Retaining Wall Considerations for Roadway Widenings

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Table of contents

Geotechnical Manual Requirements – Retaining Wall Approach

- Chapter 6 – TxDOT Geotechnical Manual

Section 1 — Retaining Wall Selection

Overview

The project engineer who seals the plans is responsible for ensuring that the retaining wall selected for a given location is appropriate. Use the following criteria to choose a retaining wall:

- Geometry. Determine applicability of wall type—cut, cut/fill, or fill—based on geometry, site constraints, and wall alignment and location. Identify available right of way. Identify location and type of existing and proposed utilities. Identify location and type of existing and proposed drainage structures.

Section 2 — Retaining Wall Layouts

General Content Layout

In general, retaining wall layouts include the following information.

- Plan View. The plan view should contain the following items:
  - Beginning and ending wall points by station, offset, and roadway alignment
  - Additional points as necessary to describe the relationship of wall alignment to roadway alignment(s)

Approach Widening Considerations

- Geotechnical Challenges
  - Widening in front of existing Retaining Walls
  - Widening on existing slopes
- Structure Types
  - Water Crossings
  - Roadway Interchanges

Widening Challenges

- Fitting wider roadway in existing ROW
  - Drainage
  - Wall/Slope Geometry
  - Roadway/Structure Stability
  - Constructability
  - Phasing and Traffic Control Approach
  - Flooding and Presence of Water

Widening Challenges

- Roadway Drainage
  - Is roadway runoff properly managed?
- Sitewide Drainage
  - Do I need a drainage ditch on ROW?

Widening Challenges

- Wall/Slope Geometry
  - Is there enough footprint to provide a stable slope?
  - What retaining wall type will fit my constraints?
  - What geometric conditions affect the retaining wall design?

Widening Challenges

- Roadway/Structure Stability
  - Slopes and Retaining Walls are structural systems.
  - What unique load conditions affect the slope or retaining wall design?

Widening Challenges

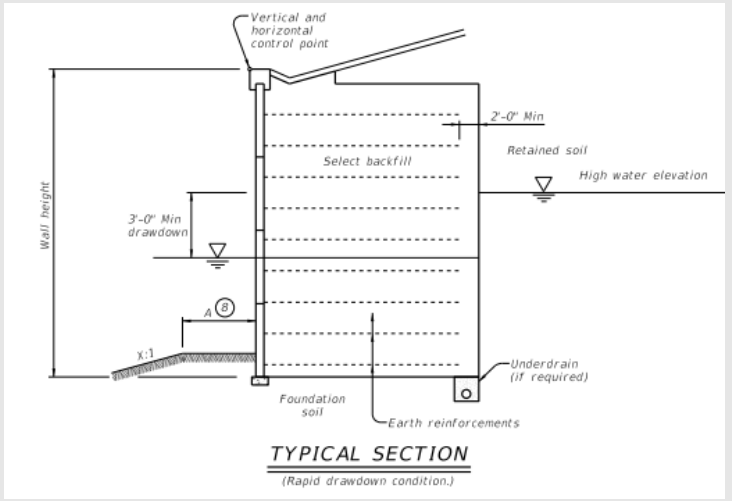
- Constructability
  - Can the selected retaining wall be built within the ROW constraints?
  - Will this add any additional challenges to construction?

Widening Challenges

- Phasing or Traffic Control Approach
  - Will the proposed wall footprint affect traffic control?
  - Will the construction procedure require additional shoring?

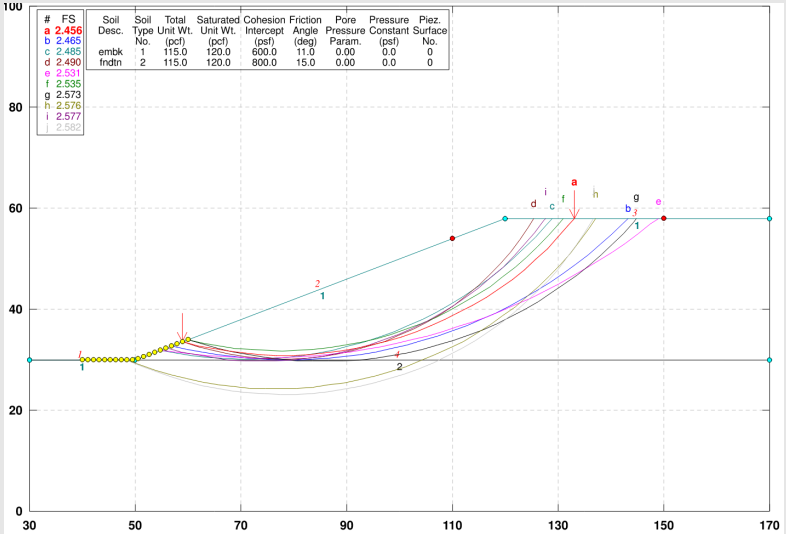
Widening Challenges

- Flooding and Inundation
  - Is the slope stable when an elevated water table is considered?
  - Is the selected retaining wall suitable to handle an inundated condition?

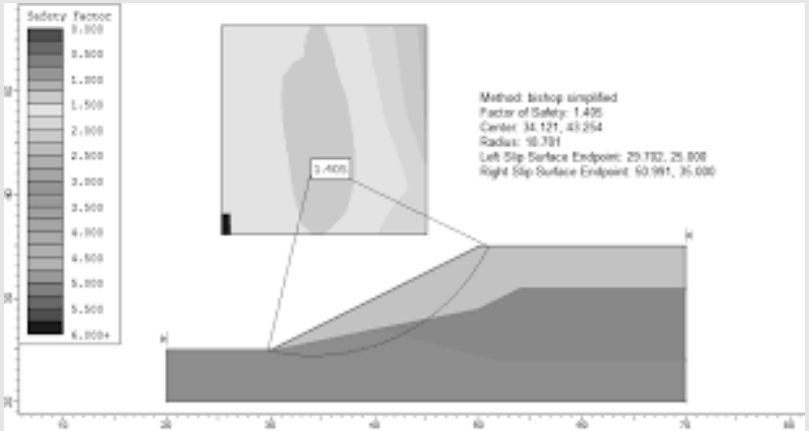


Slope Stability

- Slope is often the first thought to carry roadway approach
- TxDOT Geotechnical Manual slope stability requirement
- Global stability analysis



Evaluate all slopes, whether a cut or a fill and whether in soil or in rock, for global stability for both short-term (undrained) and long-term (drained) conditions. Specific site conditions may require evaluation for additional types of failure, such as bearing capacity, settlement, and undercutting (for rock cuts).



