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File: 1409.1

Mr. Greg Lyman, P.E.
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Subject: **Limited Geotechnical Investigation Report**
TMWA's South Meadows Parkway Well Facility Project
Double Diamond Well No. 3 in Reno, Nevada

This geotechnical report presents the results of our limited geotechnical investigation for the proposed new well building and associated improvements at the South Meadows project site in Reno, Nevada. The approximate location of the project is shown in the attached Vicinity Map (Plate 1) of this report.

We understand that an existing well head is to be enclosed within a building with approximate plan dimensions of 20 feet by 37 feet. The building is also planned to house chlorination equipment to treat the water pumped out of the well prior to being distributed to the existing water system and other equipment for monitoring and control purposes. It is also our understanding that the building may consist of a one story structure with concrete masonry unit (CMU) block walls, a metal/wood roof-frame, and a slab-on-grade floor. For the purpose of this project, we have assumed that conventional shallow foundations will be used to support the proposed structure. No underground structures such as holding tanks are planned for the project at this time.

Structural loads for the small building were not available at the time this report was prepared. Assumed structural loads are not to exceed 1 kips-per-lineal-foot (klf) to 2 klf for continuous perimeter footings. No interior column loads are anticipated for this size building. Lateral building loads are anticipated to be minimal to moderate. Similarly, no vibratory equipment is anticipated to be installed within the building.

Other pertinent improvements may also include underground utilities to connect the well to the existing local water distribution system and/or emergency discharge, and possibly paved access and a small parking area. As a result, earthwork in the order of one foot to three feet is anticipated to create a level pad for the building and surrounding areas. The well building parcel is to cover an area of approximately 9,215 square feet and to be protected by a chain link fence.

Purpose and Scope of Work

The purpose of this investigation was to explore and evaluate the subsurface conditions at the existing undeveloped well site to provide our geotechnical engineering recommendations for project design and construction. The scope of our services was outlined in our Work Order Authorization (WOA) dated July 2, 2014, and included the following:

- A review of available subsurface information contained in our files pertinent to the proposed project construction.
- Exploration of subsurface conditions within the project site utilizing two exploratory test pits.
- Laboratory testing of selected soil samples obtained during the field investigation for this project.
- Engineering analysis on which to base our recommendations for the geotechnical aspects of the project.
- Preparation of this report, which includes:
    1. A brief description of the general geologic setting and seismicity of the vicinity of the project;
    2. A discussion of the general soil and groundwater conditions at the well site with emphasis on how the conditions are expected to affect the proposed construction;
    3. Recommendations for earthwork construction, including site preparation, the reuse of on-site soils as engineered or non-engineered fill, placement of engineered fill, and a discussion of remedial earthwork;
    4. Recommendations for temporary utility excavations and backfill;
    5. Recommendations for conventional shallow spread foundation design including soil bearing values, minimum footing dimension and depth, resistance to lateral loads, estimated settlement, and International Building Code (IBC) Soil Class profile for use in structural design;
    6. Subgrade preparation for slab-on-grade concrete;
    7. A brief discussion of site drainage and moisture protection;

8. Preliminary pavement structural sections based on soil classification, and
9. Potential for site soils to corrode steel or to adversely react with concrete.

Authorization

Authorization to proceed with the scope of work outlined above was provided by Mr. Brent Farr in the form of a signed agreement between engineer and engineer's sub consultant, executed on July 29, 2014.

References

The following information was provided to H.E.M. *Consulting, LLC* (HEM) in the course of this investigation and served as the basis of our understanding of the project type and scope.

- A preliminary well facility layout showing the parcel and easement boundaries, dated July 2014, prepared by Truckee Meadows Water Authority (TMWA) personnel. This document served as the basis for the Site Plan shown on Plate 2 of this report.

In addition, the following published and unpublished references were reviewed during the preparation of this report.

- Geology and Mineral Deposits of Washoe and Storey Counties, Nevada, Bulletin 70, Nevada Bureau of Mines and Geology.
- Mount Rose NE Quadrangle, Earthquake Hazards Map, Map4Bi, Nevada Bureau of Mines and Geology.
- Mount Rose Northeast Quadrangle, Geologic Map, Map 4Bg, Nevada Bureau of Mines and Geology.
- Quaternary Fault Map of Nevada, Reno Sheet, Map 79, Nevada Bureau of Mines and Geology, 1984.
- Quaternary Faults in Nevada, Map 167, Nevada Bureau of Mines and Geology, 2008.
- USGS Earthquake Hazard Maps, 2008.

Field Exploration

The selection of the exploration locations in the field was based on the anticipated project layout and equipment accessibility. The subsurface exploration consisted of excavating two test pits using a track (rubber) mounted mini excavator with a 20-inch wide bucket. The exploratory test pits were conducted generally on the north and south sides of the proposed building footprint at the existing well head location. Test pit depths ranged from approximately 8.0 feet to a maximum of 8.25 feet below the existing ground surface (bgs). The test pits were located in the field by visual sighting and by pacing from existing features shown on the site plan (Plate 2) as a guide. No topographic map of the site was available at the time this report was prepared. Therefore, the approximate locations shown on the plan and elevations indicated on the test pit logs, if any, should be considered accurate only to the degree implied by the methods used.

Our engineer logged the subsurface soil conditions encountered in the test pits, visually classifying them in accordance with the Unified Soil Classification System (USCS), and obtained representative bulk samples for subsequent laboratory testing. Soil conditions encountered in the test pits are presented in the test pit logs, Plate 3 and Plate 4 of this report. A description of the USCS used to identify the test pit soils, key symbols, and pertinent notes are included on Plate 5.

Soil samples from the test pits were obtained by collecting representative amounts of the major soil strata encountered within the test pit excavations. Samples were packaged and sealed in the field to reduce moisture loss, and returned to our Reno office for subsequent laboratory testing. After logging and sampling was completed, test pits were backfilled with excavated soils and tamped in layers with the equipment at hand. WARNING: Test pit backfill was <u>not</u> compacted to the requirements typically specified for engineered fill. As a result, structures, slabs-on-grade, or pavements located over these areas may experience excessive settlement. Removal and re-compaction of test pit backfill may be required prior to construction of any improvements over these areas.

<u>Laboratory Testing</u>

Laboratory testing was conducted on selected test pit samples to aid in soil classification and to evaluate physical and engineering properties of the predominant soils, which may affect the geotechnical aspects of project design and construction. Laboratory testing was performed on selected soil samples to assess the following:

- Atterberg (Liquid and Plastic) Limits (ASTM D4318)
- Compaction Characteristics (ASTM D1557)
- Moisture Content (ASTM D2216)
- Particle Size Distribution (ASTM D422 and D1140)

In addition, the following analytical tests were performed by Western Environmental Testing (WET) Laboratory:

- pH, Resistivity, and Soluble Chlorides and Soluble Sulfates

Individual laboratory test results can be found on the test pit logs and on Plate 6 through Plate 9 at the end of this report.

General Geologic Setting and Seismicity

The proposed well site is located in the west central portion of the Truckee Meadows, a broad valley bounded on the west by the tall granite peaks of the Sierra Nevada Mountains, and on the east by the lower volcanic peaks of the Virginia Range. Younger volcanic rocks also bound the valley on the north and south. Faults separate the valley from the surrounding mountains as is typical of the Basin and Range province. Sediments filled the valley from a number of tributaries and ancestral lakes during the late Tertiary period. The dominant sediment source has been, and continues to be the Truckee River and its ancestral counterparts. Stream deposits were particularly voluminous after glacial periods. Since the end of the last glacial period, some 10,000 years ago, arid erosional forces combined with faulting have been the predominant processes to shape the region. These processes have created large alluvial fans that surround the valley floor of the Truckee Meadows.

