US 64/Corridor K Tunnel Options White Paper

ENVIRONMENTAL IMPACT STATEMENT
US 64/CORRIDOR K
FROM WEST OF THE OCOEE RIVER TO SR 68 NEAR DUCKTOWN
POLK COUNTY, TENNESSEE

TDOT PIN 102420.08

NOVEMBER 14 2014

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LIST OF ACRONYMS

APR	acid producing rock
CCTV	closed circuit television
DEIS	Draft Environmental Impact Statement
FHWA	Federal Highway Administration
NEPA	National Environmental Policy Act
NHS	National Highway System
STRAHNET	Strategic Highway Network
TDOT	Tennessee Department of Transportation
TESA	Tennessee Environmental Streamlining Agreement

Chapter 1.0 EXECUTIVE SUMMARY

1.1 INTRODUCTION

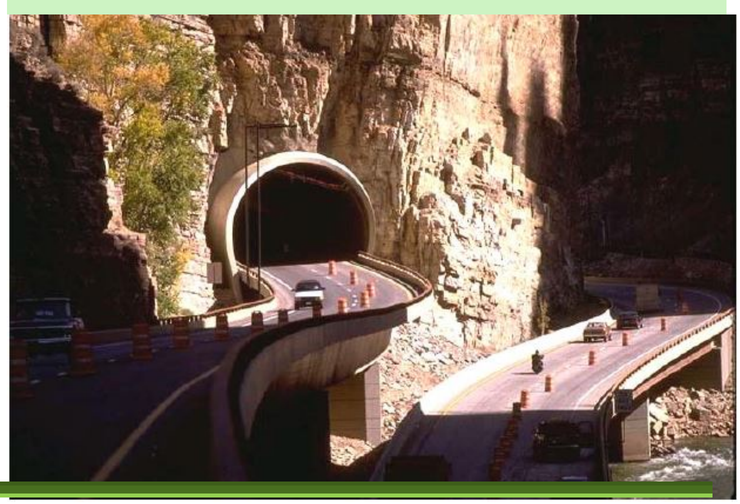
This whitepaper is the initial step in the planning and design process for consideration of a new Draft Environmental Impact Statement (DEIS) alternative for the US 64/Corridor K project, which involves tunneling in the Ocoee River Gorge. It provides a high-level feasibility analysis for two potential tunnel options including tunnel layouts, potential environmental considerations, and a range of potential construction costs. The Tennessee Department of Transportation (TDOT) has already examined various improvement alternatives that meet the need for the project. These are surface road options with, in some cases, short sections of tunnel. However, TDOT now wishes to consider options that include an approximate 6 mile tunnel between SR-30 (Greasy Creek Road) and Ocoee Powerhouse No. 3 or a series of tunnels with daylighting in between tunnel segments. Both tunnel options would be similar in regard to site location to Build Alternatives 2, 8A and 9. The general alignment of the tunnel options would improve existing US 64 from the beginning of the project up to SR-30, then be on new location north of US 64 through the Ocoee River Gorge, then tie back to the existing US 64 alignment just west of the Ocoee Whitewater Center and continue on the existing alignment to the end of the project in Ducktown. This whitepaper considers tunneling scenarios only in the middle segment of these potential options.

Two preliminary tunnel options have been developed for consideration.

- Option T1 assumes two tunnels with a bridge over Goforth Creek.
- Option T2 assumes a single, continuous tunnel.

An alternative developed “late” in the National Environmental Policy Act (NEPA) review process must go through the same evaluation as those alternatives developed “earlier” in the process. The timing of when an alternative was developed is irrelevant to the NEPA environmental review process. In addition, alternatives developed late in TDOT’s Tennessee Environmental Streamlining Agreement (TESA) process will have to adhere to the appropriate concurrence steps. Paramount to the consideration of a tunnel option is the ability to meet the established project purpose and need.

Figure 1 - Glenwood Canyon Hanging Lake Tunnels, Colorado



If TDOT determines that either Option T1 or Option T2 is to be introduced as a project alternative, it would be presented to agencies for concurrence as an alternative to carry forward for detailed study. To satisfy this requirement, a Concurrence Point (CP) 2 Supplemental Package would be prepared and submitted to TESA agencies which would have 45 days to provide comments. The alternative could also be introduced at the December (2014) TESA meeting. TDOT has the option of holding a special TESA meeting to introduce this project option, if desired.

Assuming agency concurrence to carry forward one or both of these options, it or they would need to be introduced into the DEIS and analyzed along with the other five alternatives and presented to TESA agencies at CP3.

1.2 Option Descriptions

Option T1 would generally follow the alignment of Alternative 9 crossing Greasy Creek on a 470 foot bridge and enter a tunnel in a portal on the eastern side of Greasy Creek. The tunnel would extend 20,860 feet (4.0 miles) emerging in the Goforth Creek area to cross the creek on a 500 foot bridge. The option would then re-enter a second tunnel for 8,940 feet (1.7 miles) before exiting the tunnel in the vicinity of the Ocoee No. 3 powerhouse to rejoin the existing alignment. The total length of this segment of Option T1 is 5.7 miles.

Option T2 would begin with a tunnel entrance at the eastern end of Parksville Lake. The tunnel would extend 31,620 feet (6 miles) before ending in the vicinity of the Ocoee No. 3 powerhouse where it would rejoin the existing US 64 alignment.

Both tunnel options would be designed to the same criteria as other, non-tunnel alternatives and would have a minimum 50 mph design speed. As with the other non-tunnel alternatives, the tunnel options would also address the overall purpose and need of the project by addressing roadway deficiencies, improving roadway safety, and providing system linkage to the region.

The proposed profile for each of the tunnel alignment options would eliminate long segments (up to 4.5 miles) of steep 4-7% grades that are included in the design of the other build alternatives on new location north of the Ocoee Gorge between SR-30 and Ocoee Powerhouse No. 3. This same segment of Option T1 would have a maximum 2% grade. Option T2 has a 0.5 mile segment at 2.8% but the remaining 5.5 miles of that tunnel are less than 1%. Operationally, this profile would provide traffic with a safer and more efficient alignment by eliminating long hill climbs and downhill segments requiring trucks to brake to maintain speed.

Environmental advantages of the tunnel options when compared to the surface alternatives is that environmental impacts to wetlands and in some cases streams would be notably minimized in tunnel areas. Detailed hydrologic studies have not been conducted but it is assumed that a tunnel could be located below surface water tables, thereby leaving surface waters undisturbed. Also, with the exception of areas where tunnel approaches (portals) would be constructed for ingress and egress, disturbance to wildlife and their habitat would be minimized in comparison with surface road options.

Construction of an east and west portal would substantially change the visual context of the Ocoee Gorge Setting in the vicinity of those areas, however the change in the visual context would be anticipated to occur at a lesser degree overall than other surface transportation options under consideration.

Potential project related effects that have the greatest potential for adversely impacting water quality within the study involve the disturbance of rock and soil containing acid producing rock (APR). Estimated excavation quantities for the tunnel options are less than estimates of surface transportation options by at least 3 million cubic yards, and would be expected to minimize APR exposure to surface waters. Additional hydrologic study of above ground and underground aquatic resource would be needed should one or both of these tunnel options be carried forward into the NEPA environmental document.

Cost estimates for the tunnel options were based on relevant tunnel projects completed in North America and Europe within the past decade . Because tunnel project costs are dependent on a range of project specific criteria, there is substantial variance in the costs. Comparative tunnel costs range from $99.5 million dollars to $8.5 billion dollars, with an average cost of $2.5 billion dollars. Based on the preliminary analysis described in section 6, the costs associated with the US 64/Corridor K tunnel options are expected to be towards the middle to lower end of this range. Compared to tunnel costs, the costs of the five alternatives, that have been analyzed so far, are lower, with the most expensive alternative, Alternative 2, having an expected cost of approximately $839 million dollars.

1.2.1 Site Visit

URS engineering staff and TDOT project management conducted a site visit on October 14, 2014. This report draws heavily from the Tunnel Option Memorandum which was developed as a result of the initial site visit. A copy of the Tunnel Option Memorandum and site visit photo log is included in appendix A.

Chapter 2.0 ASSUMPTIONS

To determine the feasibility of a tunnel alternative, two separate preliminary options were developed with the following design assumptions:

- Option T1
    - Option T1 assumes two separate and parallel single-lane tunnels divided into two tunnel segments by a 500-foot long bridge crossing Goforth Creek.
    - A completed tunnel diameter in the order of 25 feet for each tunnel. This allows for a single 12-foot lane, shoulders, and egress walkways.
    - For maintenance and emergency egress purposes, multiple cross adits will be required to connect the parallel tunnels. Linear spacing of the adits may be in the order of 300 feet.
- Option T2
    - Option T2 assumes a single, continuous two-lane tunnel extending the entire length from Parksville Lake to the Ocoee Whitewater Center.
    - The cross section of the alternative would include two 12-foot lanes, shoulders, and egress walkways.
    - For maintenance and emergency egress purposes, a single lane tunnel option may necessitate providing alcoves at regular intervals to accommodate disabled vehicles.

