Appendix B-3
Independent Tunnel Feasibility Study
I-81
INDEPENDENT FEASIBILITY STUDY
November 2017
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EXECUTIVE SUMMARY

1.1 PROJECT OVERVIEW

WSP has conducted this I-81 Independent Feasibility Study (Independent Feasibility Study) of the I-81 viaduct within the designated Study Area in Syracuse, New York, because the current infrastructure is approaching the end of its service life. This I-81 Independent Feasibility Study is to ensure that a tunnel and depressed highway were sufficiently analyzed to assess their feasibility and cost. In addition, this study examines alternatives that would adequately provide for vehicular traffic to replace the existing I-81 viaduct through the center of Syracuse. This study works “independently” from previous efforts that analyzed I-81 in Syracuse—such as the I-81 Corridor Study, I-81 Viaduct Project, and the I-81 Draft Environmental Impact Statement, which is underway.

As documented within previous I-81 Viaduct Project efforts, the I-81 viaduct and I-81/I-690 interchange have been the subject of community and agency concerns because of ongoing congestion and safety issues, as well as aging infrastructure. The I-81 Corridor Study identified a section of I-81 and I-690 in and near downtown Syracuse as a priority area for improvements due to a concentration of structural and geometric deficiencies, as well as frequent congestion and high vehicle crash and collision rates. Although the I-81 corridor is maintained in a state-of-good repair to ensure that its structural integrity remains safe for the travelling public, continued deterioration could lead to increased maintenance costs, weight and speed restrictions on bridges, and potentially, eventual closure of bridges.

This Independent Feasibility Study report summarizes the technical feasibility and cost of the depressed highway and tunnel alternatives. The report also documents the engineering and analyses performed, the construction cost estimates, construction duration, and the operations and the maintenance costs of the potential alternatives.

1.2 STUDY AREA

The Study Area for this Independent Feasibility Study encompasses the general downtown Syracuse neighborhood, and portions of the Park Avenue, Franklin Square, Prospect Hill, Hawley-Green, Southside, and University Hill neighborhoods. I-81 and I-690 are the two critical highways that bisect the Study Area and provide key connections to the downtown and metropolitan area for residents, employment, and students. Along I-81, the Study Area extends from Bear Street W. in the north, to just south of Martin Luther King E. in the south. Along I-690, the Study Area extends from N. Geddes Street in the west, to Walnut Street in the east (Figure 1).

1.3 INDEPENDENT FEASIBILITY STUDY PURPOSE

This Independent Feasibility Study is to ensure that tunnel and depressed highway alternatives were sufficiently analyzed to assess their feasibility, cost, and their ability to meet project goals of the overall I-81 Viaduct Project.

This report is a technical engineering report and not an environmental study. This I-81 Independent Feasibility Study was not prepared in accordance with the Department’s Project Development Manual, NEPA, SEQRA and the Viaduct Project’s August 2013 Notice of Intent to Prepare a DEIS. The I-81 Independent Feasibility Study did not study the social, economic, and environmental considerations required by NEPA and SEQRA.

If it is determined that a tunnel alternative is to be considered for further study in the I-81 Corridor DEIS, it will be subject to review under NEPA, SEQRA, etc. to determine if it is feasible and practical. In addition, connections between Interstates and any modifications to the Interstate access would need to be considered and approved by FHWA.

To provide cohesive comparisons between the alternatives put forth in this Independent Feasibility Study—and those

FIGURE 1: I-81 Independent Feasibility Study – Study Area
that have been previously developed—this study used the same two goals established for the overall I-81 project:

1. Improve safety and create an efficient regional and local transportation system within and through greater Syracuse.

2. Provide transportation solutions that enhance the livability, visual quality, sustainability, and economic vitality of greater Syracuse.

Section 2.2 provides the full list of goals and objectives that were used to develop and analyze the alternatives advanced throughout this study.

1.4 TUNNEL SOLUTIONS FOR HIGHWAYS

Placing urban highways in tunnels has several advantages and disadvantages compared with viaduct or at-grade solutions, but there are many considerations to determine the best design and construction approaches. What size of tunnel can be accommodated? What are the optimal construction methods? How can the existing highways be connected to the tunnel facility? What safety features are required in the tunnel?

Ground conditions in Syracuse are characterized by urban fill over varying glacial deposits (sands, gravels, boulders, silts, clays), over shale bedrock with potentially high in-situ horizontal stresses, and groundwater with a high saline content. Current tunneling techniques for both cut-and-cover or mined options, using a custom-designed and manufactured tunnel boring machine (TBM), can deal with the ground and water conditions. Techniques to build tunnels in coastal areas adjacent to seawater can be adapted and applied to the saline groundwater conditions here. The challenges of tunneling in an urban area include selecting an alignment that would avoid deep piles below buildings and other structures, performing ground improvement (such as grouting or ground freezing), and underpinning nearby structures as tunneling proceeds.

