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39.1 General

Signing is an integral part of the highway plan and as such is developed with the roadway and bridge design. Aesthetic as well as functional considerations are essential to sign structure design. Supporting sign structures should exhibit clean, light, simple lines which do not distract the motorist or obstruct view of the highway. In special situations sign panels may be supported on existing or proposed grade separation structures in lieu of an overhead sign structure. Aesthetically this is not objectionable if the sign does not extend below the girders or above the top of the parapet railing. Some of the more common sign support structures are shown in the following figure.

![Sign Support Structures Diagram](image)

### 39.1.1 Signs on Roadway

Roadside sign supports are located behind existing or planned guardrail as far as practical from the roadway out of the likely path of an errant vehicle. If roadside signs are located within the 30 foot corridor and not protected, break-away sign supports are detailed. Wisconsin has experienced that the upper hinge on ground mounted signs with break-away supports does not work and it is not used. Since FHWA has not approved this removal, the hinge is used on all federal projects. DMS, which includes both dynamic message signs and variable message signs, roadside sign type supports are to be protected by concrete barrier or guardrail. All overhead sign-column type supports are located at the edge of shoulder adjacent to the traveled roadway or placed behind barrier type guardrail. See the Facilities Development Manual (FDM) 11-55-20.7 for information on shielding requirements.
When protection is impractical or not desirable, the towers shall be designed with applicable extreme event collision loads in accordance to 13.4.10.

Overhead sign structures, for new and replacement structures only, are to have a minimum vertical clearance of 20'-0" above the roadway for the Oversize/Overweight (OSOW) High Clearance Route and 18'-3" for all other routes. Reference 39.4.2 for additional vertical clearance requirements when catwalk or lighting is designed with a sign bridge. See FDM 11-35-1 Attachment 1.9 for clearances relating to existing sign structures. The minimum vertical clearance is set slightly above the clearance line of the overpass structure for signs attached directly to the side of a structure.

39.1.2 Signs Mounted on Structures

Signs are typically installed along the major axes of a structure. Wisconsin has allowed sign attachment up to a maximum of a 20 degree skew. Any structure with greater skew requires mounting brackets to attach signs perpendicular to the roadway.

39.1.2.1 Signs Mounted on the Side of Structures

In addition to aesthetic reasons, signs attached to the side of bridge superstructures and retaining walls are difficult to inspect and maintain due to lack of access. Attachment accessories are susceptible to deterioration from de-icing chemicals, debris collection and moisture; therefore, the following guidance should be considered when detailing structure side mounted signs and related connections:

1. Limit the sign depth to a dimension equal to the bridge superstructure depth (including parapet) minus 3 inches.
2. Provide at least two point connections per supporting bracket.
3. Utilize cast-in-place anchor assemblies to attach sign supports onto new bridges and retaining walls.
4. Galvanized or stainless steel adhesive concrete masonry anchor may be used to attach new signs to the vertical face of an existing bridge or retaining wall for shear load application only. Overhead installation is not allowed. Reference 40.16 for applicable concrete masonry anchor requirements.

39.1.2.2 Overhead Structure Mounted Signs

Span deflections of the superstructure due to vehicle traffic are felt in overhead sign structures mounted on those bridges. The amount and duration of sign structure deflections is dependent on the stiffness of the girder and deck superstructure, the location of the sign on the bridge, and the ability of the sign structure to dampen those vibrations out; among others. These vibrations are not easily accounted for in design and are quite variable in nature. For these reasons, the practice of locating overhead sign structures onto bridges should be avoided whenever possible.
The following general guidance is given for those instances where locating a sign structure onto a bridge structure is unavoidable, which may be due to the length of the bridge, or a safety need to guide the traveling public to upcoming ramp exits or into specific lanes on the bridge.

1. Locate the sign structure support bases at pier locations.

2. Build the sign structure base off the top of the pier cap.

3. Provide set back of the tower support of the sign structure behind the back face of the parapet to preclude snagging of any vehicle making contact with the parapet.

4. Use single pole sign supports (equal balanced butterfly's) in lieu of cantilevered (with an arm on only one side of the vertical support) sign supports.