A road tunnel cross section must be able to accommodate the horizontal and vertical traffic clearances, as well as the other required elements. The typical cross section elements include the following:

- Travel lanes
- Shoulders
- Sidewalks/curbs
- Tunnel drainage
- Tunnel ventilation
- Tunnel lighting
- Tunnel utilities and power
- Water supply pipes for firefighting
- Cabinets for hose reels and fire extinguishers

- Signals and signs above roadway lanes
- Closed circuit television (CCTV) surveillance cameras
- Emergency telephones
- Communication antennae/equipment
- Monitoring equipment of noxious emissions and visibility
- Emergency egress illuminated signs at low level (so that they are visible in case of a fire or smoke condition)

Because of the length of the tunnels present a challenge in regard to maintaining acceptable air quality for cyclists and pedestrians alike, bicycle and pedestrian usage would not be practicable and are not typically permitted in tunnels.

2.1 GEOTECHNICAL SUITABILITY

The available geological information indicates the tunnels would be predominately excavated in Pre-Cambrian age rocks of the Walden Creek Group. These rocks would include sandstones, siltstones, argillaceous slate, and conglomerates of the Wilhite and Sandsuck formations. Close to the western portals the geology map indicates the tunnel may encounter a regional scale fault called the Sylco Creek Fault. Towards the eastern end of the tunnels the geology map indicates the tunnels would pass from the Walden Creek Formation into older rocks of the Great Smokey Group. This group would include greywacke, arkose, conglomerates, and slates.

These two groups of rocks are folded and faulted and have a cleavage due to low grade metamorphism. Cleavage becomes more prominent in the rocks from west to east and generally dips to the southeast.

The rocks are described as having multiple fracture orientations and fractures can be widely or closely spaced. This spacing description is not quantified in the available information. Bedding is described as being visible in most of the rocks. Slickensides are also mentioned associated with bedding and joint planes in some rock units. No other quantitative information was available regarding the rock mass characteristics or other geotechnical parameters for the rocks.

The geology memorandum also notes that the rocks along the proposed tunnel alignments can be APR. These potentially corrosive conditions would have implications for the design of tunnel support/drainage systems and the disposal of excavated tunnel spoil. It is addressed extensively in the geology report with respect to the excavation of road cuts and how these excavated materials may impact the environment. Similar issues would need to be considered for tunnel spoil disposal.

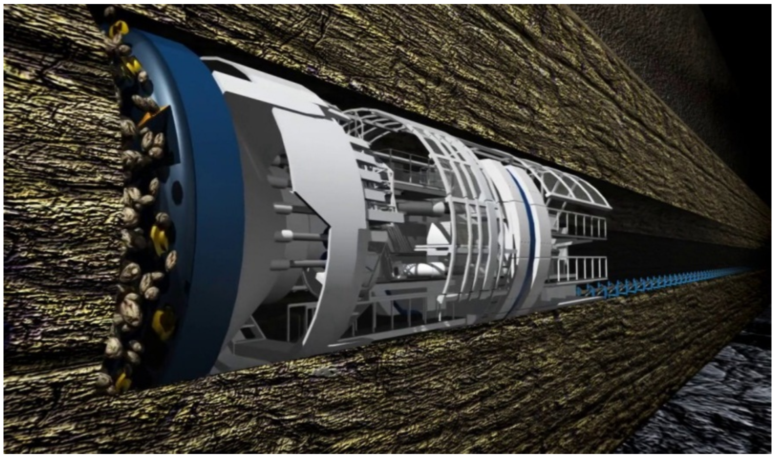
As noted above, the available information indicates that the tunnels would cross at least one major fault. Existing road cut excavations show that numerous other minor faults would also be encountered.

No information was available regarding the hydrogeology and permeability of the rock mass and how this might vary through the rock mass and in the vicinity of fault zones. Faults can often act as both barriers to groundwater flow perpendicular to the fault zone and as conduits to groundwater flow parallel to the fault zones.

2.2 TUNNEL CONSTRUCTION

Long tunnels of this type are almost exclusively excavated by tunnel boring machines (TBM) and this construction method is assumed for this project; however there would likely be some drill and blast construction and/or other tunneling methods for the portal, shafts, adits and other necessary appurtenant underground structures. The following are some preliminary observations regarding the proposed project based on the available information:

Figure 2 - Tunnel boring machine



- The excavated tunnel diameter is likely to be in the order of 25 to 28 feet based on the assumption described above. As outlined in the attached appendix A, many tunnels have been completed with diameters in this range and tunnel diameter on its own is not likely to be a technical challenge.

- The available geological information indicates that tunneling conditions are likely to be generally classified as “hard rock”. The ground conditions and hydrogeology largely control the design of the TBM, and the tunnel initial and primary support systems. While at this stage of the project numerous unknowns still exist, the conditions outlined in this memorandum can be conducive for relatively good rates of TBM excavation.

- The general rock mass behavior during excavation along with fault zones and other areas of potential poor ground conditions and groundwater inflows will all influence TBM performance and tunnel support system requirements. The frequency and length of different rock mass zones and specific poor ground condition features encountered in the tunnel are a key design issue. Fractured rock masses are typically readily excavated by TBM. However, a fractured and faulted rock mass is also likely to require a systematic ground support system such as a combination of rock bolts, mesh, and shotcrete. Increased levels of support (e.g., steel sets) may be required in areas of poor ground such as faults.

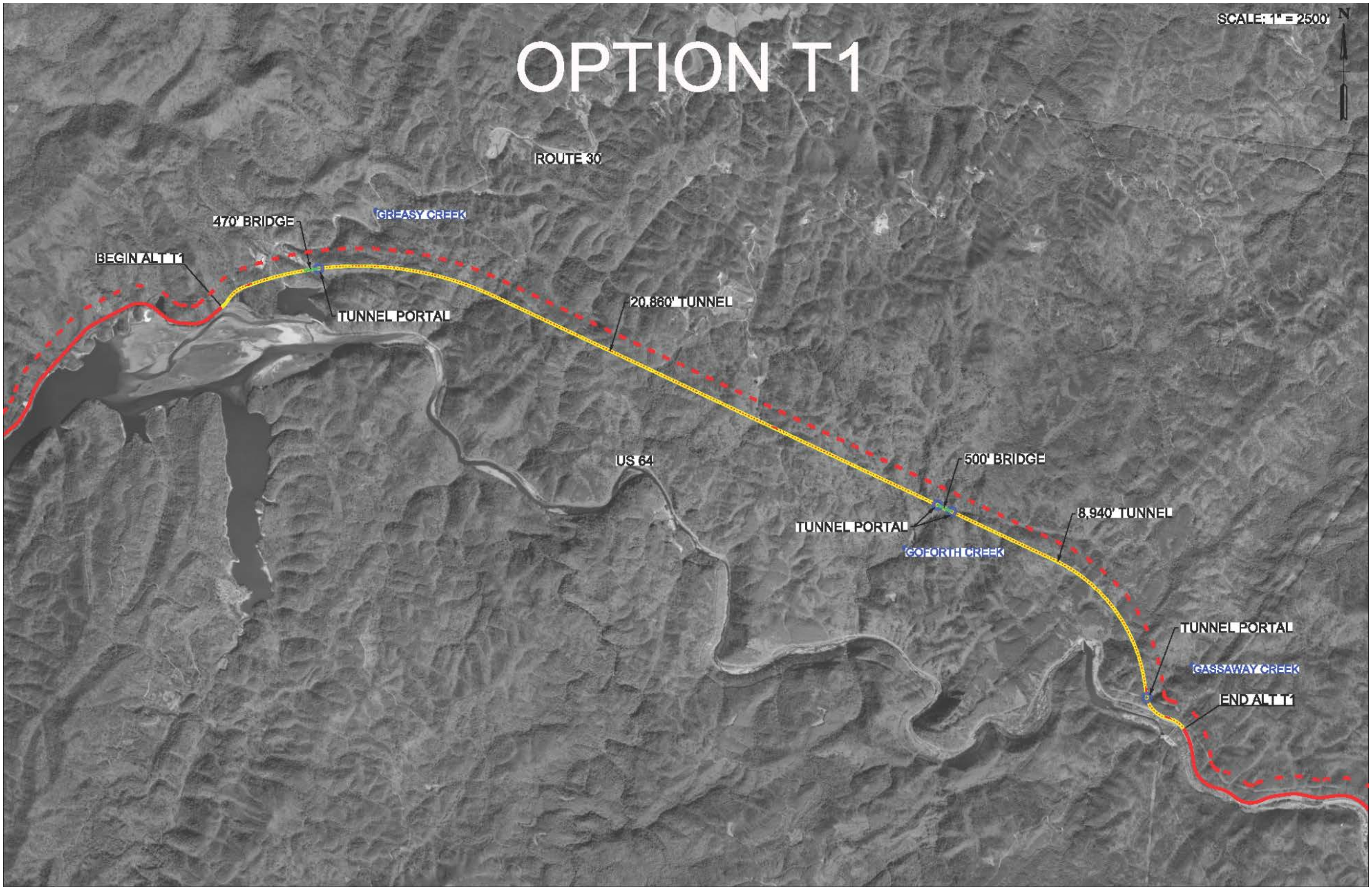
- The October 2014 site visit identified that space is limited at some of the possible tunnel portal locations. Typically, several acres are desirable for launching and receiving of the TBM and the disposal of excavated tunnel spoil. Consideration must also be given to the space required to construct portals and transition from tunnel to conventional surface roadway segments. Finally there could be a requirement for intermediate ventilation shafts. These issues will require further consideration, as will the potential acid drainage producing nature of the excavated tunnel spoil.

