the 2022 Caltrans Highway Design Manual or other acceptable methods. Traffic indices were not provided by the project engineer or owner; therefore, we have provided structural sections for several traffic indices for comparative evaluation. The public agency or design engineer should decide the appropriate traffic index for the site. Maintenance of proper drainage is necessary to prolong the service life of the pavements. Based on the current Caltrans method, an estimated R-value of 60 for the subgrade soil and assumed traffic indices, the following table provides our estimates for asphaltic concrete (AC pavement sections).

PAVEMENT STUCTURAL SECTIONS

R-Value of Subgrade Soil - 60 (estimated)

Design Method - CALTRANS 2022

Traffic Index (assumed)	Flexible Pavements	
	Asphaltic Concrete Thickness (in.)	Aggregate Base Thickness (in.)
5.0	3.0	4.0
6.0	3.5	4.0
7.0	4.5	4.0
8.0	5.0	4.0

Notes:

- 1) Asphaltic concrete shall be Caltrans, Type A HMA (Hot Mix Asphalt), $\frac{3}{4}$ inch maximum ($\frac{1}{2}$ inch maximum for parking areas), with PG70-10 PG64-16 asphalt concrete, compacted to a minimum of 95% of the Hveem density (CAL 308) or a minimum of 92% of the Maximum Theoretical Density (ASTM D2041).
- 2) Aggregate base shall conform to Caltrans Class 2 ($\frac{3}{4}$ in. maximum), compacted to a minimum of 95% of ASTM D1557 maximum dry density.
- 3) Place pavements on 12 inches of moisture conditioned (at least 2% of over optimum) native soil compacted to a minimum of 95% of the maximum dry density determined by ASTM D1557, or the governing agency requirements.

Final pavement sections may need to be determined by sampling and R-Value testing during grading operations when actual subgrade soils are exposed.

Observation and Density Testing

Site preparation and fill placement should be continuously observed and tested by a representative of a qualified geotechnical engineering firm. Near full-time observation services during the excavation and scarification process is necessary to detect undesirable materials or conditions and soft areas that may be encountered in the construction area. The geotechnical firm that provides observation and testing during construction shall assume the responsibility of "**geotechnical engineer of record**" and, as such, shall perform additional tests and investigation as necessary to satisfy themselves as to the site conditions and the recommendations for site development.

Additional Services

We recommend that **Landmark Consultants, Inc.** be retained to provide tests and observations services during construction. *The geotechnical engineering firm providing such tests and observations shall become the geotechnical engineer of record and assume responsibility for the project.*

Landmark Consultants, Inc. recommendations for this site are, to a high degree, dependent upon appropriate quality control of subgrade preparation, fill placement, and foundation construction. Accordingly, the findings and professional opinions in this report are made contingent upon the opportunity for **Landmark Consultants, Inc.** to observe grading operations and foundation excavations for the proposed construction.

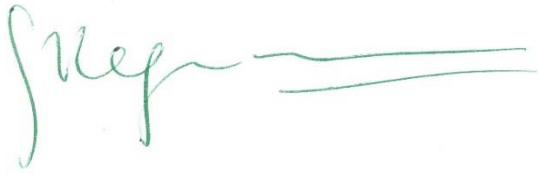
*If parties other than **Landmark Consultants, Inc.** are engaged to provide observation and testing services during construction, such parties must be notified that they will be required to assume complete responsibility as the geotechnical engineer of record for the geotechnical phase of the project by concurring with the recommendations in this report and/or by providing alternative recommendations.*

Closure

Additional information concerning the scope and cost of these services can be obtained from our office. We did not encounter soil conditions that would preclude implementation of the proposed project provided the recommendations contained in this report are implemented in the design and construction of this project.

We appreciate the opportunity to provide our findings and professional opinions regarding geotechnical conditions at the site. Please provide our office with a set of the foundation plans and civil plans for review to insure that the geotechnical site constraints have been included in the design documents. If you have any questions or comments regarding our findings, please call our office at (760) 360-0665.

Respectfully Submitted,
LandMark Consultants, Inc.



Greg M. Chandra, PE, M.ASCE
Principal Engineer



Attachments:

- Appendix A: Vicinity and Site Maps
- Appendix B: Subsurface Soil Logs and Soil Key
- Appendix C: Laboratory Test Results
- Appendix D: Soil Infiltration Test Results

TABLES

Table 1
Summary of Characteristics of Closest Known Active Faults

Fault Name	Approximate Distance (miles)	Approximate Distance (km)	Maximum Moment Magnitude (Mw)	Fault Length (km)	Slip Rate (mm/yr)
San Andreas - San Bernardino (South)	1.7	2.7	7.4	103 ± 10	30 ± 7
San Jacinto - San Bernardino	3.9	6.2	6.7	36 ± 4	12 ± 6
Cucamonga	7.3	11.6	6.9	28 ± 3	5 ± 2
Cleghorn	7.3	11.7	6.5	25 ± 3	3 ± 2
North Frontal Fault Zone - Western	9.6	15.3	7.2	51 ± 5	1 ± 0.5
San Jacinto - San Jacinto Valley	11.2	17.9	6.9	43 ± 4	12 ± 6
San Andreas - Mojave	13.7	21.9	7.1	39 ± 4	3 ± 3
San Jose	22.1	35.3	6.4	20 ± 2	0.5 ± 0.5
Sierra Madre	24.9	39.9	7.2	57 ± 6	2 ± 1
Chino Avenue	25.8	41.3	6.7	28 ± 3	1 ± 1
Helendale - S. Lockhart	28.2	45.2	7.3	97 ± 10	0.6 ± 0.4
Elsinore - Glen Ivy	28.6	45.8	6.8	36 ± 4	5 ± 2
Whittier	28.6	45.8	6.8	38 ± 4	2.5 ± 1
Clamshell-Sawpit	31.1	49.7	6.5	16 ± 2	0.5 ± 0.5
North Frontal Fault Zone - Eastern	32.3	51.7	6.7	27 ± 3	0.5 ± 0.3
Pinto Mtn.	34.6	55.4	7.2	74 ± 7	2.5 ± 2
Elsinore - Temecula	34.8	55.7	6.8	43 ± 4	5 ± 2
Puente Hills Blind Thrust	36.0	57.7	7.1	44 ± 4	0.7 ± 0.4
San Jacinto - Anza	37.2	59.5	7.2	91 ± 9	12 ± 6
Lenwood - Lockhart - Old Woman Springs	37.4	59.9	7.5	145 ± 15	0.6 ± 0.4
Garnet Hill *	38.9	62.3			
Morongo *	40.8	65.2			

* Note: Faults not included in CGS database.

Table 2
2022 California Building Code (CBC) and ASCE 7-16 Seismic Parameters

Soil Site Class:	C	<u>ASCE 7-16 Reference</u>
Latitude:	34.1706 N	Table 20.3-1
Longitude:	-117.3108 W	
Risk Category:	II	
Seismic Design Category:	E	

Maximum Considered Earthquake (MCE) Ground Motion

Mapped MCE _R Short Period Spectral Response	S_s	2.332 g	ASCE Figure 22-1
Mapped MCE _R 1 second Spectral Response	S_1	0.991 g	ASCE Figure 22-2
Short Period (0.2 s) Site Coefficient	F_a	1.20	ASCE Table 11.4-1
Long Period (1.0 s) Site Coefficient	F_v	1.40	ASCE Table 11.4-2
MCE _R Spectral Response Acceleration Parameter (0.2 s)	S_{MS}	2.798 g	= $F_a * S_s$ ASCE Equation 11.4-1
MCE _R Spectral Response Acceleration Parameter (1.0 s)	S_{M1}	1.387 g	= $F_v * S_1$ ASCE Equation 11.4-2

Design Earthquake Ground Motion

Design Spectral Response Acceleration Parameter (0.2 s)	S_{DS}	1.866 g	= $2/3 * S_{MS}$ ASCE Equation 11.4-3
Design Spectral Response Acceleration Parameter (1.0 s)	S_{D1}	0.925 g	= $2/3 * S_{M1}$ ASCE Equation 11.4-4
Risk Coefficient at Short Periods (less than 0.2 s)	C_{RS}	0.904	ASCE Figure 22-17
Risk Coefficient at Long Periods (greater than 1.0 s)	C_{R1}	0.883	ASCE Figure 22-18
	T_L	8.00 sec	ASCE Figure 22-12
	T_O	0.10 sec	= $0.2 * S_{D1} / S_{DS}$
	T_S	0.50 sec	= S_{D1} / S_{DS}
Peak Ground Acceleration	PGA_M	1.20 g	ASCE Equation 11.8-1