5. Consider the use of a Stockbridge type damper in the horizontal truss of these structures.

6. Do not straddle the pier leaving one support on the pier and one support off the pier in the case of skewed substructure units for full span sign bridges.
39.2 Specifications and Standards

Reference specifications for sign structures are as follows:

- State of Wisconsin "Standard Specifications for Highway and Structure Construction"
- ASTM "Standards of the American Society for Testing and Materials"
- AWS D1.1 Structural Welding Code (Steel)
- AWS D1.2 Structural Welding Code (Aluminum)

Standard details for full span 4-chord galvanized steel sign bridge, design data and details for galvanized cantilever steel sign truss and footing are given on the Chapter 39 Standard Details.

Standard details for overhead sign support bases are provided in the Standard Detail Drawing (SDD) sheets of the FDM.

Standard design data and details for break-away sign supports and sign attachment are given on the A Series of the Sign Plate Manual.
39.3 Materials

Wisconsin has historically specified API Spec. 5L, grade 42 pipe as the primary material for the design of sign bridge chords and columns. However, due to supply shortage, API Spec. 5L, grade 46 and 52, ASTM A500 grades B and C, and ASTM A53 grade B types E and S round HSS or pipe (tubular shapes) are allowed as alternate materials for sign bridge truss main members (chords and columns) less than 10 inches diameter. API Spec. 5L, grade 42 remains the preferred material for single column on both full span and cantilever sign bridges due to the toughness requirement to address weldability, fatigue concerns and the non-redundant nature of these structures. Thus, a stricter product specification level 2 (PSL-2) is required. Contractor may substitute grades 46 and 52 steel with the same section properties and product specification requirement for grade 42 pipe at no additional cost to the department. All plates, bars and structural angles shall be ASTM A709 grade 36. ASTM A595 grade A, A572, and A1011 have been used by manufacturers to design round, tapered steel members for overhead sign support arms and uprights. When tubular shapes are used for overhead sign supports, they shall conform to the sign bridge requirements. Unless noted otherwise in the contract plans, all field bolted connections for sign structures shall be made with direct tension indicating (DTI) washers meeting the applicable requirements of high strength A325 bolts as stated in 24.2. More details can be found in the Standard Drawings and Standard Specifications Section 641.

WisDOT policy item:

Installation of flat washers in between faying surfaces of mast arm connection plates are not allowed.
39.4 Design Considerations

39.4.1 Signs on Roadway

Supports for roadside signs are of three types, depending upon the size and type of the sign to be supported. For small signs, the column supports are treated timber embedded in the ground. For larger type I signs and DMS, the columns shall be galvanized steel supported on cylindrical concrete footings. Currently, all steel column supports for roadside type I signs are designed to break-away upon impact, while DMS supports are protected and designed without a break-away system.

WisDOT policy item:

Type I break-away sign supports and foundations are design in accordance to the “AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals 1985”. Standard design and support estimates are given in the A3 Series of the “Sign Plate Manual”

Wisconsin does not have standard design or details available for DMS roadside sign supports. Each support structure to be design by structure engineer, and the design must be in compliance with the applicable specifications listed in 39.2. An allowable soil pressure of 3.0 ksf shall be used to design the footings, unless subsurface condition is in question then investigation per 39.6.3 would be implemented to gather necessary design information. DMS sign supports and footings to be detailed with the Structure Plan Section of the contract.

39.4.2 Overhead Sign Structures

Sign structures for support of overhead signs consist of “sign bridges” and “overhead sign supports”. Sign bridges are to be either a single column cantilever or butterfly, or a space truss sign bridge supported by one or two columns at each end. For cantilever sign bridge structures, the footing is a single cylindrical shaft with wings to prevent the overturning and twisting of the structure. For space trusses having one or two steel columns on an end, the footing is composed of two cylindrical caissons connected by a concrete cross-girder. The top surface of concrete foundations for all sign bridges is to be located 3’ above the highest ground line at the foundation. Occasionally, some sign bridge columns are mounted directly on top of modified bridge parapets, pier caps and concrete towers instead of footings.

Sign bridges also include sign support members mounted directly onto structures. Sign attachments, such as galvanized steel I-beams and/or brackets, typically are anchored to the side of the bridge superstructure. A cantilever truss attached to the side of retaining walls (without a vertical column) is also common.