This is not intended to be a complete list of tunnel excavation issues. However, the available information suggests that excavation of tunnels of the diameter described above in these rock conditions is theoretically feasible and has been completed elsewhere in the world for numerous projects. The occurrence of APR is a site specific issue but this is not unique and has also been addressed in other projects.

Chapter 3.0 FIGURES

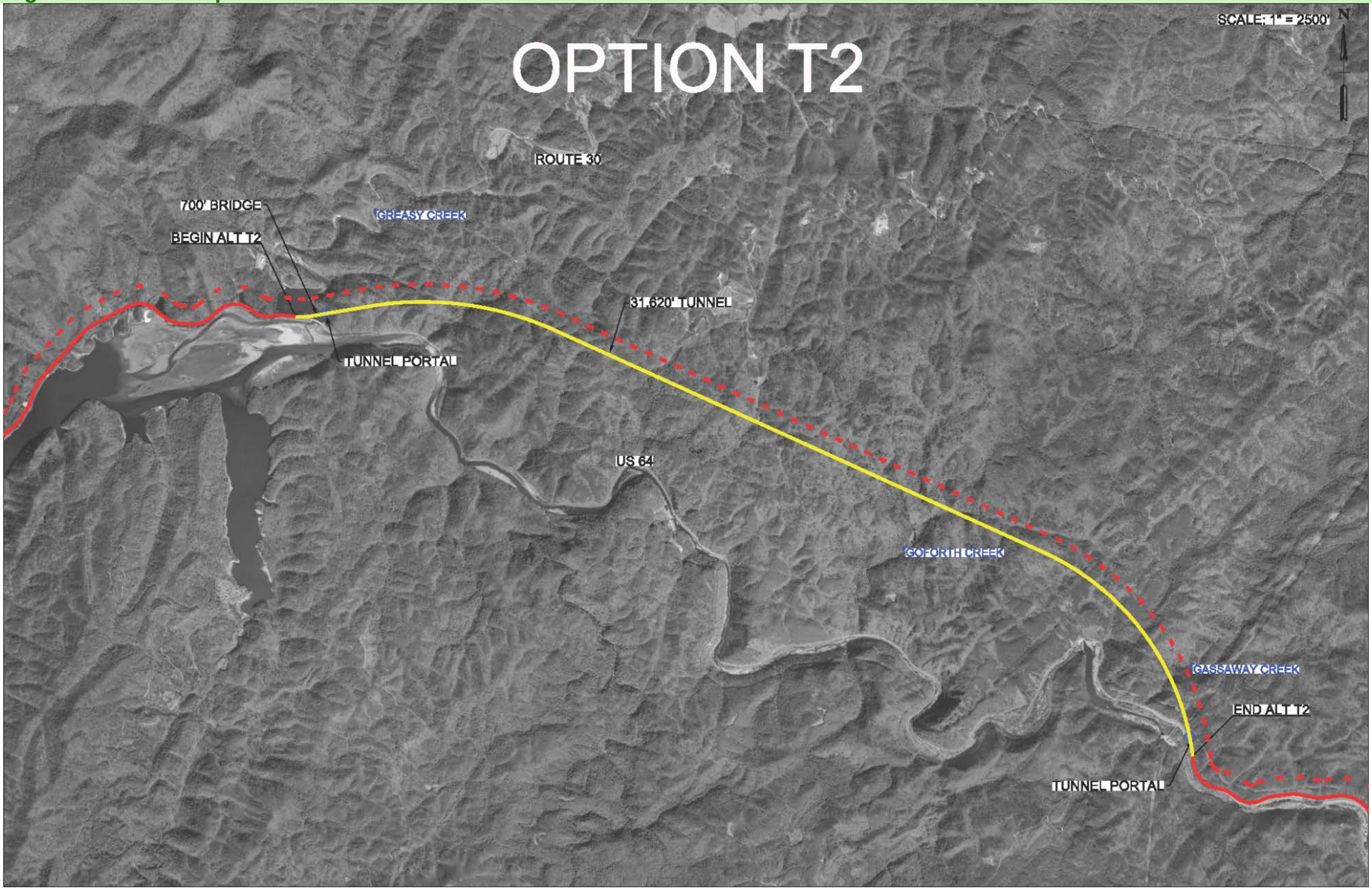
The location of the two tunnel options is north of the existing US 64 alignment through the Ocoee Gorge. Option T1 would follow the alignment of Alternative 9 crossing Greasy Creek on a 470 foot bridge and entering a tunnel in a portal on the eastern side of Greasy Creek. The tunnel would extend 20,860 feet (4.0 miles) until the vicinity of Goforth Creek emerging in the Goforth Creek area to cross the creek on a 500 foot bridge. The option would then re-enter a tunnel for 8,940 feet (1.7 miles) before exiting the tunnel in the vicinity of the Ocoee No. 3 powerhouse to rejoin the existing US 64 alignment. The total length of Option T1 is 5.7 miles. Figure 3 shows the location of Option T1.

Figure 3 - Tunnel Option T1



Option T2 would begin with a tunnel entrance at the eastern end of Parksville Lake. The tunnel would extend 31,620 feet (6 miles) before in the vicinity of the Ocoee No. 3 powerhouse to rejoin the existing US 64 alignment. Figure 4 shows the location of Option T2.

Figure 4 - Tunnel Option T2



Typical sections for the proposed tunnel options would be developed after a more thorough geotechnical investigation and further engineering analysis. The Federal Highway Administration (FHWA) has typical tunnel cross sections that can be used as a basis for understanding the design requirements for both the single lane option (Option T1) and the two lane tunnel option (Option T2).

Figure 5 shows a typical single lane road tunnel cross section including the required tunnel elements identified in the Assumptions section. Option T1 would be a single lane option.

Figure 5 - Typical single lane road tunnel cross section and elements

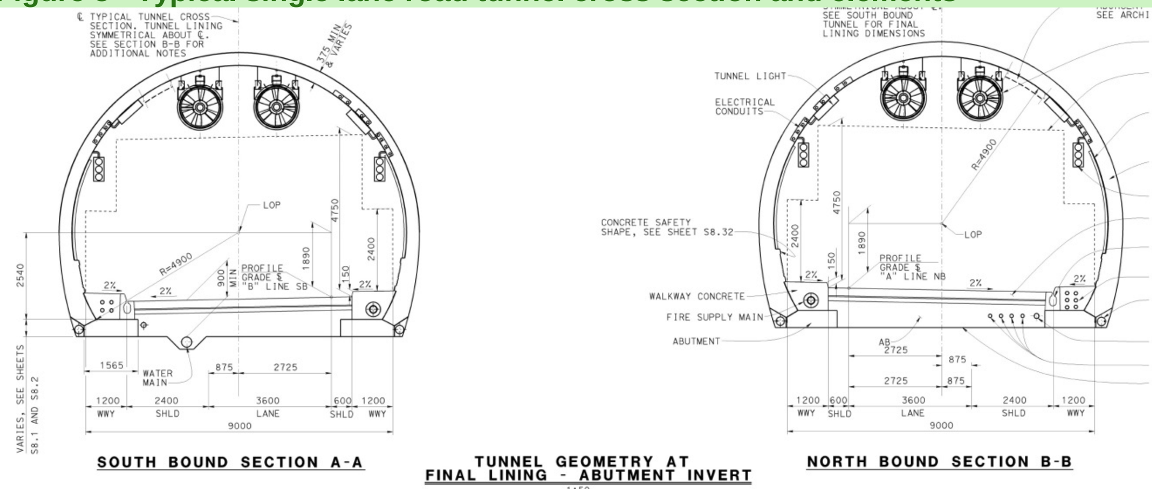
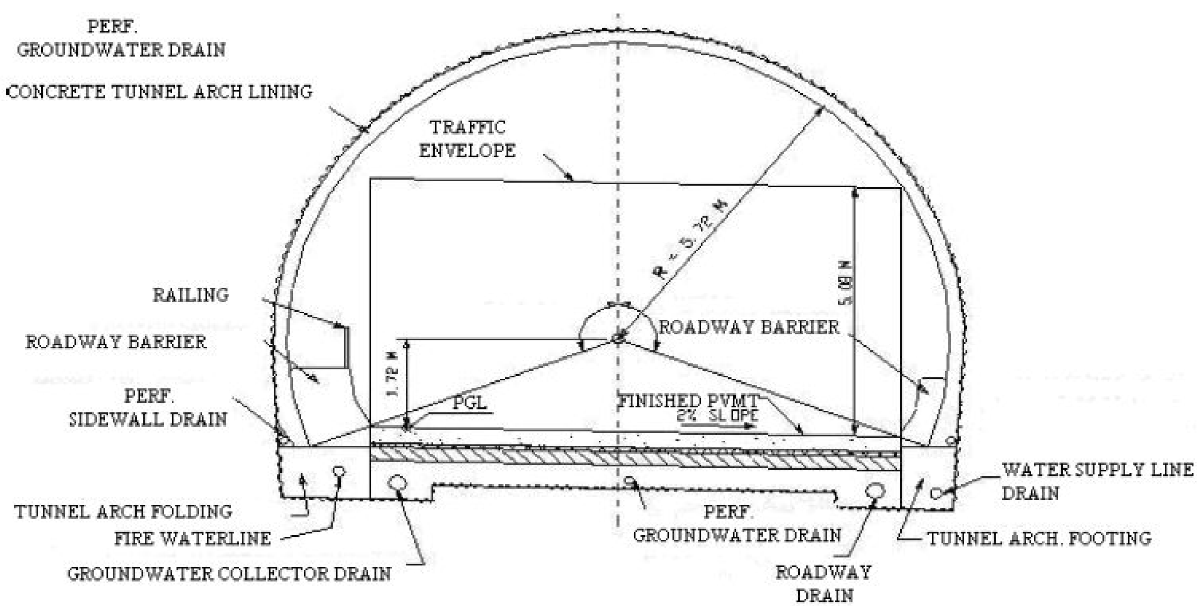


Figure 6 shows a typical two lane road tunnel cross section including the required tunnel elements identified in the Assumptions section. Alternative T2 would be a two lane alternative.

