Appendix B. Shallow Foundations Report

PLEASE NOTE

A sample foundations report is included here for reference. It is provided as an example of content, format, and organization representative of a typical Foundation Investigation and Recommendation Report for a bridge on shallow foundations. As site conditions vary widely, the investigation means and methods, and report content (including recommendations), may differ for other projects. Note that the selection and inclusion of this report as a sample does not imply that it is guaranteed to be free of errors. Please contact the Foundations Unit with any questions when interpreting a geotechnical report issued by this office or if you have any questions with respect to preparing geotechnical reports for MnDOT. The information presented here is intended for use as a resource by geotechnical engineering professionals. MnDOT makes no warranty as to the suitability of engineering reports in the style of this sample report, for other geotechnical needs, purposes, clients, or projects. NOTE: SPT boring logs, cross sections or CPT logs typically included at the end of the Foundation Investigation and Recommendation Report have been removed for this example.

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SUBJECT: S.P. 0502-96, Bridge Numbers 05009 & 05012 (District 3)
TH 10 over CSAH 2, in the City of Rice, Benton County, MN
Foundation Investigation and Recommendations Report

Project Description

This report provides Foundation Analysis and Recommendations for Bridge No's. 05009 and 05012, part of a new grade separation interchange in Rice, MN. Bridge No. 05009 is a new bridge that will carry TH 10 EB traffic and Bridge No. 05012 is a new bridge that will carry TH 10 WB traffic, both over CSAH 2. The bridges will be approximately 117.5 feet long, and the widths of Bridge No's. 05009 and 05012 will be 45.3 feet and 46.3 feet respectively. The bridge superstructures will each be single spans constructed with MN45 prestressed concrete beams and supported on semi-integral abutments with spread footings. Please refer to the attached boring plan for more details on the proposed bridge layout.

Field Investigation and Foundation Conditions

The MnDOT Foundations Unit advanced three Standard Penetration Tests (SPT), in February of 2012 and six seismic cone penetration tests (SCPT) in January of 2012. Copies of the SCPT soundings and SPT borings logs are included with this report. The three borings were taken near the abutment locations of Bridge 05009 and the south abutment of Bridge 05012. Four SCPT soundings were advanced near the abutments of both bridges. Additionally, two SCPT soundings were advanced approximately 50 feet west of Bridge 05009, which were done due to the potential need for MSE walls. However, the MSE walls are no longer needed for the project.

This site is defined by generally excellent soil conditions for use with spread footings. All SCPT soundings and SPT borings encountered predominantly sandy soils, with generally high tip stress' and blow counts throughout the granular soil that defines this site.

The water table was encountered approximately 30 feet below the ground surface (to an approximate elevation of 1036 feet) based on the SCPT soundings.

Seismic CPT soundings were taken in order to obtain shear wave velocity data for the foundation soils. Shear wave velocity has been correlated to soil stiffness and has been shown to produce accurate settlement estimates for footing and embankment loads. Table 2, found in the appendix, shows the correlation between wave speed and soil strength properties. Wave speed plots for each SCPT sounding are shown in the appendix to this report. Seismic shear wave arrival time plots have been included in the appendix as well. The seismic shear wave arrival time plots show the time it took for the shear wave to arrive at prescribed depths, shear wave velocities are derived from these data. Please contact this office for additional information on how the Seismic CPT data is acquired and analyzed.

Please refer to the attached SPT and SCPT logs, as well as seismic waterfall charts for a more complete description of the foundation soils

Foundation Analysis

Approximate roadway and footing elevations were determined from a Preliminary Bridge Plan provided by MnDOT's Bridge Office.

Substructure Foundations

Due to the dense and sandy nature of the soils present, shallow foundations are proposed and have been analyzed for use at the abutments.

Table 1: Recommended Foundation Types and Assumed Footing Elevations.

	Bridge 05009		***Bridge 05012***	
Location	***South Abutment***	***North Abutment***	***South Abutment***	***North Abutment***
Foundation	Spread Footing	Spread Footing	Spread Footing	Spread Footing
Test Used for Analysis	S05	S06	S01d	S02
Assumed bottom of Footing Elevation	1059 feet	1059 feet	1059 feet	1059 feet

Shallow Foundation – Service Limit State

An LRFD method was used for the analysis of the spread footings, using parameters based on the medium to dense sandy soils present at the site. Foundation SCPT data were used to predict the foundation settlement (service limit state). The SCPT settlement prediction model uses the shear wave velocity through the various soil strata to predict settlement. The results from the analyses are presented on the attached graphs.

One settlement graph was developed for each abutment using 1 inch of settlement as the limiting criteria for bearing capacity. The settlement at the time of setting the beams may be less than 1 inch since it is estimated that at least 75% of the total load will have already been applied to the soil due to the construction of the footing and stem itself.

To further minimize differential settlement directly underneath the footing and further reduce possible settlement, it is recommended that a 3 foot subcut be excavated over the 3 feet beyond all sides of the full length and width of the footing and recompacted with the removed material beneath the footings. Additionally, in order to protect both the integrity of the foundation soils beneath the spread footing and serve as a warning against future excavation near the spread footing, a geosynthetic soil containment system is proposed (see Figure 1 in the appendix).