Constructing a tunnel facility is a significant undertaking, but by working with the community, construction and traffic impacts may be mitigated. There are suitable open areas adjacent to existing I-81 facilities where future roadway connections can be made, and that can be used during tunnel construction operations for material staging and spoil (muck) handling and hauling operations. An example of mitigating an impact would be to require spoil dump trucks to operate during daytime hours in order to reduce nighttime noise.

Tunnels for highways would be designed to comply with National Fire Protection Association (NFPA) 502: Standard for Road Tunnels, Bridges, and Other Limited Access Highways. In addition to meeting the geometric requirements for roadways, the tunnel facility would provide a safe environment for roadway operations and would support emergency responses. Hazardous cargo and fuel trucks would be prohibited from using the tunnel. The tunnels would have a ventilation system to ensure the air is safe during traffic made up of internal combustion engine vehicles and to provide the ability to control smoke and heat in an emergency fire condition. The ventilation system would work in conjunction with fire detection and protection systems. In case of emergency, emergency egress routes for people to walk out of the incident tunnel would be provided. The roadway would be well lighted and signed for both day-to-day operations as well as under emergency conditions, to include traffic control systems, dynamic (variable) message signs, and closed-circuit televisions. The tunnel would have drainage systems to control stormwater as well as water within the tunnel to include that from maintenance washing and fire suppression. All water collected in the tunnels will be sent to the appropriate facility for treatment before discharge.

Please see the body of the report and appendices for more information and details on the topics mentioned above.
FIGURE 5: Jet Fan System

FIGURE 6: Semi-Traversal Point Exhaust System

FIGURE 7: Single Bi-Level Tunnel with Jet Fan Instillation

FIGURE 8: Dynamic (Variable) Message Signs (DMS)

FIGURE 9: Twin Bored Tunnel with Configurations with Cross Passages
1.5 COMMUNITY GRID SOLUTIONS

All of the alternatives examined as part of this study would replace and remove the existing I-81 viaduct in downtown Syracuse. This would require reconstruction of the Almond Street corridor and its intersecting streets. To be feasible, the depressed highway or tunnel alternatives would need to operate in conjunction with an improved surface street condition, which would have to accommodate most traffic to and from downtown. Therefore, it became apparent that each of the alternatives inherently need to incorporate some version of the Community Grid Alternatives established in the I-81 Viaduct Project Scoping Report and currently being analyzed as part of the Draft Environmental Impact Statement. Each tunnel option would likely have a different approach to implementing a community grid system. These alternatives could improve downtown vehicular traffic, and pedestrian and bicycle connectivity, while providing state land disposition opportunities and economic development potential. Applying these same principles, each tunnel alternative explored as part of this study would be in essence a hybrid approach. In other words, each tunnel alternative would be coupled with a supportive community grid improvement alternative to maximize downtown and regional connectivity.

Each alternative that meets the major goals of this study would affect not only traffic conditions on the highways but also on local streets. To maintain a similar amount of access to the downtown area, some existing ramps would be replaced with local access routes that would use existing corridors such as Almond Street and Erie Boulevard. These and some of the smaller roadways that provide important east-west and north-south connections through the downtown area would need to be improved to accommodate a higher level of traffic demand while balancing the needs of pedestrians and bicyclists. Therefore, the level of enhancement of the local streets would largely depend on the percentage of traffic that uses the I-81 viaduct that will divert to the surface street network (rather than into the tunnel, or onto alternative routes). Geometric features such as the number of lanes, lengths of turn bays, and new connections were considered for each alternative. Other intersection features such as signal timing and progression were also relied upon in terms of their ability to convert the existing street network into a viable community grid that would help distribute traffic as efficiently as possible.
FIGURE 12: Existing Almond Street and Jackson Street

FIGURE 13: Almond Street and Jackson Street Perspective
1.6 WHAT ALTERNATIVES ARE BEING CONSIDERED?

This Independent Feasibility Study addresses the needs and challenges in downtown Syracuse and the overall region. A long list of tunnel and depressed highway alternatives, in combination with a community grid element, were identified for consideration for their ability to improve local and regional mobility and connectivity, and to strive to promote economic growth.

We conducted a public outreach effort to help guide alternative development ideas and assist the study team with evaluation criteria and measures.

The I-81 Independent Feasibility Study began with the intent of evaluating two depressed highway alternatives and two tunnel alternatives, each with and without Community Grid improvements. (Figure 14)

Two depressed highway alternatives were examined, both along the exiting I-81 corridor. Depressed highways are structurally similar to cut-and-cover tunnels, but have no roof and could be built at a shallower depth. The long-term impact on the urban landscape would typically be worse than cut-and-cover tunnels since the highway trench would reduce connectivity between neighborhoods, especially if the highway were too shallow to allow the existing street pattern to be maintained.