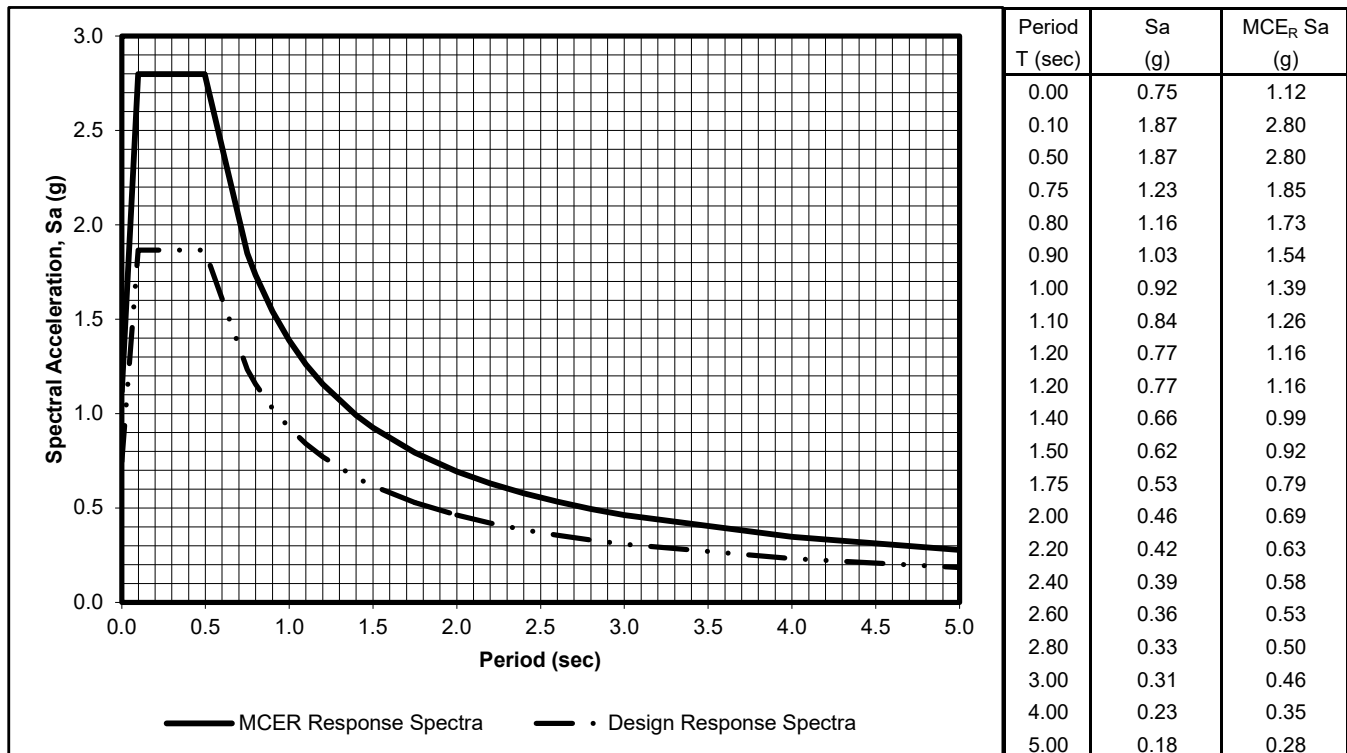
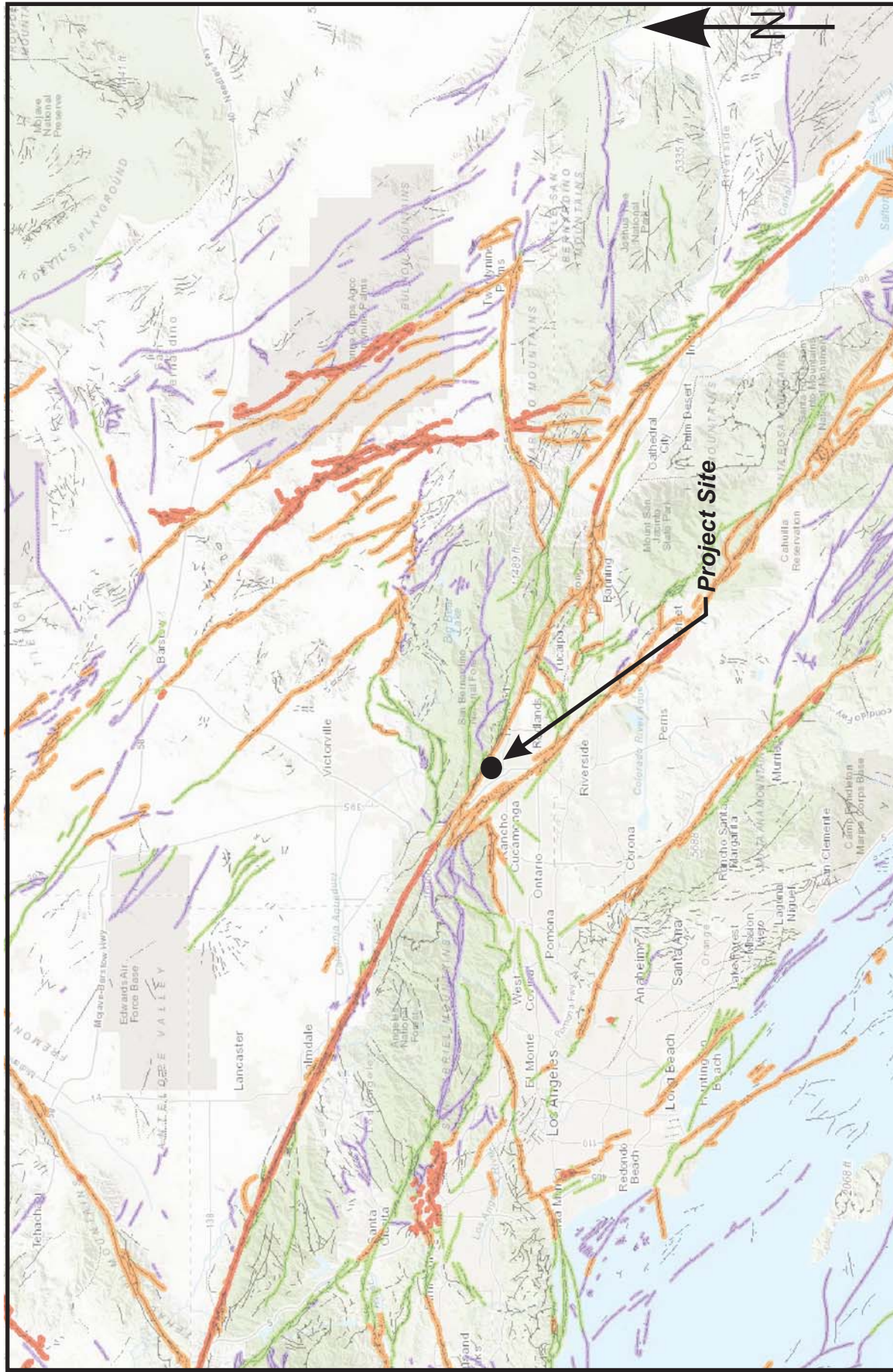


Table 3
Soil Site Class Determination per ASCE 7-16, Section 20.4
Shandin Hills MHRC - San Bernardino, CA
LCI Project No. LP23116

Boring B-1

Sample Depth	SPT Blow Count	di/Ni	Sum di/Ni	Avg. Nch
0				
5	35	0.14	0.65	62
10	26	0.19		
15	100	0.05		
20	100	0.05		
25	83	0.06		
30	100	0.05		
35	100	0.05		
40	100	0.05		