Figure 6 - Typical two lane road tunnel cross section and elements



Chapter 4.0 ENVIRONMENTAL CONSIDERATIONS

This section provides general environmental consideration associated with a tunnel option. Detailed environmental review of these project options will occur if one option or the other is carried forward in the NEPA review process.

4.1 GEOLOGY

Construction of the tunnel alternative would not address the rockfalls along the existing US 64 through the Ocoee River Gorge, however it would allow the continual use of the roadway in the event of a rockfall. The tunnel options would also require the same large rock cuts along Parksville Lake as Alternatives 2, 8A and 9 in order to upgrade the existing US 64 alignment.

4.2 APR MANAGEMENT

As noted previously, the area where the tunnel(s) would be constructed is within conglomerates of the Wilhite and Sandsuck formations. These areas have low to moderate APR potential. As with the surface alternatives, construction of the tunnel options could disturb APR rock which could leach into ground and surface water resulting in damages to plant and animal life. However these impacts can be mitigated in the same manner as outlined in the DEIS for surface alternatives. These mitigation measures include the development of an APR Management Plan, and sampling and monitoring of soils during construction.

One significant benefit of a tunnel would be the elimination of cut surfaces associated with road construction. These cut surfaces could expose pyritic material that may create acidic stormwater runoff that would require treatment prior to entering a stream.

4.3 ABOVE GROUND AND BELOW SURFACE HYDROLOGY

Further investigation is needed in order to gain a better understanding of the hydrology of the potential tunneling areas. A high level review of existing data suggests that change in the ground surface hydrology could be minimized. Below surface hydrology data suggests that the below surface hydrology in the vicinity of Parksville Lake and Goforth Creek may provide opportunities for bridging and daylighting. Subsurface water can be addressed by the tunnel design with an appropriate impervious liner. The tunnel vertical alignments provide a nominal depth below existing streams to minimize subsurface hydrologic impacts and eliminate any surface impacts.

4.4 NOISE

During construction, noise impacts could result from the tunnel boring machine and, possibly, as a result of any drilling or blasting that would be associated with the necessary appurtenant underground structures. These construction related noise impacts would likely be limited to the tunnel approaches and portals. Similarly, operational noise and vibration effects would be limited to the tunnel approaches and portals. Overall, noise and vibration impacts associated with a tunnel option would likely be less severe than a surface alternative, particularly a new alignment surface alternative.

4.5 AIR

Depending on the ventilation system used in the tunnels, air quality impacts would also likely be limited to tunnel approaches and portals. Tunnels require ventilation to clear noxious emissions from the tunnel and for fire and safety purposes. In general, tunnel ventilation can be accomplished by pushing air through the tunnel using a jet system or a central fan system, and the air can ventilate through the portals. A central dividing wall may need to be extended some distance out from the portal to prevent recirculation of polluted air, (i.e., vented polluted air from one traffic duct is prevented from entering the adjacent duct as clean air). Selection of the appropriate ventilation system could have a substantial impact on the tunnel alignment, layout, and design.

4.6 EMS/FIRE/SAFETY

For long tunnels and tunnels in remote areas, FHWA recommends that fire-fighting and emergency response personnel, equipment, and vehicles be located at portals at each end of the tunnel. This would minimize emergency response times within and around the tunnel.

The FHWA also recommends that an emergency ventilation system should be permitted to control smoke and provide fresh air for the evacuation of passengers and for support to the emergency responders. In addition, emergency tunnel lighting, fire detection, fire lines, and hydrants should be provided. Although pedestrians are not normally permitted in road tunnels, particularly long road tunnels, sidewalks are required in tunnels to provide emergency egress.

In order to avoid fires and other major accidents within the tunnel, TDOT may wish to restrict truck usage of the tunnel based on the cargo. Trucks with flammable loads or dangerous chemicals could use the existing US 64 roadway through the gorge.

4.7 DRIVER EXPERIENCE

Tunnel users would have not have views of the Cherokee National Forest, and instead would have their attention focused forward. Drivers would also not have the opportunity to pull off the road to experience prolonged views of the forest or access the forest for recreational purposes.

Studies have shown that some drivers experience anxiety and disorientation when driving in tunnels which could result in a decrease in usage of the tunnels. However the use of lighting and tunnel design can usually reduce the user discomfort.

4.8 AESTHETICS

The tunnel options would differ from the surface alternatives in that drivers using the tunnels through the Ocoee River Gorge would not have scenic views of the Cherokee National Forest in this area. Option T1 would provide daylighting for drivers on a 500-foot bridge spanning Goforth Creek; however, Option T2 would be a continuous 5.9 mile tunnel, with no views of the forest.

For users of the existing US 64 alignment, the tunnel alternative would introduce two portal areas which would likely be large enough to include emergency service and maintenance vehicles. For both tunnel options, the western portals would likely be visible from the existing US 64 alignment. The common portal area at the eastern end of the tunnel options in the vicinity of the Ocoee Whitewater Center would be visible to users of the existing US 64 alignment. The tunnels would pass through the Ocoee River Gorge Recreational Setting, and would allow views in that setting to remain largely uninterrupted.

4.9 WILDLIFE/HABITAT; DEFORESTATION

Both tunnel options would allow continued habitat connectivity north of the gorge in areas where the roadway is underground. In areas where the roadway is above ground, it would continue over bridges which would allow habitat connectivity underneath the bridge structure. The tunnel options would also minimize deforestation impacts compared to other new location alternatives. In addition, the tunnel options would have reduced light and noise impacts from vehicles compared to the other build alternatives. Light and noise coming from the approaches and portals of the tunnels could be reduced by using berms, dense vegetation, or a combination of both.

4.10 NATIONAL DEFENSE SAFETY AND SECURITY

US 64, from just west of the Ocoee River crossing to SR 68 is included in the National Highway System (NHS), US National Truck Network, and the defense-related Strategic Highway Network (STRAHNET). As part of the NHS and STRAHNET the subject project would represent a portion of an integrated transportation network intended to support the nation’s economy. Tunnel design would be accordance with federal highway safety and design guidelines.

Chapter 5.0 SUMMARY OF ALTERNATIVE COMPARISONS

Table 1 on the following page includes a highlighted list of impacts for both the five original surface alternatives and the two tunnel options. The table includes costs, transportation, and environmental impacts for all alternatives.

Table 1-1: Preliminary table of select impacts.

Resource Category	Alternative 1 (No-Build)	Alternative 2	Alternative 4	Alternative 5	Alternative 8A	Alternative 9	Option T1	Option T2
Total project length (miles)	23.0	22.3	21.2	21.6	21.4	21.1	21.1	20.8
Estimated cost of construction (millions $) (not including mitigation costs)	N/A	$819.70	$528.90	$489.60	$397.30	$382.4 / $504.8	$99.5 (million) – $8.5 (billion)	$99.5 (million) – $8.5 (billion)
Excavation quantities	N/A	57,356,000	16,237,000	15,196,000	14,690,000	14,109,000 / 12,254,000	9,032,000	8,776,000
Stream crossings (total, including intermittent)	54	60	73	70	64	60	44	43
Wetland cut/fill (acres)	0	1.03	0.04	0.04	0.67	0.67	0.67	0.67
Safety	No effect	Elimination or minimization of roadway deficiencies would provide safer driving conditions.	Diversion of traffic onto new location roadway is anticipated to reduce the number of crashes due to reduced exposure to traffic.	Diversion of traffic onto new location roadway is anticipated to reduce the number of crashes due to reduced exposure to traffic.	Diversion of traffic onto new location roadway is anticipated to reduce the number of crashes due to reduced exposure to traffic.	Diversion of traffic onto new location roadway is anticipated to reduce the number of crashes due to reduced exposure to traffic.	Diversion of traffic onto new location roadway is anticipated to reduce the number of crashes due to reduced exposure to traffic. Tunnel can be restrictive for EMS vehicles. Safety measures to create multiple access points can be constructed. Length of tunnel can distract driver.	Diversion of traffic onto new location roadway is anticipated to reduce the number of crashes due to reduced exposure to traffic. Tunnel can be restrictive for EMS vehicles. Length of tunnel can distract driver.
Transportation operations and maintenance	No impact	No adverse impact; Tunnel option would require additional operation and maintenance costs. Rockfall mitigation measures would reduce long term maintenance costs.	No adverse impact. Rockfall mitigation measures would reduce long term maintenance costs on new location section, but existing road through the Ocoee River Gorge would need long term maintenance from rockfalls.	No adverse impact. Rockfall mitigation measures would reduce long term maintenance costs on new location section, but existing road through the Ocoee River Gorge would need long term maintenance from rockfalls.	No adverse impact. Rockfall mitigation measures would reduce long term maintenance costs on new location section, but existing road through the Ocoee River Gorge would need long term maintenance from rockfalls.	No adverse impact; Tunnel option would require additional operation and maintenance costs. Rockfall mitigation measures would reduce long term maintenance costs on new location section, but existing road through the Ocoee River Gorge would need long term maintenance from rockfalls.	No adverse impact; Long tunnels would require significant additional operation and maintenance costs. Rockfall mitigation measures would reduce long term maintenance costs on new location section, but existing road through the Ocoee River Gorge would need long term maintenance from rockfalls.	No adverse impact; Long tunnel would require significant additional operation and maintenance costs. Rockfall mitigation measures would reduce long term maintenance costs on new location section, but existing road through the Ocoee River Gorge would need long term maintenance from rockfalls.

