## 3.0 TUNNEL INSPECTION REPORT

### 3.1 North Portal

The north portal opening and the headwall are located at approximately Sta. 26+65 and are constructed using stone masonry blocks with stone masonry stone cap (Photo 1). Similar materials are also used for a wingwall on the west side of the tunnel. The majority of the individual stones are in good condition; however there are a couple of areas where cracks as large as 2 inches have developed through the stones and stone cap. Vegetation around the wall has grown through the cracks and joints on each side of the tunnel headwall and wingwall (Photos 49 & 50). The headwall is also partially covered by talus along the east corner.

A noticeable 2- to 3-inch crack has developed to the right of tunnel crown that goes through the stone cap and top three stone courses (Photo 1). The crack migrates vertically down to the top of the tunnel lining course on the west side and branches into smaller cracks. The general area to the west is covered by vegetation and shows signs of loose stones and loss of mortar (Photo 49). The second area is to the east of the tunnel opening where cracks have developed at several locations throughout the headwall (Photo 51). A noticeable 4-inch space between the headwall blocks and the lining course of the tunnel was observed.

### 3.2 South Portal

The south portal opening and the headwall were constructed similar to the north portal. The headwall is in good condition overall with no major sign of cracking or movement (Photo 3). The headwall is confined by a wingwall to the west and rock slope to the east (Photos 45 & 46). Flowing water was observed along the east corner of the headwall. Additionally, vegetation has grown throughout the top half portion of the headwall. A drainage chute is running parallel to the headwall on top of the tunnel (Photos 47 & 49).

## 3.3 Tunnel Interior

The entire tunnel from Sta. 2+00 to 26+65 is constructed using brick and concrete as construction materials (Photo 4); however, stone blocks similar to the headwalls are used for the first 14 feet of tunnel (wall, springline, and ceiling) at both portal openings. Concrete was used for construction of the wall and also as lining between the brick liner and host rock in the ceiling. The entire surface of the tunnel ceiling, where bricks are present, was probably covered by a ½-inch layer of gunite which has worn off in most of the locations throughout the tunnel exposing the brick liner. Alcove spaces (7'H x 4'L x 2'D) are located every 100 feet on each side with 50-foot offset from each other through entire tunnel. From observation, the invert of the tunnel is mainly composed of sand, gravel, and cobbles. The east side of the invert has running water in a channel throughout the tunnel.

The condition of the tunnel is described in the sections below. Please refer to the attached inspection sheets in Appendix E for further information and Appendix B for listed photographs for each station section below:

<u>Station 2+00 to 4+00</u> (Photos 5 to 13)

- Stone blocks were used from Sta. 2+00 to 2+14 for wall, springline, and crown of the tunnel. Brick liner and concrete wall are present thereafter.

- Cracks have developed throughout stone liner near Sta. 2+00 which runs down from crown to the wall on both sides.

- Flowing water was observed seeping through the stone at the crown and various places near the tunnel opening.

- Spalling of concrete wall and loss of brick liner has occurred at multiple locations; additionally, concrete lining has eroded deep enough to expose natural material at crown near Sta. 2+75 and 3+25.

- Signs of heavy efflorescence and dark red staining were observed at various places throughout the section.

- Significant gunite patching was observed on the walls near Sta. 2+25 and at various locations throughout the section.

Station 4+00 to 9+00 (Photos 14 to 18)

- Major sign of spalling and deterioration of concrete wall and loss of brick liner has occurred near Sta. 4+25, 4+50, 5+25, and 6+25 and in small amounts at multiple locations throughout the section. An approximate 2.0 x 2.0-foot hole in the ceiling at Sta. 6+25 has exposed a wood form and natural rock material above the concrete tunnel lining.

- Water draining through relief holes, spalled areas, and at failed brick liner has left signs of efflorescence and red staining. Otherwise the majority of the section is damp to dry.