The project site is generally underlain by Quaternary alluvial bajada deposits comprised of sheet like aprons of fine to medium grained clayey to silty sands intercalated with medium pebble gravel, and deposits of low gradient streams that reworked gravelly outwash and alluvial fan deposits.

The site is also bounded on the east and west by queried faults of latest Quaternary age (activity in the last 130,000 years). No active (Holocene age) faults are mapped within two miles of the site. However, the site is anticipated to be subjected to moderate to strong seismic shaking during seismic events in northern Nevada.

A liquefaction evaluation of the subsurface soils at the site was not included in the current scope of work. Liquefaction is the phenomena where loose saturated granular soils loose their shear strength when subjected to cyclic loading, and become unstable. Large earthquakes may provide that type of cyclic loading. Loose sands with varying amounts of fines under saturated conditions are the most susceptible to liquefaction. Due to the presence of relatively shallow groundwater and the type of soils encountered, the potential for liquefaction during and shortly after a seismic event in the vicinity of the project does exist, but is anticipated to occur in localized areas only.

<u>Site Conditions</u>

The ground surface within the undeveloped well site was covered with thick vegetation comprised of native grasses and other chest high weed. The ground indicated a gentle slope towards the east-southeast with surface drainage by sheetflow in the same general direction. A drainage ditch was observed to the west of the well head and close to the boundary fence. A second drainage ditch was observed parallel to South Meadows parkway along the property boundary. A gate was also observed at the northwest corner of the property. A few dump piles were observed to the north and northeast of the well head. Otherwise, the well site was surrounded by undeveloped land on the east and south sides. The areas immediately adjacent to the well showed signs of previous general grading, most likely conducted when the I-580 northbound off ramp and South Meadows Parkway were under construction or at the time the well was constructed and installed, as indicated by the sandy/gravelly veneer observed at the ground surface. At the time of our investigation, the site was accessible via a dirt road coming from the Shell gas station to the east.

<u>Subsurface Conditions</u>

The subsurface conditions encountered at the site (which was confined to the immediate surroundings of the well head) at the time of our investigation consisted generally of seven inches to nine inches of sandy to gravelly fill overlying native silty and clayey sands with varying amounts of fines, a relatively thin layer of clay, and poorly graded sands with silt and gravel at depth. The test pits were extended to depths varying from 8 feet to a maximum of 8.75 feet below ground surface (bgs). Groundwater was encountered at both test pits at depths varying from 7.9 feet to 8.3 feet bgs. However, fluctuations in the level of groundwater and soil moisture conditions may occur due to variations in precipitation, nearby land use, deep well pumping, irrigation, and other factors.

The consistency of the fill soils was loose to medium dense and that of the native granular soils was considered as medium dense to dense to possibly partially cemented to the depths explored for this project. Roots were encountered in the upper soils and not to exceed depths greater than 3 inches.

Laboratory Test Results

Laboratory testing was performed as discussed in a previous section of this report in general accordance with ASTM standard methods. The laboratory test data was reviewed in combination with our field exploration information to assess and evaluate the engineering properties of the predominant soils encountered.

Laboratory test results indicate that moisture contents varied with fines and generally increased with depth. The fines contents of on-site native soils varied from about 9% to roughly 33%. The majority of the fines in the matrix of the granular soils consisted of silt, as indicated by the Atterberg (Liquid and Plastic) Limits test. Similarly, the gravel contents of the on-site granular soils varied from about 4% to roughly 30%. A compaction curve from a representative sample of the near surface soils indicated a maximum dry density of approximately 114 pounds-per-cubic-foot (pcf) at the optimum moisture content of about 13%.

Analytical testing conducted on a representative sample indicates slightly alkaline conditions with a pH of 8.03, a soluble chloride of 16 mg/kg, a soluble sulfate of 26 mg/kg, and a low resistivity of 1,200 ohm-cm under saturated conditions.

The individual laboratory test results, some of which are shown on the test pit logs, should be reviewed for more detailed information on the materials tested (refer to Plates 6 through Plate 9 at the end of this report).

Discussion and Conclusions

From a geotechnical engineering standpoint, the site may be used to accommodate the proposed improvements as planned. Based on the results of our field investigation and laboratory testing program, we have developed the following conclusions. These conclusions may change if additional information becomes available.

- The project site is generally underlain by Quaternary alluvial bajada deposits comprised of sheet like aprons of fine to medium grained clayey to silty sands intercalated with medium pebble gravel, and deposits of low gradient streams that reworked gravelly outwash and alluvial fan deposits.
- The site is also bounded on the east and west by queried faults of latest Quaternary age (activity in the last 130,000 years). No active (Holocene age) faults are mapped within two

miles of the site. However, the site is anticipated to be subjected to moderate to strong seismic shaking during seismic events in northern Nevada.

- Due to the presence of relatively shallow groundwater and the type of soils encountered, the potential for liquefaction during and shortly after a seismic event in the vicinity of the project does exist, but is anticipated to occur in localized areas only.
- No severe soil or groundwater constraints were observed which would preclude development of the proposed improvements at the site. The subsurface conditions encountered at the site consisted generally of seven inches to nine inches of sandy to gravelly fill overlying native silty and clayey sands with varying amounts of fines, a relatively thin layer of clay, and poorly graded sands with silt and gravel to the depths explored.
- Groundwater was encountered at both test pits at depths varying from 7.9 feet to 8.3 feet bgs. However, fluctuations in the level of groundwater and soil moisture conditions may occur due to variations in precipitation, nearby land use, deep well pumping, irrigation, and other factors.
- The consistency of the fill soils was loose to medium dense and that of the native granular soils was considered as medium dense to dense to possibly partially cemented to the depths explored for this project. Roots were encountered in the upper soils and not to exceed depths greater than 3 inches. Due to the presence of un-documented fills, including a few dump piles, and anticipated disturbance due to construction activities at the site, some remedial earthwork during site grading and possibly some minor modifications to planned structures and pavements may be required during site development.
- We anticipate that site grading and excavations for shallow footing and utility trenches can be performed with conventional excavation equipment such as a rubber tire backhoe or small excavator.
- On-site granular soils are anticipated to be generally suitable for reuse as engineered fill.
- Based on the analytical test results, on-site soils should be considered severely corrosive to ferrous metals.

Specific recommendations for project design and construction, including mitigation of potential problems, are presented in the following section of this report.

Recommendations

Site Clearing and Preparation

Prior to construction, soils with organics or deleterious materials within the improvement areas should be stripped and disposed of outside the construction limits. We estimate the average depth of stripping to be approximately less than four inches across the majority of the site. Deeper stripping/grubbing of soils with organics may be required in localized areas. Stripped soil with organics should not be incorporated into engineered fill and should be removed from the site.

The soils engineer should be present during stripping, and removal operations to verify removal depths and to evaluate whether buried obstacles exist. Special care should be exercised in evaluating whether loose or soft utility or excavation backfills exist, which could adversely affect the performance of the proposed improvements. Excavations resulting from removal operations should be cleaned of all loose, soft, or otherwise disturbed soils and widened as necessary to allow access to compaction equipment.

