November 7, 2014

Mr. Paul Knutzen, PE
Meier Architecture Engineering
8697 Gage Boulevard
Kennewick, Washington 99336

RE: GEOTECHNICAL ENGINEERING STUDY; BEDROCK CHARACTERIZATION USING SEISMIC REFRACTION, SAGECREST ELEMENTARY SCHOOL, KENNEWICK, WASHINGTON

Dear Mr. Knutzen:

Shannon & Wilson, Inc. presents this letter report summarizing our bedrock characterization/rippability study at the proposed Sagecrest Elementary School site in Kennewick, Washington.

BACKGROUND

The Kennewick School District proposes to construct Sagecrest Elementary School in south Kennewick, Washington. Site plans by MMEC Architecture indicate the school site is north of the Kennewick Irrigation District (KID) canal and south of the future W 38th Avenue. The site currently consists primarily of an agricultural field with the eastern site portion covered with weeds/grasses and/or sagebrush.

The project geotechnical study (by others) included seven backhoe excavated test pits. The test pit excavations generally encountered bedrock at approximately 1½ to 2½ feet below the existing ground surface (bgs); refusal was generally at 2½ to 3 feet bgs. One test pit encountered bedrock approximately 5½ feet bgs, and refusal at 5¾ feet bgs.

Meier indicates the bedrock depth is well within the planned grading elevations. Meier requests this seismic refraction study to evaluate importing material to raise site grades versus potential rock excavation/grading.
SEISMIC REFRACTION SURVEY

Shannon & Wilson completed five (5) seismic refraction (SR) lines (L1 through L5) spread around the proposed elementary school site. We describe the SR study below and provide results of our rock characterization and excavation methods assessment in following sections. We show the approximate SR line locations in Figure 2, Site and Exploration Plan.

Methodology

A seismic refraction survey consists of a series of tasks to produce, record, and analyze seismic waves to determine the seismic velocity of subsurface materials. In general terms, we derive the seismic velocity of the subsurface from the travel time of compressional wave (P-wave) energy over the distance from the source to recording devices. An impulsive source generates P-wave energy at the surface. The P-wave energy propagates into the subsurface and is refracted along subsurface interfaces (likely layers) representing an increase in velocity. The P-wave energy returns to the surface where an array of geophones detects the waves, and a seismograph records them. We analyze these data to produce theoretical depth, thickness, and seismic velocity of the subsurface layers. We correlate the seismic velocity of the subsurface materials to soil and rock types and rock weathering and competency.

Data Acquisition

Shannon & Wilson completed three SR lines at various locations across the proposed project site. Each seismic line consists of seven (7) shot points distributed along a collinear array of 24 geophones, with a multi-channel receiver (seismograph) located at one end of the array to collect the data. We placed geophones at 10-foot intervals along the array. We generated compressional wave (P-wave) energy at each shot point using multiple impacts with an 18-pound sledge hammer striking an aluminum or steel plate placed on the ground surface.

Our field representative led the field exercises and monitored the data acquisition. We located the seismic lines by taping and referencing from known site features, and obtained global positioning system (GPS) points to correlate to the provided survey for plotting. We obtained a relative elevation profile along each SR line for analysis input using a construction laser level.

Data Analysis

Shannon & Wilson analyzed the data using Geometric, Inc.’s SeisImager computer program. We prepared the enclosed Figures 3 through 7, Seismic Refraction Profile, based on our acquired data and analyses. We discuss the SR survey results below.
EXCAVATION CHARACTERISTICS

Excavation characteristics based on seismic velocities of subsurface materials have been developed by construction equipment manufacturers. CAT publishes the “Caterpillar Performance Handbook,” which relates the performance of the D8, D9, D10, and D11 dozers to the p-wave velocity of various rock types, including Igneous rock formations such as Granite, Basalt, and Trap Rock. Seismic velocity ranges considered “Rippable” and “Non-Rippable” are tabulated for a D8 through D11R dozer (with single shank ripper) in the following table; velocities between “Rippable” and “Non-Rippable” are typically considered “Marginal.”

<table>
<thead>
<tr>
<th>Dozer Class</th>
<th>Compressional Wave Velocity Range (fps)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Rippable</td>
</tr>
<tr>
<td>D8R/D8R Series II</td>
<td>&lt; 6,300</td>
</tr>
<tr>
<td>D9R</td>
<td>&lt; 7,550</td>
</tr>
<tr>
<td>D10R</td>
<td>&lt; 8,000</td>
</tr>
<tr>
<td>D11R</td>
<td>&lt; 8,850</td>
</tr>
</tbody>
</table>

fps = feet per second

The above information should be used only as a general guideline; rock rippability also depends on many other factors beyond the seismic velocity. These factors include the rock jointing and fracture patterns, the equipment operator experience, and the equipment and excavation methods selected. “Marginal” and/or “Non-Rippable” seismic velocities will be lower than those indicated above for an excavator.