FIGURES

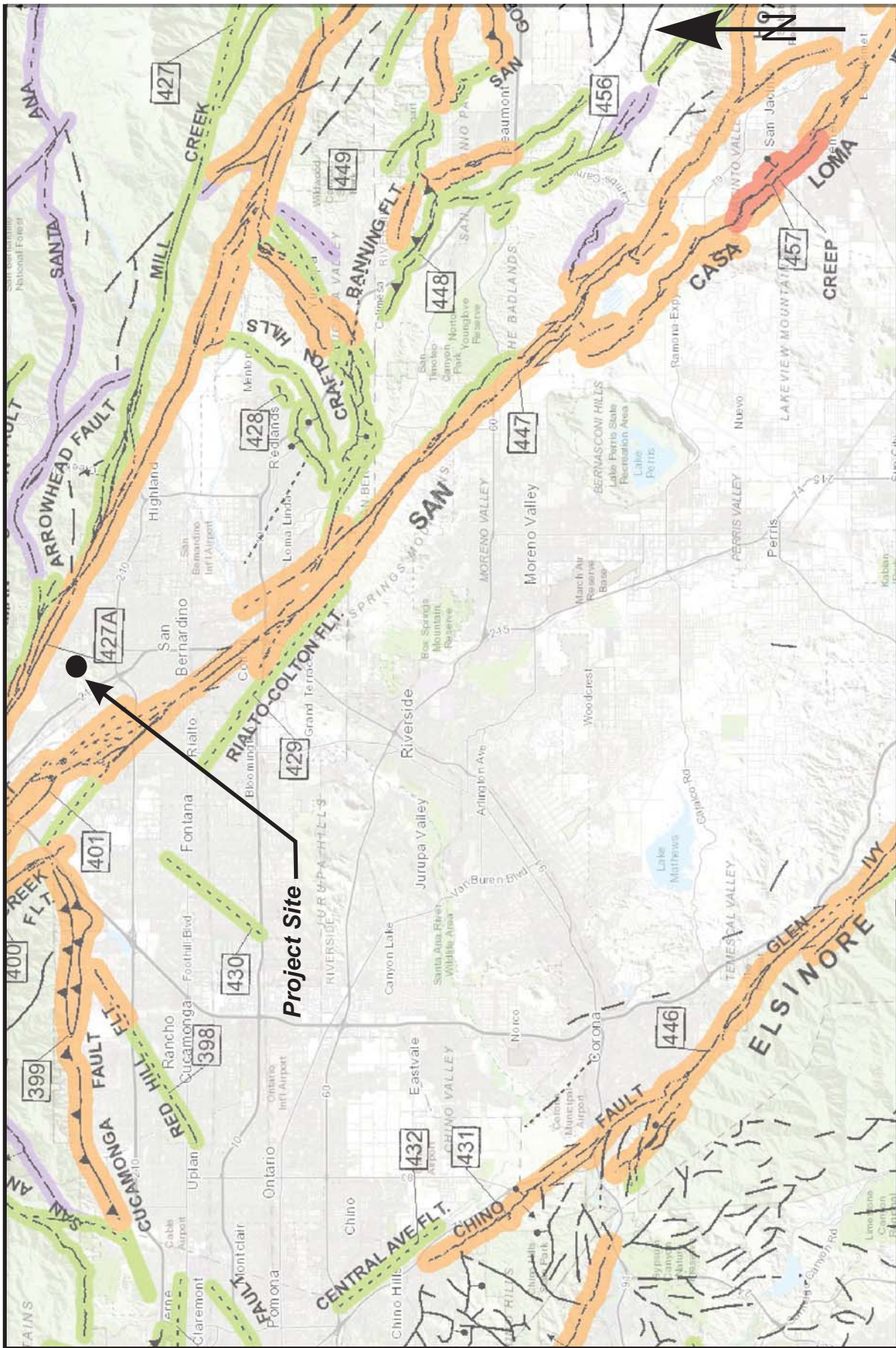


Source: California Geological Survey 2010 Fault Activity Map of California <https://maps.conservation.ca.gov/cgs/fam/>

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Regional Fault Map

Figure 1



Source: California Geological Survey 2010 Fault Activity Map of California
<https://maps.conservation.ca.gov/cgs/fam/App/index.html>

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Map of Local Faults

Figure 2

Fault traces on land are indicated by solid lines where well located, by dashed lines where approximately located or inferred, and by dotted lines where concealed by younger rocks or by lakes or bays. Fault traces offshore are queried where continuation or existence is uncertain. Concealed faults in the Great Valley are based on maps of selected subsurface horizons, so locations shown are approximate and may indicate structural trends only. All offshore faults based on seismic reflection profile records are shown as solid lines where well defined, dashed where inferred, queried where uncertain.

Fault along which historic (last 200 years) displacement has occurred and is associated with one or more of the following:

(a) a recorded earthquake with surface rupture. (Also included are some well-defined surface breaks caused by ground shaking during earthquakes, e.g. extensive ground breakage, not on the White Wolf fault, caused by the Arvin-Tehachapi earthquake of 1952). The date of the associated earthquake is indicated. Where repeated surface ruptures on the same fault have occurred, only the date of the latest movement may be indicated, especially if earlier reports are not well documented as to location of ground breaks.

(b) fault creep slippage - slow ground displacement usually without accompanying earthquakes.

(c) displaced survey lines.

A triangle to the right or left of the date indicates termination point of observed surface displacement. Solid triangle indicates known location of rupture termination point. Open black triangle indicates uncertain or estimated location of rupture termination point.

Date bracketed by triangles indicates local fault break.

No triangle by date indicates an intermediate point along fault break.

Fault that exhibits fault creep slippage. Hachures indicate linear extent of fault creep. Annotation (creep with leader) indicates representative locations where fault creep has been observed and recorded.

Square on fault indicates where fault creep slippage has occurred that has been triggered by an earthquake on some other fault. Date of causative earthquake indicated. Squares to right and left of date indicate terminal points between which triggered creep slippage has occurred (creep either continuous or intermittent between these end points).

Holocene fault displacement (during past 11,700 years) without historic record. Geomorphic evidence for Holocene faulting includes sag ponds, scarps showing little erosion, or the following features in Holocene deposits: offset stream courses; linear scarps, shutter ridges, and triangular faulted spurs. Recent faulting offshore is based on the interpreted age of the youngest strata displaced by faulting.

Late Quaternary fault displacement (during past 700,000 years). Geomorphic evidence similar to that described for Holocene faults except features are less distinct. Faulting may be younger, but lack of younger overlying deposits precludes more accurate age classification.

Quaternary fault (age undifferentiated). Most faults of this category show evidence of displacement sometime during the past 1.6 million years; possible exceptions are faults which displace rocks of undifferentiated Plio-Pleistocene age. Unnumbered Quaternary faults were based on Fault Map of California, 1975. See Bulletin 201, Appendix D for source data.

Pre-Quaternary fault (older than 1.6 million years) or fault without recognized Quaternary displacement. Some faults are shown in this category because the source of mapping used was of reconnaissance nature, or was not done with the object of dating fault displacements. Faults in this category are not necessarily inactive.

Fault Map Legend

ADDITIONAL FAULT SYMBOLS

Bar and ball on downthrown side (relative or apparent).

Arrows along fault indicate relative or apparent direction of lateral movement.

Arrow on fault indicates direction of dip.

Low angle fault (barbs on upper plate). Fault surface generally dips less than 45° but locally may have been subsequently steepened. On offshore faults, barbs simply indicate a reverse fault regardless of steepness of dip.

OTHER SYMBOLS

Numbers refer to annotations listed in the appendices of the accompanying report. Annotations include fault name, age of fault displacement, and pertinent references including Earthquake Fault Zone maps where a fault has been zoned by the Alquist-Philo Earthquake Fault Zoning Act. This Act requires the State Geologist to delineate zones to encompass faults with Holocene displacement.

Structural discontinuity (offshore) separating differing Neogene structural domains. May indicate discontinuities between basement rocks.

Brawley Seismic Zone, a linear zone of seismicity locally up to 10 km wide associated with the releasing step between the Imperial and San Andreas faults.