Seven tunnel alternatives, with various sub-options were considered. Highways in tunnels are “out of sight and out of mind,” compared with elevated, at-grade, or depressed alternatives. Removing some of the existing highway viaducts from the urban landscape and placing highways in tunnels create conditions that promote urban renewal. However, for traffic to descend into a tunnel from a viaduct or other highway, a transition structure is required with sections that are either elevated, at-grade, or depressed. Minimizing any negative impact of these transition sections on downtown Syracuse while achieving the objectives for traffic flow were key considerations during this study.

The two applicable tunneling methods would be bored and cut-and-cover. Bored (or mined) tunnels would be constructed using TBMs. These machines can be operated to result in negligible settlement at the ground surface, which can allow tunnels to be constructed under existing buildings, streets and other infrastructure with minimal disturbance.

Cut-and-cover tunneling would involve excavating a trench that is wider than the highway. This would require moving existing features within the footprint to be removed, which limits its potential in urban areas. Upon completion, the land over the tunnel could be redeveloped. Cut-and-cover tunnel alignments were studied among the existing interstate corridors and on certain nearby city streets. Limited additional sections of cut-and-cover tunnel were studied where such tunnels would be required for transitions into bored tunnels.

As each alternative examined included demolition of I-81 viaduct, it became clear that just relocating I-81 into a tunnel or depressed highway alignment would not work without reconstruction of local city streets. Therefore, it was determined that each alternative examined would include community grid improvements. The community grid includes enhancements to existing streets along the I-81 corridor, and elsewhere. The studied alternatives would have fewer connections between the interstates and the city streets than presently exist. The enhanced street grid would allow for local flow of traffic and connectivity.

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**FIGURE 14:** Proposed Alternatives
FIGURE 15: Solid Pile and Lagging, 2nd and Hope Station, Metro Regional Connector, Los Angeles, CA

FIGURE 16: TBM Tunneling in Saline Conditions, Miami, FL

FIGURE 17: Double-Deck Tunnel, Seattle, WA
1.7 KEY FINDINGS & CONCLUSIONS

The original study scope anticipated developing two tunnel alternatives and two depressed highway alternatives—all with and without community grid improvements. The existing I-81 and I-690 interstate systems in downtown Syracuse are largely on viaduct structures. The key challenge to take an elevated highway (I-81) and place it underground but try to re-establish connections with I-690 that would remain elevated. The team briefly considered placing both interstates underground, but trying to establish an underground interchange was quickly determined to not be a feasible alternative due to constructibility issues, property required, as well as high cost.

After initial development of two depressed highway alternatives and seven potential tunnel alternatives, an initial screening was conducted. The study team came to consensus on the following points: The depressed highway alternatives did not meet the goals of the study. The options would further divide neighborhoods and close off more local streets. Significant construction challenges for utility relocations and to keep I-81 viaduct open during construction (or electing to close I-81 for several years to allow construction) are additional disadvantages for these alternatives. Depressed highway alternatives are not recommended and were eliminated from further study.

Community grid improvements are integral to each tunnel alternative that was examined. It is clear that no alternative should be recommended without community grid improvements.

The seven tunnel alignments were reviewed and Green, Yellow and Purple alternatives were dismissed from further consideration and study.

Therefore, the Independent Feasibility Study shifted to examine in greater detail four tunnel alternatives, each with community grid improvements. These tunnel alternatives would have different northern portals and roadway connections that would provide distinct choices and unique features as to the advantages and disadvantages. These four tunnel alternatives carried forward are as follows:

- The Red Alternative would minimize construction complexity and risk by mining under I-690 without a direct interstate-to-interstate connection.
- The Orange Alternative would maintain connectivity between I-81 and I-690, including reconstruction and improvement of the I-690 viaduct.
- The Green Alternative would maintain connectivity between I-81 and I-690, while maximizing the use of the existing I-690 infrastructure. It would also minimize easements required outside of the public right-of-way.
- The Blue Alternative would maintain connectivity between I-81 and I-690, while facilitating future reconstruction of the I-690 viaduct. It would also minimize weaving maneuvers between I-81 and I-690 and minimize disruption to interstate traffic during construction.
Short Depressed Highway Alternative

**Aligned along the existing I-81 Viaduct**

**Length**: 0.65 Miles

**Schedule**: 7-10 Years *

**Cost**: $3-3.5 B*

**Property**: No full takings | No building takings

**Advantages**:
- Maintains existing connections to I-690
- Short alignment / lower cost
- Martin Luther King Boulevard could remain open

**Disadvantages**:
- Permanent division of City with limited (or no) connections to community grid
- Extended closure of I-81 during construction
- Major disruption to city streets during construction
- Multiple city streets closed permanently
- Snow removal difficult

*If I-81 is closed and demolished before construction, cost is lower and duration is shorter. If I-81 remains open during construction, cost is higher and duration is longer.*

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Long Depressed Highway Alternative

**Aligned along the existing I-81 Viaduct**

**Length**: 0.9 Miles

**Schedule**: 7-10 Years *

**Cost**: $3.5 - 4 B

**Property**: No full takings | No building takings

**Advantages**:
- Maintains existing connections to I-690
- Martin Luther King Boulevard could remain open
- Relatively short