Chapter 6.0 REFERENCES

FHWA; *Technical Manual for Design and Construction of Road Tunnels – Civil Elements*, December, 2009

URS. 2014; *US 64/Corridor K Draft EIS*, October, 2014.

URS. 2014; *Tunnel Option Memorandum*, November 3, 2014

APPENDIX A

Tunnel Option Memorandum

ENVIRONMENTAL IMPACT STATEMENT

US 64/CORRIDOR K

FROM WEST OF THE OCOEE RIVER TO SR 68 NEAR DUCKTOWN

POLK COUNTY, TENNESSEE

TDOT PIN 102420.08

NOVEMBER 3, 2014

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INTRODUCTION

This memorandum provides preliminary information associated with consideration of a tunnel option for part of the US 64/Corridor K project through the Appalachian Mountains in Polk County, Tennessee. Further evaluations will be required to appropriately consider all issues for a Conceptual Study of the proposed tunnel project.

The Tennessee Department of Transportation (TDOT) is currently studying proposed improvement options for one of the last remaining sections of Corridor K to be addressed. This involves an approximate 24-mile segment of US 64, known as the Ocoee River Gorge section, that transverses the southeastern portion of the Cherokee National Forest. This is an existing two-lane highway. This remaining section of US 64/Corridor K being considered for improvements does not meet current highway design standards, and is located along a zone of high hazard for rockfalls.

TDOT has already completed various environmental impact statements for a number of improvement options. These are typically surface road options with, in some cases, short sections of tunnel. TDOT now wishes to consider an option that includes an approximate 6 mile tunnel between the eastern end of Parksville Lake and Gassaway Creek. Two preliminary tunnel options have been developed for consideration and are shown on Figures 1(Option T1) and 2 (Option T2).

Option T1 assumes two single-lane tunnels with an intermediate 500-foot long bridge located approximately 3.9 miles from the western portal.

Option T2 assumes a single, continues two-lane tunnel.

URS engineering staff and TDOT project management conducted a site visit on October 14, the photographic record is provided in Appendix A.

OBJECTIVES

The specific issues addressed in this preliminary memorandum are:

- possible tunnel cross sections;
- potential geological conditions and tunnel excavation methods; and
- possible ranges of tunneling costs based on a comparison with published and unpublished data for similar tunnels.

This memorandum concludes with an outline of the recommended tasks to complete a Conceptual Study for this project.

SCOPE OF WORK

The scope of work completed for this phase of the project includes:

- A one day site visit to the vehicle accessible sections of the project.
- A review of the available geotechnical information for the project corridor[1]
- A desk top review of available published and unpublished construction cost information for similar projects.

[1] Draft Geology Technical Memorandum , EIS US 64/Corridor K, March 2013

TUNNEL LAYOUT

Two preliminary options have been prepared. Conceptual level plans and profile graphics are shown on Figures 1 and 2. For the purpose of this memorandum, the following assumptions have been made regarding the layout of the tunnel:

- Option T1 has been assumed with two single-lane tunnels, each with a length of 6 miles (31,680 feet).
- A completed tunnel diameter in the order of 25 feet for each tunnel. This allows for a single highway, shoulders, and egress walkways[2].
- For maintenance and emergency egress purposes, cross adits will be required between the tunnels. Linear spacing of the adits may be in the order of 300 feet.
- The tunnel envelope will need to incorporate: ventilation; lighting; fire suppression systems; telecommunication; and drainage.
- With a single lane tunnel option it may be necessary to provide alcoves at regular spacing to accommodate disabled vehicles.

It should be noted that this preliminary evaluation has identified a number of road tunnels of similar or greater length than the proposed layouts for this project. In particular the Norwegians have completed at least two road tunnels in excess of 6 miles (Laerdal Tunnel - 15 miles completed in 2000 and Jondal Tunnel - 6.5 miles in 2012).

A summary of some relevant tunnel projects and associated characteristics is provided in the attached Table 1. As discussed at the end of this memorandum, if TDOT wish to proceed with a Conceptual Study for this project the database can be expanded to include further projects, including other relevant US road tunnel projects.

TUNNEL CONDITIONS

Geology

Figure 3 is a geology map for the site area from the Draft Geology Technical Memorandum completed for the EIS (March 2013). The available geological information indicates the tunnels will be predominately excavated in Pre-Cambrian age rocks of the Walden Creek Group. These rocks include sandstones, siltstones, argillaceous slate, and conglomerates of the Wilhite and Sandsuck Formations. Close to the western portals the geology map indicates the tunnel may encounter a regional scale fault called the Sylco Creek Fault. Towards the eastern end of the tunnels the geology map indicates the tunnels will pass from the Walden Creek Formation into older rocks of the Great Smokey Group. This group includes greywacke, arkose, conglomerates, and slates.

These two groups of rocks are folded and faulted and have a cleavage due to low grade metamorphism. Cleavage becomes more prominent in the rocks from west to east and generally dips to the south east.

The rocks are described as having multiple fracture orientations and fractures can be widely or closely spaced. This spacing description is not quantified in the available information. Bedding

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[2] Preliminary evaluation based on US DOT Technical Manual for Design and Construction of Road Tunnels

is described as being visible in most of the rocks. Slickensides are also mentioned associated with bedding and joint planes in some rock units. No other quantitative information was available regarding the rock mass characteristics or other geotechnical parameters for the rocks.

The geology memorandum also notes that these rocks can be acid producing. These potentially corrosive conditions will have implications for the design of tunnel support/drainage systems and the disposal of excavated tunnel spoil. It is addressed extensively in the geology report with respect to the excavation of road cuts and how these excavated materials may impact the environment. Similar issues will need to be considered for tunnel spoil disposal.

As noted above, the available information indicates that the tunnels will cross at least one major fault. Existing road cut excavations show that numerous other minor faults will also be encountered.

No information was available regarding the hydrogeology and permeability of the rock mass and how this may vary through the rock mass and in the vicinity of fault zones. Faults can often act as both barriers to groundwater flow perpendicular to the fault zone and as conduits to groundwater flow parallel to the fault zones.

Tunnel Construction

Long tunnels of this type are almost exclusively excavated by Tunnel Boring Machines (TBM) and this construction method is assumed for this project; albeit there would likely be some drill and blast construction and/or other methods for the portal, shafts, adits and other necessary appurtenant underground structures. The following are some preliminary observations regarding the proposed project based on the available information:

- The excavated tunnel diameter is likely to be in the order of 25 to 28 feet based on the assumption described above. As outlined in the attached Table 1, many tunnels have been completed with diameters in this range and tunnel diameter on its own is not likely to be a technical challenge.
- The available geological information indicates that tunneling conditions are likely to be generally classified as “hard rock”. The ground conditions and hydrogeology largely control the design of the TBM, and the tunnel initial and primary support systems. While at this stage of the project numerous unknowns still exist, the conditions outlined in this memorandum can be conducive for relatively good rates of TBM excavation.
- The general rock mass behavior during excavation along with fault zones and other areas of potential poor ground conditions and groundwater inflows will all influence TBM performance and tunnel support system requirements. The frequency and length of different rock mass zones and specific poor ground condition features encountered in the tunnel are a key design issue. Fractured rock masses are typically readily excavated by TBM. However, a fractured and faulted rock mass is also likely to require a systematic ground support system such as a combination of rock bolts, mesh and shotcrete. Increased levels of support (e.g.steel sets) may be required in areas of poor ground such as faults.
- The site visit identified that space is limited at some of the possible tunnel portal locations. Typically several acres are desirable for launching and receiving of the TBM and the disposal of excavated tunnel spoil. Consideration must also be given to the space required to construct portals and transition from tunnel to conventional surface roadway segments. Finally there could be a requirement for intermediate ventilation

shafts. These issues will require further consideration, as will the potential acid drainage producing nature of the excavated tunnel spoil.

