Preparation of the Foundation Report (FR)

To support the preparation of the Draft Structure Plans, Specifications and Estimate, SD provides the following data in a request for a Foundation Report:

- Scope of proposed work
- Location and site plans
- Utility plan
- Draft structure general plan
- Foundation plan showing support locations and elevations
- Approximate design structure loads at each support (FDDS per MTD 3 1 and 4 1)
- If needed, a request for soil structure interaction analysis results, such as p_y, t_z, and q_z curves.
- Preliminary or Final Hydraulic Report
- Project schedule
  - Date final design loads will be available
  - Foundation Report due date
Table 1. Shallow Foundation General Data

<table>
<thead>
<tr>
<th>Support No.</th>
<th>Design Method</th>
<th>Finished Grade Elevation (ft)</th>
<th>BOF Elevation (ft)</th>
<th>Footing Size (ft)</th>
<th>Permissible Settlement under Service Load (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abut 1</td>
<td>WSD</td>
<td>480.5</td>
<td>476.5</td>
<td>15</td>
<td>52.67</td>
</tr>
<tr>
<td>Abut 4</td>
<td>WSD</td>
<td>475.5</td>
<td>471.5</td>
<td>15</td>
<td>47.67</td>
</tr>
</tbody>
</table>
Used to compare the load demands (stress) to both the bearing resistance and the permissible contact stress.

Table 2. Shallow Foundation Load Data

<table>
<thead>
<tr>
<th>Support No</th>
<th>Vertical Load (kip)</th>
<th>Effective Dimensions (ft)</th>
<th>Horizontal Load in Long Direction (kip)</th>
<th>Total Load</th>
<th>Effective Dimensions (ft)</th>
<th>Permanent Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abut 1</td>
<td>3245</td>
<td>13.7 52.67</td>
<td>N/A</td>
<td>2703</td>
<td>14.3 52.67</td>
<td></td>
</tr>
<tr>
<td>Abut 4</td>
<td>3225</td>
<td>13.5 47.67</td>
<td>N/A</td>
<td>2629</td>
<td>14.5 47.67</td>
<td></td>
</tr>
</tbody>
</table>

Used to calculate both the nominal bearing resistance and the permissible contact stress for elastic settlement.

Table 3. Deep Foundation General Information

<table>
<thead>
<tr>
<th>Support No</th>
<th>Design Method</th>
<th>Pile Type</th>
<th>Finished Grade Elevation (ft)</th>
<th>Ultimate Elevation (ft)</th>
<th>Pile Cap Size (in)</th>
<th>Permissible Settlement under Service Load (in)</th>
<th>Number of Piles per Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abut 1</td>
<td>WSD</td>
<td>24” CIDH</td>
<td>490.5</td>
<td>476.75</td>
<td>9.0</td>
<td>52.67</td>
<td>20</td>
</tr>
<tr>
<td>Pier 2 Alt 1</td>
<td>LRFD</td>
<td>24” CIDH</td>
<td>483.5</td>
<td>466.25</td>
<td>28</td>
<td>39</td>
<td>35</td>
</tr>
<tr>
<td>Pier 2 Alt 2</td>
<td>LRFD</td>
<td>96” CIDH</td>
<td>483.5</td>
<td>472.0</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
</tr>
<tr>
<td>Pier 3 Alt 1</td>
<td>LRFD</td>
<td>24” CIDH</td>
<td>482.0</td>
<td>466.25</td>
<td>28</td>
<td>39</td>
<td>35</td>
</tr>
<tr>
<td>Pier 3 Alt 2</td>
<td>LRFD</td>
<td>96” CIDH</td>
<td>482.0</td>
<td>472.0</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
</tr>
<tr>
<td>Abut 4</td>
<td>WSD</td>
<td>24” CIDH</td>
<td>473.5</td>
<td>471.75</td>
<td>9.0</td>
<td>47.67</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 4. Deep Foundation Load Data

<table>
<thead>
<tr>
<th>Support No.</th>
<th>Compression</th>
<th>Tension</th>
<th>Compression</th>
<th>Tension</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Support</td>
<td>Max Per Pile</td>
<td>Per Support</td>
<td>Max Per Pile</td>
</tr>
<tr>
<td>Pier 1 Alt. 1</td>
<td>2310</td>
<td>140</td>
<td>1776</td>
<td>N/A</td>
</tr>
<tr>
<td>Pier 2 Alt. 2</td>
<td>6075</td>
<td>N/A</td>
<td>6587</td>
<td>400</td>
</tr>
<tr>
<td>Pier 3 Alt. 1</td>
<td>9824</td>
<td>N/A</td>
<td>2400</td>
<td>0</td>
</tr>
<tr>
<td>Pier 3 Alt. 2</td>
<td>6699</td>
<td>N/A</td>
<td>4750</td>
<td>8649</td>
</tr>
<tr>
<td>Abut 4</td>
<td>2635</td>
<td>140</td>
<td>2039</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Used to calculate the pile design tip elevation for pile groups, to satisfy the factored comp. load.