**Disadvantages**:
- Permanent division of City with limited (or no) connections to community grid
- Extended closure of I-81 during construction
- Major disruption to city streets during construction
- Harrison Street closed permanently
- Buried valley crossing the alignment result in deep walls and high cost

*If I-81 is closed and demolished before construction, cost is lower and duration is shorter. If I-81 remains open during construction, cost is higher and duration is longer.*
Red Alternative

**GENERALLY ALIGNED WEST OF THE EXISTING I-81 VIADUCT, ALONG SOUTH TOWNSEND STREET.**

**LENGTH** 2.2 Miles

**SCHEDULE:** 9 Years

**COST:** $3.3 B | Tunnel Work - 70%  Surface Work - 30%

Annual O&M Cost: $14 M

**PROPERTY**

Total full takings: 30 | Total full takings with buildings: 17

2 historic building takings - 315/329 North Salina Street (Optional)

**ADVANTAGES:**

- Favorable geometry for a tunnel mining portal south of the railroad
- Avoids risk of tunneling under I-81
- Construction costs are relatively low compared to orange and green alternatives

**DISADVANTAGES:**

- No direct connection between I-81 and I-690
- Traffic interstate connection viable by I-481 and I-90
- Passes under private land

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**Red North Portal - Looking South Along I-81 Towards Downtown Syracuse**

**Red Alternative Composite Map**

**Red Alternative**

**GENERALLY ALIGNED WEST OF THE EXISTING I-81 VIADUCT, ALONG SOUTH TOWNSEND STREET.**

**LENGTH** 2.2 Miles

**SCHEDULE:** 9 Years

**COST:** $3.3 B | Tunnel Work - 70%  Surface Work - 30%

Annual O&M Cost: $14 M

**PROPERTY**

Total full takings: 30 | Total full takings with buildings: 17

2 historic building takings - 315/329 North Salina Street (Optional)

**ADVANTAGES:**

- Favorable geometry for a tunnel mining portal south of the railroad
- Avoids risk of tunneling under I-81
- Construction costs are relatively low compared to orange and green alternatives

**DISADVANTAGES:**

- No direct connection between I-81 and I-690
- Traffic interstate connection viable by I-481 and I-90
- Passes under private land
**Orange Alternative**

**ALIGNED IMMEDIATELY WEST OF THE I-81 VIADUCT.**

- **LENGTH:** 1.6 Miles
- **SCHEDULE:** 9 Years
- **COST:** $3.6 B | Tunnel Work - 50%  | Surface Work - 50%
  Annual O&M Cost: $10 M
- **PROPERTY:** Total full takings: 22  | Total full takings with buildings: 12
  1 historic building takings- 315 North Salina Street (Optional)
- **ADVANTAGES:**
  - Enables connections to I-690
  - Relatively short tunnel
  - Reconstruction of I-690 fixes non-conforming features
- **DISADVANTAGES:**
  - Replacement of the railroad bridge at Burt Street. Impact to railroad operations.
  - Passes under multi-story parking structure for Madison Towers
  - Passes under private land

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**Orange Portal - Looking South East Near Downtown Syracuse**

**Orange Alternative Composite Map**
Green Alternative

Aligned Immediately East of the I-81 Viaduct.

**Length:** 1.2 Miles  
**Schedule:** 9 Years

**Cost:** $3.0 B | Tunnel Work - 60%  
Surface Work - 40%

Annual O&M Cost: $8 M

**Property:**
Total full takings: 6  
Total full takings with buildings: 2  
No historic building takings

**Advantages:**
- Enables connections to I-690, while limiting modifications to the existing I-690 roadways and structures
- Relatively short tunnel
- Requires less reconstruction of I-690 than the Orange Alternative

**Disadvantages:**
- Does not address I-690 deficiencies and limits future options for improving I-690
- Confined geometry throughout
- Requires permanent closure of Water Street, Washington Street and E Fayette Street
- I-690 WB to I-81 SB connection will be permanently removed
Blue Alternative

Aligned southwest of downtown Syracuse, and connects into West Street close to the interchange with I-690.

Length: 2.6 miles
Schedule: 10 years
Cost: $4.5 B | Tunnel work - 75% | Surface work - 25%
Annual O&M cost: $17M

Property: Total full takings: 42 | Total full takings with buildings: 22 | No historic building takings

Advantages:
- Avoids risk of tunneling under I-81 (encountering piles, settlement)
- Has limited impact on I-690 elevated section.
- Uses existing West Street interchange (with modifications) for connecting to I-690

Disadvantages:
- Longest tunnel
- Property acquisitions required at West Street
- Utility relocations required at West Street
As mentioned above, the community grid is a vital part of all options, with a central Almond Street corridor that would provide connections for local traffic to efficiently reach local destinations and to access the interstate highways. Each alternative appears to be technically feasible, but the estimated costs and benefits would be different. Future studies could combine certain attributes from two or more alternatives.