This is not intended to be a complete list of tunnel excavation issues. However, the available information suggests that excavation of tunnels of the diameter described above in these rock conditions is theoretically feasible and has been completed elsewhere in the world for numerous projects. The occurrence of acid generating rocks is a site specific issue but this is not unique and has also been addressed in other projects.

TUNNELING COSTS

Tunnel project costs are dependent on a range of project specific criteria and a top down or bottom up cost estimate should be prepared for a project from as earlier stage as possible. The large number of variables makes comparisons with cost data from completed projects problematic. However, it can be useful to provide at least an indication of the possible range of likely construction costs. Table 1 lists a preliminary range of completed tunnel projects and published information regarding construction costs. The following observations are made regarding this information:

- Highway projects have been selected to ensure generally similar design criteria are applicable. However, two rail projects have also been included as design criteria are broadly the same.
- Projects have only been selected from North America and Europe where construction costs are, at a high level, broadly comparable.
- Costs have not been adjusted for inflation. However, to minimize the impact of this variable only projects from the past 10 years have been selected.
- Only TBM tunnel projects have been selected.
- Tunnels in various ground conditions have been selected although a number of these projects are in hard rock.
- The number of tunnels and the number of highway lanes per tunnel vary from project to project. This has a significant impact on tunnel costs per linear foot. To at least partially normalize the data for this issue column K on Table 1 shows the cost per highway lane per linear foot. This has been calculated by dividing the total tunnel cost (column I) by the length of tunnel in feet (column C) and by the total number of highway lanes (columns E x F).
- In column L the data from column K has then been used to calculate a range of comparison cost for construction of the proposed Corridor K Tunnel based on the assumption of two 6-mile tunnels, each with one highway lane (2 x 31,680 = 63,360 linear highway feet).
- Even with this partial normalization the calculated comparison costs for the proposed tunnel project still have a large range ($99 M to $8,400 M). However, the following should be noted:
- The higher projected costs (in excess of $3,000 Million) are based on complex projects in urban environments. Both of these issues significantly increase costs.
- The lower projected costs are generally associated with longer, hard rock tunnels in rural environments and are more similar to the proposed project.

- Of particular interest are the Jorndal and Eiksund Projects in Norway. Completed in 2012 and 2008 respectively, these two long tunnel projects were completed for approximately $121 M and $120 M each utilizing single two and three lane tunnels. An earlier 15 mile long tunnel (Laerdal Tunnel in 2000) was completed for $125 Million. This tunnel was not included in Table 1 due to the time elapsed since completion. The Norwegians have developed a reputation for completing comparatively low cost road tunnel projects although design criteria may not be similar to a US tunnel and ground conditions will also be different and these low costs should be treated with caution.

In summary, Table 1 demonstrates the inherent challenges associated with using completed project construction data to predict future project costs. However, it does provide a range of data and based on the types of projects, the costs for the proposed Corridor K tunnels may be towards the middle to lower end of this range.

FURTHER INVESTIGATION

If requested by TDOT, URS will provide further investigation of the following:

- Development of concept level design criteria for both proposed tunnel layouts (twin tunnels vs single tunnel).
- A desk top review of all available geological and geotechnical information for the project site and wider area.
- A walk-over study of the project site and mapping of selected outcrops to collect some quantitative rock mass characteristic information.
- Preliminary characterization of likely rock mass tunnel conditions along the tunnel length.
- Preliminary evaluation of likely initial tunnel support requirements, groundwater control measures, and tunnel lining.
- Development of concept level construction methodology along with identification of potential construction sites/spoil disposal areas and project sequencing.
- Further development of the database shown in attachment Table 1 and a top down project cost estimate with listing of appropriate assumptions and contingencies
- Development of preliminary risk register and identification of any potential fatal flaw issues.
- Comparative evaluation of tunnel alternatives with other conventional options using key project planning and design criteria (e.g. construction costs, environmental impact, operational issues, operation and maintenance costs, etc.)