In order to better correlate shallow foundation settlement prediction models with actual settlement seen in the field, the foundation systems should be monitored as described in Item 9 of the Recommendations

Shallow Foundation – Strength Limit State
The strength limit state of the soil's nominal bearing capacity was computed for varying footing widths.

The following are the resistance factors for evaluation of the strength limit state performance limits based on the latest LRFD code.

Bearing Resistance, using SPT = 0.45
Bearing Resistance, using CPT = 0.55
Sliding, Cast-in-Place Concrete on Sand = 0.80

Refer to the following figures in the appendix for the nominal bearing resistance and service limit state for the substructures on this project.

Figure 2: Bridge No. 05009 South Abutment – 1.0 inch settlement
Figure 3: Bridge No. 05009 North Abutment – 1.0 inch settlement
Figure 4: Bridge No. 05012 South Abutment – 1.0 inch settlement
Figure 5: Bridge No. 05012 North Abutment – 1.0 inch settlement

Approach Embankment Settlement
Due to the sandy nature of the soil at this site, settlement caused by the embankment fill will be minor and immediate.

<u>Recommendations</u>

Based on the existing conditions along with an analysis of the project soils, we recommend:

1. Topsoil and other organic material be removed from areas where fill is to be placed. These soils be excavated and replaced with Granular Borrow (MnDOT spec. 3149.2B1) and compacted to 95% to 100% Standard Proctor density.

2. The bridge be supported on spread footing foundations with capacities defined in the nominal bearing resistance graphs (Figures 2 to 5). The graphs show predicted available geotechnical resistance based on footing width for the strength/extreme-event limit states and service limit state at each abutment location; a graph is presented for 1.0 inch of deflection. Recent studies have shown that most of the

settlement at bridge abutments built on granular soils occurs during the construction of the foundations and placement of the soil backfill.

The service limits state (Green broken line in the graph) is expected to control the design. Strength/extreme-event limit state (red line in the graph) information is presented on the same charts **Note that the scales are different for the service limit state [left side] and strength/extreme-event limit state [right side] data.**

3. A 3 foot subcut is required beneath footings to be located on or in native soils. Backfill subcut with the removed material and compact to 95% to 100 % Standard Proctor density. Wrap the face of the subcut as shown in Figure 1 to both maintain foundation soil strength and protect against future disturbance.

4. The footings be buried a minimum of 4.5 feet below the final ground line for frost protection.

5. Drainage be installed as appropriate at the footing locations to ensure that the bearing soils and soils behind the abutment are free draining. Drainage be provided from the base of the footing subcut soils and from the rear of the abutment walls, similar to retaining wall drainage plans as used on recent projects.

6. Drainage from the bridge deck and the roadway areas not be directed onto unprotected embankment slopes to prevent erosion.

7. Any pipes (water mains or drainage culverts) be appropriately gasketed or cased to minimize risk of erosion from pipe leakage or breakage. Refer to MnDOT's LRFD Bridge Design Manual (Section 2.4.1.6) for guidance on utility placement near shallow foundations.

8. Embankment slopes be constructed at 2H : 1V slopes, or flatter, for stability and to reduce erosion from overland flow. Vegetation be established as quickly as possible after construction to minimize the potential for erosion.

9. For the accurate monitoring and documentation of the performance (deflection) of structures built with shallow foundations, survey targets are necessary with a minimum of four per shallow foundation (to adequately provide redundancy and tilt data). These targets must be mounted in such a way that they can be surveyed throughout the entire construction process of the structural footing and complete superstructure such that the deflection can be recorded and evaluated as the entire weight of the foundation and structural system is loaded onto the foundation soils, see Figure 6 in the appendix. Posts mounted through the footing toe or into the foundations of the piers, with survey targets at the free end, are possible systems. Traditional surveying equipment may be used, or reflective targets and Total Station equipment may be employed. All measurements must be measured with respect to a fixed datum and any targets that are damaged or destroyed must be reset and surveyed as soon as possible. Survey systems of a minimum 0.005 foot precision are required. The targets shall be shot once affixed to the structure to develop a baseline reading prior to backfilling and abutment wall construction. The survey targets should be surveyed daily during backfilling activities greater than 3 feet or structural construction on the foundation, and weekly through the remainder of substantial completion of the structures.