RESULTS

Recorded seismic velocities range from approximately 500 to 6,500 feet per second (fps) over SR lines L1 and L2, and greater than approximately 7,500 fps in SR lines L3, L4, and L5. We estimate an approximately 2- to 4½-foot-thick overburden (i.e., less than approximately 1,000 fps) layer is present across all SR lines. We estimate bedrock velocities grade to above 8,000 fps as indicated in the following table.

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ESTIMATED DEPTH TO SEISMIC REFRACTION VELOCITIES ABOVE 8,000 fps

<table>
<thead>
<tr>
<th>SR Line</th>
<th>Depth* (feet)</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>L1</td>
<td>&gt;30</td>
<td>NA</td>
</tr>
<tr>
<td>L2</td>
<td>&gt;30</td>
<td>NA</td>
</tr>
<tr>
<td>L3</td>
<td>5½</td>
<td>21½</td>
</tr>
<tr>
<td>L4</td>
<td>17 ½</td>
<td>20</td>
</tr>
<tr>
<td>L5</td>
<td>9</td>
<td>&gt;30</td>
</tr>
</tbody>
</table>

*Note: Listed depths assume the use of a D10R dozer.

fps = feet per second

We enclose the interpreted SR line profiles in Figures 3 through 7. The figures illustrate the seismic velocity variations in the upper subsurface horizon. Color shading represents seismic velocities according to the velocity scale on the figure right side. The seismic velocity profile shows a general increase in velocity with depth.

The seismic refraction method assumes increasing velocities with depth and may not be able to identify low-velocity layers below higher-velocity materials. The seismic profile lines designating the interface of seismic velocity layers are approximate; the transition between soil/rock types may be abrupt or gradual. We make no recommendations, expressed or implied, based on the findings of our seismic refraction surveys.

LIMITATIONS

This letter report was prepared for the exclusive use of Meier, Inc. as it relates to the geotechnical aspects discussed herein. Its purpose is to provide information on factual data only; it should not be construed as a warranty of subsurface conditions, such as those interpreted from the exploration logs and subsurface conditions discussions in this report and project reports to date.

Shannon & Wilson, Inc. based this report on the acquired data. The accuracy of our findings is subject to the inherent limitations of the seismic refraction investigation technique and specific site conditions. The lines designating the interface of seismic velocity layers on our seismic profiles are approximate. The transition between soil/rock types may be abrupt or gradual. Seismic refraction
surveys usually reflect average conditions. We make no recommendations, expressed or implied, based on the findings of our seismic refraction surveys.

Within the limitations of scope, schedule, and budget, the conclusions and recommendations presented in this letter report were prepared in accordance with generally accepted professional geotechnical and geological principles and practice in this area at the time this letter report was prepared. We make no other warranty, either expressed or implied.

Our scope of services did not include an evaluation regarding the presence or absence of wetlands, or an evaluation regarding the presence or absence of hazardous or toxic materials in the soil, surface water, groundwater, or air on or below or around this site. If such contamination exists, it would not be possible to determine it within this limited scope of work.

Shannon & Wilson prepared the enclosed “Important Information about Your Geotechnical/Environmental Report” to assist you and others in understanding the use and limitations of our reports.

Please call if you have any questions or require additional information.

Sincerely,

SHANNON & WILSON, INC.

Clinton A. Wilson, P.E.
Principal Engineer

CAW:RWS:TMG/caw

Enc: Figure 1: Vicinity Map
     Figure 2: Site and Exploration Plan
     Figure 3: Seismic Refraction Profile - Line L1
     Figure 4: Seismic Refraction Profile - Line L2
     Figure 5: Seismic Refraction Profile - Line L3
     Figure 6: Seismic Refraction Profile - Line L4
     Figure 7: Seismic Refraction Profile - Line L5
     Important Information about Your Geotechnical/Environmental Report
NOTE
Map adapted from aerial imagery provided by Google Earth Pro, reproduced by permission granted by Google Earth™ Mapping Service.
NOTE
Figure adapted from file 748400XC01.dwg received October 27, 2014.
Sagecrest Elementary School
Kennewick, Washington

SEISMIC REFRACTION PROFILE
LINE 1
November 2014 22-1-03087-001

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FIG. 3
FIG. 4

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INC.