Existing structures to be demolished and/or removed should be designated in the field and removed in accordance with applicable regulations or project specifications. Other structures to remain in place should be properly labeled and protected as necessary. Utilities to remain should be properly tapped and/or re-routed as necessary. No existing underground structures and/or utilities to be abandoned should remain directly under the proposed building footprint. All man-made debris including remnants of demolished structures, existing dump piles, utility remnants, conduits, man-made trash, equipment remnants, and other foreign matter should be removed from the site.

Dust control will be the responsibility of the contractor. A dust control plan should be prepared by the owner, civil engineer, or contractor prior to the start of grading or earthwork for this project.

Following site stripping and any required removals, we recommend that exposed soil surfaces including those to receive engineered fill, pipe bedding, or to be used for the support of pavements or other exterior concrete flatwork should be scarified in place to a depth of at least 6 inches, moisture conditioned to within 2% above optimum, and re-compacted to at least 90% relative compaction.

NOTE: Wherever referenced in his report, relative compaction should be established by comparing the measured in-situ dry density and moisture content to the maximum dry density and moisture content determined in accordance with the ASTM D1557 test method.

Earthwork

General Site Grading

We anticipate that grading and excavations within the building area and associated utility lines at the site can be performed with conventional earthmoving equipment. Further, the type and amount of fines of on-site soils are considered moisture sensitive. As a result, care should be exercised when moisture conditioning on-site soils during construction, which may become unstable very quickly if moisture is added abruptly or indiscriminately and not allowed to distribute uniformly. In addition, vibratory equipment should be used cautiously and discretely during construction to mitigate unstable conditions from developing.

Engineered fill should consist of relatively granular soils free (less than 2%) of organics, with a liquid limit (LL) less than 35%, a plasticity index (PI) of less than 15%, 100% passing the 4-inch sieve, and less than 35% passing the No. 200 sieve. In general, on-site granular soils are considered suitable as engineered fill, provided all oversize material is removed and moisture conditioning of the soils is properly implemented. Saturated or unstable soils should not be incorporated into engineered fill. The project's soils engineer should approve any import fill, prior to being transported to the site.

Oversize material (greater than 4 inches in maximum dimension) should not be included in any engineered fill that will support future structural loads. Some oversize material up to 12 inches in maximum dimension may be used in the deeper portions of fills (greater than 2 feet below of bottom of foundations or utility excavations) and/or beneath paved areas provided individual pieces are placed and spaced far enough apart to prevent nesting.

Soils used for engineered fill should be uniformly moisture conditioned to within 2% above optimum, placed in 6-inch to 8-inch loose lifts, and compacted with appropriate compaction equipment to achieve at least 90% relative compaction. A shrinkage factor of about 5% to 10% should be anticipated when compacting on-site soils. Fill placed within non-structural areas of the project (e.g. areas that will not support structures, concrete slabs-on-grade, pavements or other improvements) may be compacted to a minimum relative compaction of 85%. No fill material shall be placed, spread, or rolled while it is frozen or thawing, saturated, or during unfavorable weather conditions.

Fill placed on slopes steeper than 5 horizontal to 1 vertical (5H:1V) should be keyed and benched into existing stable on-site soils. In general, keyways should extend into medium dense or stiff undisturbed native soils or properly compacted engineered fill, be a minimum of 8 feet wide, 2-feet to 4-feet in depth, and extend the full length of the slope. Benching can be conducted simultaneously with placement of fill. However, the soils engineer should check the method and extent of benching.

Material with more than 30% greater than ¾-inch particles is not applicable for conventional compaction testing. If used, these materials should be uniformly moisture conditioned to within 2% of optimum moisture content, placed in loose layers not exceeding 1 foot, and compacted with a minimum of 5 passes with a sheepsfoot compactor and until a stable and non-yielding surface is obtained. Other types of compaction equipment may require thinner lifts. This type of fill should be placed under continuous monitoring/observation by a field representative of the soils engineer.

Temporary Trench Excavations and Backfill

Based on the excavation conditions encountered within the test pits, we anticipate that excavations for footings and utility trenches can be conducted with a conventional backhoe or small excavator. We expect the walls of footing and/or utility trenches to stand near vertical without significant sloughing to a maximum height of 5 feet, provided that proper moisture contents are maintained. If saturated conditions are encountered, if trenches are extended deeper than 5 feet, or are allowed to dry out, the excavations may become unstable. Shoring or sloping of any deep trench walls may be necessary to protect personnel and provide temporary stability. A movable steel shield will likely be the most economical shoring method for utility trench excavations, if warranted. All excavations should comply with current OSHA safety requirements for Type C soils (Federal Register 29 CFR, Part 1926).

During wet weather, small earth berms or other methods should be used to prevent runoff water from entering excavations. Water should be collected and disposed of outside the construction limits of the project. Heavy construction equipment, building materials, excavated soil, and vehicular traffic should not be allowed within a distance of one-third the excavation height or 10 feet, whichever is greater, from the top of excavations.

For the construction of underground utilities, pipe zone backfill (material beneath and in the immediate vicinity of the pipe) should consist of clean, granular material free of clay and organic matter and be such a size that 100% passes the ¾-inch sieve, not more than 10% passes the No. 200 sieve, and have a minimum sand equivalent of 30. Trench immediate backfill (material placed between the pipe zone backfill and finished subgrade) may consist of on-site soils which are free of debris and organic matter and have a maximum particle size of 4 inches. Pipes should be laid with socket or collar ends of the pipe at the up-slope end, or as indicated by the manufacturer.

Backfill for trenches or other excavations within pavement areas, beneath floor slabs, and adjacent to foundations should be compacted in 6-inch to 8- inch loose layers with mechanical tampers. Jetting and/or flooding should not be permitted. We recommend that all backfill be compacted to at least 90% relative compaction. The moisture content of compacted backfill soils should be within 2% above optimum. Poor compaction in utility trench backfill may cause excessive settlement resulting in damage to overlying improvements.

Remedial Earthwork

We expect that construction activity disturbed on-site soils are most likely to underlie the building foundations and possibly some undocumented surface fills under slab floors for this project. The undocumented fills encountered on site, including our exploratory test pit backfills, and loose or otherwise disturbed soils are not considered adequate to support the proposed improvements. As a result, construction of the proposed improvements without the recommended remedial earthwork is likely to result in unsatisfactory performance.

We recommend that the existing on-site soils under foundations be over-excavated and replaced with properly compacted engineered fill. Over-excavation and replacement of on-site soils should extend to at least 12 inches below bottom of footings and 6 inches horizontally beyond the edges of foundations. Similarly, to mitigate any differential movements under slab-on grade floors, the upper 6 inches below finish subgrade elevations should be scarified in place; properly moisture conditioned, and re-compacted as indicated in the *Site Clearing and Preparation* section of this report. In addition, any exposed subgrades to receive engineered fill or to support pavements should be prepared in accordance with the *Site Clearing and Preparation* section of this report.

Shallow Foundations

We recommend conventional spread foundations founded on at least 12 inches of properly compacted engineered fill (may include 6 inches of in-place re-compacted subgrades) be used to support the proposed new well building. Exterior foundations should be embedded a minimum of 24 inches below lowest adjacent finish grade for frost protection and confinement. Interior footings should be bottomed at least 12 inches below lowest adjacent finish grade for proper confinement. Wall foundation dimensions should satisfy the requirements listed in the applicable edition of the International Building Code. Reinforcing steel requirements for foundations should be provided by the design engineer.