- Gunite patching and failed patch was observed at various locations. Unsound and loose gunite was observed at various locations revealing disintegrated concrete wall.

Station 9+00 to 14+00 (Photos 19 to 20)

- Significant spalling and scaling of the concrete wall was evident near Sta. 9+75, 10+50, 13+25, and 13+80 and in small areas throughout the section. Minor areas of brick liner are also affected at these sections near the transition between the concrete wall and brick liner.

- Seepage of water was observed at relief holes, brick to concrete transition, spalled areas, and at cracks. Signs of efflorescence and red staining are also evident throughout the section. Section is mostly dry to damp where the tunnel is in better condition.

Station 14+00 to 19+00 (Photos 21 to 24)

- Loss of brick liner at crown has occurred exposing concrete tunnel lining above from Sta. 14+75 to 15+25. A significant loss of wall material was observed at Sta. 18+75. Minor scaling and spalling throughout the ceiling and wall section.

- Seepage was seen through relief holes and various places such as brick to concrete transition, spalled area, and between cracks. Signs of efflorescence and red staining buildup are also evident near the areas. This section is mostly dry to damp where tunnel is in better condition.

- Significant patching at crown of tunnel from Sta. 16+25 to 17+25 and 17+75 to 18+75. Smaller areas of patching and patch failure are also evident throughout the tunnel. Unsound and loose gunite, (some areas near failure), were observed at various locations revealing disintegrated concrete wall.

Station 19+00 to 24+00 (Photos 25 to 33)

- Major scaling, spalling, and cracking are observed throughout the section. Sta. 21+00, 21+75 to 22+50, and 23+00 to 24+60 have missing brick liner at ceiling exposing the concrete tunnel lining. Evidence of fallen brick from brick liner on ground at various locations indicates recent failure. Near Sta. 22+25, spalling of brick liner and concrete has exposed a wood form and natural rock above. Spalling/scaling was observed on the wall and ceiling throughout the section. Debris has piled up on the ground at areas with significant material loss.

- Seepage through relief holes and various places such as brick to concrete wall transition, spalled area, and between cracks was observed. Significant efflorescence and red staining has built up near places where dripping water is present.

- Significant gunite patching and failed patch were observed throughout the section. Unsound and loose gunite patching was observed at various locations revealing a disintegrated concrete wall behind. Exposed reinforcement and failed patching was observed from Sta. 21+75 to 22+00 on the west wall. Significant debris collected on the ground from patch failure.

<u>Station 24+00 to 26+65</u> (Photos 34 to 44)

- Major scaling, spalling, and cracks were seen throughout the section. A significant amount of liner and concrete tunnel lining material has collapsed. A large portion of the tunnel liner near Sta. 26+50 has collapsed creating a large hole, approximate 9 x 18 feet, in the east springline of the tunnel. Water is being drained through the hole channeled by a chute that is above the tunnel. Existing stone blocks near the tunnel face are loose and have developed major cracks.

- Water seepage at various locations and under patched locations were observed throughout the section. Red staining near flowing water was also noted. Dry places had heavy efflorescence buildup near the brick to concrete wall transition indicating that seepage had previously occurred.

- Significant gunite patching was observed throughout the section. Patching has failed at many locations revealing further scaling of the tunnel liner and wall. Loose gunite was also observed at various locations on the wall.

- This part of the tunnel represents the most serious deterioration.

## 4.0 ROCK CUT INSPECTION REPORT

### 4.1 North Portal

The rock cut adjacent to the north portal on the east side starts from the tunnel face at Sta. 26+65 and extends to Sta. 28+65 giving a length of about 200 feet. The rock cut slope at the north portal is approximately 70 feet in height from the ground level. It is composed of two geological units and several different types of rocks. Trees and vegetation are located above the cliff where the slope is shallower. Appendix D shows the photo mosaic of the rock cut.