SEISMIC REFRACTION PROFILE
LINE 2

November 2014
22-1-03087-001

LEGEND

Feet per Second

Relative Elevation (Feet)

Distance (Feet)

East

West

Sagecrest Elementary School
Kennewick, Washington

Approximate Scale in Feet

Source: 6250226864 | Code: 22-1-03087-001 | Date: 11-05-2014 | Login: bac

Filename: J:\221\03087-001\22-1-03087-001 Seismic Profiles.dwg
FIG. 6

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SEISMIC REFRACTION PROFILE
LINE 4

Sagecrest Elementary School
Kennewick, Washington

November 2014

LEGEND

Feet per Second

Relative Elevation (Feet)

Distance (Feet)

Approximate Scale in Feet

East

West

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230

0 50 100 150 200 250 300 350 400 450 500 550 600 650 700 750

Filename: J:\221\03087-001\22-1-03087-001 Seismic Profiles.dwg
Date: 11-05-2014
Login: bac
FIG. 7

SEISMIC REFRACTION PROFILE
LINE 5

Sagecrest Elementary School
Kennewick, Washington
November 2014

LEGEND
Feet per Second

Relative Elevation (Feet)
Distance (Feet)

East
West

0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230

0 50 60 70 80 90 100 110 120

0 20 40

Approximate Scale in Feet

SHANNON & WILSON, INC.
Environmental Consultants

Source: Fig.:230-0885-000/23-000-05, S. Hannon, M. H. Wilson, Inc.
Date: 11-05-2014
Login: bac
Filename: J:\221\03087-001\22-1-03087-001 Seismic Profiles.dwg
IMPORTANT INFORMATION ABOUT YOUR GEOTECHNICAL/ENVIRONMENTAL REPORT

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT’S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally. Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.
A REPORT'S CONCLUSIONS ARE PRELIMINARY.

The conclusions contained in your consultant's report are preliminary because they must be based on the assumption that conditions revealed through selective exploratory sampling are indicative of actual conditions throughout a site. Actual subsurface conditions can be discerned only during earthwork; therefore, you should retain your consultant to observe actual conditions and to provide conclusions. Only the consultant who prepared the report is fully familiar with the background information needed to determine whether or not the report's recommendations based on those conclusions are valid and whether or not the contractor is abiding by applicable recommendations. The consultant who developed your report cannot assume responsibility or liability for the adequacy of the report's recommendations if another party is retained to observe construction.

THE CONSULTANT'S REPORT IS SUBJECT TO MISINTERPRETATION.

Costly problems can occur when other design professionals develop their plans based on misinterpretation of a geotechnical/environmental report. To help avoid these problems, the consultant should be retained to work with other project design professionals to explain relevant geotechnical, geological, hydrogeological, and environmental findings, and to review the adequacy of their plans and specifications relative to these issues.

BORING LOGS AND/OR MONITORING WELL DATA SHOULD NOT BE SEPARATED FROM THE REPORT.

Final boring logs developed by the consultant are based upon interpretation of field logs (assembled by site personnel), field test results, and laboratory and/or office evaluation of field samples and data. Only final boring logs and data are customarily included in geotechnical/environmental reports. These final logs should not, under any circumstances, be redrawn for inclusion in architectural or other design drawings, because drafters may commit errors or omissions in the transfer process.

To reduce the likelihood of boring log or monitoring well misinterpretation, contractors should be given ready access to the complete geotechnical engineering/environmental report prepared or authorized for their use. If access is provided only to the report prepared for you, you should advise contractors of the report's limitations, assuming that a contractor was not one of the specific persons for whom the report was prepared, and that developing construction cost estimates was not one of the specific purposes for which it was prepared. While a contractor may gain important knowledge from a report prepared for another party, the contractor should discuss the report with your consultant and perform the additional or alternative work believed necessary to obtain the data specifically appropriate for construction cost estimating purposes. Some clients hold the mistaken impression that simply disclaiming responsibility for the accuracy of subsurface information always insulates them from attendant liability. Providing the best available information to contractors helps prevent costly construction problems and the adversarial attitudes that aggravate them to a disproportionate scale.

READ RESPONSIBILITY CLAUSES CLOSELY.

Because geotechnical/environmental engineering is based extensively on judgment and opinion, it is far less exact than other design disciplines. This situation has resulted in wholly unwarranted claims being lodged against consultants. To help prevent this problem, consultants have developed a number of clauses for use in their contracts, reports and other documents. These responsibility clauses are not exculpatory clauses designed to transfer the consultant's liabilities to other parties; rather, they are definitive clauses that identify where the consultant's responsibilities begin and end. Their use helps all parties involved recognize their individual responsibilities and take appropriate action. Some of these definitive clauses are likely to appear in your report, and you are encouraged to read them closely. Your consultant will be pleased to give full and frank answers to your questions.

The preceding paragraphs are based on information provided by the ASFE/Association of Engineering Firms Practicing in the Geosciences, Silver Spring, Maryland