Foundations constructed in accordance with the recommendations of this geotechnical report may be designed for an allowable soil bearing capacity of 2,500 pounds-per-square-foot (psf) for dead loads plus long term live loads. The allowable soil bearing capacity was calculated using a minimum foundation width of 18 inches and an embedment depth of 12 inches. The allowable bearing pressure may be increased by one-third for total loading conditions, including wind and seismic forces. The allowable bearing pressure is a net value, therefore, the weight of the foundation below grade and backfill may be neglected when computing dead loads.

According to the 2006 IBC guidelines and the subsurface conditions encountered during this investigation, a Site Class D, as outlined in Table 1613.5.2, is considered applicable to evaluate seismic loads for this project. The spectral response acceleration values corresponding to a Site Class B and a 2% probability of exceedance in 50 years for the 0.2 second (short) period and the 1-second period at the location of the project are 2.16g and 0.717g, respectively. Therefore, the recommended site coefficients $F_a = 1.0$ (Table 1613.5.3(1)) and $F_v = 1.5$ (Table 1613.5.3(2)) as a function of the Site Class D should be implemented for design.

Resistance to lateral loads may be provided by frictional resistance between the bottom of concrete foundations and the underlying soils, and by passive resistance against the sides of foundations. A coefficient of friction of 0.4 may be used between the poured-in-place concrete foundations and the underlying properly compacted engineered fill. Passive resistance available in properly compacted engineered fill may be calculated using a resistance of 180 psf per foot of depth, up to a maximum of 2,500 psf. Both passive and frictional resistance may be assumed to act concurrently.

Total settlement of an individual foundation will vary depending on the plan dimensions of the foundation and the actual load supported. Based on the anticipated foundation dimensions and loads, we estimate that total post-construction settlement of footings designed and constructed in accordance with the recommendations of this report will be in the order of 1 inch or less. Differential settlements between similarly loaded adjacent footings is expected to be less than ½ inch, provided all individual building footings are founded on similar materials (i.e. all on at least 12 inches of properly compacted engineered fill). Differential settlement between adjacent footings founded on dissimilar material (i.e. one footing on un remediated on-site soils and one footing on properly compacted engineered fill) may approach and even exceed the maximum anticipated total settlement. Settlement of all foundations constructed in accordance with the recommendations of this report is expected to occur rapidly and should be essentially complete shortly after initial application of the loads.

Prior to placing steel or concrete, footing excavations should be cleaned of all debris, loose, soft, or disturbed soil, and water. Any loose, soft, or otherwise disturbed soil in the bottom of footing excavations should be re-compacted to at least 90% relative compaction or removed to expose firm and stable properly compacted engineered fill. The project's soils engineer should observe footing excavations just prior to placing steel or concrete to verify the implementation of the recommendations provided in this report.

Concrete Slab-on-Grade Construction

Due to the presence of undocumented fills or construction activity disturbed soils at the site; interior concrete slabs should be supported on at least 6 inches of properly re-compacted subgrades. Similarly, prior to constructing exterior slabs-on-grade or other flatwork, the exposed subgrade should be scarified to a minimum depth of 6 inches, moisture conditioned to within 2% above optimum moisture content, and re-compacted to at least 90% relative compaction. Scarification and re-compaction may not be required if exterior slabs or other flatwork are to be placed on at least 6 inches of properly compacted engineered fill.

All concrete floor slabs should have a minimum thickness of 4 inches. Slab thickness and structural reinforcement requirements within the slab should be determined by the design engineer. At least 4 inches of Type 2 aggregate base should be placed beneath slab-on-grade floors to provide uniform support. The aggregate base should be moisture conditioned to near optimum and compacted to at least 95% relative compaction. The subgrade should be protected against drying until the concrete slab is constructed.

In floor slab areas where moisture sensitive floor coverings are planned, an impermeable membrane (e.g.10 mil thick polyethylene) should be placed over the base course to reduce the migration of moisture vapor through the concrete slab. The impermeable membrane should be protected by 2 inches of fine moist sand placed above the membrane. The sand cover will provide protection for the membrane and will promote uniform curing of the concrete. The sand cover should be moistened (not wet) and tamped prior to pouring the slab.

Preliminary Pavement Sections

Re-compacted subgrade soils should provide adequate support for asphalt concrete (AC) pavements around the well building or other access areas within the site. Based on our experience in northern Nevada and the types of fines encountered during our investigation at the site, environmental aspects, such as freeze-thaw cycles and thermal cracking will most likely govern the life of AC pavements. Thermal cracking of the AC pavements allows more water to enter the pavement section, which promotes deterioration and increases of maintenance costs. Based on the anticipated traffic and environmental conditions at the site, we recommend a minimum pavement section of 3 inches of AC on at least 6 inches of Type 2 aggregate base. Alternatively, eight inches of coarse gravel may be used in lieu of the pavement section indicated above, if maintenance of the gravel pavement is conducted regularly. The coarse gravel may consist of crushed durable 2-inch minus material.

After completion of utility trench backfill and prior to placement of aggregate base or gravel, the upper 6 inches of exposed subgrade soils should be scarified in place, uniformly moisture conditioned to within 2% above optimum, and re-compacted to at least 90% relative compaction. The aggregate base should be uniformly moisture conditioned to near optimum and compacted to at least 95% relative compaction. The material type, placement, and compaction for base materials and asphalt concrete should conform to the Standards Specifications for Public Works Construction.

Site Drainage and Moisture Protection

Final elevations at the site should be planned so that drainage is directed away from the building foundations and associated improvements. Access and other adjacent areas should be sloped and drainage gradients maintained to carry surface water away from all improvements and into a properly designated discharge area or off the site.

Corrosion Mitigation Measures

As pointed out earlier in this report, on-site soils are slightly alkaline with low soluble chlorides and soluble sulfates. Therefore, Type II cement can be used for concrete in direct contact with these soils. The relatively low resistivity of the on-site soils on the other hand indicates a severe corrosivity against ferrous metals. As a result, corrosion mitigation measures such as cathodic protection, coatings, and or wrappings, and at least 3 inches of concrete cover for reinforcing steel are recommended as a minimum for this project.

Plan Review and Construction Observation and Testing

We recommend that HEM conduct a review of the project plans and specifications to check the proper interpretation and implementation of the earthwork, foundations, and drainage recommendations presented in this report. In addition, the recommendations presented in this report are based on the assumption that an adequate program of tests and observations will be implemented during construction for compliance with the approved design. These tests and observations should include, but not necessarily limited to the following:

- Observation and testing during site preparation and earthwork.
- Observation of foundation excavations.
- Observation and backfill testing of trench backfill.
- Observation and testing of construction materials.
- Consultation as may be required during construction.

Additional information concerning the scope of these services can be obtained from our office.

Limitations

Recommendations contained in this report are based on our subsurface field explorations, laboratory testing program, and our understanding of the proposed construction. This report has been prepared for design purposes and for the specific application for the proposed well building and associated appurtenances, and in accordance with generally accepted standards of practice at the time this report was written. If the scope of the proposed construction changes from the items described herein, our recommendations should be reviewed by us and may require written modification. No warranty, express or implied, is made.

