Alaska
Department of Transportation and Public Facilities

Bridge Foundation Report Policy

July 25, 2011

Introduction

This revision replaces the June 30, 2008 Bridge Foundation Report Policy.

1. Bridge Foundation Report Policy

1.1. Policy:

Use the following policy to develop the Structural Foundation Engineering Report (SFER) and provide support for bridge design and construction activities.

2.1. Overview and Intent:

The Department designs and constructs bridges in conformance with the *AASHTO LRFD Bridge Design Specifications (AASHTO)* and other DOT&PF documents. These specifications provide requirements for field exploration, foundation analysis, and field monitoring of bridge foundations and aid in the development of the SFER. The generation of the SFER report requires the coordination of several functional groups.

The intent of this policy is to:

(1) outline the interaction between the design team members,
(2) define the process for developing and implementing the SFER recommendations, and
(3) describe the support activities commonly required during bridge construction projects.

3.1. Overview of the Bridge Foundation Design Process:

The Regional Project Manager (PM) requests support from the Department's Statewide Materials Section (GEOTECH) to aid in developing site selection and roadway alignment options during the **Preliminary Design Phase** (pre-environmental document). The PM requests support from the Department's Bridge Section (BRIDGE) to develop bridge type alternatives. The GEOTECH and BRIDGE recommendations are used by the PM to support the identification of a preferred project alternative. Based upon the project objectives, the PM determines the preferred bridge alternative and site selection. Once selected, BRIDGE will send the preferred bridge alternative and site selection information (including preliminary plans in AutoCAD format) to the PM. The PM will arrange for a geotechnical investigation and foundation design recommendations by GEOTECH.

> ***NOTE:*** *GEOTECH and BRIDGE typically communicate directly with each other. However, the PM is the primary contact for BRIDGE and GEOTECH and should be copied in most correspondence, particularly those addressing project scope, schedule or budget. Comply with all of the requirements of the Alaska Highway Preconstruction Manual (e.g. article 450.9.1 Bridge Design and article 450.9.6 Geotechnical Investigations).*

GEOTECH prepares a subsurface exploration plan based on the preferred bridge alternative(s). This typically occurs during the **Preliminary Design Phase**. BRIDGE reviews and comments on the plan. PM approval is required prior to executing the subsurface exploration plan. The subsurface exploration findings are used to generate the Foundation Geology Report (refer to the *Alaska Geotechnical Procedures Manual* for additional information) which in turn helps generate the Preliminary SFER and the Final SFER.

The Preliminary SFER is prepared by the GEOTECH during the **Preliminary Design Phase** in order to identify feasible foundation types and design parameters. The preliminary subsurface information serves as the basis of the Preliminary SFER which BRIDGE uses to determine the most economically feasible foundation.

Once BRIDGE has identified the preferred bridge foundation, GEOTECH generates the Final SFER. The Final SFER is prepared during the **Design Phase**, prior to generating the final stamped bridge plans.

> ***NOTE:*** *The preceding schedule requires GEOTECH to conduct field exploration during the Preliminary Design Phase of the project. However, funding and other issues (e.g. environmental permitting) may preclude the execution of field explorations during the Preliminary Design Phase. When field exploration must be postponed until the Design Phase, the time allotted for preparing the SFER may be compressed.*

3.1.1. Preliminary Design Phase Interaction

Collaboration between BRIDGE and GEOTECH is required to generate the Foundation Geology Report and Preliminary SFER. Key components of this exchange area as follows:

GEOTECH needs / BRIDGE provides

- the proposed bridge configuration (i.e., the preliminary General Layout and Site Plan drawings for the bridge options).
- the foundation locations. (Typically the centerline support station and skew are shown on the Site Plan drawings.)
- the total estimated factored loads (Strength I) to the foundation elements that will be used in determining reasonable sizes of foundation elements and requisite subsurface testing depths.
- the total estimated Service I loads to the foundation elements.
- a list of special bridge needs and concerns, if any (e.g., "limit support settlements for the proposed structure to about one inch under Service Load combinations" or "the existing bridge has shown signs of frost jacking at pier 2").
- an estimate of the scour depth at in-water piers. (A method for estimating local pier scour is provided in Figure 1 to facilitate preliminary design in advance of a formal bridge hydraulic study.)
- historic subsurface and pile driving data. (BRIDGE may have historic pile driving records or other relevant information in their files that may aid in the development of foundation recommendations. If such data exists, copies will be sent to GEOTECH.)