Geologic Time Scale	Years Before Present (Approx.)	Fault Symbol	Recency of Movement	DESCRIPTION	
				ON LAND	OFFSHORE
Quaternary	Late Quaternary			Displacement during historic time (e.g. San Andreas fault 1906). Includes areas of known fault creep.	
				Displacement during Holocene time.	Fault offsets seaboard sediments or strata of Holocene age.
				Faults showing evidence of displacement during late Quaternary time.	Fault cuts strata of Late Pleistocene age.
				Undivided Quaternary faults - most faults in this category show evidence of displacement during the last 1,600,000 years; some faults in this category which displace rocks of undifferentiated Pre-Pleistocene age.	Fault cuts strata of Quaternary age.
Pre-Quaternary	1,600,000'			Faults without recognized Quaternary displacement or evidence of displacement during Quaternary time. Not necessarily inactive.	Fault cuts strata of Pliocene or older age.
				4.5 billion (Age of Earth)	

Quaternary now recognized as extending to 2.6 Ma (Walker and Geissman, 2009). Quaternary faults in this map were established using the previous 1.6 Ma criterion.

APPENDIX A

Project Site



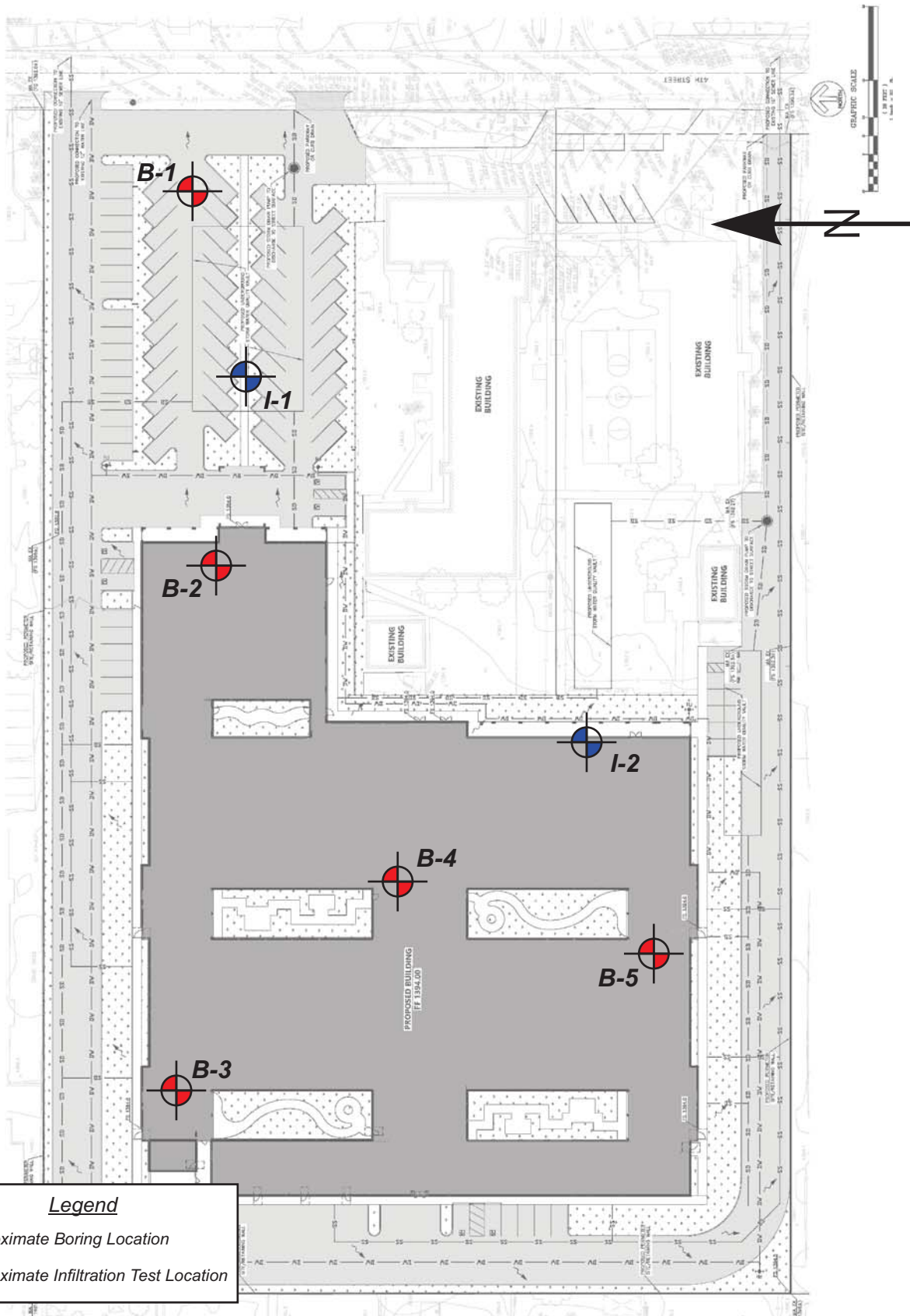
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Project No.: LP23116

Vicinity Map

Plate
A-1



LANDMARK
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Project No.: LP23116

Site and Exploration Map

Plate
A-2



117° 18' 44" W



Map Scale: 1:2,540 if printed on A portrait (8.5" x 11") sheet



Map projection: Web Mercator Corner coordinates: WGS84

117° 18' 29" W



Natural Resources
Conservation Service

Web Soil Survey
National Cooperative Soil Survey

7/24/2023
Page 1 of 3

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Project No.: LP23116

USDA Soil Conservation
Soil Service Map

Plate
A-3

MAP LEGEND

Area of Interest (AOI)

Area of Interest (AOI)

Soils

Soil Map Unit Polygons

Soil Map Unit Lines

Soil Map Unit Points

Special Point Features

Blowout

Borrow Pit

Clay Spot

Closed Depression

Gravel Pit

Gravelly Spot

Landfill

Lava Flow

Marsh or swamp

Mine or Quarry

Miscellaneous Water

Perennial Water

Rock Outcrop

Saline Spot

Sandy Spot

Severely Eroded Spot

Sinkhole

Slide or Slip

Sodic Spot

Water Features

Streams and Canals

Transportation

Rails

Interstate Highways

US Routes

Major Roads

Local Roads

Background

Aerial Photography

Spoil Area

Stony Spot

Very Stony Spot

Wet Spot

Other

Special Line Features

MAP INFORMATION

The soil surveys that comprise your AOI were mapped at 1:24,000.

Warning: Soil Map may not be valid at this scale.

Enlargement of maps beyond the scale of mapping can cause misunderstanding of the detail of mapping and accuracy of soil line placement. The maps do not show the small areas of contrasting soils that could have been shown at a more detailed scale.

Please rely on the bar scale on each map sheet for map measurements.

Source of Map: Natural Resources Conservation Service
Web Soil Survey URL:
Coordinate System: Web Mercator (EPSG:3857)

Maps from the Web Soil Survey are based on the Web Mercator projection, which preserves direction and shape but distorts distance and area. A projection that preserves area, such as the Albers equal-area conic projection, should be used if more accurate calculations of distance or area are required.

This product is generated from the USDA-NRCS certified data as of the version date(s) listed below.

Soil Survey Area: San Bernardino County Southwestern Part, California
Survey Area Data: Version 14, Sep 6, 2022