Attachments:

Foundation Soil Containment System Detail (Figure 1)
Spread Footing Bearing Resistance Graphs (Figures 2 to 5)
Typical Optical Survey Target Placement (Figure 6)
Foundation Investigation Plan & Profile
SPT Index Sheet
SPT Logs (T01-T03, MnDOT Unique Numbers 75780, 75790 & 75791)
CPT Index Sheet
SCPT Logs (S01d, S02-S06, MnDOT Unique Numbers 75749 – 75754)
Seismic Shear Wave Arrival Time Charts (S01d, S02 – S06)

cc:

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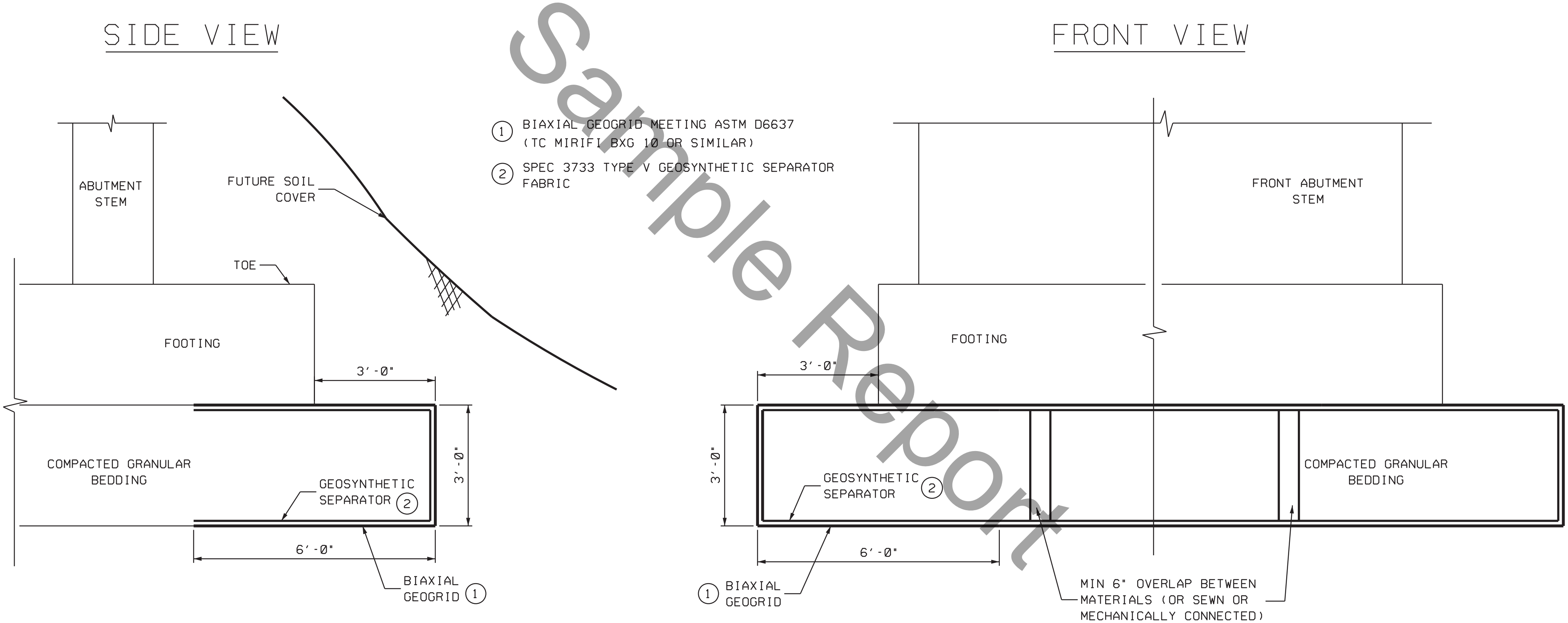
File