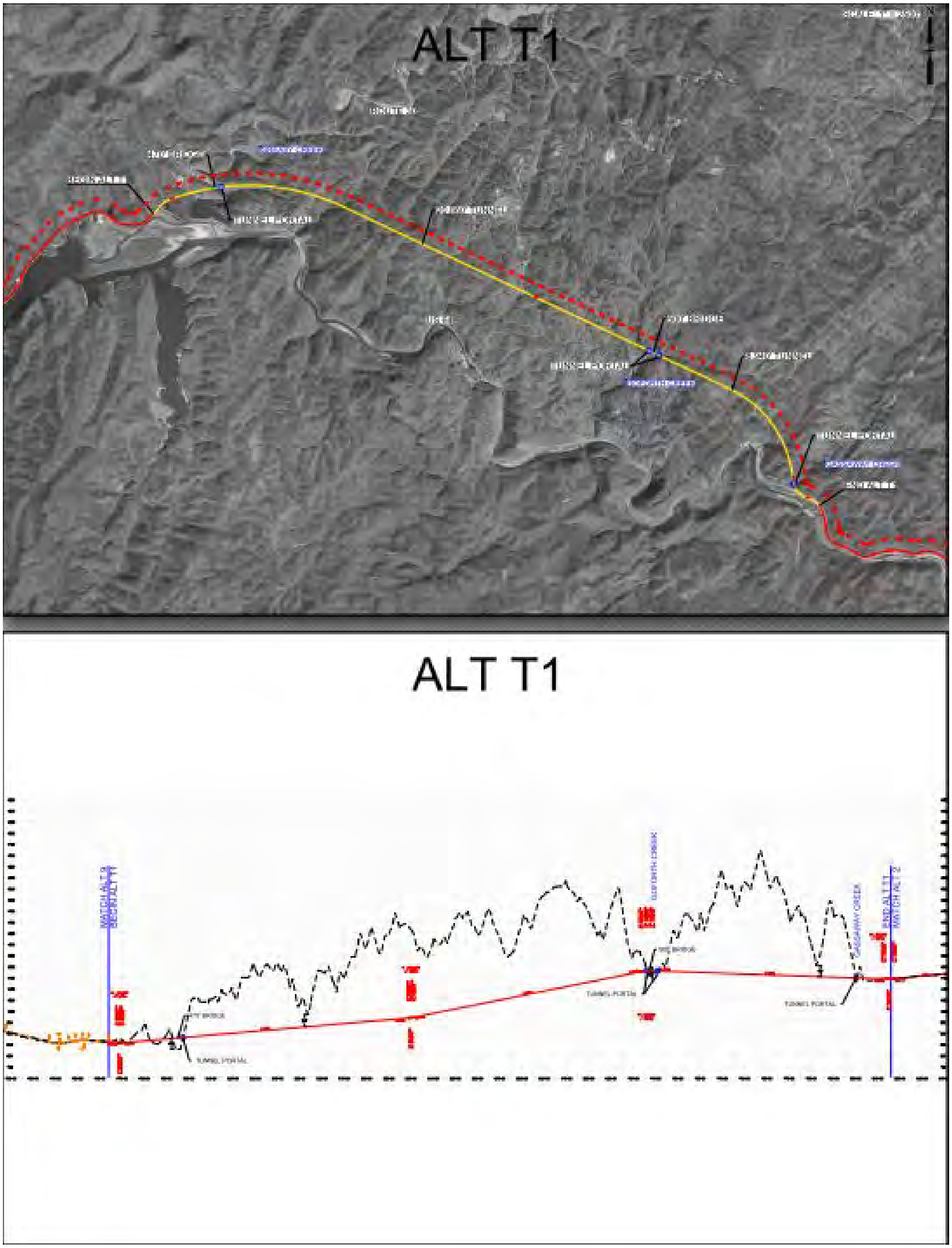


Figure 1 – Corridor K Tunnel Option T1

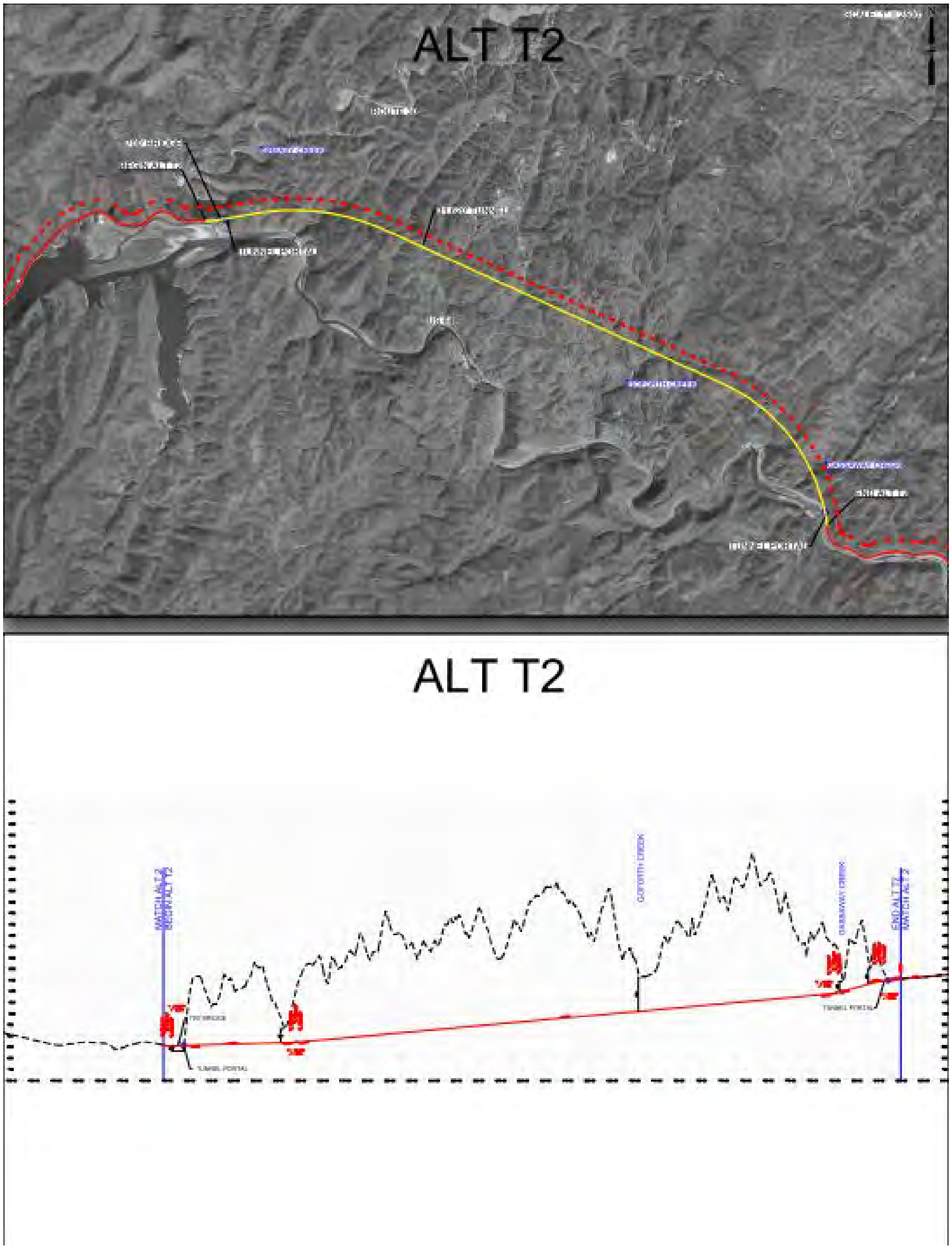


Figure 2 – Corridor K Tunnel Option T2

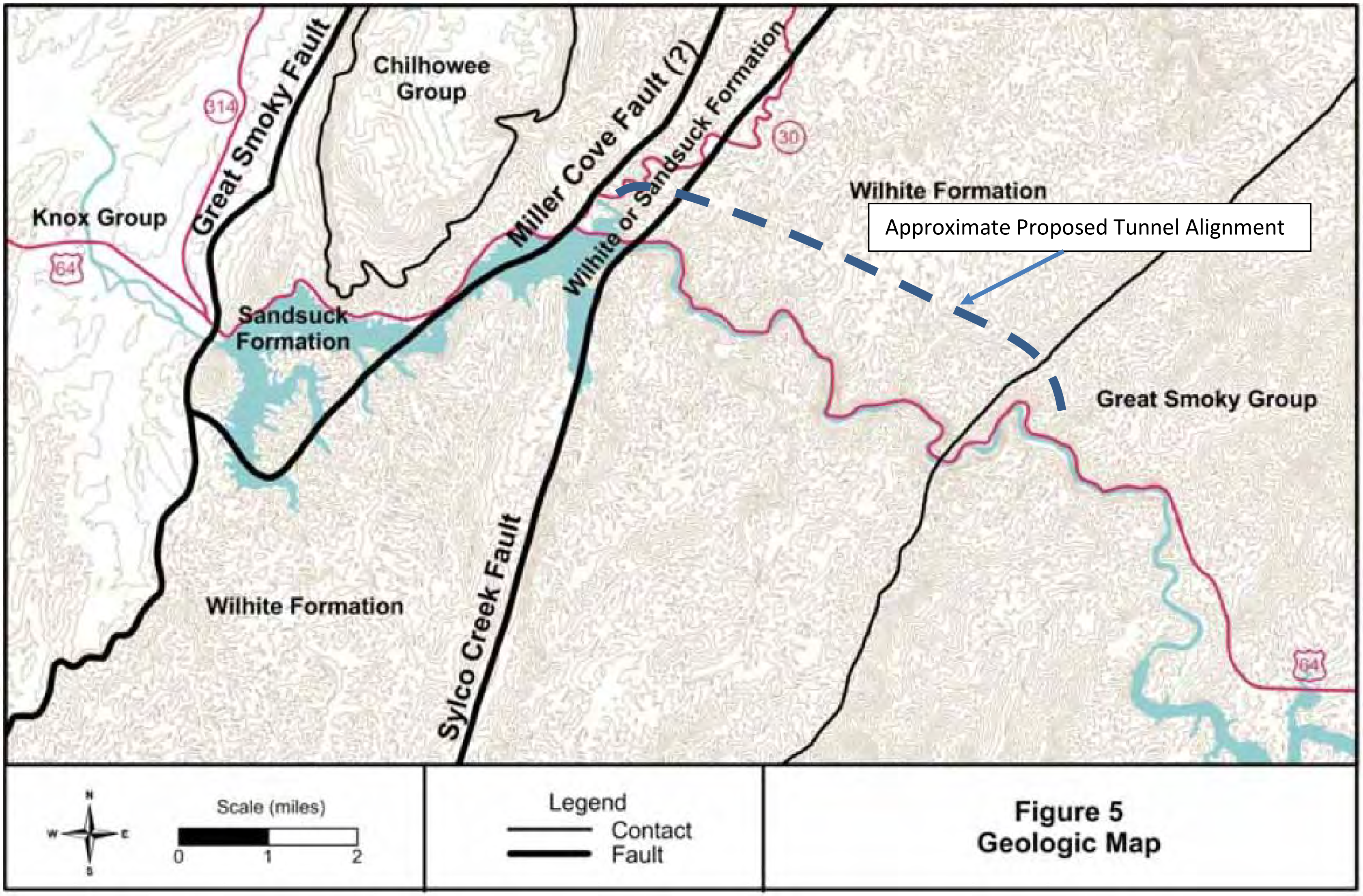


Figure 3 – Regional Geology Map from Draft Geology Technical Memorandum (March 2013)

Table 1 – Summary of Selected Published Data for Completed Tunnel Projects

A	B	C	D	E	F	G	H	I	J	K	L	M
Tunnel Project	**Location**	**Tunnel Length (linear ft)**	**Diamter (ft) - if known**	**No. of Tunnels**	**No. of lanes per tunnel**	**Construction Method**	**Ground Conditions - if known**	**Total Tunnel Cost (USD in millions)**	**Year Tunnel Completed**	**Cost/ Lane/ linear ft in USD Millions**	**Calculated Equivalent Cost of Corridor K Tunnels - USD in Millions (Column K x 63,360 feet = Column L)**	**Comments**
Legacy Way	Brisbane, Australia	15,423	41	2	2	TBM	Rock	$1,570	2014	$0.0509	**$3,224.90**	
Tunnels du Banne	Switzerland	3,563		2	2	TBM	Rock	$43	2004	$0.0060	**$382.33**	
Beacon Hill	Seattle, USA	5,280	21	2	1	TBM		$309	2009	$0.0585	**$3,708.00**	Light Rail
Pannerdensch Tunnel	Holland	8,790	28	2	1	TBM	Varied	$166	2004	$0.0189	**$1,196.56**	Rail
Westeschelde	Holland	21,648	37	2	2	TBM		$1,000	2003	$0.0231	**$1,463.41**	
Dublin Port	Ireland	15,312	38	2	2	TBM	Rock	$1,000	2006	$0.0327	**$2,068.97**	
Wesertunnel	Germany	8,448	37	2	2	TBM	Soft Ground	$275	2004	$0.0163	**$1,031.25**	
A86	Paris, France	32,800	37	1	4	TBM		$4,176	2009	$0.0318	**$2,016.70**	
Port of Miami	Miami, USA	4,200	35	2	2	TBM		$667	2014	$0.0794	**$5,031.09**	
Eiksund Tunnel	Norway	25,476	33	1	3	TBM	Rock	$120	2008	$0.0016	**$99.48**	
Alaskan Way	Seattle, USA	10,560	57	2	2	TBM		$2,800	Under Construction	$0.1326	**$8,400.00**	
Airport Link	Brisbane, Australia	22,304		2	2	TBM	Rock	$2,800	2010	$0.0628	**$3,977.04**	
Jorndal Tunnel	Norway	34,320		1	2	TBM	Rock	$121	2012	$0.0018	**$111.69**	

Notes: Two single-lane, 6 mile long tunnels, equals 31,680 linear feet each and 63,360 linear highway feet in total.