All parties to the project, including the design engineer, contractor, subcontractors, etc, should be made aware of this report in its entirety. The use of information contained in this report for bidding purposes should be done at the Contractor's option and risk.

We trust that the information presented in this letter –style report provides the information required to meet the needs for project planning and design. If you have any questions, or would like to discuss the contents of this report in detail, please do not hesitate to contact our office.

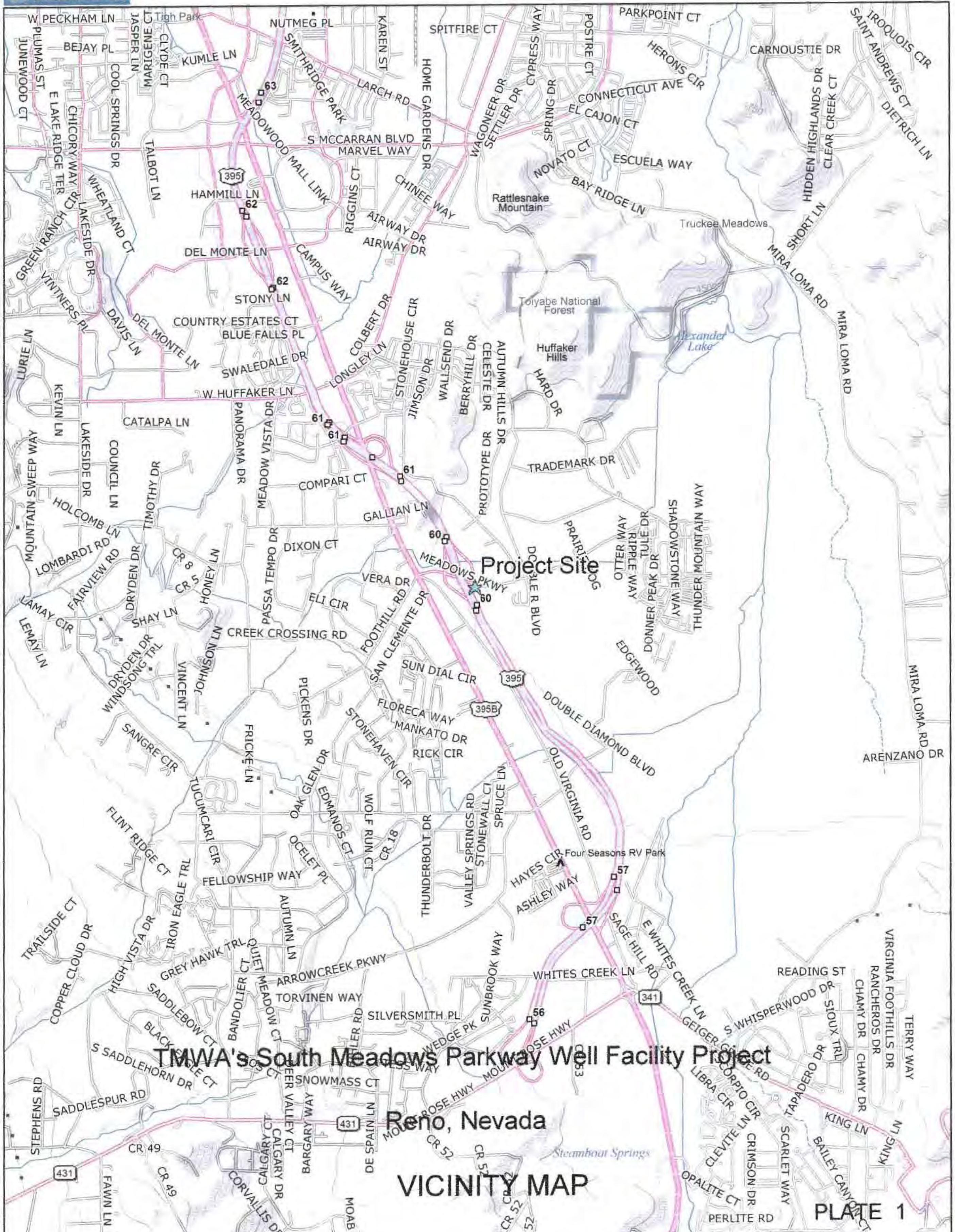
Sincerely,
H.E.M. *Consulting, LLC*

12-31-15

8-22-14

Hector E. Marin, Ph.D., P.E.
Principal Engineer

Attachments:
Plate 1 – Vicinity Map
Plate 2 – Site Plan
Plate 3 – Log of Test Pit TP-1
Plate 4 – Log of Test Pit TP-2
Plate 5 – Key to Symbols
Plate 6 – Compaction Test Report
Plate 7 – Liquid and Plastic Limits Test Report
Plate 8 – Particle Size Distribution Report
Plate 9 – WET Laboratory Analytical Report