Similar to sign bridges, all overhead sign supports have single galvanized steel column supported on a cylindrical caisson footing or on top of bridge elements. Cross members can be one chord (monotube), two chord without web elements, or planar truss in either cantilever or full span structure.
The following design data is employed for designing steel sign bridges and overhead sign supports.

Wind Velocity = 90 mph based on the 3-second gust wind speed map and its corresponding methods to find wind pressure.

Dead Load = Wt. of Sign, supporting structure, catwalk, railings and lights.

Ice Load = 3 psf to one face of sign and around surface of members.

<table>
<thead>
<tr>
<th>Group Load</th>
<th>Load Combination</th>
<th>% of Allowable Stress</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>DL</td>
<td>100</td>
</tr>
<tr>
<td>II</td>
<td>DL + W</td>
<td>133</td>
</tr>
<tr>
<td>III</td>
<td>DL + Ice + (1/2)W(^a)</td>
<td>133</td>
</tr>
<tr>
<td>IV</td>
<td>Fatigue</td>
<td>c</td>
</tr>
</tbody>
</table>

Table 39.4-1
Group Load Combinations

\(^a\) Minimum Wind Load = 25 psf

\(^c\) See Fatigue section of AASHTO for fatigue loads and stress range limits.

<table>
<thead>
<tr>
<th>Wind Components</th>
<th>Normal</th>
<th>Transverse</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combination 1</td>
<td>1.0</td>
<td>0.2</td>
</tr>
<tr>
<td>Combination 2</td>
<td>0.6</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Table 39.4-2
Wind Components

WisDOT policy item:

Fatigue group loads application is exempt on four chord full span sign bridges supporting type I and II signs mounted on concrete footings as detailed on Standards 39.02 and 39.03. The exemption is also applied to full span overhead sign supports mounted on top of standard concrete bases.

Steel cantilevered sign bridge structures (four chord structures carrying type I and II signage) detailed on Standards 39.10 thru 39.12 are classified, for purposes of fatigue design, as Category 1 structures. These cantilevered support structures are designed to resist Natural Wind Gust and Truck-Induced Gust wind effects, but not designed for Galloping wind effects due to the substantial stiffness and satisfactory performance history in this state. The design of these structures are in accordance to the AASHTO “Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals, 4th Edition” and interim Revisions.
All other sign structures shall be designed with applicable design specifications as stated in 39.2.

Steel cantilever sign bridge trusses are designed and fabricated from tubular shapes for chords and angle shapes for web members. Columns are made from pipe sections. The minimum thickness for the members is indicated on the steel cantilever Standard detail.

Steel full span sign bridge trusses are designed and fabricated from tubular shapes for chords and angle shapes for web members. The minimum thickness of steel web members is 3/16 inch and 0.216 inches for chord members. The connections of web members to chords are designed for bolting or shop welding to allow the contractor the option to either galvanize individual members or complete truss sections after fabrication. The columns are either steel pipe or tubular shape sections with web members (planar truss), see 39.3 for additional details. Steel base plates are used for anchor rod support attachment.

When butt welding round sections, a back-up plate is required since the plates can only be welded from one side. The plate must be of adequate width for film to be used during weld inspection. The exposed weld is ground smooth for appearance as well as fatigue. Shop splices typically done with the use of butt weld, but quality on large weld is difficult to achieve and not economical. Therefore, designers are advised to limit weld size to 5/8", and avoid shop splice on single column member whenever possible.

Aluminum sign bridges are currently not being designed for new structures. Rehabilitation and repair type work may require use of aluminum members and shall be allowed in these limited instances. The following guidelines apply to aluminum structures in the event of repair and rehabilitation type work.

Aluminum sign bridge trusses are designed and fabricated from tubular shapes shop welded together in sections. The minimum thickness of truss chords is ¼ inch and the minimum outside diameter is 4 inches. The recommended minimum ratios of “d/D” between the outside diameters “d” of the web members and “D” of chord members is 0.4. A cast aluminum base plate is required to connect the aluminum columns to the anchor rods. AASHTO Specifications require damping or energy absorbing devices on aluminum overhead sign support structures to prevent vibrations from causing fatigue failures. Damping devices are required before and after the sign panels are erected on all aluminum sign bridges. Stock-bridge type dampers are recommended.