Please refer to Chapter 5 for details on the connections and functions that would be achieved by each alternative. The design and construction of any of these tunnel alternatives in downtown Syracuse would be a major undertaking. The capital costs would be significant and are summarized in Table 1. (See Section 5.7 and Appendix K for more.)

Costs include:
- Tunneling and Heavy Civil
- Ventilation and Fire Life Safety Systems
- Bridge & Ramp
- Civil Highway
- Right of Way and Property Easement
- Soft Costs
- Escalation and risk reserve

The project schedule was developed starting at the end of the environmental process with receipt of the Record of Decision (ROD). The time to complete the required geotechnical exploration program, obtain needed permits, procure needed property for right-of-way and perpetual subterranean easements, complete final design, construct the new facilities and demolish the existing viaduct would take about nine years (plus or minus). The project could be delivered by conventional design-bid-build or by an alternative delivery method such as design-build. (See Section 5.8 for more.)

As presented in more detail in Chapter 6, Table 2 summarizes how each of the four final alternatives compares in relation to the I-81 Viaduct Project goals.

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<tr>
<th>Alternative</th>
<th>Cost</th>
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<tr>
<td>Red</td>
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<td>Orange</td>
<td>$3.6 B</td>
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<td>Green</td>
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<td>Blue</td>
<td>$4.5 B</td>
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**TABLE 1:** Alternative Cost Estimates

It is technically feasible to design and construct a tunnel alternative that meets the study goals and improve the transportation system in Syracuse metropolitan area.

A tunnel alternative is not the low cost option.

Community grid improvements must be incorporated into all alternatives that remove the I-81 viaduct.
If a tunnel alternative is determined to be considered further for study in the I-81 Corridor DEIS, the Orange Alternative, as presented in the I-81 Independent Feasibility Study, is recommended as the tunnel option to be included. The tunnel portion is relatively short compared to other alternatives and the north portal would be near the existing I-81 and I-690 interchanges. This alternative would also reconstruct and reconfigure significant portions of I-690 to make better connection to I-81 coming out of its tunnel, which would drive the cost higher than other alternatives, but would provide more benefits (as shown in the Table 22, the Alternative Comparison Matrix in Chapter 6 on page 93).

Please note that comparing the tunnel alternatives in this Independent Feasibility Study to the rebuild the viaduct alternative, the community grid alternative, or the no-build alternative was beyond the scope of this study.
2 PROJECT PLANNING CONTEXT

2.1 PROJECT OVERVIEW & HISTORY

The Interstate-81 (I-81) corridor is vital to the regional transportation network and provides the downtown and greater Syracuse area with a critical north-south transportation route for commuters, travelers, and commercial vehicles. I-81—specifically the 1.4-mile elevated viaduct near downtown Syracuse—is deteriorating and nearing the end of its useful life due to age, wear, and harsh winter weather conditions. Ramps to I-690 connect I-81 to the critical east-west highway. Both I-81 and I-690 provide transportation access through Syracuse’s dense urban center and influence the urban fabric and economic makeup of the region’s largest economic center. The purpose of this project is to perform an “independent” feasibility study, separate from the I-81 Viaduct Project and other past and ongoing study efforts (Table 3), to understand the infrastructure needs and assess different tunnel construction solutions along this corridor. A preferred alternative should provide the I-81 corridor with the infrastructure needed to support long-range planning efforts and effectively consider the community’s vision of downtown Syracuse and the greater metropolitan area.

### Past Proposals & Studies

<table>
<thead>
<tr>
<th>Possible Alignments</th>
<th>Details</th>
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<tbody>
<tr>
<td>I-81 Corridor Study</td>
<td>Four potential build strategies were proposed:</td>
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<tr>
<td></td>
<td>• Reconstruction of the viaduct</td>
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<td>• Viaduct removal with at-grade boulevard</td>
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<td>• Viaduct removal with tunnel</td>
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<td>• Viaduct removal with depressed highway</td>
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<td>I-81 Viaduct Project</td>
<td>Project alternatives considered (N of alternatives):</td>
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<td>• Viaduct Alternative (5)</td>
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<td>• Community Grid Alternative (2)</td>
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<td>• Tunnel Alternative (7)</td>
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<td>• Depressed Highway Alternative (2)</td>
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<td>• Other Alternative (2)</td>
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<tr>
<td>I-81 Draft Environmental Impact Statement</td>
<td>Review of alignments advanced in the I-81 Viaduct Project</td>
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<td>• Within the Scoping Report, NYSDOT recommended three viaduct alternatives, two community grid alternatives, and the No Build Alternative to be further evaluated in the Draft Environmental Impact Statement (DEIS).</td>
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<td>• All tunnel and depressed highway options were dismissed.</td>
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<td>• The I-81 Viaduct Project identified structural deficiencies and nonstandard highway features while making an effort to improve the I-81 corridor and support long-range transportation and planning efforts.</td>
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<tr>
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<td>• This report was intended to assist agencies and the public to better understand the purpose and need for the project, project objectives, potential alternatives and environmental.</td>
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<td>• The goal of the American Institute of Architect’s Chapter I-81 Task Force, has been to support the NYSDOT design team by bringing an urban design and planning element to the project.</td>
</tr>
<tr>
<td></td>
<td>• The Task Force analyzed alignment options put forward in the I-81 Viaduct project and recommends supporting the Community Grid option.</td>
</tr>
<tr>
<td>Develop Cost-Effective Transportation Options</td>
<td>Reroute I-81 through a two-mile tunnel under University Hill, bypassing the viaduct and constructing a boulevard in its place</td>
</tr>
<tr>
<td></td>
<td>• Provides for permanent removal of the viaduct while maintaining I-81 through the city.</td>
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<tr>
<td></td>
<td>• Preserves exiting traffic patterns on I-81 during the construction period of the tunnel.</td>
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<td></td>
<td>• Provides traffic relief and prevents gridlock.</td>
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<td></td>
<td>• Minimal property taking required.</td>
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</tbody>
</table>