The rock cut slope consists of rocks from Lower Connoquenessing and Mauch Chunk Formation (Appendix C). A 12-foot thick, light brown, cross bedded sandstone representing the lower most unit of the Lower Connoquenessing is at the top. This layer contains various size projecting beds that have the potential to dislodge and fall. Many of the boulders at the toe have originated from this layer. A few projections are overhanging by almost 2 feet. Below the sandstone the Mauch Chuck Formation consists of alternating colors of red to gray shale that is 15 feet thick followed by a grey to red claystone unit approximately 1 foot thick. Following the claystone, gray shale approximately 3½ feet thick was observed followed by light brown cross bedded sandstone approximately 8 feet thick. The lowest observable unit is a red to gray shale layer with a thickness of approximately 30 feet all the way down to the ground level. Much of the debris at the toe of the slope has originated from differential weathering of shale and claystone from the Mauch Chunk Formation. The differential weathering is undercutting the massive sandstone above. At its maximum, the debris is approximately 35 feet in height and 45 feet in length and starts from the tunnel and runs along the entire rock cut to Sta. 28+50.

A measurable set of joints in the top most shale unit were measured with strikes ranging from 100 to 130 degrees azimuth and dip direction measured from 70 to 90 degrees N-NW. Joint spacing of anywhere from 1 to 3 feet was also observed.

## 4.2 South Portal

The rock cut adjacent to the south portal on the east side starts from the tunnel face and extends over 350 feet along the tunnel trail and Armstrong Trail running along the river. The rock cut slope at the south portal is approximately 80 feet in height from the ground level. It is composed of three geological units and several different rock types. Trees and vegetation are located above the cliff where the slope is shallower. Appendix D shows the photo mosaic of the rock cut.

The south tunnel opening consists of Upper Connoquenessing, Quakertown coal, and Lower Connoquenessing geological units (Appendix C). Upper Connoquenessing consists of cross bedded light brown sandstone that is approximately 20 feet thick. Underlying the Upper Connoquenessing is coal, sandstone, and shale of the Quakertown coal unit that is roughly 10 feet thick. Below the Quakertown coal is the Lower Connoquenessing sandstone which is massive cross bedded with sporadic lenticular red shale units observed all the way down to ground level.

An overhang in the Upper Connoquenessing sandstone sticks out 3 to 4 feet and is approximately 30 feet wide and 8 feet thick. Many of the boulders on the ground have originated from this layer. Differential weathering of the Quakertown coal unit has produced a debris pile 10 feet high near the toe. Joints measured in the lower sandstone unit had strikes ranging from 250 to 300 degrees azimuth with dips measuring 80 to 90 degrees S-SW. A drainage ditch exists at the base of the rock cut flowing south.

## 4.3 Flooding and Historical Slope Movement

The area in the vicinity of the tunnel portal openings is in the 100-year flood plain. However, historical past flooding has not been known to cause slope failures around the tunnel openings. Large rain events (5.5 inches) have triggered debris slides ("debris avalanches") in the slopes above the Allegheny River in the vicinity of the North Portal[10]. However, evidence of debris slides was not observed at the North or South portals during this investigation.

## 5.0 ANTICIPATED TUNNEL REPAIR OPTIONS

The condition of the tunnel walls, springline and crown varies from good to failed (see Appendix E for Inspection sheets). Due to the age of the tunnel and its lack of maintenance over the years, it will require a significant amount of repairs to make the tunnel safe for passage of pedestrians. The anticipated repairs range from gunite/shotcrete to new tunnel liners. New steel or concrete tunnel liners could be used in areas of the tunnel that exhibit the most severe deterioration. Tunnel liners would require minimal maintenance in the future. Shotcrete could be used in the less deteriorated areas of the tunnel as a repair method, however, routine maintenance would be required. With either method of repair water seepage/drainage needs to be addressed as water/ice is a cause of severe deterioration.

The best long-term repair would be to install tunnel liner throughout the entire tunnel. The recommendations listed below are the “minimum” repairs that would allow the tunnel to be used as a trail.