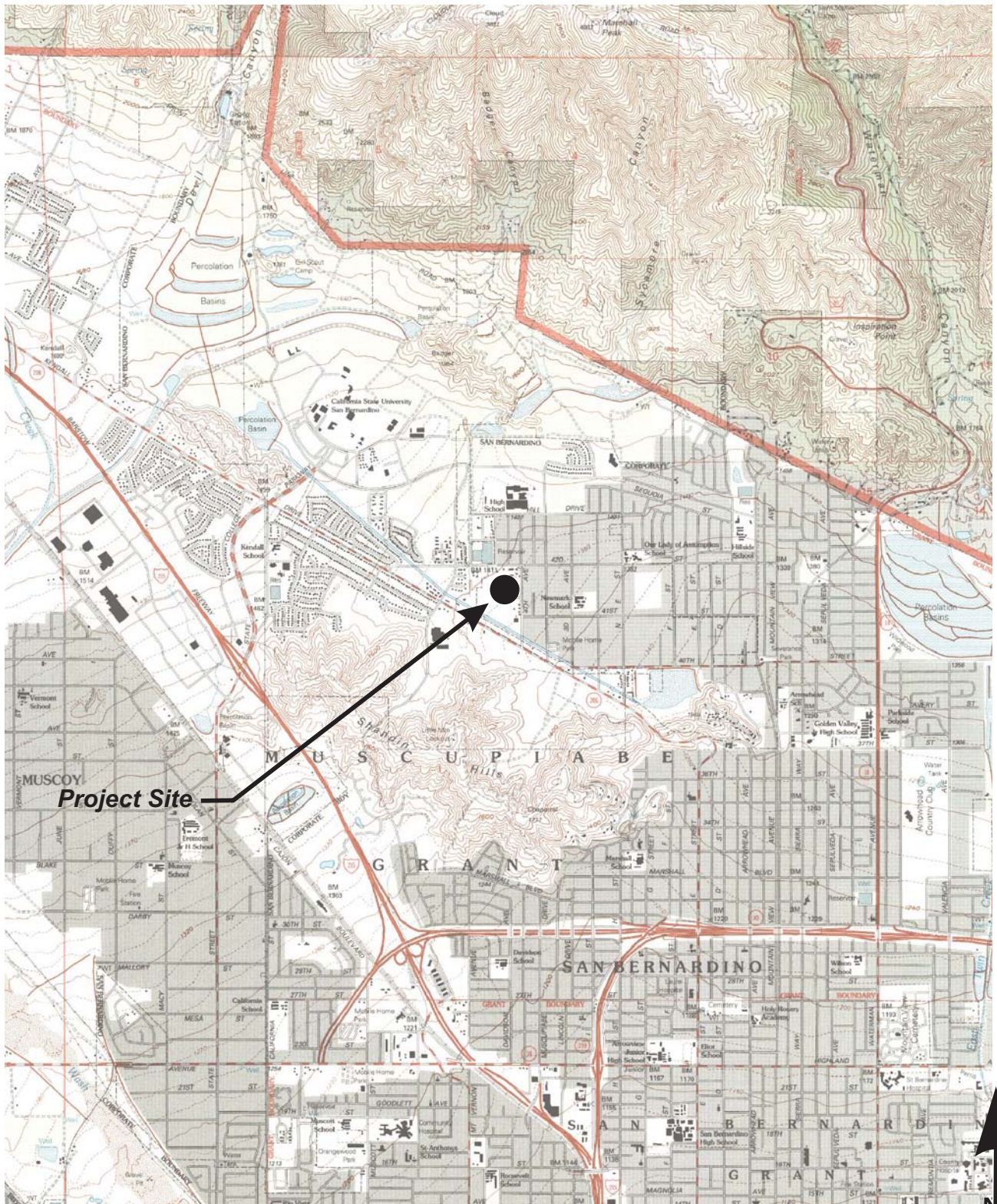
Soil map units are labeled (as space allows) for map scales 1:50,000 or larger.

Date(s) aerial images were photographed: Mar 17, 2022—Jun 12, 2022

The orthophoto or other base map on which the soil lines were compiled and digitized probably differs from the background imagery displayed on these maps. As a result, some minor shifting of map unit boundaries may be evident.

Map Unit Legend

Map Unit Symbol	Map Unit Name	Acres in AOI	Percent of AOI
SpC	Soboba stony loamy sand, 2 to 9 percent slopes	0.1	0.3%
TuB	Tujunga loamy sand, 0 to 5 percent slopes	5.6	17.5%
TvC	Tujunga gravelly loamy sand, 0 to 9 percent slopes	26.4	82.2%
Totals for Area of Interest		32.1	100.0%



Reference: USGS Topographic Map
San Bernardino North, CA Quadrangle
Scale 1:25,000

Site Coordinates
Lat: 34.1706N
Long: -117.3108W

LANDMARK
Geo-Engineers and Geologists

Project No.: LP23116

Topographic Map

Plate
A-4

LEGEND



SPECIAL FLOOD HAZARD AREAS SUBJECT TO INUNDATION BY THE 1% ANNUAL CHANCE FLOOD

The 1% annual flood (100-year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water-surface elevation of the 1% annual chance flood.

ZONE A	No Base Flood Elevations determined.
ZONE AE	Base Flood Elevations determined.
ZONE AH	Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.
ZONE AO	Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.
ZONE AR	Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.
ZONE A99	Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.
ZONE V	Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.
ZONE VE	Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.



FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.



OTHER FLOOD AREAS

ZONE X

Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.



OTHER AREAS

ZONE X

Areas determined to be outside the 0.2% annual chance floodplain.

ZONE D

Areas in which flood hazards are undetermined, but possible.



COASTAL BARRIER RESOURCES SYSTEM (CBRS) AREAS

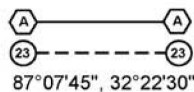


OTHERWISE PROTECTED AREAS (OPAs)

CBRS areas and OPAs are normally located within or adjacent to Special Flood Hazard Areas.

	1% annual chance floodplain boundary
	0.2% annual chance floodplain boundary
	Floodway boundary
	Zone D boundary
	CBRS and OPA boundary
	Boundary dividing Special Flood Hazard Area Zones and boundary dividing Special Flood Hazard Areas of different Base Flood Elevations, flood depths or flood velocities.
	Base Flood Elevation line and value; elevation in feet*
(EL 987)	Base Flood Elevation value where uniform within zone; elevation in feet*

* Referenced to the North American Vertical Datum of 1988



Cross section line

Transect line

Geographic coordinates referenced to the North American Datum of 1983 (NAD 83), Western Hemisphere

2476000m N

1000-meter Universal Transverse Mercator grid values, zone 11N

600000 FT

5000-foot grid ticks: California State Plane coordinate system, zone VI (FIPSZONE 0406), Lambert Conformal Conic projection

DX5510 x

Bench mark (see explanation in Notes to Users section of this FIRM panel)

● M1.5

River Mile

APPENDIX B

DEPTH	FIELD				LOG OF BORING No. B-1 SHEET 1 OF 1	LABORATORY		
	SAMPLE	USCS CLASS.	BLOW COUNT	POCKET PEN. (tsf)		DESCRIPTION OF MATERIAL	DRY DENSITY (pcf)	MOISTURE CONTENT (% dry wt.)
5					SILTY SAND (SP): Reddish gray, dry, medium dense, fine to coarse grained	103.6	3.0	Passing #200 = 15.4%
10			20		SAND (SP): Reddish brown, dry, medium dense, fine to coarse grained, some fine gravel			
15			15			122.9	3.3	Passing #200 = 4.9%
20			52		SAND (SP-SM): Brown, dry, medium dense to dense, fine to coarse grained, some fine gravel			
25			29				2.	Passing #200 = 5.4%
30								
35								
40								
45								
50								
55								
60					Groundwater was encountered at time of drilling. This is not considered the stabilized groundwater depth as groundwater may rise to a level higher than that measured in borehole.			

DATE DRILLED: 6/22/23	TOTAL DEPTH: 21.5 feet	DEPTH TO WATER: NA
LOGGED BY: L. Jackson	TYPE OF BIT: Hollow Stem Auger	DIAMETER: 8 in.
SURFACE ELEVATION: Approximately 1395 ft	HAMMER WT.: 140 lbs.	DROP: 30 in.

PROJECT NO. LP23116		PLATE B-1
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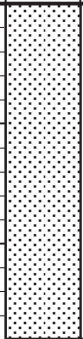
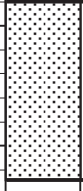
DEPTH	FIELD				LOG OF BORING No. B-2 SHEET 1 OF 1	LABORATORY		
	SAMPLE	USCS CLASS.	BLOW COUNT	POCKET PEN. (tsf)		DESCRIPTION OF MATERIAL	DRY DENSITY (pcf)	MOISTURE CONTENT (% dry wt.)
5			60		SAND (SP-SM): Reddish brown to brown, dry, dense to very dense, fine to coarse grained, some fine gravel moist	99.9	1.5	Passing #200 = 9.8%
10			34				1.7	Passing #200 = 8.7%
15			33				8.8	
20			40				3.1	Passing #200 = 7.7%
25			50/5"				2.4	
30			50/6"			125.6	2.2	Passing #200 = 6.2%
35								
40								
45								
50								
55								
60					Groundwater was encountered at time of drilling. This is not considered the stabilized groundwater depth as groundwater may rise to a level higher than that measured in borehole.			