**Table 3:** I-81 Historical Background
2.2 STUDY GOALS

The goals of this I-81 Independent Feasibility Study (Independent Feasibility Study) were derived from the previous and ongoing efforts of the I-81 Viaduct Project (as described in Section 1.3). The goals of this study and previous studies were intended to align in order to help develop an equal basis for comparing alternatives. Although the goals of these study efforts align, the objectives for this feasibility study were formed at its outset in an effort to perform an independent analysis. The goals and objectives of this Independent Feasibility Study serve to identify, assess, and select alternatives. The following are the two major goals and five key categories of this Independent Feasibility Study used in the evaluation process:

- Improve safety and create an efficient regional and local transportation system within and through greater Syracuse
- Improve interstate geometry
- Maintain or enhance interstate-to-interstate connections
- Minimize cost
- Provide transportation solutions that enhance the livability, visual quality, sustainability, and economic vitality of greater Syracuse
- Enhance the livability of the surrounding area
- Minimize adverse environmental impacts

As shown in Table 4, the selected goals and objectives address a range of issues including roadway design, interstate connectivity, land/infrastructure management, environmental and pedestrian impacts, and cost effectiveness. The goals provide a broad measure of characteristics that would be required to meet the project’s purpose. The objectives in turn define a series of specific metrics to allow for an objective comparison among alternatives. The goals and objective were used throughout the alternative development phase to inform the development of criteria and performance measures, and to lend coherence to the decision-making and selection process.

### Table 4: Project Goals & Objectives

<table>
<thead>
<tr>
<th>Goal</th>
<th>Objective</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve safety and create an efficient regional and local transportation system within and through greater Syracuse</td>
<td>Decommission aging viaduct structure(s).</td>
<td>Maintain I-81 interstate status, with interstate highway standards.</td>
</tr>
<tr>
<td></td>
<td>Improve interstate geometry</td>
<td>Correct non-conforming highway geometry on I-81 and I-690.</td>
</tr>
<tr>
<td></td>
<td>Improve safety.</td>
<td>Improve mobility.</td>
</tr>
<tr>
<td>Improve safety and create an efficient regional and local transportation system within and through greater Syracuse</td>
<td>Maintain I-81 through movement on interstate highway.</td>
<td>Maintain I-81 interstate status, with interstate highway standards.</td>
</tr>
<tr>
<td></td>
<td>Correct non-conforming geometry on I-81 and I-690.</td>
<td>Maintain or enhance connections between I-81 (south of Syracuse) and I-690 (west of Syracuse).</td>
</tr>
<tr>
<td></td>
<td>Improve safety.</td>
<td>Maintain or enhance other connections between I-81 and local streets.</td>
</tr>
<tr>
<td>Minimize Cost</td>
<td>Minimize capital cost.</td>
<td>Minimize operations, maintenance and repair costs.</td>
</tr>
<tr>
<td></td>
<td>Minimize infrastructure that has limited remaining service life and high maintenance costs.</td>
<td>Utilize existing transportation infrastructure that has decades of remaining service life.</td>
</tr>
<tr>
<td>Enhance the livability of the surrounding area</td>
<td>Minimize use of elevated or depressed highways.</td>
<td>Minimize disruption to the local street grid, including street closures and altering the vertical or horizontal geometry of local streets.</td>
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<td></td>
<td>Enhance north-south and east-west connectivity on local streets.</td>
<td>Enhance access to transit services.</td>
</tr>
<tr>
<td></td>
<td>Maintain and improve access to transit services.</td>
<td>Maximize opportunities for land development.</td>
</tr>
<tr>
<td>Minimize adverse environmental impacts</td>
<td>Minimize noise, vibration and dust during construction.</td>
<td>Minimize traffic impacts to interstate highways during construction.</td>
</tr>
<tr>
<td></td>
<td>Minimize traffic impacts to local streets during construction.</td>
<td>Minimize residential displacements.</td>
</tr>
<tr>
<td></td>
<td>Minimize community facility displacements.</td>
<td>Minimize commercial displacements.</td>
</tr>
<tr>
<td></td>
<td>Minimize impacts to Onondaga Creek.</td>
<td>Minimize air quality, noise and vibration impacts.</td>
</tr>
</tbody>
</table>
| | Minimize visual impacts. | Note: Connections between Interstates and any modifications to the Interstate access would need to be considered and approved by FHWA.
2.3 TRAFFIC CONDITIONS & DEFICIENCIES