BRIDGE needs / GEOTECH provides

- the subsurface exploration plan. (The PM, responsible for controlling the project's scope, schedule and budget, must formally approve the plan. A copy of the plan is typically sent to BRIDGE for comment.)
- the Preliminary SFER, described in the following section, containing an array of deep and shallow foundation options. (Feasible foundation types are examined to determine the most cost-effective structure. It is important that an ample variety of foundation recommendations be prepared to allow for meaningful cost comparisons.)

3.1.2. Design Phase Interaction

Ideally, BRIDGE would receive the Final SFER two months before the stamped PS&E due date. Collaboration between BRIDGE and GEOTECH is required to generate the Final SFER. Key components of this exchange are as follows:

GEOTECH needs / BRIDGE provides

- the review PS&E documents (typically distributed by PM to GEOTECH as part of the Review PS&E process).
- the final total factored loads (Strength I) to the foundation. (These values will be provided in the foundation Data Table on the Site Plan drawing.)
- the final total Service I loads to the foundation for settlement analysis, if necessary.
- the final scour depth. (These values will be provided in the Hydraulic and Hydrologic Summary table on the Site Plan drawing.)

BRIDGE needs / GEOTECH provides

- the stamped Final SFER containing the final Foundation Geology Report as described in the following section.
- the final pile driving special provisions, if necessary (*e.g., field monitoring requirements, pile driving concerns such as hard driving, pile tip reinforcement requirements, pre-boring requirements, etc. that are not addressed in the Department's Standard Specifications*).
- comments on the foundation design shown in plans. (*GEOTECH will verify that the bridge foundation agrees with the Final SFER recommendations.*)

4.1. Content Requirements of the SFER:

The Preliminary SFER and Final SFER contain the information indicated in the following subsections. The Preliminary SFER is primarily focused on design recommendations such as foundation capacity charts and feasible foundation types. The Final SFER is a fully developed report with supporting analysis and documentation.

4.1.1. Requirements of the Preliminary SFER

The Preliminary SFER provides geotechnical design data and recommendations for deep and/or shallow foundations.

(1) Geotechnical Data

The Preliminary SFER contains the following geotechnical data.

- the preliminary Foundation Geology Report, including test hole locations, geological description of soils and rock, SPT data, ground water table locations, temperature data, permafrost depth, and other data as applicable.
- the description of bedrock properties when present, including planes of weakness, joints, faults, rock type, Rock Quality Designation (RQD), etc. as they relate to the foundation recommendations.
- the subsurface soil description, including unit weight, relative density, moisture content, phi angle, and lateral stiffness parameters and modeling recommendations for each layer of soil. (*BRIDGE will perform the lateral pile / shaft analysis.*)
- the presence of permafrost, high ground water table, and soil stability considerations.
- the AASHTO seismic site class designation (*i.e., "A" through "E" and, in special cases, "F")* and applicability of code-specified seismic response spectra (*i.e., Are there local faults that would result in seismic demands greater than those provided in the AASHTO LRFD Bridge Design Specifications?*).

(2) Deep Foundation Data

Deep foundations (typically steel H-piles, steel pipe piles and drilled shafts) are typically used at water crossings, in poor soils, and in other locations where shallow foundations are inappropriate. Preliminary design recommendations on a variety of pile and shaft sizes are required to determine the most cost-effective bridge foundation and bridge. The Preliminary SFER contains deep foundation recommendations including:

- Capacity tables and charts presenting the axial and uplift vertical resistance, including scour effects, as a function of embedment depth. (*This data is used to establish the Estimated Pile Tip Elevation for piles or the Tip Elevation for drilled shafts.*)
- Capacity tables and charts presenting the axial and uplift vertical resistance, excluding scour effects, as a function of embedment depth. (*This data is used for establishing the vertical resistance at time of construction, without regard to scour or other reductions in vertical resistance.*)

- Capacity tables and charts presenting the axial and uplift vertical resistance, including liquefaction effects, as a function of embedment depth. (*The effects of scour and liquefaction may act concurrently.*)
- Capacity tables and charts presenting the non-seismic nominal downdrag load (*e.g. settlement, consolidation, etc.*) either as a single value or as a function of embedment, as appropriate.
- Capacity tables and charts presenting the nominal seismic induced downdrag load (*primarily due to liquefaction effects)* presented as either a single value or as a function of embedment, as appropriate.