Engineering Resources

- TxDOT Geotechnical Manual Requirements
  - Chapter 7

For global stability of a slope, a minimum factor of safety of 1.3 is required for both the long-term drained condition and the short term undrained condition. Make the factor of safety 1.5 or greater for slope or walls that support abutment, buildings, critical utilities, or for other installations with a low tolerance for failure.

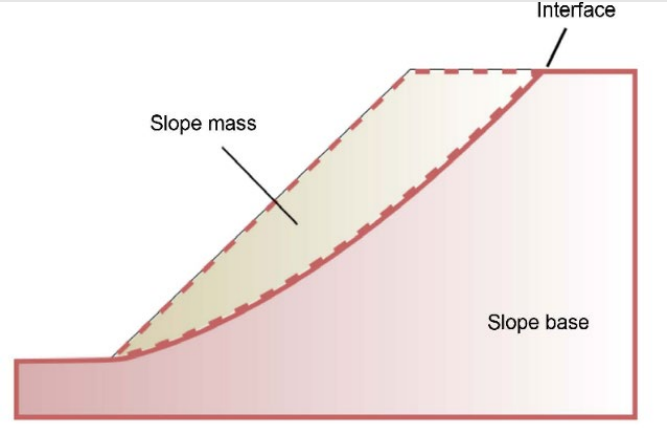
Table 7-1: Plasticity Index Range for Exposed Side Slopes Required for FS =1.3 for the Long Term or Drained Condition

Slope X:1	Plasticity Index (PI) (%)
2.5 to 1	< 5
3.0 to 1	< 20
3.5 to 1	< 35
4.0 to 1	< 55
4.5 to 1	< 85

- Specification Requirements
  - Item 132

Design Considerations

- What can we do during design?
  - Geotechnical Stability
    - Material composition
    - Slope angle
    - Surcharge condition



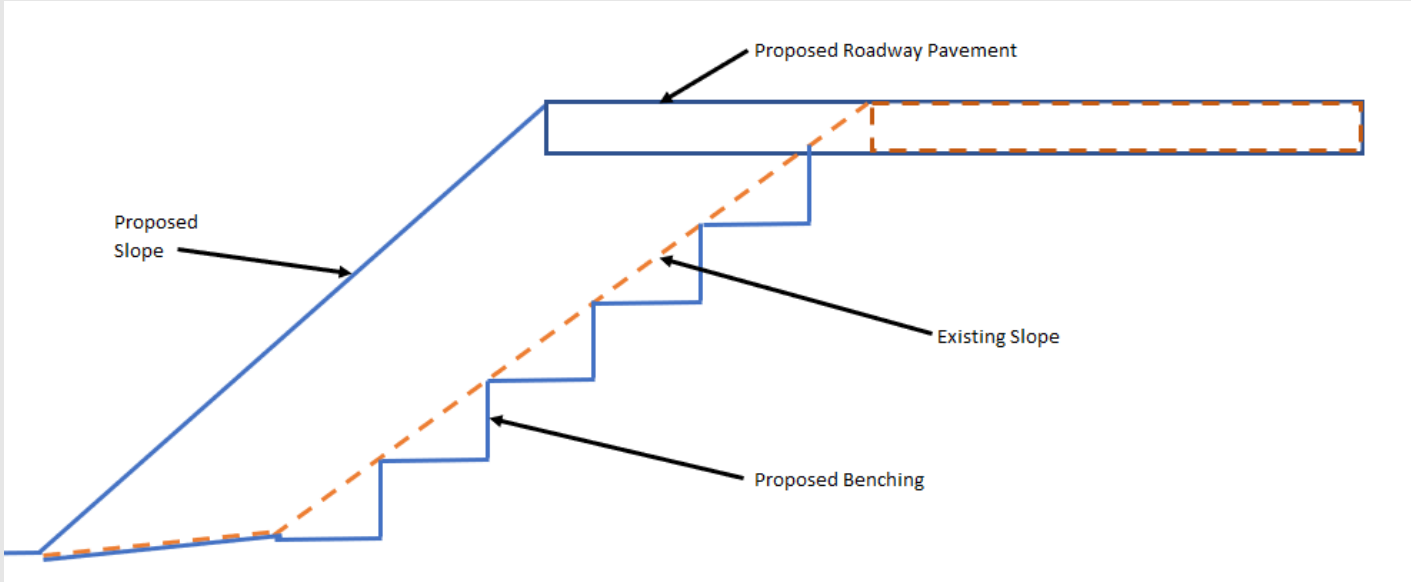
Why is Slope Stability Important?

- Damage to Underground Utilities
- Maintenance Cost
- Traffic Impacts

Slope Cladding

- Slope Cladding for widening can create artificial slip surface
- Item 132 Embankment Requirement
- Surface Preparation

Scarify and loosen the unpaved surface areas, except rock, to a depth of at least 6 in. unless otherwise shown on the plans. Bench slopes before placing material. Begin placement of material at the toe of slopes. Do not place trees, stumps, roots, vegetation, or other objectionable material in the embankment. Simultaneously recompact scarified material with the placed embankment material. Do not exceed the layer depth specified in Section 132.3.4., "Compaction Methods."



Surface Treatment Limitations – Flexible Revetment

- Limitation: Slope not steeper than 2:1 maximum (Rule of Thumb)

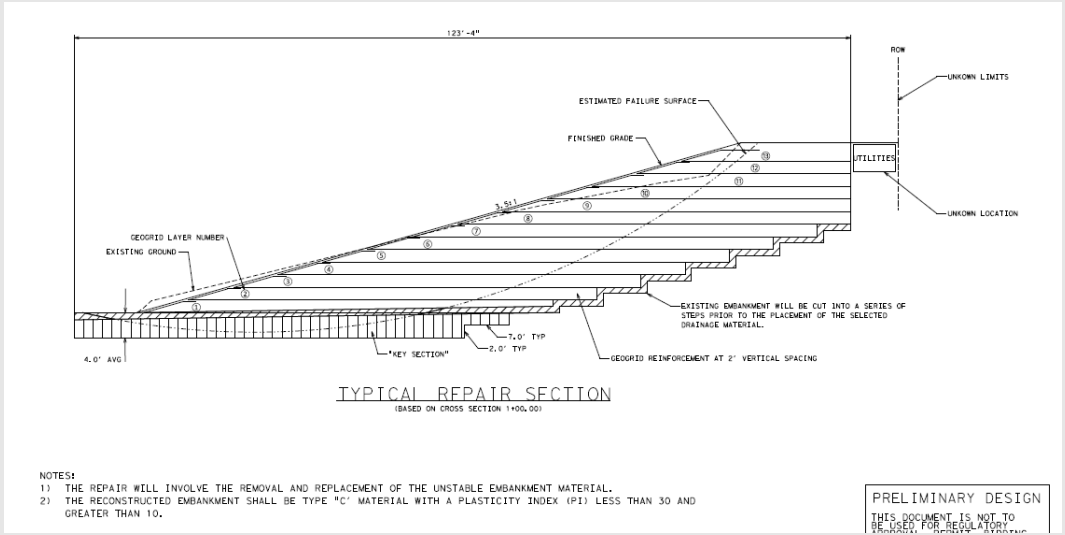
- Not steeper than 3:1 slope recommended

What Are My Options?