Much of the traffic congestion experienced on the existing highway network is attributed to the I-690 interchange with I-81 and with the ramps that provide access to the downtown area. In particular, the weaving sections and off-ramps on I-81 near Harrison Street operate very poorly during the peak hours. This is partially a result of the signalized intersections immediately adjacent to the ramps and their limited capacity to process the large demand of traffic generated by the major institutions in the area. The section of I-81 northwest of the I-690 interchange is also problematic given the numerous access points and lack of capacity on the mainline. The high volume of traffic demand in this area results in poor levels of service and is made worse by the large numbers of vehicles making weaving maneuvers.

The high volume of exiting or entering highway traffic creates congestion at these local points of contact. The local street network in downtown Syracuse does not provide ideal circulation for vehicles. As a result, traffic congestion and delays on the local streets occur primarily around the access points to and from I-81 such as East Adams Street and Harrison Street as well as along the major corridors such as Almond Street and Erie Boulevard. To optimize distribution among the surface street network, any tunnel alternatives need to also incorporate the maintenance and enhancement of connections between the interstates and the city streets. A solution that displaces part of the existing traffic volume carried by the existing elevated highway directly onto the surface street network will tend to exacerbate existing issues unless mitigated.

2.4 LAND USE PLANNING IN SYRAUCE

While developing alternatives for I-81, it is important to understand the current land use planning context. This context provides some clarity as to local transportation and land use policy goals and objectives and will ensure that each alternative is not in conflict with future economic development goals of the City of Syracuse. These plans—which include the City of Syracuse Comprehensive Plan 2040—highlight the need for the downtown to preserve and strengthen its urban identity and to reinforce downtown and University Hill as the core of regional employment and business and economic development.

Each alternative investigated as part of this Independent Feasibility Study—particularly the community grid elements—is consistent with achieving these goals. Some community grid improvements would reconnect downtown to the Medical Centers and Syracuse University area, which is a particularly important goal of the City of Syracuse.

2.5 PUBLIC ENGAGEMENT

The importance of a proactive public involvement process is a common theme across all infrastructure projects. A robust but targeted public outreach process facilitates the collection of meaningful, substantive input to inform the development and evaluation of infrastructural alternatives and roadway changes that best address the project’s purpose and need, and goals and objectives. Extensive public outreach and stakeholder involvement has been part of the multi-year I-81 Viaduct Project. Nevertheless, public outreach for this Independent Feasibility Study was undertaken to solicit input from the public about the specific scope of this study regarding the feasibility of tunnel and depressed-highway alternatives. The public outreach has assisted in the consultant teams’ evaluation criteria and measures to evaluate alternatives. Ideas and concerns that the public raised were shared with all project team members so that they could be appropriately integrated into the planning, engineering and design elements of the project. The public outreach approach was a multi-level approach to ensure that the City of Syracuse and the surrounding areas were aware of the ongoing project. The effort began March 9, 2017, and concluded April 7, 2017. The following communication tools were used to support the public outreach effort:

- Newspaper
  - A letter requesting information was posted in The Citizen and The Post-Standard newspapers. Public input was received by email (to I-81Input@pbworld.com) or sent by regular mail to WSP.
  - A website was created (www.i-81independentstudy.com/) that provides the same information as the letter but also includes a Study Area map that defines the project limits.

- Online Media
  - Informational pop-up ads and banners appeared on www.auburnpub.com and www.syracuse.com webpages (at random). These pop-up ads were clickable and would then forward the reader to the I-81 Independent Study website to read the letter and look at the Study Area map.

- Email (“E-Blast”)
  - The I-81 Viaduct Project’s team shared a database
3 DESIGN & ENGINEERING CONSIDERATIONS

3.1 HIGHWAY DESIGN

Prior to developing alignment alternatives, design criteria were developed for urban principal arterials-interstate and ramps that were used to guide the development of the various tunnel alternatives, including sections of I-690 and I-81 and ramps as recommended in any given alternative. Design criteria were also developed for local urban roads, collector, and arterial roads that were used to guide the development of various modifications to local streets. All alternatives would reconstruct local roads and connections, and modify interstate ramp connections to meet project goals and objectives.

Design criteria for civil elements were developed using the following reference documents:

- NYSDOT Highway Design Manual Chapter 2, Design Criteria (February 27, 2017)

The criteria for the alternatives were developed using the same reference documents. The AASHTO Technical Manual draws reference to the AASHTO Green Book and to local regulatory requirements but also points out that standards should be developed for each project on a case-by-case basis to ensure that the most efficient tunnel section is used. Separate from the reference documents, the design criteria were adopted in a manner that considered the most efficient tunnel section that could be provided for both single bore and twin bore tunnels. In the case of the alternatives reviewed, the design criteria for urban principal arterials-interstate were able to be accommodated by the proposed tunnel alignment and sections.