For driven pile foundations, use the unfactored nominal resistance when preparing the vertical capacity with depth tables or charts. For drilled shafts, use the factored nominal resistance when preparing the vertical resistance with depth tables or charts. Deep foundations recommendations account for the following:

- Scour effects which reduce the amount of soil around the pile or shaft, reducing the member's vertical and lateral resistance. The Hydraulic and Hydrologic Report addresses scour effects and are summarized in the Hydraulic and Hydrologic Summary table on the bridge Site Plan drawing. For the Preliminary SFER**,** use the graph provided in Figure 1 to estimate scour effects. Figure 1 relates stream velocity and depth to estimated scour depth. In lieu of more accurate information, assume that the water flow velocity, V1, is 15 FPS. For multiple-column, pile-extension piers assume a 20^o water flow angle of attack (labeled "Angle=20" on the chart). For single column piers assume a 0^o water flow angle of attack (labeled "Angle=0." The value "a" is the pile or shaft diameter.). For the Final SFER, the scour values provided in the Hydraulic and Hydrologic Summary table are used as the basis of the design.
- Liquefaction effects caused by seismic-induced ground motion which reduce the member's vertical and lateral resistance. The Preliminary SFER includes the soil's liquefaction potential (*high, medium or low*), liquefied soil properties, deformations due to lateral soil flow and settlement, and subsequent downdrag loads. (*BRIDGE does not typically use H-piles or shallow foundations in liquefiable soils where lateral spread is possible.)*
- Downdrag loads which reduce the member's vertical and lateral resistance. GEOTECH shall provide recommendations for addressing downdrag (*e.g., "sleeve the uppermost 10 feet of the pile" or "as required in Section 505-3.09 of the Standard Specifications"*).
- Spacing and group effects that would have a tendency to reduce the vertical and lateral capacity of the piles or shafts and/or minimum pile spacing shall be addressed.
- Rock socket length that may be required to develop vertical or lateral resistance. The minimum rock socket length shall be provided. (*Collaboration between BRIDGE and GEOTECH may be required in establishing rock socket length in high seismic hazard areas where the development of the member's overstrength capacity is required.)*
- Other foundation demands such as those associated with frost jacking and heave shall be addressed in the SFER and design recommendations shall be provided.

All DOT&PF projects require field monitoring of pile driving operations. For driven pile foundations, the DOT&PF will specify the use of either:

- the "Wave equation analysis without pile dynamic measurements" or
- a "Driving criteria established by dynamic test with signal matching."

The corresponding Dynamic Analysis resistance factors, φ_{dyn}, shall be taken from the most current edition of the AASHTO LRFD Bridge Design Specifications (as of June 2010, $\varphi_{dyn} = 0.50$ and $\varphi_{dyn} = 0.65$, for "Wave equation analysis without pile dynamic measurements" and "Driving criteria established by dynamic test with signal matching," respectively) or as superseded by Department policy. The Preliminary SFER should include recommendations for field-monitoring. In the absence of field monitoring recommendations, BRIDGE will determine field-monitoring requirements based on the most cost-effective option.

(3) Shallow Foundation Data

Shallow foundations are typically used for non-water crossings (*e.g. highway interchanges*) where the underlying soil has good bearing capacity. The Preliminary SFER contains shallow foundation recommendations including:

- Nominal soil bearing resistance at the Service, Strength, and Extreme Event limit states as a function of effective footing width.
- Minimum embedment depth required due to frost penetration and other factors affecting the nominal soil bearing resistance. (*In most cases, BRIDGE will require that the bottom of the footing be at least three feet below the finished ground line.*)
- Need for replacement of the existing soil with engineered material. (*In some cases, the existing soil may be replaced with the Foundation Fill material identified in the Department's Standard Specifications for Highway Construction.*)
- Ground water table location and its effects on the nominal soil bearing capacity. (*Use the highest anticipated ground water table when determining the nominal bearing resistance.*)

4.1.2. Requirements of the Final SFER

The recommendations of the Final SFER are the same to those of the Preliminary SFER except that they address only the bridge foundation elements used in the final bridge design. The full body of the text is developed in the Final SFER expounding upon:

- Geotechnical data and interpretation
- Discussion of foundation recommendations
- Seismic conditions and liquefaction
- Analysis methods and limitations
- Construction issues and recommendations
- Sealed and signed test hole location and boring log plan sheets
- References

BRIDGE cannot submit the stamped PS&E to the PM before receiving the Final SFER.

5.1. Plan Set Information:

The following information will be provided on either the bridge Site Plan drawing or, if present, the Foundation Plan drawing.