- Slope is unstable in design. What's next?
  - Reinforced Soil Slopes
  - Retaining Walls
  - Adding additional ROW
  - Modifying Bridge Length

Reinforced Slope

- Slope interlaid with geogrid reinforcement
  - Geogrid placed at 2’ typical vertically
  - Geogrid wrapped around face to provide soil confinement

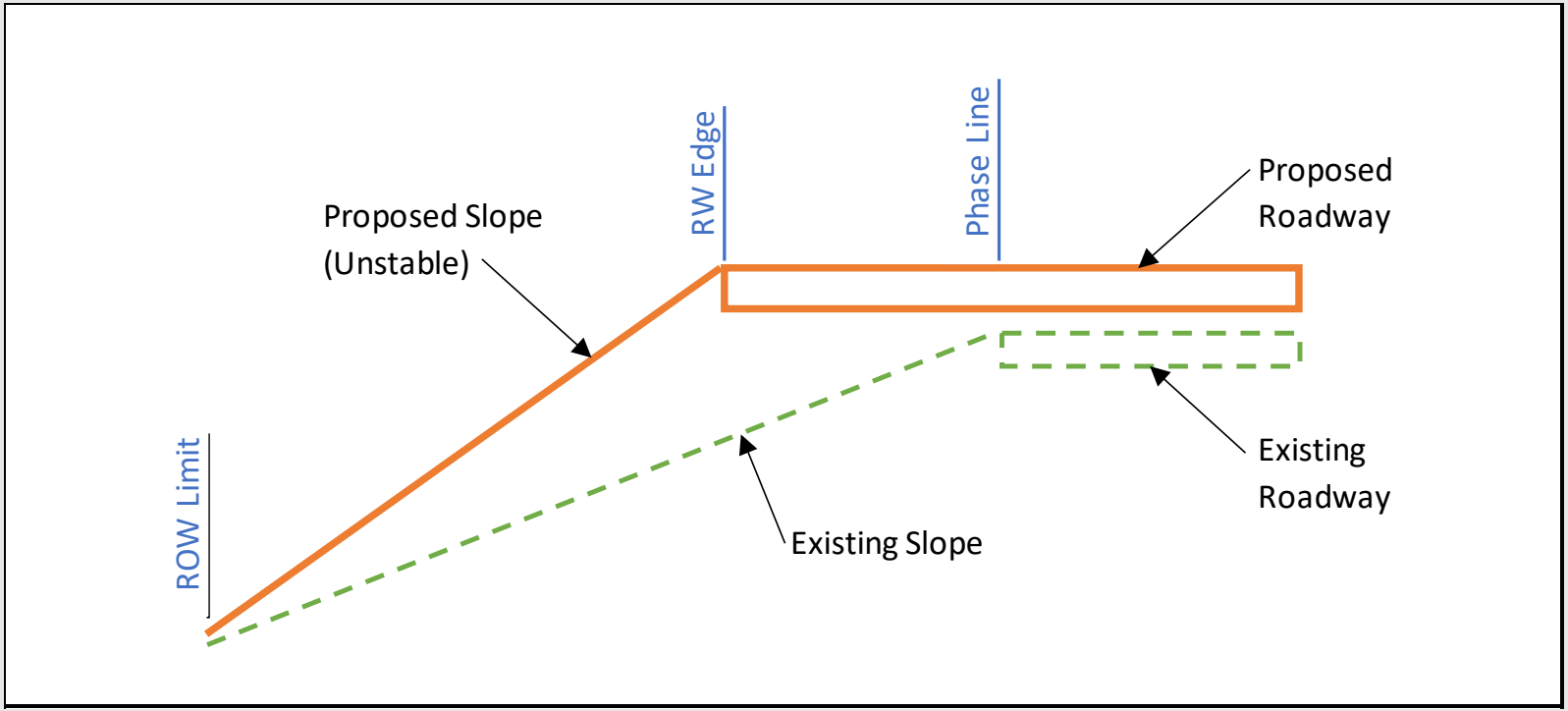


Reinforced Slopes

- Benefits
  - Increases stability of proposed slopes
  - Provides seamless approach to the abutment slope
- Drawbacks
  - May require shoring or cutting into existing slope to install
  - Steeper slopes are harder to maintain
  - Surface erosion can still be a problem
  - Scour/erosion can be a major concern
  - Slope may be limited by traffic safety