Station 2 + 00 to Sta. 6 + 50

- New tunnel liner is recommended due to the extent and severity of the tunnel deterioration. Significant portions of brick are missing and the concrete crown is visible and severely deteriorated in some areas.

Station 6 + 50 to Station 19 + 00

- Scaling to remove all loose material and gunite/shotcrete applied to the tunnel springline, crown and walls. Existing weepholes should be cleaned and new weephole pipes should be installed at all damp/wet areas to help prevent deterioration. Patching of the liner may be required in several areas upon a more in-depth inspection.

Station 19 +00 to Station 26 + 65

- New tunnel liner is recommended due to the extent and severity of the tunnel deterioration. Near the portal a large section of the concrete crown has failed where a large hole exists. This hole should be repaired as part of the new liner.

Surface Water Drainage Structures Near Portals

Existing timber and steel drainage structures exist above the portals. Their purpose is to convey surface water from upland across the tunnel (see photos). They are in a failed condition. Possible repair options include the following:

- Divert the surface water away from the portals. This would be very difficult and expensive due to the mountainous terrain and additional right-of-way or easements would be required.

- Slope Pipe – A bar screen would be necessary at the pipe inlet to prevent debris from clogging the pipe and children from falling into the pipe. The bar screen would require routine cleaning.

- Replace existing pipe (north portal) and chute (south portal) – Replacement of existing is the recommended option due to construction costs, safety, and maintenance costs. It would also maintain the historic look of these components.

Tunnel Drainage

It is very important that significant amounts of surface water runoff from outside the tunnel not be allowed to enter the tunnel. All ground water that enters the tunnel should be conveyed by pipe or open channel to outside the tunnel. Minor grading both inside and outside the tunnel could address the tunnel drainage issues. The tunnel floor slopes mildly from one end to the other end and a ditch is present on the east side the entire length of the tunnel.

Interior Lighting

It is recommended to install luminaires inside interior portions of the tunnel. Due to the tunnel length and horizontal curve, it is very dark beyond several hundred feet inside the tunnel. One option is electric powered lighting, however, there is no electric available near either portal, therefore it would have to be brought down the hill from either SR68 or Phillipston Road (800 ft) or up the trail (7,000 ft) from Phillipston. Another option would be to install solar panels to power the lighting. Whichever option is chosen the design should be such that it deters vandalism.

Miscellaneous

Based on our most recent experience on the Climax Tunnel during cold weather, a method to "block off" wind from entering the tunnel should be considered. The result of shielding the tunnel from wind during cold weather significantly lessens the possibility of icicle formations which would extend the life of the chosen repairs. The shield could consist of a permanent or seasonal door or drape. These options and others should be considered in more detail during final design.

## SUMMARY OF COST ESTIMATES

| Construction Cost Estimates | | | |
|---|---|---|---|
| **Repair Option** | **North Portal** | **Tunnel Interior** | **South Portal** |
| Tunnel Liner – Entire Length | | $10,106,500 | |
| Liner Sta 2 + 00 to 6 + 50 | | $1,890,000 | |
| Shotcrete Sta 6 + 50 to 19 + 00 | | $1,450,000 | |
| Liner Sta 19 + 00 to 26 + 25 including crown repair at Sta 26 + 50 | | $3,263,000 | |
| Interior Lighting | | $150,000* | |
| Surface Water Drainage Structures Near Portals | $44,000 | | $104,000 |

Total = $6,901,000 (Liner portions, shotcrete, lighting, drainage structures)
Total = $10,404,500 (Liner entire tunnel, lighting, drainage structures)

Notes:

1. Tunnel liner cost estimate information used from Climax Tunnel Stabilization Project completed in 2015.
2. Construction Cost Estimates assume use of prevailing wage rates.