FIGURE 1:
GEOSYNTHETIC CONTAINMENT SYSTEM DETAIL



FOR INFORMATION ONLY

Figure 2: Bridge No. 05009 South Abutment – 1.0 inch Settlement

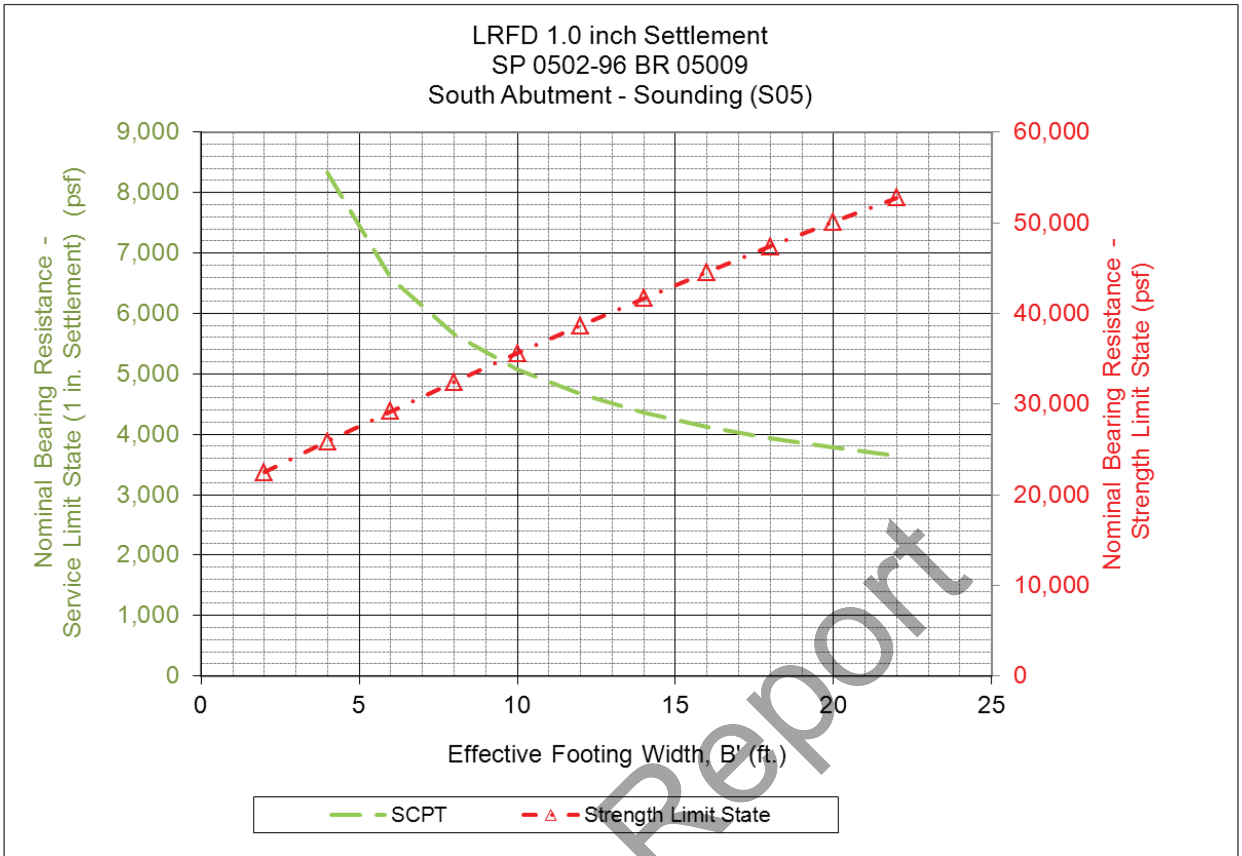


Figure 3: Bridge No. 05009 North Abutment – 1.0 inch Settlement

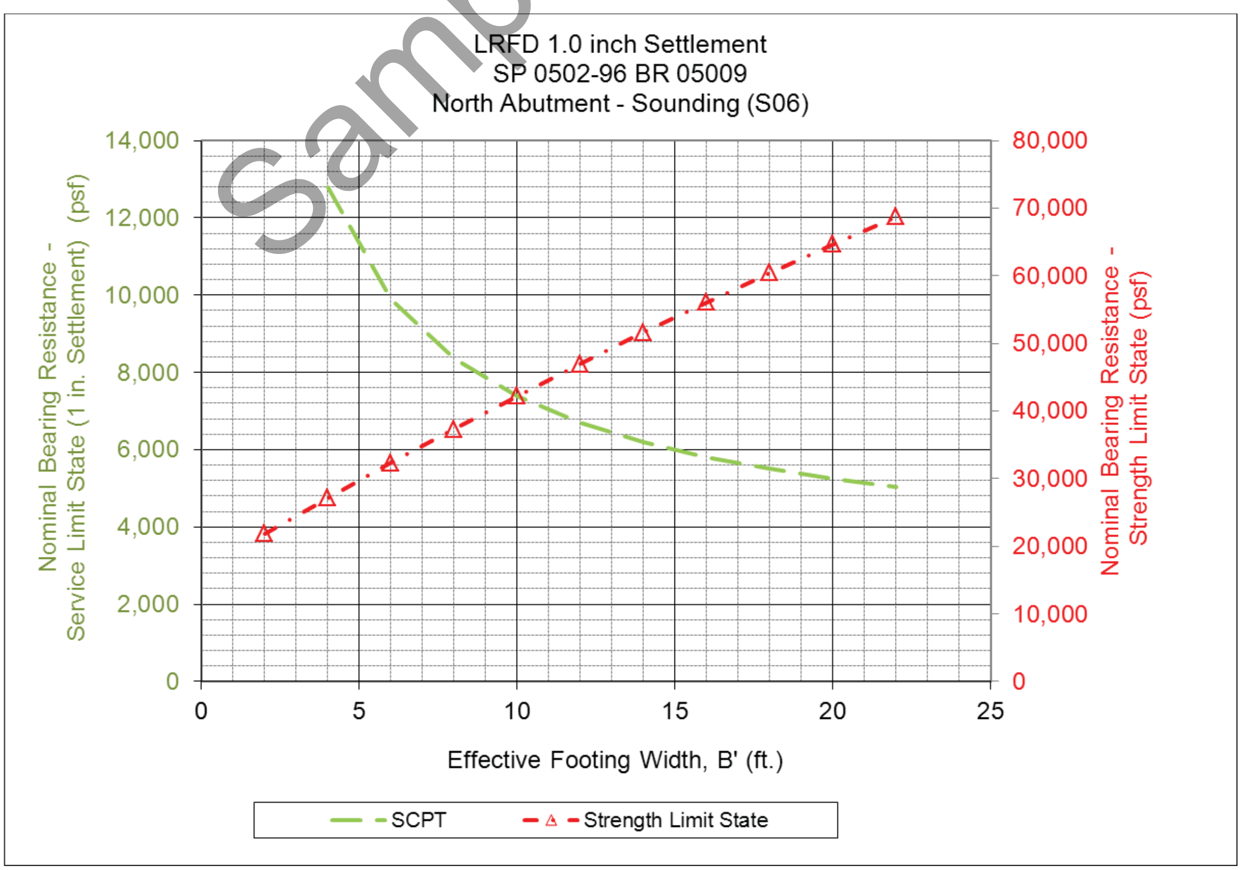