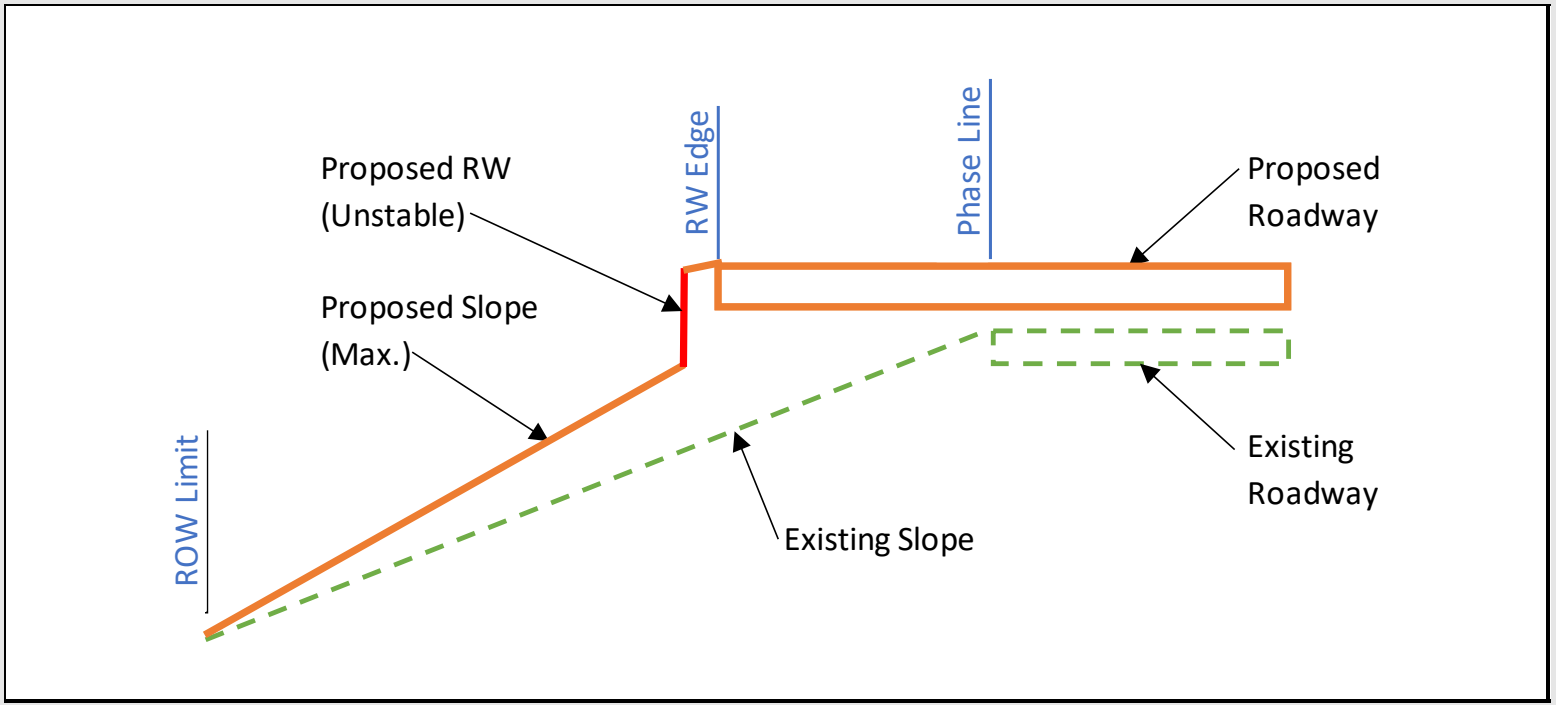
Retaining Wall Example – Initial Slope

- Approach for a creek crossing - Slope Unstable



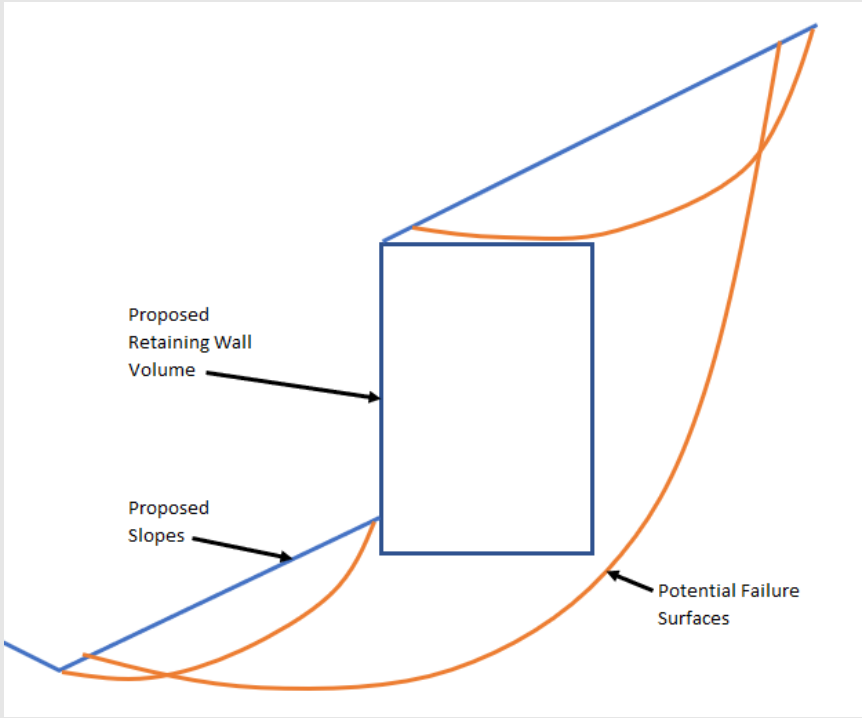
Retaining Wall Example – Vertical

- Perched Retaining Wall – Wall Unstable

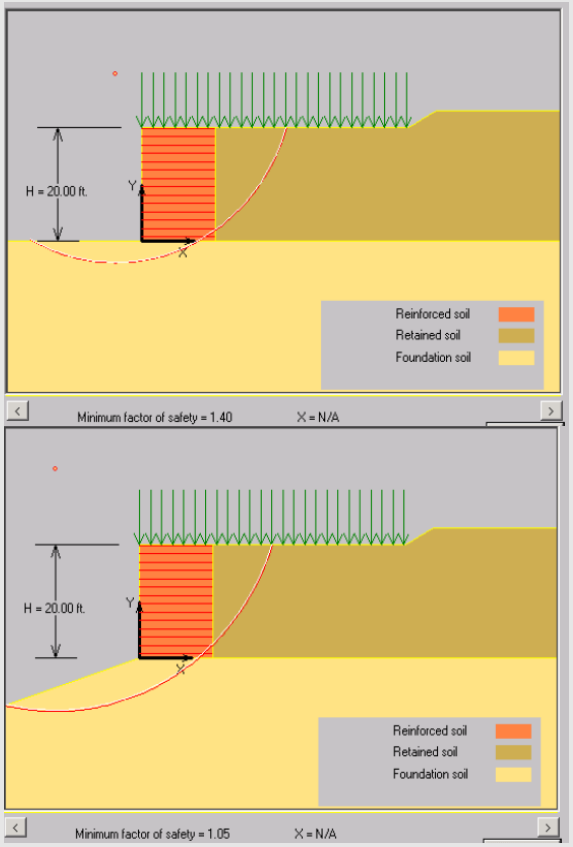


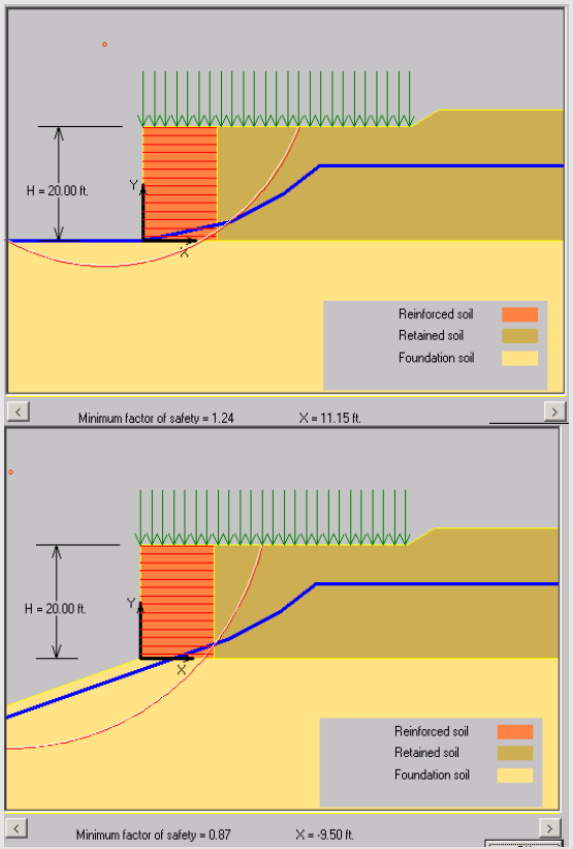
Slopes Near Retaining Walls

- Placing steep slopes near retaining walls may provide false economy
  - Slopes can fail locally
  - Cause maintenance difficulty
  - Failure is more difficult to repair