Install permanent signs to sign structures at the time of erection. If the signs are not available, install sign blanks to control vibration. For sign bridges, blanks are attached to a minimum of one-fourth the truss length near its center. The minimum depth of the blanks is equal to the truss depth plus 24 inches. The blanks are to be installed to project an equal dimension beyond the top and bottom chord members. Overhead sign support blanks are equal to the same sizes and at the same locations as the permanent signs. Contact BOS Structures Design Section at 608-267-2869 for further guidance on other vibration controlling methods.

Do not add catwalks to new sign bridges unless they contain DMS over traffic. Catwalks add additional cost to a structure and present a maintenance issue. They can be added if a decision is made to light the signs in the future. Design structures with type I and II signs for a 2'-0" additional (total of 22'-0" for the OSOW High Clearance Route and 20'-3" for all others) vertical clearance when they are located in a continuous median freeway lighting area, for new
and replacement sign bridges only. Structures with DMS may require larger vertical clearance to the bottom of the sign depending on the type of catwalk being designed for future installation. The sign bridge should be structurally designed to support a catwalk for those cases where the additional clearance is provided for possible future attachment. Additional accommodations for potential future lighting include providing hand holes in the columns, rodent screens and conduits in the concrete bases.

For structures that are not located in continuous median freeway lighting areas or do not contain DMS, the additional structure height should not be utilized. Therefore, new and replacement sign bridge vertical clearance should be 20'-0" for the OSOW High Clearance Route and 18'-3" for all other routes. No hand holes, rodent screens or conduits shall be installed on the structure in this case. However, all DMS sign bridges require hand holes, rodent screens and conduits.

Brackets, if required, for maintenance of light units are required to support a 2'-3" wide catwalk grating and a collapsible aluminum handrail. Brackets and handrailing for type I and II signs are fabricated from aluminum sections, whereas DMS support brackets are made of galvanized steel. Catwalk grating and toe plates are fabricated from steel and shall be galvanized.

Contract plans shall include details and notes indicating if hand holes are required on one or both towers of the sign bridge.

Overhead sign supports are typically not lit, nor do they require sign maintenance. Therefore, do not detail a catwalk on this type of structure. Also do not detail hand holes, rodent screens and conduits unless the structure is designed to carry an LED changeable message sign, traffic signals or luminaires.

Design of all Sign Bridge structures should reflect some provision for the possibility of adding signs in the future (additional sign area). Consideration should include the number of lanes, possible widening of roadway into the median or shoulder areas, and use of diagrammatic signs to name a few. The truss design should reflect sizing the chords for maximum force at the center of the span. The design of the tower columns and truss webs should allow for signs being placed (say sometime in the future) more skewed to one side than the other. Columns should be selected the same size (outside diameter x thickness) for each side and the design shall reflect different lengths on either side as required by site conditions.

The design sign area and maximum sign depth dimensions for type I and II signs shall be explicitly listed with the design data in the contract plans. Use 3 psf dead load for these types of signs. Provide manufacturer overall DMS dimensions in the plans along with the total weight of the signs. Other loads such as Catwalks, lights and associated attachments must also be included in the overall design data in the contract plans.

The following guidance is recommended for estimating design sign areas.

1. Type I and II signs on full span sign bridges, design sign area equals the largest value resulting from the four requirements below:
   a. Total actual sign area.
b. Two (2) times the controlling tower tributary sign area. Tributary area is computed based on the application of the lever rule on a simply supported truss.

c. Twelve (12) times the number of lanes times the maximum sign depth. The number of lanes is defined as the clear roadway width (including median and shoulders) divided by 12 and rounding down to the nearest whole number.

d. Maximum sign depth times 60% of the span length (center to center of tower).

For design purposes, the standard sign depth shall be limited between 12'-0" and 16'-0". Therefore, vertical clearance and column lengths are to be sized with sign depth not less than 12'-0", unless requested otherwise in the structure survey report. Mega projects with series of sign bridges may deviate from the above requirements provided that coordination is made with the BOS Structures Design Section.

2. Type I and II maximum design sign area for galvanized steel cantilever sign truss is detailed on the Standard for Galvanized Steel Cantilever Sign Truss. Sizing the column length and vertical clearance with 12'-0" sign depth is recommended for future accommodation.