Used to calculate the pile design tip elevation controlled by elastic settlement.

Used to calculate the pile design tip elevation for an individual pile, to satisfy the factored comp. load.

Table 5. Scour Data

<table>
<thead>
<tr>
<th>Support No.</th>
<th>Long Term Scour Elevation (Degradation and Contraction) (ft)</th>
<th>Short Term Scour Depth (Local) (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abut 1</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>Pier 2</td>
<td>477</td>
<td>5</td>
</tr>
<tr>
<td>Pier 3</td>
<td>477</td>
<td>5</td>
</tr>
<tr>
<td>Abut 4</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Used for calculations with the Extreme Event Limit State Loads.

Used for calculations with both the Service Limit State Loads and the Strength Limit State Loads.
The focus of the Foundation Report is to provide foundation recommendations in a Pile Data Table or Spread Footing Data Table. However, the FR is written for an audience that includes:

- Bidding contractors
- Structure design engineer
- Specifications engineer
- Construction engineer
- Attorneys

The Foundation Report updates PFR information and includes design and construction recommendations based on site specific information.

- Project description and scope
- Existing facilities and proposed improvements
- Physical setting
- Geology and soil conditions
- Ground water conditions
- Laboratory Testing
- Seismicity
- Liquefaction
- Scour evaluation
- Corrosion evaluation
- Slope stability analyses
- Design analyses and recommendations*
- Construction considerations*
- Available project information
- LOTBs are attached
Contents of the design analyses and recommendations section

- Summary of geotechnical calculation methods used to develop the design recommendations
- The findings are presented in both the Recommendations Tables and the Data Tables.
- Approach embankment settlement delay period
- Recommendations for the mitigation of downdrag forces on driven piles or drilled shafts
- Requirements for pre drilling or pilot holes to facilitate the installation of driven pile foundations

The Geotechnical Design Report (GDR) provides recommendations such as embankment design, cut slope design and slope stabilization recommendations.

The construction considerations section provides information based on the borehole logs, laboratory tests and site observations:

- Obstructions to pile driving
- Obstructions to shaft drilling
- Whether the caving of excavations is anticipated
- For potential bidders, highlight the existence of variable subsurface conditions that may affect construction methods and production rates.
Typical steps for developing the foundation recommendations

1. Confirm the proposed foundation design types and loads with the designer:
   - Abutment 1 and Abutment 4
     Spread footing, or
     A group of 24 inch diameter drilled shafts
   - Pier 2 and Pier 3
     A group of 24 inch diameter drilled shafts, or
     One 96 inch diameter drilled shaft

2. Produce subsurface models for all of the bridge support locations

3. Analyze settlement of the foundation soils at the bridge support locations in response to the placement of new fill

4. Analyze the stability of existing and proposed natural and constructed slopes adjacent to the bridge foundations

5. Consider the constructability of the proposed foundation configurations

6. Perform geotechnical analyses of the proposed shallow foundations

7. Perform geotechnical analyses of the proposed deep foundations

8. Write the Foundation Report

Produce a subsurface model for each important location
Produce a subsurface model for each important location

Abutment 4
- sandstone
- sand
- clay

Evaluate the approach embankment settlement at the abutments

Abutment 1
- 6 feet of fill
- Elastic settlement 0.0 inches
- Consolidation settlement 0.0 in.

Abutment 4
- 10 feet of fill
- Elastic settlement 0.3 inches
- Consolidation settlement 1.1 in.
Consider movement of the adjacent slopes that can impact the structure foundations

Abutment 1  Abutment 4

Shallow foundations design analyses procedures (LRFD)

1. Nominal bearing resistance
   1. Calculate the nominal bearing resistance using the effective footing dimensions provided.
   2. Compare to the factored nominal bearing resistance to the bearing pressure applied by the structure.

2. Permissible contact stress
   1. Determine the magnitude of pressure that when applied to the effective footing dimensions will result in the limiting magnitude of tolerable foundation settlement.
   2. Compare the permissible contact stress to the Service Limit State bearing stress.
Dry Creek Bridge foundation design
Abutment 1 and Retaining wall 1R foundation alternatives are spread footings and 24 inch drilled shafts

The proposed bottom of footing for Abutment 1 and Retaining wall 1R will be in moderately hard, slightly weathered sandstone.

The sandstone has sufficient rock mass strength to provide a bearing resistance with applied safety factor that exceeds the applied factored bearing pressure.

The sandstone has very low compressibility, therefore the permissible contact stress exceeds the applied factored bearing stress.

Abutment 4 foundation alternatives are a spread footing and 24 inch drilled shafts

Abutment 4 will be founded on an engineered fill overlying soft and medium stiff lean clay, and loose sand. Sandstone was encountered at elevation 453.