DATE DRILLED: 6/22/23
 LOGGED BY: L. Jackson
 SURFACE ELEVATION: Approximately 1396 ft

TOTAL DEPTH: 31.5 feet
 TYPE OF BIT: Hollow Stem Auger
 HAMMER WT.: 140 lbs.

DEPTH TO WATER: NA
 DIAMETER: 8 in.
 DROP: 30 in.

PROJECT NO. LP23116		PLATE B-2
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DEPTH	FIELD				LOG OF BORING No. B-3 SHEET 1 OF 1	LABORATORY		
	SAMPLE	USCS CLASS.	BLOW COUNT	POCKET PEN. (tsf)		DESCRIPTION OF MATERIAL	DRY DENSITY (pcf)	MOISTURE CONTENT (% dry wt.)
5			26		SAND (SP): Reddish brown, dry, medium dense, fine to coarse grained, some fine gravel	116.9	2.7	Passing #200 = 2.2%
10			16		No recovery			
15			68		SAND (SP-SM): Reddish gray to brown, dry, dense to very dense, fine to coarse grained, some fine gravel	132.5	1.6	Passing #200 = 5.4%
20			38					
25								
30								
35								
40								
45								
50								
55								
60					Groundwater was encountered at time of drilling. This is not considered the stabilized groundwater depth as groundwater may rise to a level higher than that measured in borehole.		2.5	

DATE DRILLED: 6/22/23
LOGGED BY: L. Jackson
SURFACE ELEVATION: Approximately 1400 ft

TOTAL DEPTH: 21.5 feet
TYPE OF BIT: Hollow Stem Auger
HAMMER WT.: 140 lbs.

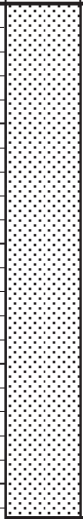
DEPTH TO WATER: NA
DIAMETER: 8 in.
DROP: 30 in.

PROJECT NO. LP23116		PLATE B-3
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DEPTH	FIELD				LOG OF BORING No. B-4 SHEET 1 OF 1	LABORATORY			
	SAMPLE	USCS CLASS.	BLOW COUNT	POCKET PEN. (tsf)		DESCRIPTION OF MATERIAL	DRY DENSITY (pcf)	MOISTURE CONTENT (% dry wt.)	OTHER TESTS
5			35		SAND (SP-SM): Reddish brown to dark brown, dry, medium dense to very dense, fine to coarse grained, some fine gravel	125.4	2.1		
10			26				2.1		Passing #200 = 9.6%
15			50/6"			132.5	2.9		
20			50/4"				1.9		Passing #200 = 6.5%
25			83			114.0	2.4		
30			50/6"				2.7		Passing #200 = 7.5%
35			50/3"				2.6		
40			50/6"				2.9		Passing #200 = 6.1%
45									
50									
55									
60					Groundwater was encountered at time of drilling. This is not considered the stabilized groundwater depth as groundwater may rise to a level higher than that measured in borehole.				

DATE DRILLED: <u>6/22/23</u>	TOTAL DEPTH: <u>41.5 feet</u>	DEPTH TO WATER: <u>NA</u>
LOGGED BY: <u>L. Jackson</u>	TYPE OF BIT: <u>Hollow Stem Auger</u>	DIAMETER: <u>8 in.</u>
SURFACE ELEVATION: <u>Approximately 1398 ft</u>	HAMMER WT.: <u>140 lbs.</u>	DROP: <u>30 in.</u>

PROJECT NO. LP23116		PLATE B-4
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DEPTH	FIELD				LOG OF BORING No. B-5 SHEET 1 OF 1	LABORATORY		
	SAMPLE	USCS CLASS.	BLOW COUNT	POCKET PEN. (tsf)		DESCRIPTION OF MATERIAL	DRY DENSITY (pcf)	MOISTURE CONTENT (% dry wt.)
5			32		SAND (SP): Reddish brown to gray brown, dry, medium dense to very dense, fine to coarse grained, some fine gravel	123.2	2.9	Passing #200 = 4.3%
10			18				3.3	
15			63				3.2	
20			75/9"				1.4	
25					Groundwater was encountered at time of drilling. This is not considered the stabilized groundwater depth as groundwater may rise to a level higher than that measured in borehole.			
30								
35								
40								
45								
50								
55								
60								
DATE DRILLED: 6/22/23					TOTAL DEPTH: 21.5 feet		DEPTH TO WATER: NA	
LOGGED BY: L. Jackson					TYPE OF BIT: Hollow Stem Auger		DIAMETER: 8 in.	
SURFACE ELEVATION: Approximately 1394 ft					HAMMER WT.: 140 lbs.		DROP: 30 in.	
PROJECT NO. LP23116							PLATE B-5	

DEFINITION OF TERMS

PRIMARY DIVISIONS			SYMBOLS		SECONDARY DIVISIONS	
Coarse grained soils More than half of material is larger than No. 200 sieve	Gravels	Clean gravels (less than 5% fines)		GW	Well graded gravels, gravel-sand mixtures, little or no fines	
		More than half of coarse fraction is larger than No. 4 sieve	Gravel with fines		GP	Poorly graded gravels, or gravel-sand mixtures, little or no fines
				GM	Silty gravels, gravel-sand-silt mixtures, non-plastic fines	
			GC	Clayey gravels, gravel-sand-clay mixtures, plastic fines		
	Sands		Clean sands (less than 5% fines)		SW	Well graded sands, gravelly sands, little or no fines
		More than half of coarse fraction is smaller than No. 4 sieve	Sands with fines		SP	Poorly graded sands or gravelly sands, little or no fines
				SM	Silty sands, sand-silt mixtures, non-plastic fines	
				SC	Clayey sands, sand-clay mixtures, plastic fines	
Fine grained soils More than half of material is smaller than No. 200 sieve	Silts and clays			ML	Inorganic silts, clayey silts with slight plasticity	
	Liquid limit is less than 50%			CL	Inorganic clays of low to medium plasticity, gravelly, sandy, or lean clays	
				OL	Organic silts and organic clays of low plasticity	
	Silts and clays			MH	Inorganic silts, micaceous or diatomaceous silty soils, elastic silts	
	Liquid limit is more than 50%			CH	Inorganic clays of high plasticity, fat clays	
				OH	Organic clays of medium to high plasticity, organic silts	
Highly organic soils				PT	Peat and other highly organic soils	

GRAIN SIZES

Silts and Clays	Sand			Gravel		Cobbles	Boulders
	Fine	Medium	Coarse	Fine	Coarse		
	200	40	10	4	3/4"	3"	12"
	US Standard Series Sieve				Clear Square Openings		

Sands, Gravels, etc.	Blows/ft. *
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Over 50

Clays & Plastic Silts	Strength **	Blows/ft. *
Very Soft	0-0.25	0-2
Soft	0.25-0.5	2-4
Firm	0.5-1.0	4-8
Stiff	1.0-2.0	8-16
Very Stiff	2.0-4.0	16-32
Hard	Over 4.0	Over 32

* Number of blows of 140 lb. hammer falling 30 inches to drive a 2 inch O.D. (1 3/8 in. I.D.) split spoon (ASTM D1586).

** Unconfined compressive strength in tons/s.f. as determined by laboratory testing or approximated by the Standard Penetration Test (ASTM D1586), Pocket Penetrometer, Torvane, or visual observation.

Type of Samples:

☐ Ring Sample

☐ Standard Penetration Test

☐ Shelby Tube

☒ Bulk (Bag) Sample

Drilling Notes:

1. Sampling and Blow Counts

Ring Sampler - Number of blows per foot of a 140 lb. hammer falling 30 inches.

Standard Penetration Test - Number of blows per foot.

Shelby Tube - Three (3) inch nominal diameter tube hydraulically pushed.