APPENDIX A

PHOTOGRAPHIC RECORD OF SITE VISIT

Photographic Record:
Feasibility Study Site Walk
October 14, 2014

Tennessee Department of Transportation
US 64 /Corridor K
Tunnel Alternative Feasibility Study
Polk County, Tennessee

Prepared by URS Corporation

400 Northpark Town Center
1000 Abernathy Rd NE Suite 900
Atlanta, GA 30328

URS Project Number: 31826571

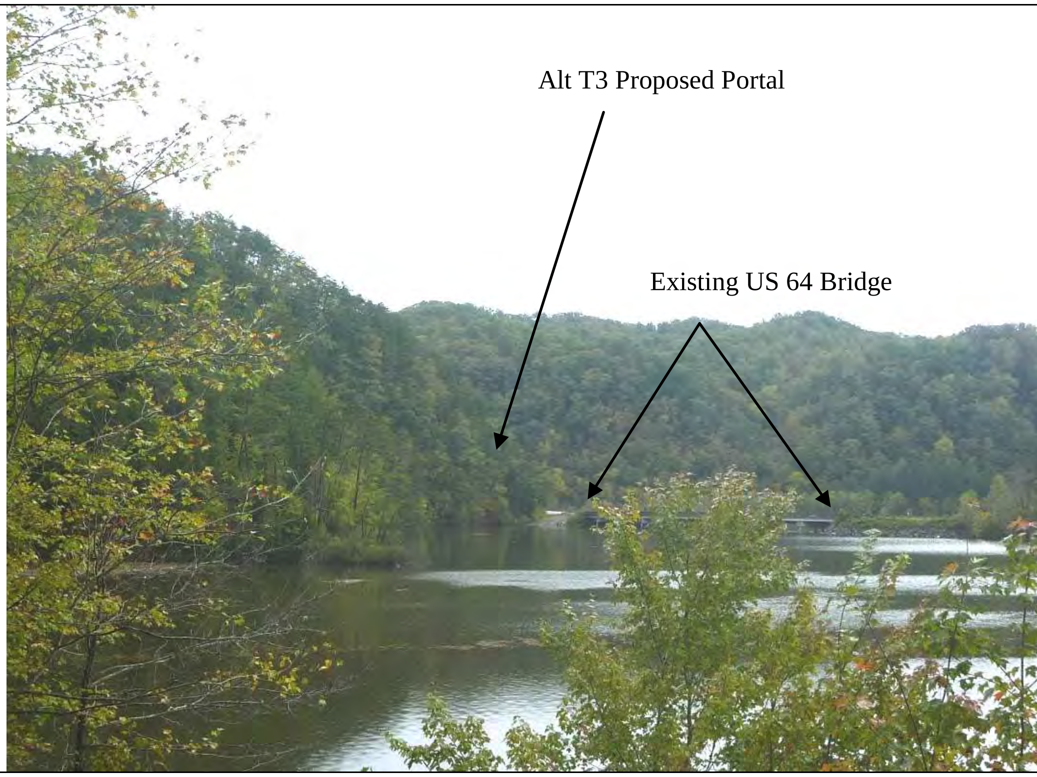
Photo #: 1	
Photo Filename: P1050235.jpg	
Date of Photo: 10/14/2014	
Location: Greasy Creek	
View Direction: SE	
Description: View across Greasy Creek towards existing US 64 Bridge and portal location for Alt T3. Access via park/campground road off of US 30.	

Photo #: 2	
Photo Filename: P1050240.jpg	
Date of Photo: 10/14/2014	
Location: US 64 shoulder	
View Direction: NE	
Description: Curve approaching east side of existing bridge crossing Greasy Creek. South side of hillside at Alt T3 portal location shown on left.	

Project Number: 31826571	**Project Location:** Polk County, TN	**Prepared By:** Lance Finnefrock, P.E.

Photo #: 3	
Photo Filename: P1050242.jpg	
Date of Photo: 10/14/2014	
Location: US 64 shoulder	
View Direction: E	
Description: Slope face at proposed beginning portal location for tunnel Alt T3. Very limited work space for tunnel launch area due to close proximity to bridge and confluence of Greasy Creek and the Parksville Lake. Potential solutions could include over-water work platform (e.g. temporary floating structure or permanent piled structure) or massive rock cut into hillside.	

Photo #: 4	
Photo Filename: P1050243.jpg	
Date of Photo: 10/14/2014	
Location: US 64 shoulder	
View Direction: NW	
Description: Confluence of Greasy Creek and Parksville Lake. Extremely limited work space at Alt T3 portal location.	

Photo #: 5	
Photo Filename: P1050246.jpg	
Date of Photo: 10/14/2014	
Location: US 64 shoulder	
View Direction: NW	
Description: Exposed rock outcrop along south side of hillside at Alt T3 portal location. Notice steeply-inclined cleavage and/or bedding dip.	

Photo #: 6	
Photo Filename: P1050245.jpg	
Date of Photo: 10/14/2014	
Location: US 64 shoulder	
View Direction: N	
Description: Exposed rock outcrop along south side of hillside at Alt T3 beginning portal. Notice steeply-inclined cleavage and/or bedding dip.	

Photo #: 7	
Photo Filename: P1050247.jpg	
Date of Photo: 10/14/2014	
Location: US 64 shoulder	
View Direction: N	
Description: Close-up view of rock outcrop.	

Photo #:
8

Photo Filename:
P1050249.jpg

Date of Photo:
10/14/2014

Location:
US 64 shoulder

View Direction:
n/a

Description:
Sample of rock outcrop formation, from previous rockfall. Note planar, fissile bedding and/or cleavage.

Photo #:
9

Photo Filename:
P1050281.jpg

Date of Photo:
10/14/2014

Location:
Greasy Creek

View Direction:
E/SE

Description:
View from west side of Greasy Creek, looking towards Alt T portal location. No clear access to the east side was evident during site visit. Significant clearing on both sides of the creek would be required.

Photo #: 10	
Photo Filename: P1050256.jpg	
Date of Photo: 10/14/2014	
Location: Maddens Branch Creek / US 64	
View Direction: NW	
Description: Recent rockslide at proposed Alt T2A bridge location. Proposed portal location at right would require massive rock cut for access. Open cut required on west side of creek.	

Photo #: 11	
Photo Filename: P1050250.jpg	
Date of Photo: 10/14/2014	
Location: Maddens Branch Creek / US 64	
View Direction: NW	
Description: Rock outcrop referred to as “the bulge”. TDOT staff indicated white painted areas exhibited several inches of outward movement following a recent rockslide to the east.	

Photo #: 12	
Photo Filename: P1050253.jpg	
Date of Photo: 10/14/2014	
Location: Maddens Branch Creek / US 64	
View Direction: N	
Description: Jointed rock mass near "the bulge".	

Photo #: 13	
Photo Filename: P1050254.jpg	
Date of Photo: 10/14/2014	
Location: Maddens Branch Creek / US 64	
View Direction: N	
Description: Folding and faulting in the rock mass just east of "the bulge".	

Photo #: 14	
Photo Filename: P1050257.jpg	
Date of Photo: 10/14/2014	
Location: Ocoee Dam #2	
View Direction: NW	
Description: Location of 2009 rock slide, which closed US 64 for several months. Slide surface has been stabilized with patterned rock bolts.	

Photo #: 15	
Photo Filename: P1050263.jpg	
Date of Photo: 10/14/2014	
Location: US 64	
View Direction: NW	
Description: Preferred location of tunnel end portal for all alternatives due to low point (draw) in hill range. Less mass excavation would be required here than surrounding areas to provide staging area/access.	

Photo #: 16	
Photo Filename: P1050265.jpg	
Date of Photo: 10/14/2014	
Location: Goforth Creek / US 64	
View Direction: NW	
Description: View from US 64 looking NW along Goforth Creek.	

Photo #: 17	
Photo Filename: P1050279.jpg	
Date of Photo: 10/14/2014	
Location: Goforth Creek, <1 mi north of US 64	
View Direction: S	
Description: Trail along Goforth Creek leading from US 64 to proposed tunnel creek crossing. Not suitable for construction traffic due to whitewater rafting and fishing in the creek along this trail.	

Photo #: 18 & 19	 
Photo Filename: P1050271.jpg P1050272.jpg	
Date of Photo: 10/14/2014	
Location: Goforth Creek	
View Direction: NE (top) N (bottom)	
Description: Field near alignment crossing of Goforth Creek. Creek is past treeline ahead. Relatively flat area supports staging area for tunnel daylight & overland bridge, but no access from US 64 to the south. Construction access would need to be via improved forestry roads from the north.	

Photo #: 20	
Photo Filename: P1050277.jpg	
Date of Photo: 10/14/2014	
Location: Goforth Creek	
View Direction: East	
Description: Alignment creek crossing at Goforth Creek. Area is flat enough to support staging area for portal and bridge, but limited access to area. Temporary bridge over creek required for access.	

Photo #:	21
Photo Filename:	P1050274.jpg
Date of Photo:	10/14/2014
Location:	Goforth Creek
View Direction:	East
Description:	Location of proposed alignment crossing Goforth Creek.

Photo #:	22
Photo Filename:	P1050236.jpg
Date of Photo:	10/14/2014
Location:	US 64
View Direction:	East
Description:	Approx. 1000 ft east of Alt T tie-in to US 64, located west of Greasy Creek. Existing bridge in distance. Note tanker truck traffic.