3. DMS sign bridges should be designed with the actual sign dimensions in addition to those of type I and II signs and catwalk as applied.

4. Overhead sign supports are generally designed with the actual sign dimensions and locations. Exception to the approach may be granted to structures with anticipated change in signage.
39.5 Structure Selection Guidelines

Sign structures are composed of “sign bridges” and “overhead sign supports”. Either type of sign structure can be configured to be a cantilever sign structure (one column to a horizontal truss arm) or a full-span sign structure (two towers, one on each end of the span). Single pole (butterfly) is another type of sign bridge (chords centered on a single column). Roadside sign supports are an exception to the above naming convention.

39.5.1 Sign Bridges

Sign bridges generally carry type I and II signs, and occasionally DMS. These are large sign structures with sign depths ranging from 5'-0” or less to 18'-0” in the case of large diagrammatic signs. Butterfly sign bridges are limited to 218 sq. ft. of sign area per side. Total sign areas accommodated are up to 264 sq. ft. on cantilever sign bridges. Total sign areas accommodated on full span sign bridges range from 250 to over 1000 sq. ft. These ranges are for approximate guide only. Butterfly sign bridges consisted of either a single chord, or double chord without web members. Other sign bridges generally have truss members consisting of four round chord and angle web members supporting signs on the span or arm (although some three chord structures have been used for full span sign bridges). Towers are comprised of one column for a butterfly, cantilever and full span three chord sign bridges. Full span four round chord sign bridge towers usually consist of two columns joined by angle web members at each end of the span. All “Sign Bridges” are designed by the Bureau of Structures or a consultant. Structure contract plans provide full details that a fabricator can construct the sign bridge from. Standard details for the full-span four chord sign bridge associated with this Chapter of the WisDOT Bridge Manual require a design for each sign bridge structure including foundations. Standard design and details for steel cantilever sign bridge and footing are available for use without performing individual design if a structure meets the limitations required by the standards. These details are used for type I and II sign applications only.

Sign bridges carrying DMS require special consideration. Special concerns include:

1. Size and weight of the sign panel, and attachment location with respect to the axis of the truss.

2. Size and weight of catwalk, and attachment location with respect to the axis of the truss.

3. Consideration of wind effects unique to these signs.

4. Modification to support brackets. All catwalk and sign bracket connections shall be made with friction type connections and high strength A325 bolts with DTI washers.

Wisconsin recommends the use of the Minnesota four chord steel angle truss configuration for sign bridges carrying DMS, providing that the designer checks the design of each member and connection details and make necessary modification to conform to the latest AASHTO Standard specification requirements as stated in 39.2. Each foundation shall be designed and included in the contract plans with the sign bridge structures.
39.5.2 Overhead Sign Supports

Overhead sign supports are smaller sign structures carrying type II (smaller) directional signs, limited amounts of type I signs and small LED or changeable message signs. Type II sign depths have ranged from 3'-0" to 4'-0" deep for traffic directional signs, and up to 10'-0" for small information type I signs. When a sign is larger than 10'-0" deep, the structure is to be designed as a sign bridge. Cantilever overhead sign supports accommodated up to 45 sq. ft. of sign area. Total sign areas accommodated on full span overhead sign supports range up to 300 sq. ft. These ranges are again an approximate guide and can be more or less depending on variables such as span length, location of the sign with respect to the tower(s) the height of the tower(s), etc. Towers are comprised of single column (uniform or tapered pipe) for either the cantilever or full span overhead sign support. Arms on cantilever or the span on a full span overhead sign support are either one chord (uniform or tapered pipe), or two chords with or without angle web members depending on the span length and sign depth. Due to the variability of factors that can influence the selection of structure type, designers are encouraged to contact BOS Structures Design Section for further assistance when sign areas fall outside of the above limits, or when structural geometry is in question. “Overhead Sign Supports” are normally bid by contractor and designed by a fabricator or by another party for a fabricator to construct. Typical structures with steel poles on standard concrete bases usually have the least plan detail associated with them and are normally depicted in the Construction Detail portion of the state contract plans. However, it is recommended that plan development for projects with multiple structures, such as major or mega projects, and structures mounted on non-standard supports to be prepared by structural engineers and placed in section 8 of the contract plans along with the sign bridge plans. When a standard concrete base design is required the corresponding SDD sheets shall be used as drawings, and they must be inserted into the contract plans for overhead sign supports. See the FDM 11-55-20 for more information on “Overhead Sign Supports”.
39.6 Geotechnical Guidelines

Several potential problems concerning the required subsurface exploration for foundations of sign structures exist. These include:

- The development and location of these structures are not typically known during the preliminary design stage, when the majority of subsurface exploration occurs. This creates the potential for multiple drilling mobilizations to the project.