* Could vary based on detailed evaluation and option chosen.

| Design and Inspection Estimate | |
|---|---|
| Design, Consultation | $400,000 |
| Inspection | $158,000• |
| TOTAL | $558,000 |

• Based on 50 weeks construction, 40 hours per week, plus 10% overtime.

## 6.0 ANTICIPATED ROCK CUT REPAIR OPTIONS

The exposed rock cut slopes near the north and south portals have undergone significant differential weathering resulting in talus growth and rock falls in the vicinity of the rock cuts. Talus growth at toe is directly a result of weathering of shale and claystone unit in rock cuts. Rock falls are the result of surficial blocks becoming detached from the cut face due to weathering and/or after losing base support from weathering of shale and claystone.

Several repair options are considered for stabilization of the cut slope. Many of these options may require initial scaling and trimming of the slope and removal of talus piles in order to stabilize the current conditions of the slope before installation of any repair options can be implemented. Additionally, any loose boulders, trees, shrubs, and material should be removed at the top of the cut slope.

Flexible Barrier Fences

A flexible barrier fence is installed as a measure to contain falling rock and perimeter fallen rock from passing a certain point namely the edge of the bike trail. The barrier is designed to absorb energy through deformation of the fence material and breaking elements. The fence material is generally made up of deformable cables and/or mesh, and the most common types are woven wire-rope mesh net or interlocking ring nets.

The interlocking of rings in mesh can provide the greatest deformation and energy absorption. The mesh is commonly supported by steel posts anchored into a foundation with grouted bolts. The foundation is usually a mass of concrete or concrete cap secured by rock bolts. Anchor steel ropes are installed upslope to resist high-energy events to absorb energy and provide additional supports to the fence. Some of the largest fences are capable of handling impact energies up to 5000 kJ (1,844 feet-tons)[5].

After removal of the talus pile, this option would require the installation of minimum 10 feet high flexible fence barriers near the cut slope starting from the face of both portals and running parallel to the cut slope. The north portal side would require approximately 200 feet of fence from the tunnel face. The south portal side would require approximately 350 feet of fence from the tunnel face. Periodic maintenance and inspection of the fence and cleaning of debris fallen behind the fence would be required. Based on material, installation, and labor cost from Maccaferri, the total cost of this option would be approximately $630,000. Please refer to Appendix G for detailed information on cost.

Mesh and Cable Nets – Draped Mesh

Mesh and cable nets are used to hold rocks behind the mesh or direct them to a catchment area near the toe of the slope. Mesh can be installed as draped or unsecured (anchored at the top of the slope only) or secured (attached at the top and bottom of the slope with rock anchors). Draped mesh and slope anchored mesh are two of the most common types of nets.

Draped nets, consisting of wire mesh or cable netting, are suspended by anchors installed near the top of the slope and hung over vertical or near-vertical slopes. They are typically used on slopes between 50 to 150 feet high and slopes ranging from 35 degrees (from vertical) to overhanging[(5)]. They are designed to contain rockfall from freefall and to a control descent as rocks travel down the slope.

Draped nets can be secured and unsecured. The secured system is anchored at the top and bottom and contains the rockfall better than the unsecured system by containing the rockfall closer to the face. The unsecured system is only anchored at the top of the slope and allows rockfall to occur between the net and the slope face.

The net option would require the installation of the net along the whole rock cut slope. The north portal would require approximately 200 feet in length and south portal about 350 feet in length. The Upper and Lower Connoquenessing sandstone overhangs sticking out at various locations will need to be trimmed out before installing the net. The net will be anchored well behind into the slope where it flattens compared to the cut slope. The north portal has enough catchment space for an unsecured draped system to be installed providing that the talus at the toe of the rock cut is removed. The south portal does not have enough catchment space to install an unsecured draped system thus a secured system should be considered. The total estimated cost for this option would be approximately $620,000 based on current material, installation, and labor cost from Maccaferri. Please refer to Appendix G for detailed information on cost.