Figure 4: Bridge No. 05012 South Abutment – 1.0 inch Settlement

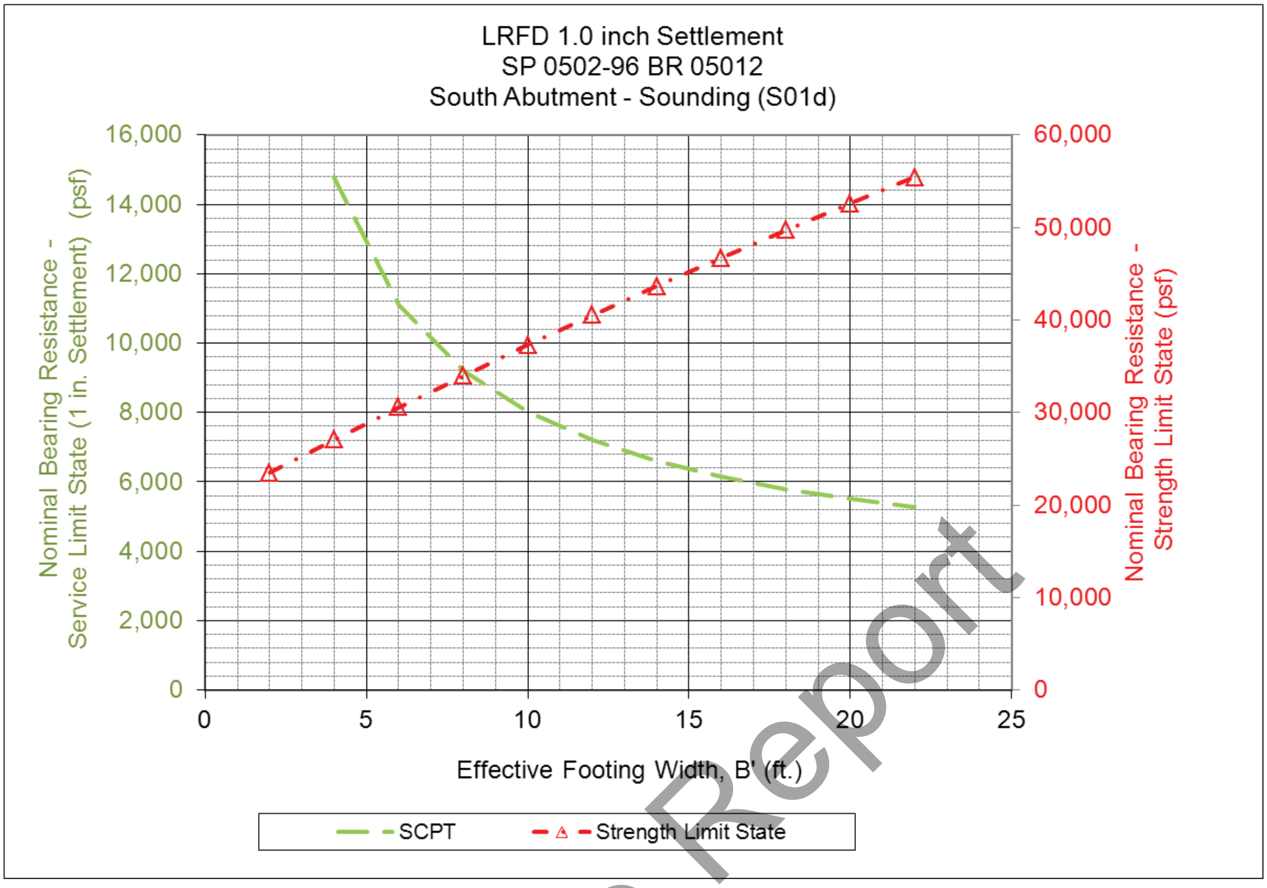


Figure 5: Bridge No. 05012 North Abutment – 1.0 inch Settlement