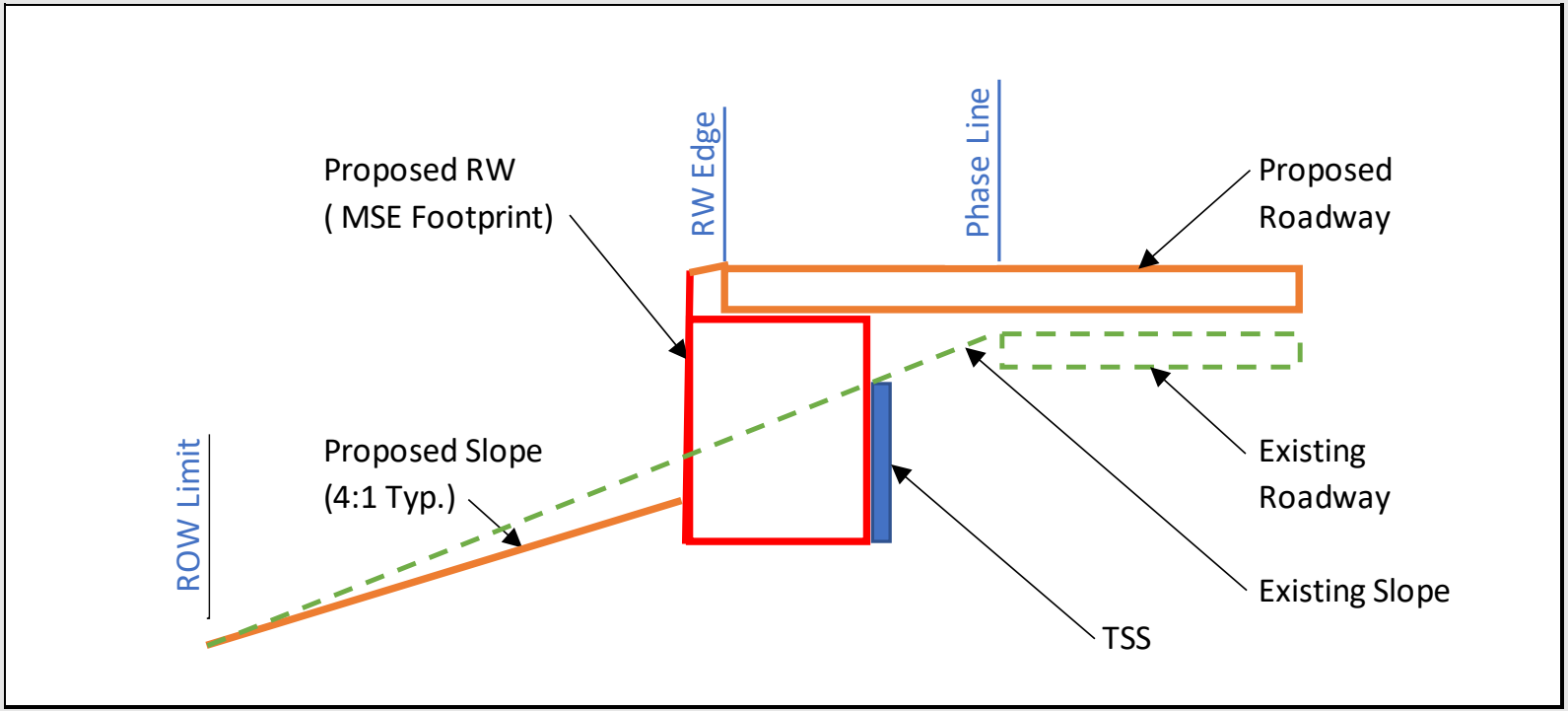
Global Stability Analysis





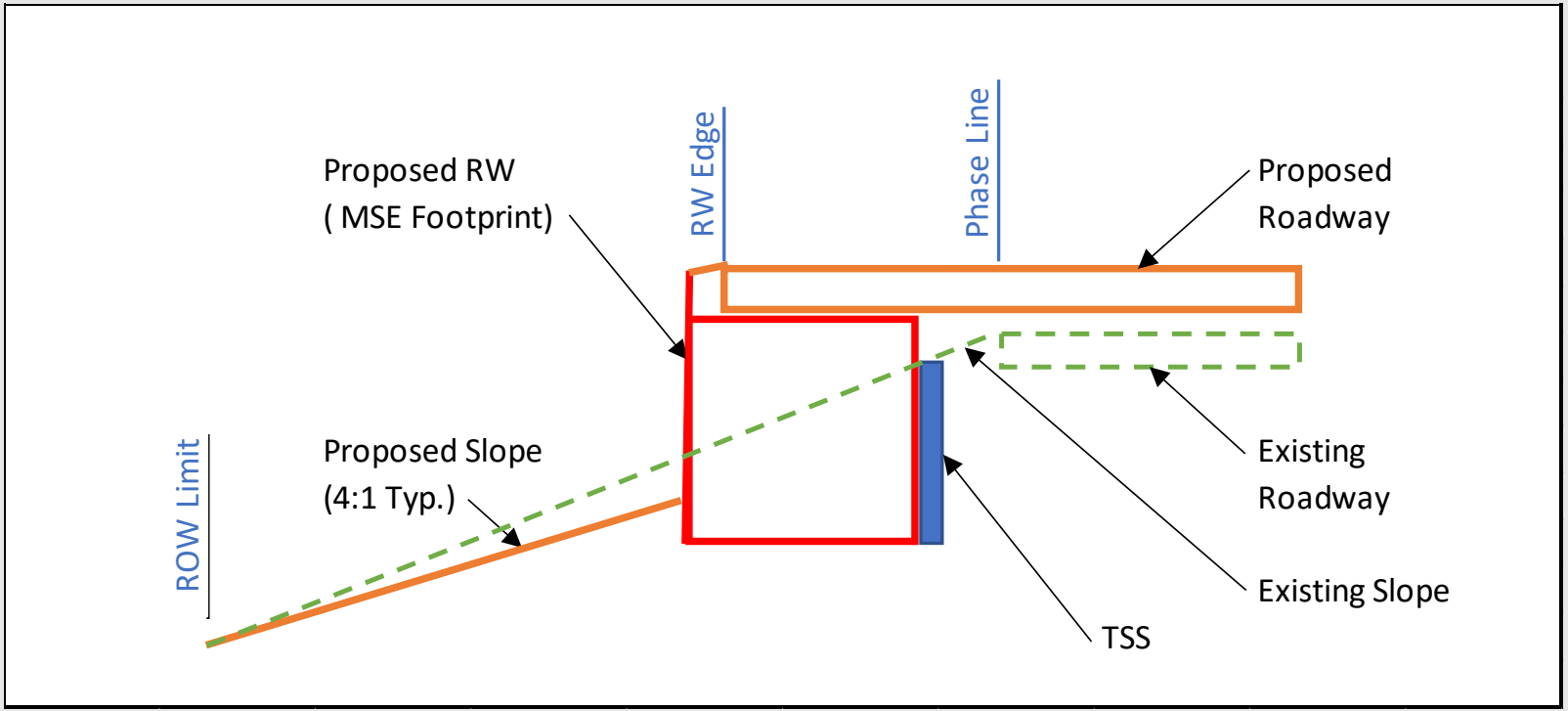
Retaining Wall Example - Deepened

- Results in longer (width) and deeper retaining wall



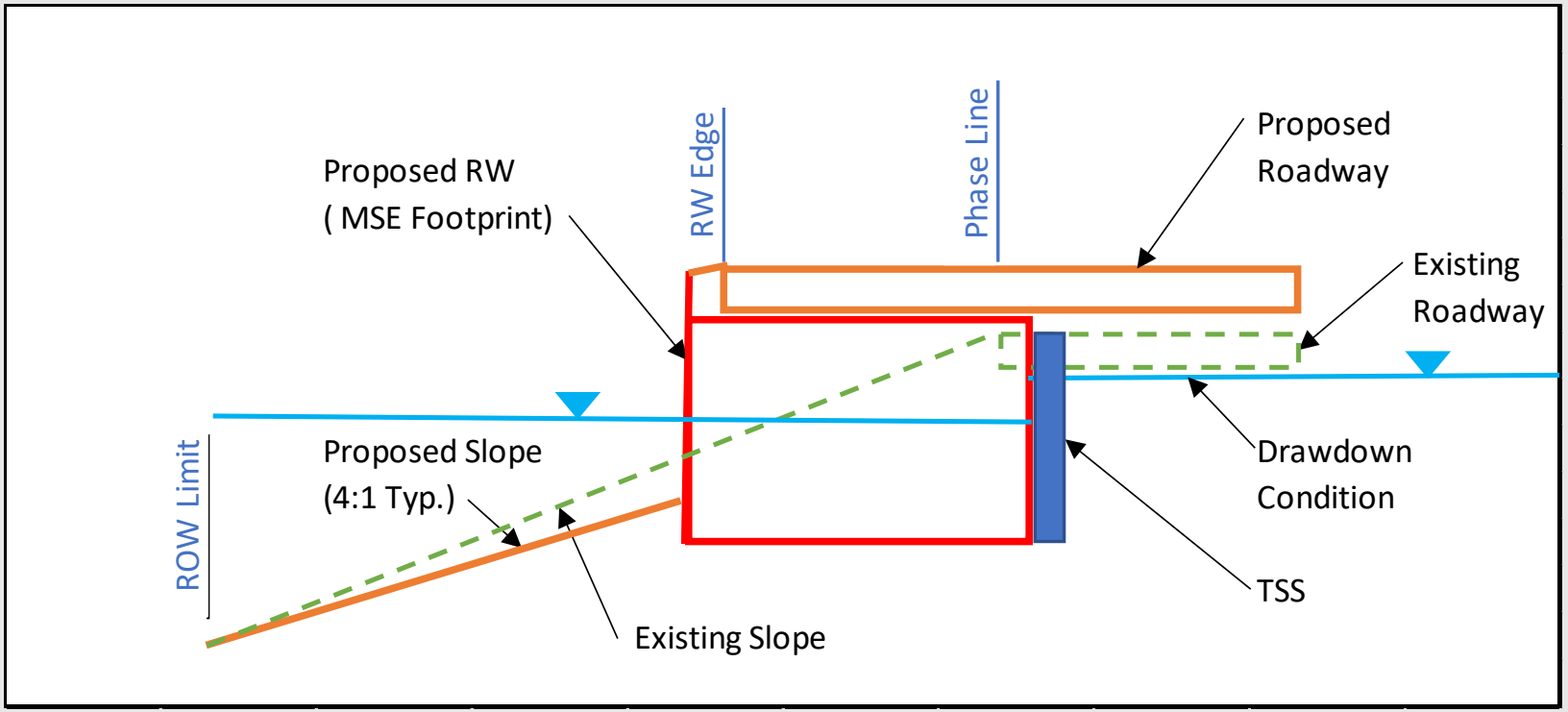
Retaining Wall Example – Weak Foundation Soil

- Weak existing embankment – increases reinforcement length



Retaining Wall Example – Inundation Condition

- Creek crossing hydraulics – drawdown analysis



Retaining Wall Example – Final Condition

- Reinforcement length 1.5xH to 2.0xH possible
- May affect traffic control
- Adds shoring cost