2. P. P. = Pocket Penetrometer (tons/s.f.).

3. NR = No recovery.

4. GWT = Ground Water Table observed @ specified time.

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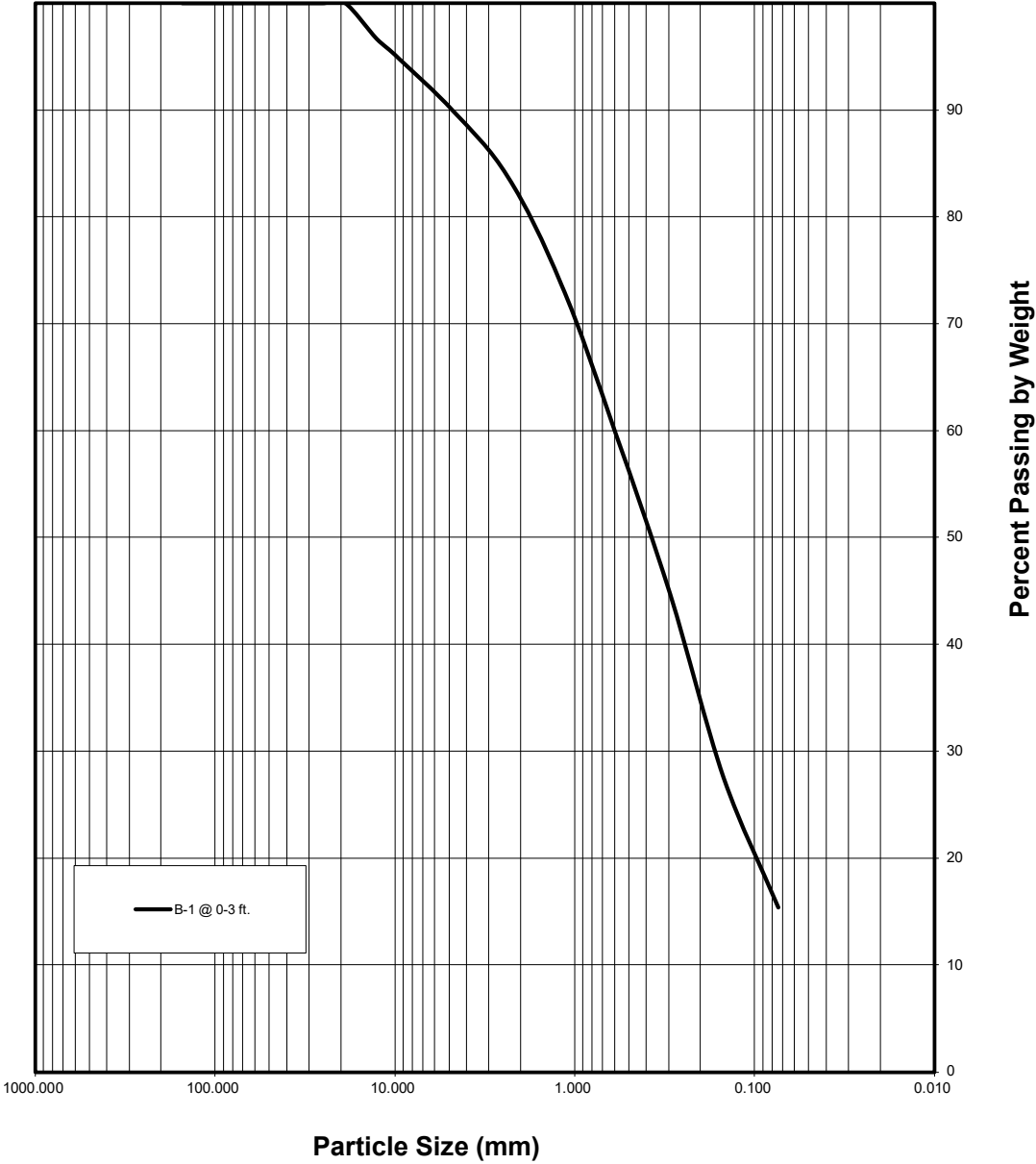
Project No. LP23116

Key to Logs

Plate
B-6

APPENDIX C

SIEVE ANALYSIS						
Cobbles and Boulders	Gravel		Sand			Silt and Clay
	Coarse	Fine	Coarse	Medium	Fine	



LANDMARK CONSULTANTS, INC.

CLIENT: New Gen HC

PROJECT: Shandin Hills MHRC - San Bernardino, CA

JOB No.: LP23116

DATE: 06/23/23

CHEMICAL ANALYSIS

Boring:	B-1	Caltrans Method
Sample Depth, ft:	0-3	
pH:	7.8	643
Electrical Conductivity (mmhos):	--	424
Resistivity (ohm-cm):	9,300	643
Chloride (Cl), ppm:	80	422
Sulfate (SO₄), ppm:	23	417

General Guidelines for Soil Corrosivity

Material Affected	Chemical Agent	Amount in Soil (ppm)	Degree of Corrosivity
Concrete	Soluble Sulfates	0 - 1,000	Low
		1,000 - 2,000	Moderate
		2,000 - 20,000	Severe
		> 20,000	Very Severe
Normal Grade Steel	Soluble Chlorides	0 - 200	Low
		200 - 700	Moderate
		700 - 1,500	Severe
		> 1,500	Very Severe
Normal Grade Steel	Resistivity	1 - 1,000	Very Severe
		1,000 - 2,000	Severe
		2,000 - 10,000	Moderate
		> 10,000	Low



Project No.: LP23116

**Selected Chemical
Test Results**

**Plate
C-2**

Client: New GEN HC

Project: Shandin Hills MHRC - San Bernardino, CA

Project No.: LP23116

Date: 6/30/2023

Lab. No.: N/A

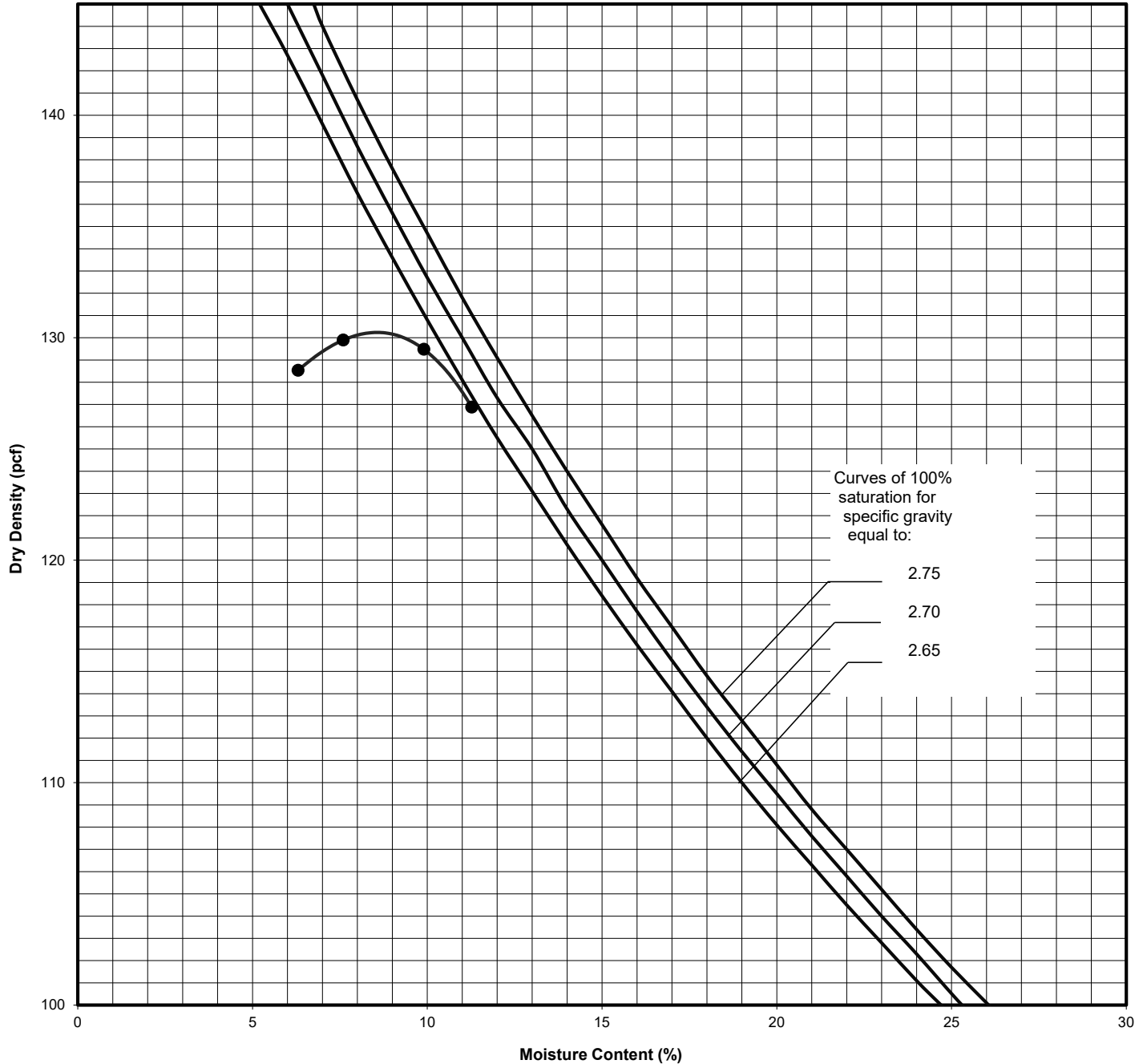
Soil Description: Olive-Brown Silty Sand w/ Gravel

Sample Location: B-1 @ 0-3 ft.