Scaling and Trimming with Rock Bolts and Shotcrete

Scaling and trimming is the process of removing loose, unstable, or overhanging material that might dislodge or affect the trajectory of falling rock by creating a launching point for materials falling from above. Hand scaling, mechanical scaling, and trim blasting are some ways to scale and trim a rock cut. The removal of these unstable materials and overhanging boulders generally provides safer conditions, but as a stand-alone stabilization and mitigation measure, scaling and trimming requires constant maintenance of the slope every two to ten years based on site conditions.

Once the scaling and trimming of the overhanging rocks, weathered materials, and unstable surface is completed, additional support and improvements can be implemented in order to reduce the maintenance of the rock cut. Installation of rock bolts (internal stabilization) with shotcrete (external stabilization) would further improve the rock cut. Rock bolts are generally used on rock masses that may show instability or have potential for it. The bolts can be installed in a grid pattern to support the rock cut slope and any individual blocks. Support from bolts is provided through shear strength of the steel and friction along weak planes. Once rock bolts are installed, shotcrete can be applied to the rock face to provide additional protection from differential weathering of materials. A drainage system (weep drains, drainage boards) should be installed to control water behind the shotcrete.

From past experience on similar types of work, the estimated cost for this option is $1,064,000 for both portal areas of the tunnel. Refer to Appendix G for detailed information on cost.

## Extend Tunnel Liner

A prefabricated tunnel liner can also be used to mitigate the problem by extending the liner through and past areas where potential fallouts can occur. The tunnel liner can be constructed to specific thickness, length, and radius to meet the final tunnel dimension requirements. The fabricated liner could extend from the tunnel face and outward beyond the rock cut slope.

This option includes the delivery of 16x10-foot Conspan concrete arches at $1,330/LF and an additional $1,500/LF for footings, placement, and aggregate fill over arch to dampen rock fall impact. This would result in a total cost of approximately $1,606,500 for both portal areas. Refer to Appendix G for information on material and item estimates.

## Catchment Ditch

Catchment ditches are flat or negatively sloped ground sections at the toe of rock cut slopes and are used to dissipate rockfall energy and catch the fallen rocks. They are generally located between the sides of the roads or trails and the cut slope filled with soil. They are very effective, easy to maintain, and inexpensive to construct. However, due to space restriction on the south side of the tunnel portal to allow proper catchment ditch size, this option should not be considered a viable option for mitigation against the rock slope on the south portal.

Based on Colorado Rockfall Simulation Program (CRSP), the rock cut slope at the north portal will have sufficient space to allow a catchment ditch option. The ditch dimensions are 15 feet wide and 3 feet deep. This option would cost $118,000 for the north portal. The ditch should be designed to prevent the ponding of water. Refer to Appendix G for more detailed information on this option.

## Laying/Cutting Back the Slope

Laying or cutting the slope back to flatten the slope is another viable option. By flattening the current near vertical slope back to 0.5H:1V or excavating benches below the overhanging sandstone layers would have a stabilizing effect. The cut can be made through the process of pre-splitting. Pre-splitting is a process that requires holes to be drilled at the top of the slope and detonating explosives in the holes to create a fracture or crack along a certain line of interest (generally at the slope face). Hoe-ram excavation has been used successfully as well. Depending on the slope height, this process can be completed in multiple step-down layers. However, this option may require additional property and weathering of the shale and claystone would still continue and create possible instability in the future and some form of catchment ditch, fence, or drape would be needed at that time. Additionally, cutting rock slope shallower than 0.5 H:1V will not daylight at the current steepness of the existing ground surface above the rock cuts. The total cost of this option is $1,055,000 for both portal areas.