There is no scour anticipated at Abutment 4.

The 24 inch diameter drilled shafts will have specified tip elevations of 433 feet.

The 24 inch diameter drilled shafts will be installed with the plastic pipes that are necessary for the concrete testing needed for a wet pour.
Deep foundation design analyses

- A bridge support location may require calculations for all of the following design tip elevations:
  1. Strength Limit State compression per pile
  2. Strength Limit State compression for the pile group
  3. Extreme Event Limit State compression per pile
  4. Extreme Event Limit State compression for the pile group
  5. Strength Limit State tension per pile
  6. Strength Limit State tension for the pile group
  7. Extreme Event Limit State tension per pile
  8. Extreme Event Limit State tension for the pile group
- Additionally, it is necessary to calculate the design tip elevation for the permissible settlement threshold when the Service Limit State Load is applied:
  For the group of piles, or
  Per pile
- The specified tip elevation is the lowest of as many as these 9 calculated design tip elevations.

Analyses of drilled shafts that penetrate rock

Design tip analyses for compression and tension load demands
Drilled shaft group analyses

Nominal resistance calculation
Equivalent Pier

Pile group settlement calculation
Equivalent Footing

Abutment 4 drilled shaft layout is used for the pile group analyses.
Dry Creek Bridge foundation design

Pier 2 foundation alternatives are a group of 24 inch CIDH piles and one 96 inch diameter drilled shaft. This is the design tip elevation for an individual drilled shaft, for the Strength Limit State compression load.

Dry Creek Bridge foundation design

Pier 3 foundation alternatives are a group of 24 inch CIDH piles and one 96 inch diameter drilled shaft. This is the design tip elevation for an individual drilled shaft, for the Strength Limit State compression load.
Draft Foundation Report provides foundation data tables

Revised Foundation Report request

- Revised general plan
- Revised FDDS provides
  Piers 2 and 3 will be supported on groups of five 60 inch diameter drilled shafts
- Revised foundation load demands
- Pier and abutment detail plan sheets
60" C10H Piles
Not All Piles Shown

Table 2. LRFD Service Limit State I Load Data

<table>
<thead>
<tr>
<th>Support No.</th>
<th>Design Method</th>
<th>Pile Type</th>
<th>Factor</th>
<th>Cut-off</th>
<th>Pile Cap</th>
<th>Permanent Movement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Movement in Service Load (kip)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>in lbf per support</td>
</tr>
<tr>
<td>Per 2</td>
<td>LR75</td>
<td>60&quot; CIDH</td>
<td>483.5</td>
<td>486.25</td>
<td>28.5</td>
<td>32</td>
</tr>
<tr>
<td>Per 3</td>
<td>LR65</td>
<td>60&quot; CIDH</td>
<td>482.0</td>
<td>486.25</td>
<td>22.5</td>
<td>32</td>
</tr>
</tbody>
</table>

Table 2. LRFD Service Limit State I Load Data

<table>
<thead>
<tr>
<th>Support No.</th>
<th>Total Vertical Load (kip)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Per Support</td>
</tr>
<tr>
<td>Per 2</td>
<td>8133</td>
</tr>
<tr>
<td>Per 3</td>
<td>9824</td>
</tr>
<tr>
<td></td>
<td>7875</td>
</tr>
</tbody>
</table>

Table 3. LRFD Strength and Extreme Event Limit State Load Data

<table>
<thead>
<tr>
<th>Support No.</th>
<th>Strength Limit State (Group H) (kip)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Compressive</td>
</tr>
<tr>
<td></td>
<td>Per Support</td>
</tr>
<tr>
<td>Per 2</td>
<td>10824</td>
</tr>
<tr>
<td>Per 3</td>
<td>12101</td>
</tr>
</tbody>
</table>

Pier 2 and 3 drilled shaft layout for the analysis of the nominal resistance and settlement of the drilled shaft group.

Completed revised pile data table

<table>
<thead>
<tr>
<th>Location</th>
<th>Pile Type</th>
<th>Nominal Resistance (kip)</th>
<th>Design Tip Elevation ($)</th>
<th>Specified Tip Elevation ($)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pier 2</td>
<td>60 inch CIDH</td>
<td>3430</td>
<td>325 (a)</td>
<td>433</td>
</tr>
<tr>
<td>Pier 2</td>
<td>24 inch CIDH</td>
<td>580</td>
<td>438 (b)</td>
<td>450</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200</td>
<td>450 (c)</td>
<td>450</td>
</tr>
</tbody>
</table>

Notes:
1) Design tip elevation for the abutment is controlled by: (a) Compression, (c) Settlement, (d) Lateral Load
2) Design tip elevation for Bents are controlled by: (a) Compression, (c) Settlement, (d) Lateral Load
3) The specified tip elevation shall not be raised.
Questions?