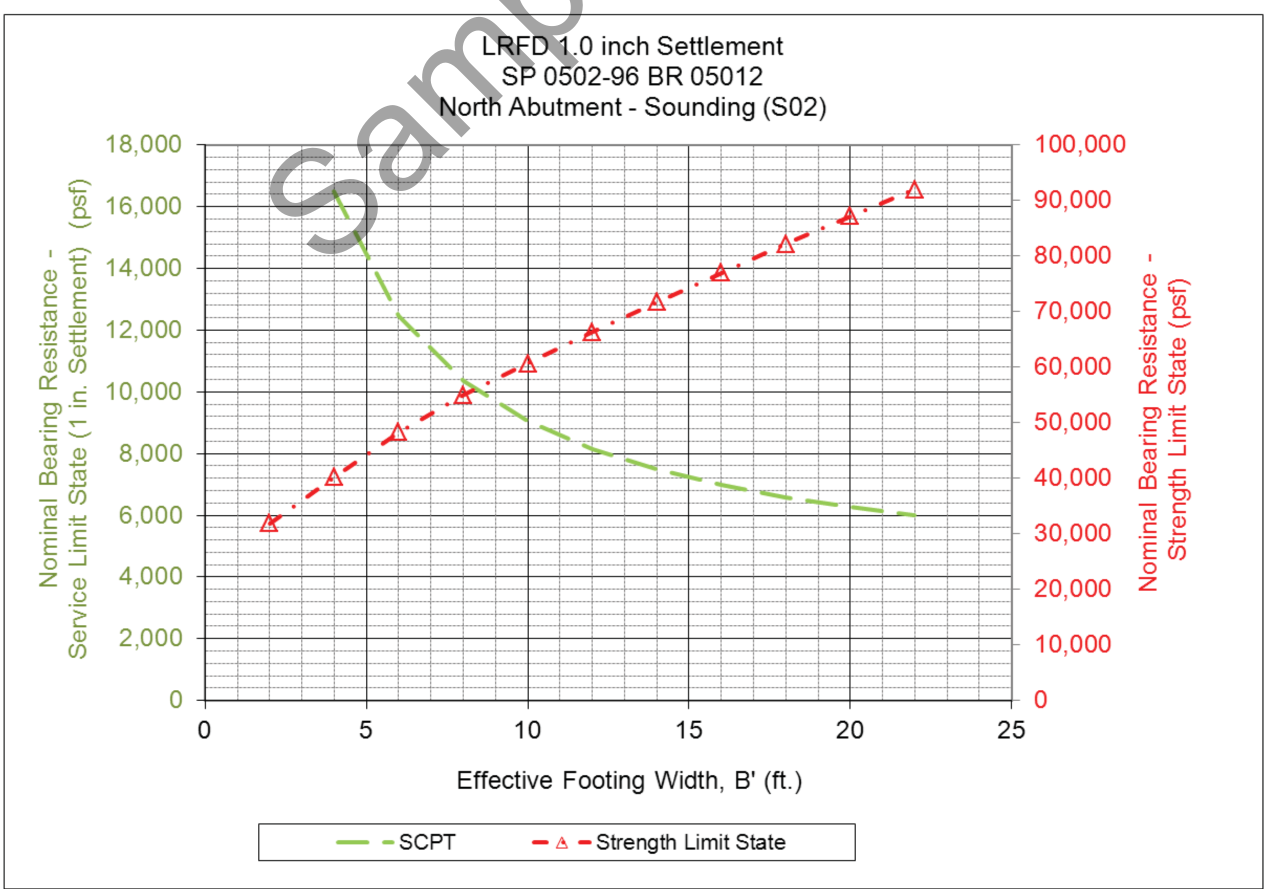
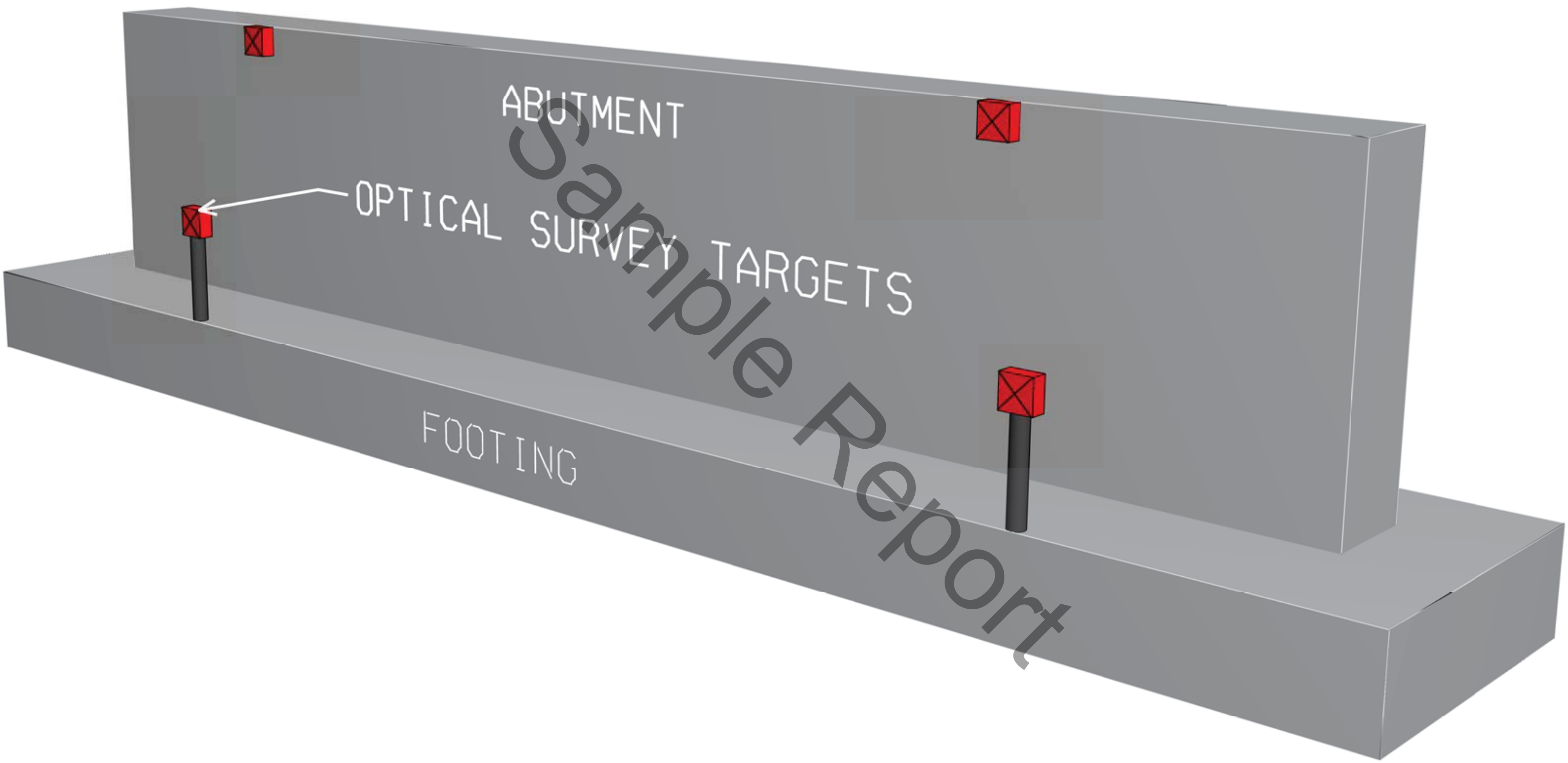
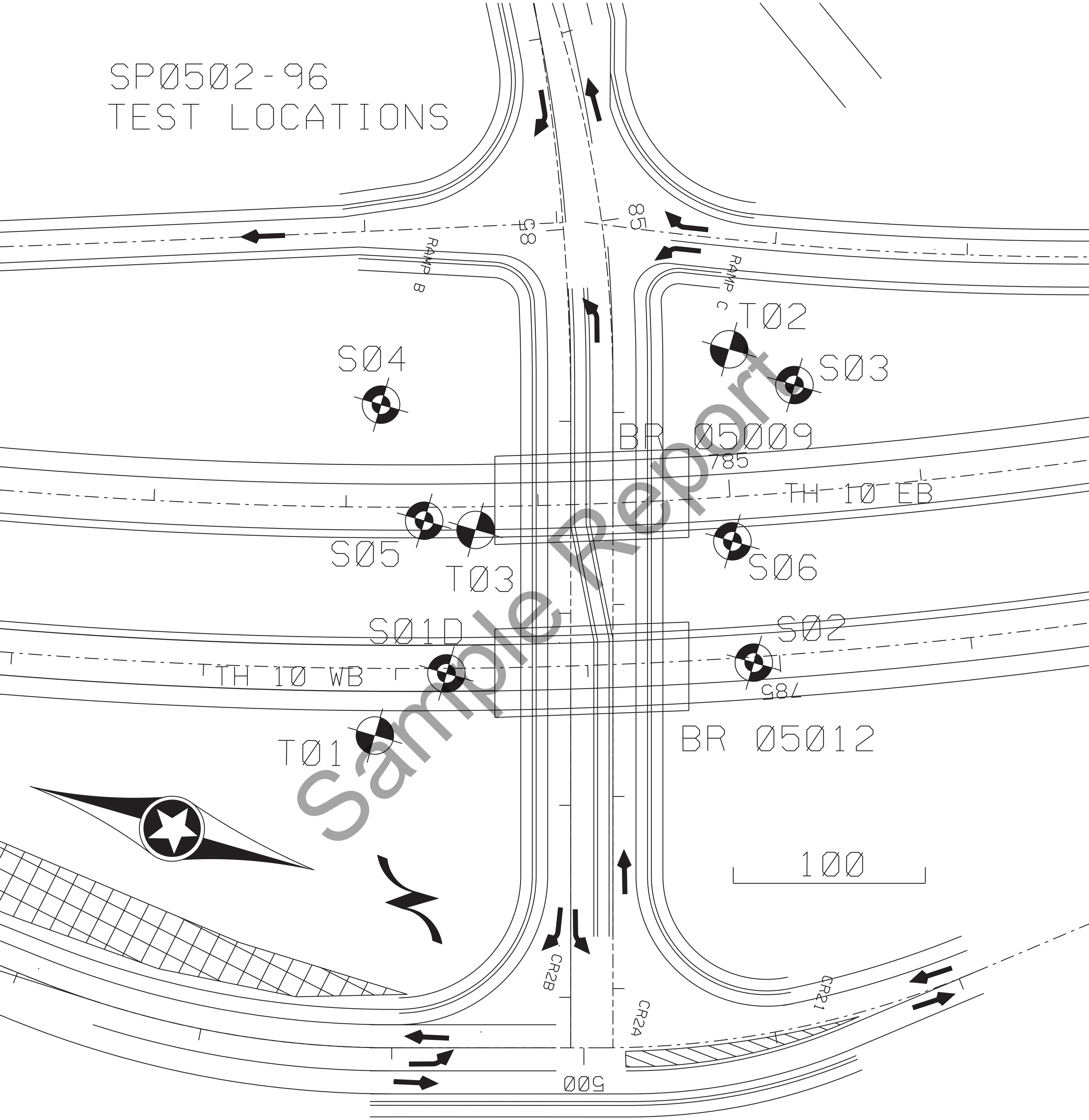