Retaining Wall – End Condition

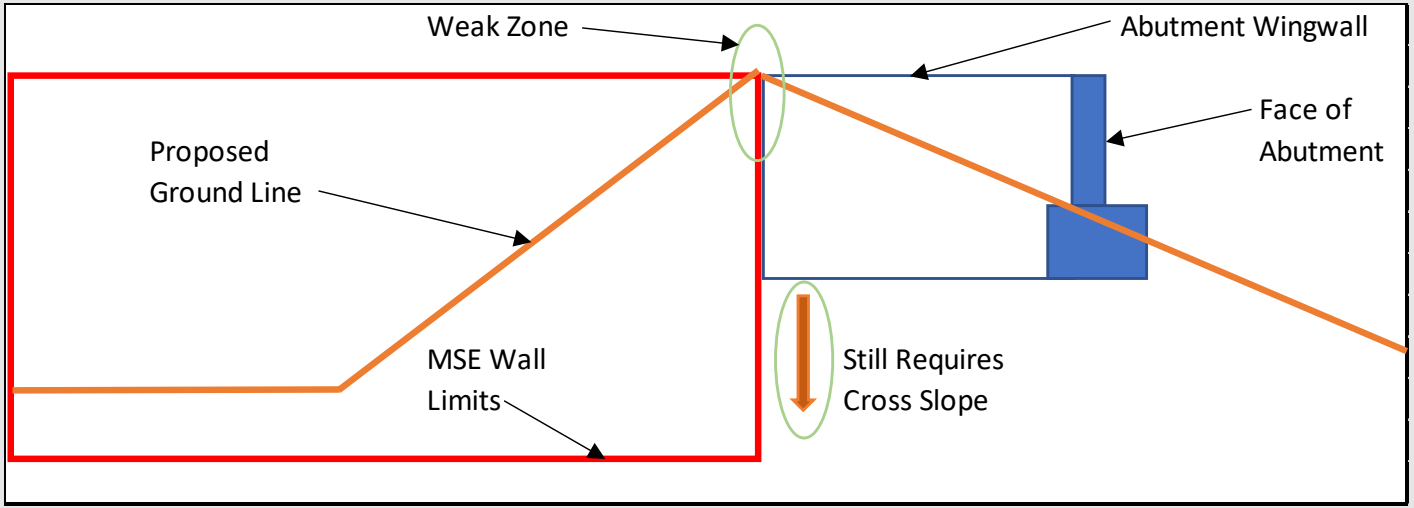
- Three options for a creek crossing
  - End wall in front of abutment
  - End wall near abutment cap or wingwall
  - Wrap around the front of the structure

Retaining Wall End Condition

- End wall in front of abutment
  - Modifies construction procedure for abutment drilled shaft
  - Requires difficult shoring layout
  - Abutment slope wall vulnerable to scour

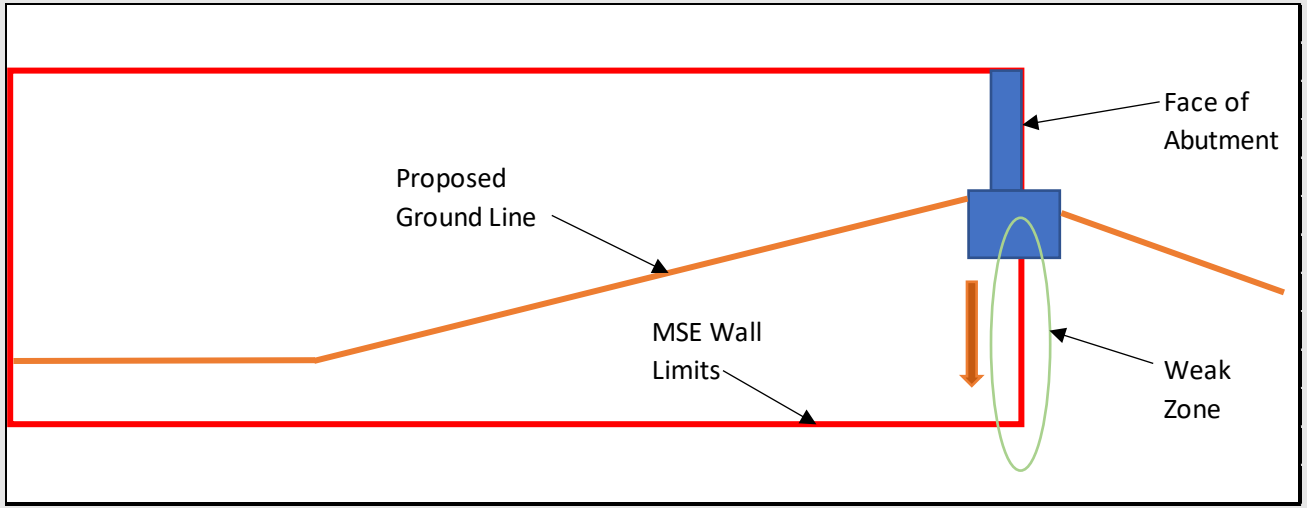
Retaining Wall – End Condition

- Retaining Wall Ending at the Edge of Abutment Wing Wall
  - Requires difficult shoring layout
  - Creates potentially vulnerable embankment condition
  - Still requires slope on approach



Retaining Wall – End Condition

- Retaining Wall Ending at the Edge of Abutment Cap
  - Requires difficult shoring layout
  - Creates potentially vulnerable embankment condition
  - Modifies Construction procedure for outside abutment shaft



Retaining Wall – End Condition

- Wall wraps around the front of the abutment
  - Wall needs to be designed for scour
  - Adds additional hydraulic considerations to the channel
  - Affects drilled shaft design approach

Retaining Wall Selection

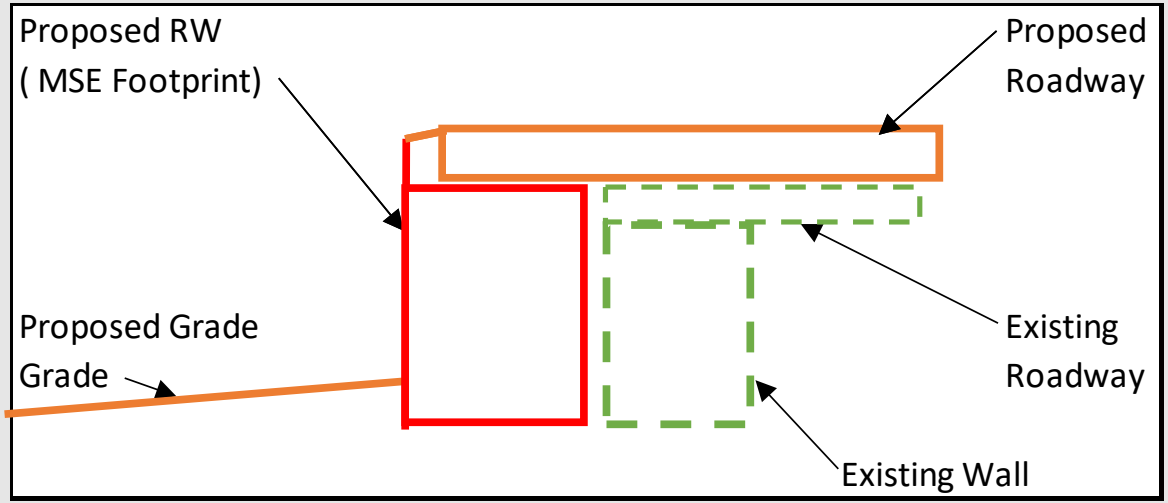
- MSE Walls
- Cantilever Walls
  - Drilled shaft walls
  - Sheet pile walls