- Sometimes these structures are located in areas of proposed fill soils. The source and characteristics of this fill soil is unknown at the time of design.

- The unknowns associated with these structures in the scoping/early design stages complicate the consultant contracting process. How much investigation should be scoped in the consultant design contract?

Currently, all sign structure foundations are completely designed and detailed in the project plans. Sign-related design information can be found in the FDM or Bridge Manual as described in the following sections.

WisDOT policy item:
The length of a cast-in-place shaft foundation shall be limited to 20'-0" for both sign bridges and overhead sign supports. Deviation from this policy item may be allowed provided coordination is made with BOS Structures Design Section.

39.6.1 Sign Bridges

WisDOT has created a standard foundation design for cantilever sign bridges carrying Type I and II signs. This standard foundation is presented on the Standard for Cantilever Truss Footing. The wings on this single shaft footing are used to help resist torsion. If a cantilever sign bridge exceeds the criteria/limitations (shown on the Standard for Galvanized Steel Cantilever Sign Truss), the standard foundation shall not be utilized, and an individual foundation must be fully designed. This customized design will involve determining the subsurface conditions as described in section 39.6.3.

Foundations supporting all butterfly and full span sign bridges are custom designed. They generally have two cylindrical shafts connected by a concrete cross-girder below the columns. Other foundations such as single shaft, pile foundation and spread footing may be detailed when subsurface condition, constructability issue or economic present a more desirable design. WisDOT has no standard details for the foundations of these structures.

39.6.2 Overhead Sign Supports

Overhead sign supports are described in FDM 11-55-20. In addition, Section 641 of the Standard Specifications outlines the design/construction aspects of these structures.
If these structures are carrying type I and II signs, and meeting several criteria/limitations that are listed on the SDD’s, the designer can use WisDOT-developed standard foundations for them. The designer can then insert the proper SDD sheet into the plans. SDD sheets exist for cantilever overhead sign supports. These single shaft bases for cantilever overhead sign supports vary in depth and range from 24” to 42” in diameter (SDD 15c22-2 thru 15c25-2). Another SDD sheet applies to full-span overhead sign supports and is 36” in diameter (SDD 15c15-3). The standard foundations in these SDD sheets were designed using slightly conservative soil design parameters. If the design criteria for these standard designs are not met, the SDD sheets cannot be used, the structure foundation must be fully designed and the unique details shall be done in accordance to the overhead sign support mounted on non-standard supports procedure described in 39.5.2. This involves determining the subsurface conditions as described in the following section.

39.6.3 Subsurface Investigation and Information

No subsurface investigation/information is necessary for any of the sign structures that meet the limitations for allowing the use of WisDOT standard foundations. Appropriate subsurface information is necessary for any of these structures that require custom designs.

There may be several methods to obtain the necessary subsurface soil properties to allow for a custom design of foundations, as described below:

- In areas of fill soils, the borrow material may be unknown. The designer should use their best judgment as to what the imported soils will be. Standard compaction of this material can be assumed. Conservative soil design parameters are encouraged.

- The designer may have a thorough knowledge of the general soil conditions and properties at the site and can reasonably estimate soil design parameters.

- The designer may be able to use information from nearby borings. Judgment is needed to determine if the conditions present in an adjacent boring(s) are representative of those of the site in question.

- If the designer cannot reasonably characterize the subsurface conditions by the above methods, a soil boring and Geotechnical report (Site Investigation Report) should be completed. Necessary soil design information includes soil unit weights, cohesions, phi-angles and location of water table.

Designers, both internal and consultant, should also be aware of the potential of high bedrock, rock fills and the possible conflict with utilities and utility trenches.
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