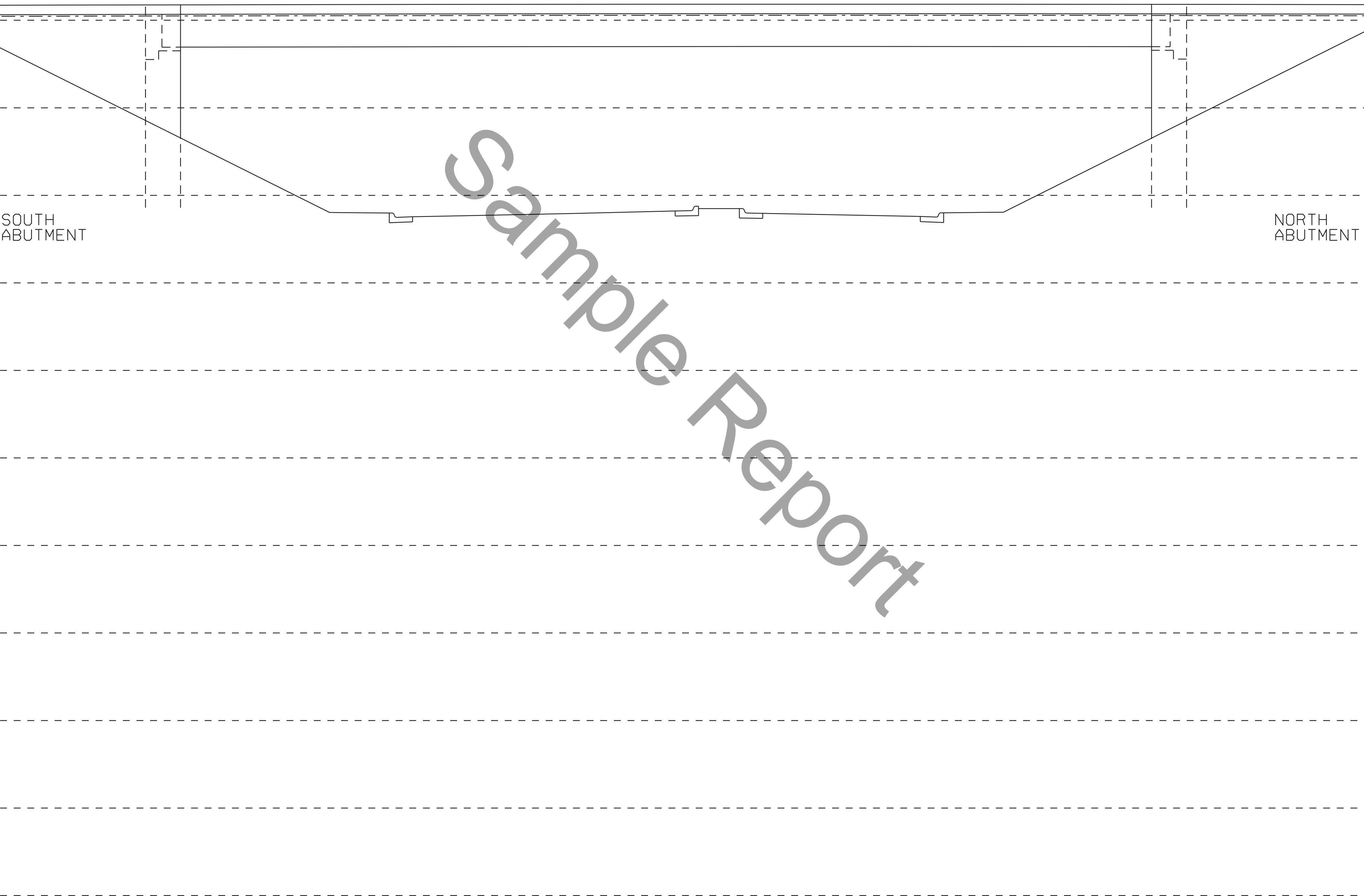
Figure 6: Typical Optical Survey Target Placement



SP0502-96
TEST LOCATIONS



BRIDGE NO. Ø5Ø12



BORING ELEVATIONS

BRIDGE NO. Ø5ØØ9