5.1.1. Foundation Data Tables

BRIDGE will provide the following table in all bridge plans utilizing piles as a foundation element. The special provisions provide the level of field monitoring and the associated Resistance Factor is provided in the Pile Data Table as shown below. Currently, a Resistance Factor of 0.50 indicates that *"Wave equation analysis without pile dynamic measurements"* will be used. Currently, a Resistance Factor value of 0.65 indicates that a *"Driving criteria established by dynamic test with signal matching"* is required.

Table 1 Pile Data Table Example

Pile Data Table							
	Driving Criteria				Design Data		
Location	Pile Type	Minimum Penetration (FT)	Estimated Pile Tip Elevation (FT)	Minimum Driving Resistance (K)	Strength I Factored Load (K)	Nominal Resistance (K)	Resistance Factor, φ
Abut. 1	HP14X117	40.0	1415.0	600	350	550	0.65
Pier 2	4'-0" x 1" Pipe	60.0	1400.0	1400	800	1250	0.65

Minimum Penetration of the pile is typically based upon lateral resistance requirements (e.g. seismic or ice demands). The Estimated Pile Tip Elevation is based upon the factored estimated resistance after scour, downdrag, liquefaction, and all other pile resistance conditions have been taken into consideration. Since scour, downdrag, and other pile resistance reductions are not present during pile driving, the Minimum Driving Resistance, in most cases, will be greater than the Nominal Resistance. The Nominal Resistance of the pile is the anticipated pile capacity after all applicable pile resistance reductions have occurred. The Strength I Factored Load must be less than the Nominal Resistance multiplied by the Resistance Factor.

BRIDGE will provide the following table in all bridge plans that utilize drilled shaft foundations.

Table 2 Drilled Shaft Data Table Example

Drilled Shaft Data Table						
	Installation Criteria				Design Data	
Location	Shaft Diameter	Tip Elevation (FT)	Minimum Rock Socket Length (FT)	Minimum Top of Rock Socket Elevation (FT)	Strength I Factored Load (K)	Nominal Resistance (K)
Pier 2	8'-0"	1624.0	16.0	1640.0	2100	4200

The drilled shaft Tip Elevation and Minimum Rock Socket Length shall be provided in the SFER. All material that is encountered above the specified Minimum Top of Rock Socket Elevation shall not be included in the Minimum Rock Socket Length (e.g., in the above table, rock encountered above elevation 1640.0 does not contribute towards the 16.0 foot Minimum Rock Socket Length). If rock is not anticipated then the table will be provided with "NA."

The Nominal Resistance of the drilled shaft is the anticipated shaft capacity after all applicable reductions have occurred. The Strength I Factored Load must be less than the Nominal Resistance multiplied by the appropriate Resistance Factor(s).

BRIDGE will provide the level of field inspection for drilled shafts (e.g. down-hole inspection and bottom cleanliness) in the special provisions.

BRIDGE will provide the following table in all bridge plans that utilize shallow foundations.

Table 3 Footing Pressure Table Example

Footing Pressure Table			
Location	Strength I Factored Load (KSF)	Nominal Bearing Resistance (KSF)	Bearing Resistance Factor, φ
Abut. 1	5.2	12.0	0.45
Abut. 3	4.9	12.0	0.45

5.1.2. Seismic Parameters

BRIDGE will provide the seismic design parameters, as shown below, in the "GENERAL NOTES" of the Site Plan drawing. The spectral acceleration values are provided in the *AASHTO LRFD Bridge Design Specifications* and the *AASHTO Guide Specifications for LRFD Seismic Bridge Design*. The Site Class and Liquefaction Potential are provided in the SFER.

SEISMIC PARAMETERS………... PGA = 0.25
Ss = 0.65
S1 = 0.20
Site Class = C
Liquefaction Potential = Low
AASHTO 7% probability of exceedence in 75 years

For Site Class F soils or other situations where a site specific response spectra is used in the bridge design, include the site specific spectra on the bridge plans sheets.

5.1.3. Log of Test Hole Borings

BRIDGE will incorporate the sealed and signed test hole location and boring log plan sheets in the final bridge plans.

6.1. Construction Support:

Both GEOTECH and BRIDGE need to be available during construction to address construction-related foundation and geotechnical questions and problems and to provide technical advice to the Construction Project Engineer.

For pile foundations, the GEOTECH will need to:

- review the adequacy of the Contractor's proposed pile driving plan,
- review the adequacy of the Contractor's proposed pile driving hammer,
- provide the pile driving acceptance criteria (*also known as the inspector's chart*) when a *"Wave equation analysis without pile dynamic measurements"* is specified,
- provide preliminary pile driving acceptance criteria when *"Driving criteria established by dynamic test with signal matching"* is specified and
- generate the scope of services to the Construction Project Engineer when a *"Driving criteria established by dynamic test with signal matching"* is specified and interact with the PDA Consultant once his/her services have been acquired.