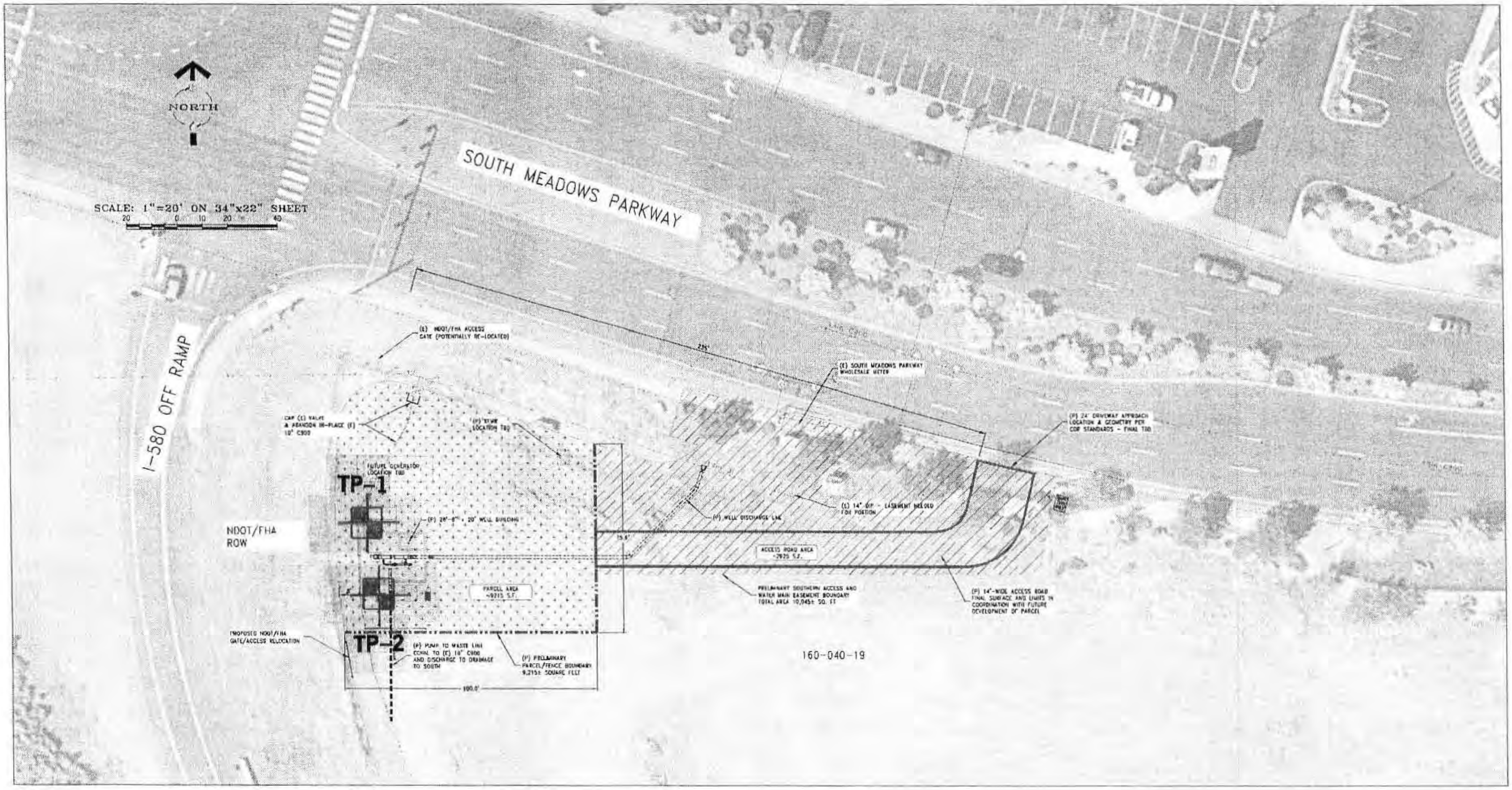


Data use subject to license.

Scale 1 : 50,000

1" = 4,166.7 ft

Data Zoom 12-0



LEGEND

PROPOSED EASEMENT

PROPOSED PARCEL

TP- Approximate test pit location

REVISION	DESCRIPTION	BY	APP	DATE				
					WORK ORDER NO. 15-0016 DESIGNED SWB DRAWN SWB DATE JULY 2014 CHECKED SUBMITTED RECOMMENDED APPROVED	TRUCKEE MEADOWS WATER AUTHORITY 1355 CAPITAL BLVD. / PO BOX 30013 RENO, NEVADA 89520-3013 PH 775-834-8000 / FX 775-834-8003	SITE PLAN	DOUBLE DIAMOND WELL #3 PRELIMINARY WELL FACILITY LAYOUT AND PARCEL/EASEMENT BOUNDARIES	SHEET NUMBER PLATE 2

REF: Preliminary Well Facility Layout, dated July 2014, by TMWA

TEST PIT LOG
Test Pit No.: TP-1

PROJECT	PROJECT NO.
TMWA's South Meadows Parkway Well Facility	1409.1
CLIENT	DATE
Farr West Engineering	8-5-14
LOCATION	ELEV.
North side of well head (see Plate 2)	
EXCAVATION METHOD	LOGGER
Cat 304 CR mini excavator with 20-inch bucket	HEM

DEPTH TO - Water: 7.917 When checked: 8-5-14 Caving:

ELEVATION/ DEPTH	SOIL SYMBOLS AND SAMPLERS: GRAPHIC	BULK	DRIVEN	USCS	DESCRIPTION	DENSITY pcf	MOISTURE %
0				FILL	Fill: POORLY GRADED GRAVEL with Sand (GP), moist, loose to medium dense, root layer at about 3"		
				SM SM	BROWN TO DARK BROWN SILTY SAND with Gravel (SM), moist, dense to partially cemented, some clay -- MC=9%		9
2				SM SM	DARK BROWN SILTY SAND (SM), moist, dense, some clay -- MC=19%, LL=33%, PL=26%, PI=7% -- brown to dark brown, medium dense to dense to partially cemented, fine sand		19
4							
6				SP	BROWN POORLY GRADED SAND with Silt and Gravel (SP) , moist to very moist, dense -- saturated		
8					Test Pit terminated at approximately 8'-0". Groundwater encountered at approximately 7'-11". Test Pit backfilled with excavated soils and tamped in layers with equipment at hand.		
10							

Notes:

PLATE 3

TEST PIT LOG
Test Pit No.: TP-2

PROJECT	PROJECT NO.
TMWA's South Meadows Parkway Well Facility	1409.1
CLIENT	**DATE**
Farr West Engineering	8-5-14
LOCATION	**ELEV.**
South side of well head (see Plate 2)	
EXCAVATION METHOD	**LOGGER**
Cat 304 CR mini excavator with 20-inch bucket	HEM

DEPTH TO - Water: 8.25 When checked: 8-5-14 Caving:

ELEVATION/ DEPTH	SOIL SYMBOLS AND SAMPLERS: GRAPHIC	BULK	DRIVEN	USCS	DESCRIPTION	DENSITY pcf	MOISTURE %
0				FILL	Fill: BROWN POORLY GRADED SAND with Gravel (SP), moist, loose to medium dense, root layer at about 3"		
				SM	BROWN TO DARK BROWN SILTY FINE SAND (SM), moist, dense to partially cemented, trace of gravel -- MC=7%		7
2				CL	DARK BROWN SANDY CLAY (CL), moist, very stiff -- PP=4.5tsf -- pH=8.03, resistivity=1,200ohm.cm, soluble chlorides= 16ppm,soluble sulfates=26ppm, maximum DD=114pcf at optimum MC=14% -- MC=23%		23
4				SC	GRAYISH BROWN CLAYEY SAND (SC), moist to very moist, dense to partially cemented -- MC=21%		21
				SM	BROWN TO DARK BROWN SILTY SAND (SM), moist to very moist, dense		
6				SP	BROWN POORLY GRADED SAND with Silt and Gravel (SP) , moist to very moist, dense		
8				SP			14
10					Test Pit terminated at approximately 8'-9". Groundwater encountered at approximately 8'-3". Test Pit backfilled with excavated soils and tamped in layers with equipment at hand.		

Notes:

PLATE 4

KEY TO SYMBOLS

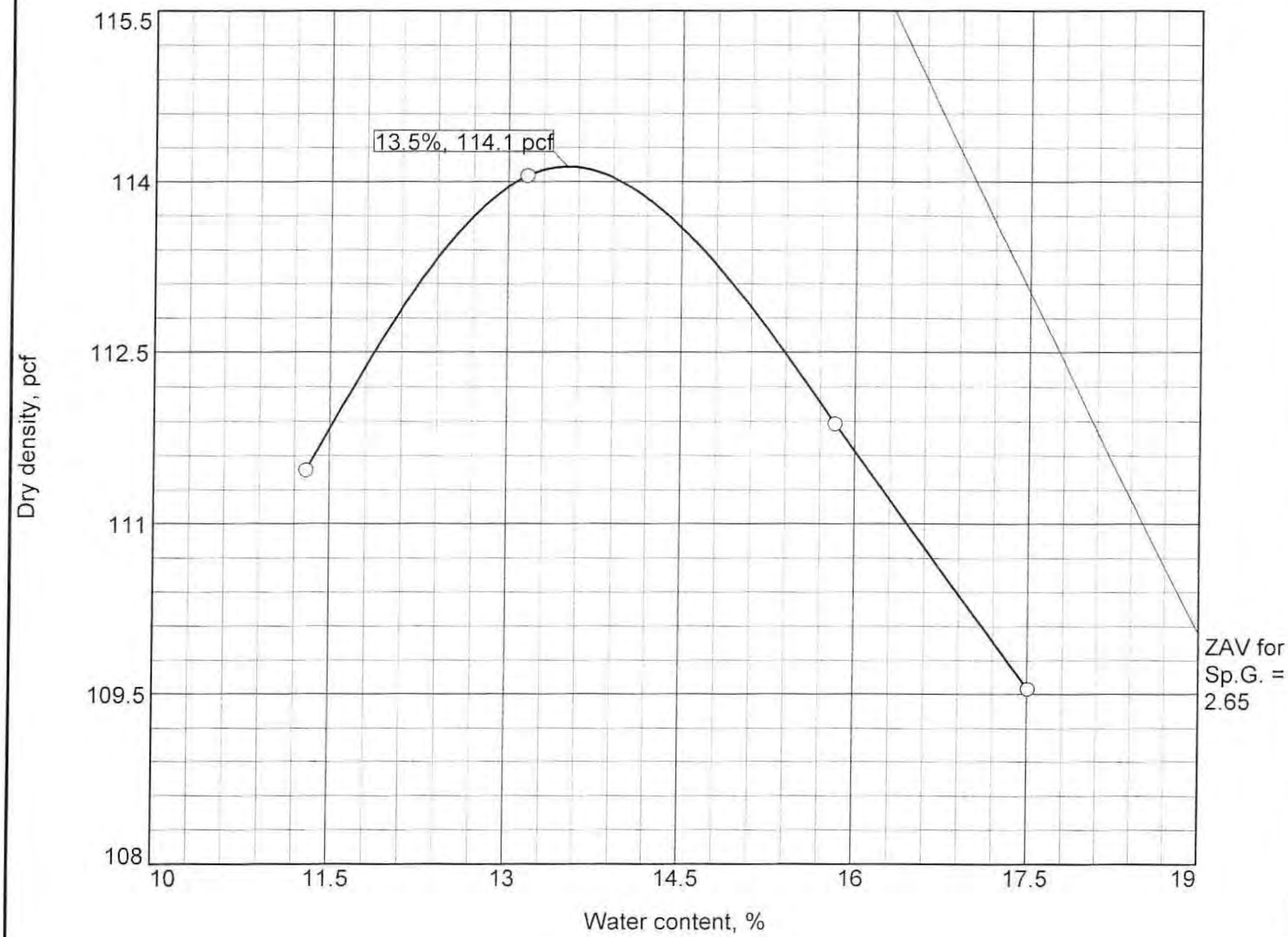
Symbol	Description
Strata symbols	
	Fill
	Silty sand with gravel
	Silty sand
	Poorly graded sand with silt and gravel
	Low plasticity clay
	Clayey sand
	Poorly graded sand
Misc. Symbols	
	Water table

Symbol	Description
Soil Samplers	
	Bulk sample

Notes:

1. Exploratory test pits were excavated on 8-5-14 using a CAT 304 CR mini excavator.
2. Groundwater was encountered at depths varying from 7'-11" to 8'-3" at the time of excavation.
3. Test pit locations were paced from existing features shown on the site plan as a guide. Elevations, if any, were extrapolated from contour lines shown on a plan provided by the client.
4. These logs are subject to the limitations, conclusions, and recommendations in this report.
5. B-Bulk Sample, LL-liquid limit, PL-plastic limit, PI-plasticity index, PP-Pocket Penetrometer Test.
6. Results of laboratory tests conducted on samples recovered during this investigation are reported on Plate 6 through Plate 9 at the end of this report.

COMPACTION TEST REPORT



Test specification: ASTM D 1557-91 Procedure C Modified

Elev/ Depth	Classification		Nat. Moist.	Sp.G.	LL	PI	% > 3/4 in.	% < No.200
	USCS	AASHTO						
2.6								

TEST RESULTS	MATERIAL DESCRIPTION
Maximum dry density = 114.1 pcf Optimum moisture = 13.5 %	Silty, Clayey Sand (SC-SM)

Project No. 1409.1 **Client:** Farr West Engineering

Project: TMWA's South Meadows Parkway Well Facility

○ **Source of Sample:** TP-2

Remarks:

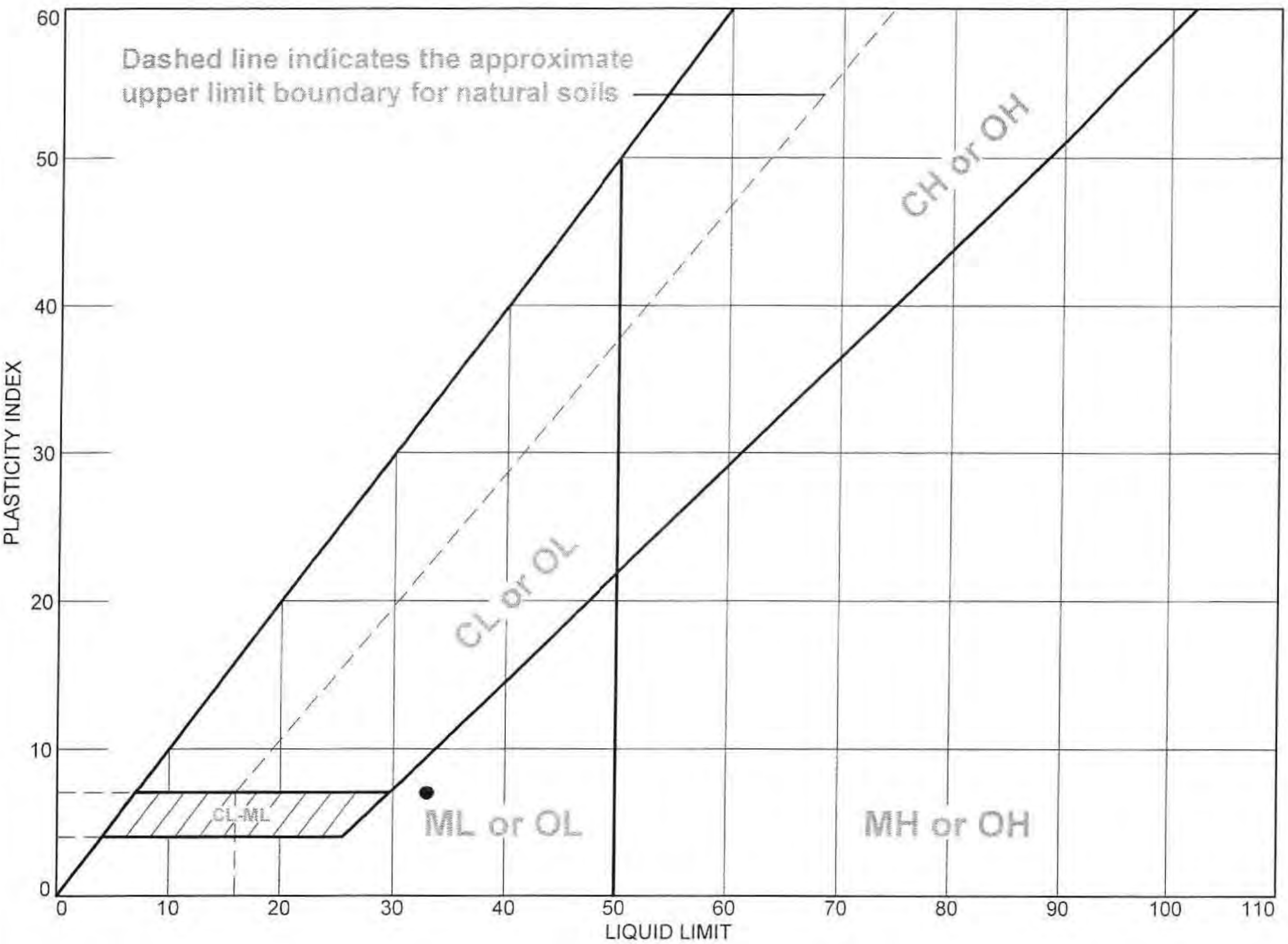
H. E. M. Consulting, LLC

Reno, NV

PLATE 6

Tested By: WR **Checked By:** HEM

LIQUID AND PLASTIC LIMITS TEST REPORT



	MATERIAL DESCRIPTION	LL	PL	PI	%<#40	%<#200	USCS
●	Silty Sand (SM)	33	26	7	77.0	33.0	SM

Project No. 1409.1 **Client:** Farr West Engineering

Project: TMWA's South Meadows Parkway Well Facility

● **Source of Sample:** TP-1 **Depth:** 2.75

Remarks:

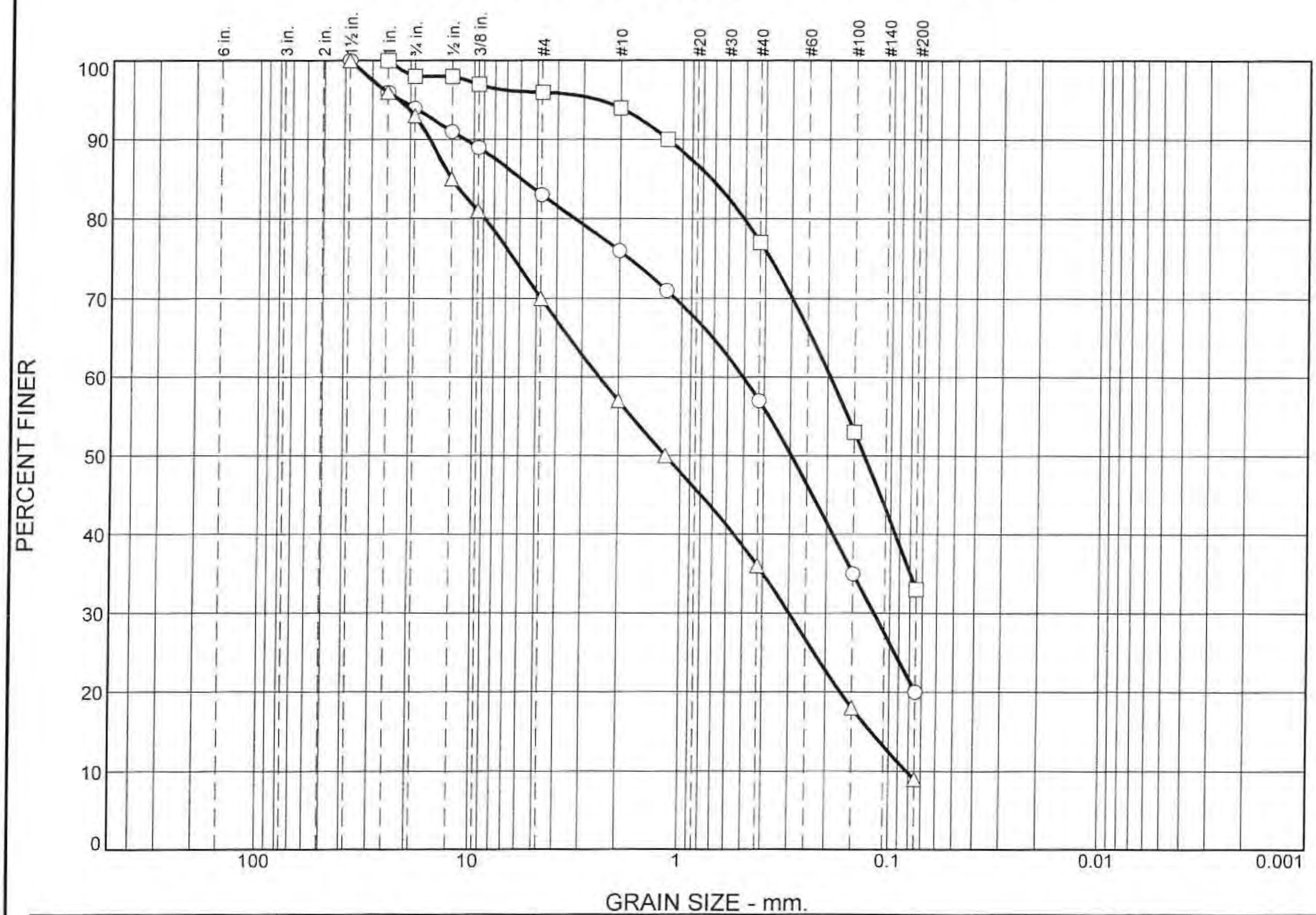
H. E. M. Consulting, LLC

Reno, NV

PLATE 7

Tested By: WR **Checked By:** HEM

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	6.0	11.0	7.0	19.0	37.0	20.0	
□	0.0	2.0	2.0	2.0	17.0	44.0	33.0	
△	0.0	7.0	23.0	13.0	21.0	27.0	9.0	

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_c	C_u
○			5.9469	0.5067	0.2969	0.1194				
□	33	26	0.7330	0.1954	0.1346					
△			12.7000	2.4757	1.1800	0.3002	0.1217	0.0816	0.45	30.34

Material Description	USCS	AASHTO
○ Silty Sand with Gravel (SM)	SM	
□ Silty Sand (SM)	SM	A-2-4(0)
△ Poorly Graded Sand with Silt and Gravel (SP)	SP	

Project No. 1409.1 **Client:** Farr West Engineering
Project: TMWA's South Meadows Parkway Well Facility

○ **Source of Sample:** TP-1 **Depth:** 1.25
□ **Source of Sample:** TP-1 **Depth:** 2.75
△ **Source of Sample:** TP-2 **Depth:** 7.375

Remarks:

H. E. M. Consulting, LLC

Reno, NV

PLATE 8

Tested By: WR **Checked By:** HEM

Western Environmental Testing Laboratory
Analytical Report

H.E.M. Consulting, LLC
P.O. Box 19104
Reno, NV 89511
Attn: Hector Marin
Phone: (775) 852-5011 **Fax:** (775) 852-5011
PO\Project: *14019.1 / Well Blds*

Date Printed: 8/18/2014
OrderID: *1408084*

Customer Sample ID: TP-2 / B-6 0'-5'
WETLAB Sample ID: 1408084-001
Collect Date/Time: 8/5/2014 08:00
Receive Date: 8/5/2014 11:10

Analyte	Method	Results	Units	DF	RL	Analyzed	LabID
General Chemistry							
Paste pH	SW846 9045D	8.03	pH Units	1		8/7/2014	NV00925
Resistivity	SM 2510B	1200	ohms.cm	1	1.0	8/7/2014	NV00925
Anions by Ion Chromatography							
Chloride	EPA 300.0	16	mg/kg	15	15	8/7/2014	NV00925
Sulfate	EPA 300.0	26	mg/kg	15	15	8/7/2014	NV00925
Sample Preparation							
Saturated Paste Preparation	CSTPM S:1.0	Complete		1		8/6/2014	NV00925
3:1 DI Water Extraction	WL 3.0	Complete		1		8/6/2014	NV00925

DF=Dilution Factor, RL=Reporting Limit, ND=Not Detected or <RL