Combination Rock Cut Repair Options

Through the initial evaluation of rock cut repair options, the Catchment Ditch at the North Portal and the Flexible Fence Barrier at the South Portal appear to be the most economical options. However, space limitations on the South Portal do not allow an effective flexible fence barrier installation close to and at the South Portal Face. Therefore, three (3) additional options were evaluated for the rock cut outside the South Portal. These three options are Catchment Fence on Rock Cut Slope, Drape and Fence, and Drape and Catchment Ditch. These are presented below:

Catchment Fence on Rock Cut Slope (South Portal)

Catchment fence on rock cut slope is similar to flexible barrier option except that the fence would be installed near the top of the slope at approximately 45 degree angle from horizontal. This option would catch any falling debris above the fence thus eliminating any debris falling onto the trail. The proposed fence would be approximately 10 feet high and stretch the entire length of 350 feet of exposed rock slope at south portal. This option would cost approximately $410,000 for the south portal for material, installation, and regular maintenance. Refer to Appendix G for more detailed information on this option.

Drape and Fence (South Portal)

Drape and Fence utilizes the combination of Draped Mesh option with Flexible Fence Barrier option. This option would utilize the draped mesh on the upper half of the slope to control the decent of falling debris and guide it near the ground surface. By adding the flexible fence, it would contain the falling debris within the area designated for fallen debris and provide maximum usable space for trail. The fence would be 10 feet high and extend 350 feet along the rock slope. This option would cost approximately $380,000 for the south portal for material, installation, and maintenance. Refer to Appendix G for more detailed information on this option.

Drape and Catchment Ditch (South Portal)

Drape and Catchment Ditch utilizes the combination of Draped Mesh option with Catchment Ditch option. This option, similarly to 'Drape and Fence' option, would utilize the draped mesh on the upper half of the slope to control the decent of falling debris and guide it near the ground surface. By adding the catchment ditch, fallen debris energy would be dissipated and debris would be retained in the ditch. The ditch would be approximately 12 feet long and 2 feet deep for it to retain acceptable amount of debris. This option would cost approximately $305,000 for the south portal for material, installation, and maintenance. Refer to Appendix G for more detailed information on this option.

**SUMMARY OF COST ESTIMATES**

| | **Construction Cost Estimates** | | |
|---|---|---|---|
| **Repair Option** | **North Portal** | **South Portal** | **Total** |
| | | | |
| Flexible Fence Barrier | $240,000 | $390,000 | $630,000 |
| Mesh & Cable Nets | $235,000 | $385,000 | $620,000 |
| Scaling & Trimming - Bolting | $621,500 | $442,500 | $1,064,000 |
| Tunnel Liner Extension | $591,000 | $1,015,500 | $1,606,500 |
| Catchment Ditch | **$118,000** | N/A | $118,000 |

| | | | |
|---|---|---|---|
| Layback Slope | $535,000 | $520,000 | $1,055,000 |
| Catchment Fence on Rock Cut Slope | * | $410,000 | $410,000 |
| Drape and Fence | * | $380,000 | **$380,000** |
| Drape and Catchment Ditch | * | $305,000 | $305,000 |

*Notes: Option not analyzed.

** Additional cost of $10 per LF should be applied to each side where chain link fence would be required for pedestrian protection.

Rock Cut Repair

Based on Summary of Cost Estimates, the least costly option for repairing the rock slope at the North Portal is a catchment ditch at the base of the slope. Due to space restrictions on the South Portal, a combination of draped mesh and flexible fence is recommended in order to maximize space for trail. Draped mesh and catchment ditch is not recommended because it would encroach the trail more than the recommended option. The combined costs of one catchment ditch for the North Portal and Draped Mesh / Fence Barrier for the South Portal is approximately $503,500. This includes adding a 550 ft (200 ft for north portal and 350 ft for south portal) of chain link fence for pedestrian protection.

North Portal = $118,000 (Catchment Ditch)
South Portal = $380,000 (Draped Mesh and Flexible Fence)
Chain Link Fence = $5,500
Approximate Cost = **$503,500**

| **Design and Inspection Estimate** | |
|---|---|
| Design for Rock Cuts | $40,000 |
| Construction Phase Assistance | $10,000 |
| TOTAL | $50,000 |