For drilled shaft foundations both GEOTECH and BRIDGE will be required to:

- review the adequacy of the Contractor's proposed shaft installation plan and
- review field inspection reports (*e.g., shaft cleanliness, cross-hole-sonic logs, etc.*).

For shallow foundations, GEOTECH may be required to evaluate foundation adequacy when the actual soils deviate from those presented in the Foundation Geology Report and Final SFER (*e.g., groundwater table, rock characteristics, soil type, etc.*).

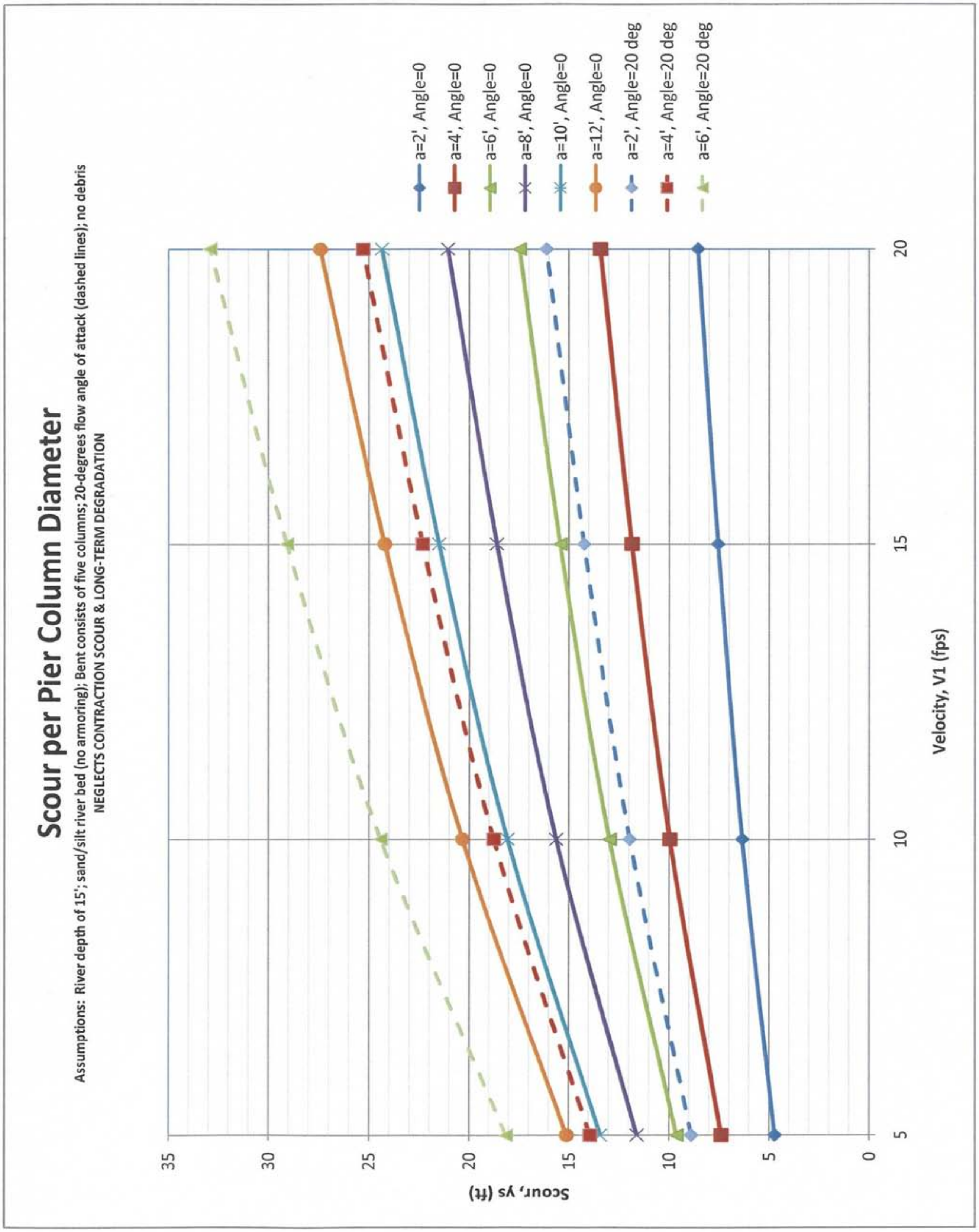

Figure 1 Preliminary Pier Scour Estimation Graph