MSE Walls

- Benefits
  - Straightforward to design/detail
  - Handles inundation well
  - Most common retaining wall type

MSE Walls

- Drawbacks
  - Requires large footprint to install
  - May require temporary special shoring to install
  - Reinforcement length may increase from plan minimums

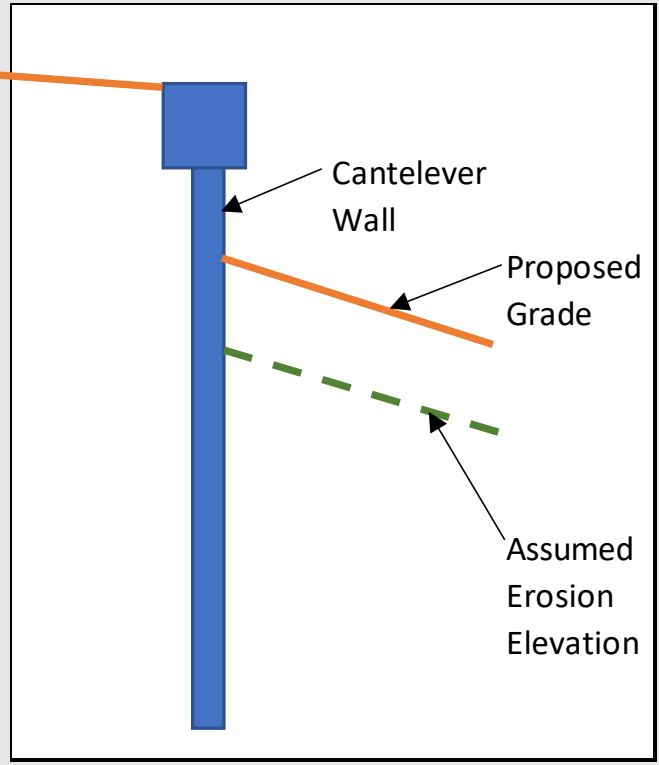


Cantilever Walls

- Drilled shaft Wall
- Sheet Pile Wall

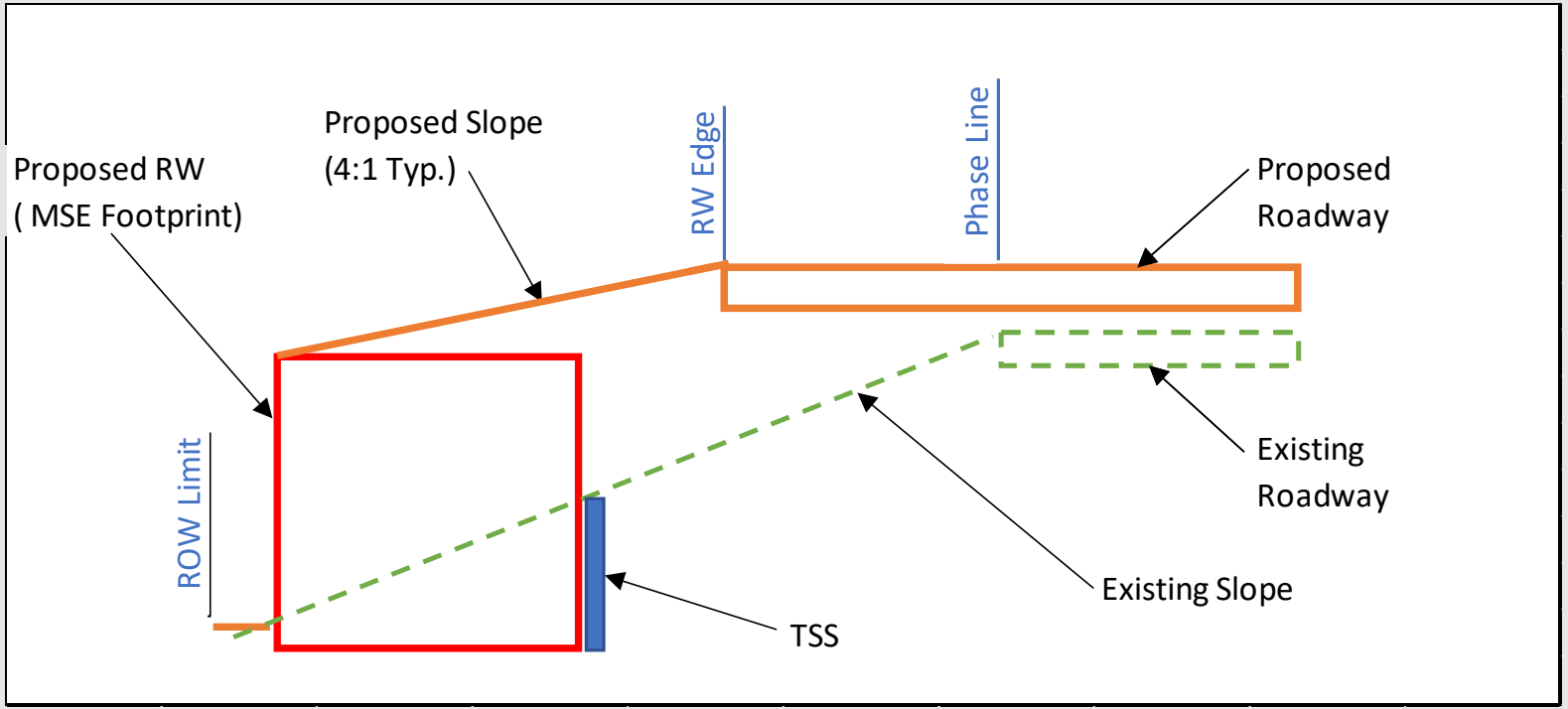
Cantilever Walls

- Can be used in hybrid cut/fill scenario
  - Benefits
    - Requires less reworking of material (cutting and filling)
    - Can be easily designed to accommodate erosion in front
    - Less overall footprint than MSE walls (no need for shoring)
    - Can be anchored (tied-back) if needed
  - Drawbacks
    - Increased Wall Cost
    - Wall height limitations (Need anchors over H=~10')



Retaining Wall Placement

- Location of retaining wall is another consideration



Bridge Lengthening

- Bridge Length can also minimize embankment height
  - Shallower slopes
  - Can eliminate need for retaining walls

Conclusions

- Understanding constraints when selecting geotechnical structures
- Considerations differ between projects
  - Identify potential issues as early as possible in the project
  - Involve Geotechnical Engineer as soon as feasible
- Consider feasibility of acquiring additional ROW
- Take wall stability considerations into account when formulating wall layout
- Consider approach geometry and design implications when determining bridge length

QUESTIONS:

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