Test Method: ASTM D-1557 A

Maximum Dry Density (pcf): 130.2

Optimum Moisture Content (%): 8.6



APPENDIX D

LANDMARK CONSULTANTS, INC

Project:	Shandin Hills MHRC	Project No:	LP23116	Date:	7/10/2023
Test Hole No:	I-1	Tested By:	Maddy E		
Depth of Test Hole, D_T :	60"	USCS Soil Classification:	SM		
Test Hole Dimensions (inches)			Length	Width	
Diameter (if round)=	6"	Sides (if rectangular)=			

Sandy Soil Criteria Test*

Trial No.	Start Time	Stop Time	Time Interval, (min.)	Initial Depth to Water (in.)	Final Depth to Water (in.)	Change in Water Level (in.)	Greater than or Equal to 6"? (y/n)
1	8:02	8:15	13.00	16.00	48.00	32.00	Yes
2	8:25	8:40	15.00	23.00	36.00	13.00	Yes

*If two consecutive measurements show that six inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Other wise, pre-soak (fill) overnight. Obtain at least twelve measurements per hole over at least six hours (approximately 30 minute intervals) with a precision of at least 0.25".

Trial No.	Start Time	Stop Time	Δt Time Interval (min.)	D_o Initial Depth to Water (in.)	D_f Final Depth to Water (in.)	ΔD Change in Water Level (in.)	Percolation Rate (min./in.)
1	8:41	8:51	10.00	27.00	34.00	7.00	1.43
2	8:51	9:01	10.00	25.00	32.00	7.00	1.43
3	9:01	9:11	10.00	24.00	32.00	8.00	1.25
4	9:11	9:21	10.00	23.00	31.00	8.00	1.25
5	9:21	9:31	10.00	23.00	31.00	8.00	1.25
6	9:31	9:41	10.00	21.00	29.00	8.00	1.25
7							
8							
9							
10							
11							
12							

COMMENTS:



Project No.: LP23116

Percolation Test Results

Plate
D-1

PERCOLATION RATE CONVERSION

CLIENT: New Gen HC
PROJECT: Shandin Hills MHRC
PROJECT NO.: LP23116
DATE: 7/14/2023

TEST HOLE NO: I-1

Time interval, Δt = 10 inches

Initial Depth to Water, D_0 = 21 inches

Final Depth to Water, D_f = 29 inches

Total Depth of Test Hole, D_T = 60 inches

Test Hole Radius, r = 4 inches

The conversion equation is used:

$$I_t = \frac{\Delta H 60 r}{\Delta t (r + 2H_{avg})}$$

" H_0 " is the initial height of water at the selected time interval

$$H_0 = D_T - D_0 = 60 - 21 = 39 \text{ inches}$$

" H_f " is the final height of water at the selected time interval

$$H_f = D_T - D_0 = 60 - 21 = 31 \text{ inches}$$

" ΔH " is the change in height over the time interval

$$\Delta H = \Delta D = H_0 - H_f = 39 - 31 = 8 \text{ inches}$$

" H_{avg} " is the average head height over the time interval

$$H_{avg} = (H_0 + H_f) / 2 = (39 + 31) / 2 = 35 \text{ inches}$$

" I_t " is the tested infiltration rate

$$I_t = \frac{\Delta H 60 r}{\Delta t (r + 2H_{avg})} = \frac{(8 \text{ in})(60 \text{ min/hr})(4 \text{ in})}{(10 \text{ min})(4 \text{ in} + 2(35 \text{ in}))} = 2.59 \text{ in/hr}$$

LANDMARK

Geo-Engineers and Geologists

Project No.: LP23116

Percolation Rate Conversion

Plate
D-2

LANDMARK CONSULTANTS, INC

Project:	Shandin Hills MHRC	Project No:	LP23116	Date:	7/10/2023
Test Hole No:	I-2	Tested By:	Maddy E		
Depth of Test Hole, D_T :	60"	USCS Soil Classification:	SM		
Test Hole Dimensions (inches)			Length	Width	
Diameter (if round)=	6"	Sides (if rectangular)=			

Sandy Soil Criteria Test*

Trial No.	Start Time	Stop Time	Time Interval, (min.)	Initial Depth to Water (in.)	Final Depth to Water (in.)	Change in Water Level (in.)	Greater than or Equal to 6"? (y/n)
1	8:15	8:30	15.00	0.00	23.00	23.00	Yes
2	8:32	8:47	15.00	9.00	22.00	13.00	Yes

*If two consecutive measurements show that six inches of water seeps away in less than 25 minutes, the test shall be run for an additional hour with measurements taken every 10 minutes. Other wise, pre-soak (fill) overnight. Obtain at least twelve measurements per hole over at least six hours (approximately 30 minute intervals) with a precision of at least 0.25".

Trial No.	Start Time	Stop Time	Δt Time Interval (min.)	D_o Initial Depth to Water (in.)	D_f Final Depth to Water (in.)	ΔD Change in Water Level (in.)	Percolation Rate (min./in.)
1	8:48	8:58	10.00	8.00	18.00	10.00	1.00
2	8:58	9:08	10.00	9.00	17.00	8.00	1.25
3	9:08	9:18	10.00	10.00	17.00	7.00	1.43
4	9:18	9:28	10.00	11.00	16.00	5.00	2.00
5	9:28	9:38	10.00	12.00	17.00	5.00	2.00
6	9:38	9:48	10.00	9.00	14.00	5.00	2.00
7							
8							
9							
10							
11							
12							

COMMENTS:



Project No.: LP23116

Percolation Test Results

Plate
D-3

PERCOLATION RATE CONVERSION

CLIENT: New Gen HC
PROJECT: Shandin Hills MHRC
PROJECT NO.: LP23116
DATE: 7/14/2023

TEST HOLE NO: I-2

Time interval, Δt = 10 inches

Initial Depth to Water, D_0 = 9 inches

Final Depth to Water, D_f = 14 inches

Total Depth of Test Hole, D_T = 60 inches

²Test Hole Radius, r = 4 inches

The conversion equation is used:

$$I_t = \frac{\Delta H 60 r}{\Delta t (r + 2H_{avg})}$$

" H_0 " is the initial height of water at the selected time interval

$$H_0 = D_T - D_0 = 60 - 9 = 51 \text{ inches}$$

" H_f " is the final height of water at the selected time interval

$$H_f = D_T - D_0 = 60 - 14 = 46 \text{ inches}$$

" ΔH " is the change in height over the time interval

$$\Delta H = \Delta D = H_0 - H_f = 51 - 46 = 5 \text{ inches}$$

" H_{avg} " is the average head height over the time interval

$$H_{avg} = (H_0 - H_f) / 2 = (51 + 46) / 2 = 48.5 \text{ inches}$$

" I_t " is the tested infiltration rate

$$I_t = \frac{\Delta H 60 r}{\Delta t (r + 2H_{avg})} = \frac{(5 \text{ in})(60 \text{ min/hr})(4 \text{ in})}{(10 \text{ min})((4 \text{ in}) + 2(48.5 \text{ in}))} = 2.18 \text{ in/hr}$$

LANDMARK

Geo-Engineers and Geologists

Project No.: LP23116

Percolation Rate Conversion

Plate
D-4