The tunnel alternatives were conceptually designed to satisfy the urban principal arterial-interstate standards as shown in the NYSDOT Design Manual. Key components of the standards used for tunnel mainline (interstate) include the following:

- Design Speed = 50 mph. All tunnel alternatives were evaluated with a design speed of 50 mph standard. Design speeds in the approaches beyond the tunnel section and at grade tunnel downgrades would be consistent with existing conditions. Preliminary investigations determined that this minimum design speed would not result in design conflicts that would have suggested use of lower design speeds. Should subsequent design effort reveal a desire to increase curvature to avoid specific properties or structures to better optimize the project, a lower design speed could be evaluated. The design speed criteria did not affect the selection of the tunnel section. The design standard of 50 mph dictates the following critical design criteria:

  - Maximum Grade 6% – The design team reviewed alternatives and attempted to use a 4% grade. This was generally achievable at the southern tunnel portal. However, using a 4% grade for the northern portals, near downtown Syracuse, resulted in unacceptable impacts to the existing city street grid, so this approach was not pursued. A 6% grade is permitted in rolling terrain within urban areas. It is also permissible in accordance with AASHTO. Grades greater than 4% (while being at or less than 6%) were solely employed in areas where flatter grades would result in undesirable impacts to urban development.
  - Minimum Stopping Sight Distance 425 feet – Sight distance horizontal geometry elements were developed to cognizant of stopping sight distances, consistent with AASHTO guidance, which indicates that sight distance can be a governing criteria. The location of tunnel walls was reviewed to ensure that minimum distances could be met within the tunnel. Adjustment of shoulder widths and curve radii have generally been implemented in this study to accommodate design requirements for sight distances based on each tunnel tube’s diameter. For example, in the single-bore bidirectional tunnel, the larger shoulder would be located on the inside of radial curves to maximize sight distances without further flattening the curve or further increasing tunnel diameter.
  - Minimum Radius Curve – Tunnel alignments were developed to exceed this minimum radius curvature. In most cases, the tunnel alignment would not follow right-of-way limits and thus reduction in the curve radius and speed would not have a tangible benefit other than minimizing property easement acquisition. We also note that the alternatives that seek to following the current right-of-way would have additional constructability concerns (such as existing I-81 viaduct piles) that could obfuscate the benefits of minimizing easement acquisitions by way of minimizing the radius curve by reducing the design speed. A curve radius of less than approximately 1,500 feet would require special tunnel boring machine (TBM) considerations. The curve radius used within the proposed tunnel alternatives is far greater than the minimum radius of 833 feet. Minimum radius is less important in cut-and-cover areas of construction since the section would be able to be widened to accommodate additional shoulder width separate from geometric restrictions imposed by TBM.

- Minimum radius used to design bored tunnels were as follows:
  - Twin Bore (43 feet 8 inches diameter) – minimum radius = 2269 feet
  - Single Bore (57 feet 0 inches diameter) – minimum radius = 1500 feet

- The radii used for design purposes exceed the minimum requirement from Chapter 2 and exceeds the minimum requirement within the AASHTO document but is consistent with the governing nature of sight distance on other design elements.
  - Shoulder Widths – The tunnel alternatives would not provide the full shoulder width as indicated in the Highway Design Manual. A single-bore bi-level tunnel would accommodate a 6-foot shoulder width but would vary its location such that it would be placed on the interior of each curve. In the case of traffic moving northbound on a left trending curve, the wider shoulder would be located on the left side of traffic, not the right side as prescribed in the Highway Design Manual. In the case of both the single bore and twin bore tunnel options, the geometry of the bore would not permit the design of a 10-foot shoulder. The proposed twin bore tunnel concepts would provide two 4-foot shoulders on both the right and left sides, which is consistent with the recommendations for tunnels contained in the AASHTO Manual. The AASHTO document indicates that many factors should be considered when developing criteria for shoulder widths but notes that a minimum of 4-foot shoulders are acceptable widths. Further, the document notes that it is common to reduce the shoulder width of interstate sections from that shown in the approaching section due to geometry constraints within the tunnel. The proposed single bore tunnel concepts propose one 6-foot shoulder and one 4-foot shoulder. To compensate for shoulder width reductions, the horizontal curvature was subsequently increased to permit the stopping sight distance to be compliant. The unique relationship between tunnel diameter, shoulder widths, horizontal curvature, and design speed is described below and illustrated in Table 5 and Table 7. Outside of the tunnel construction, the approach roadway transition to the Chapter 2 shoulder width sections.

- Roadway Section Lane Widths of 12 feet – Typical tunnel alignments would include two lanes (both north and southbound) along with shoulder widths as indicated above. We note per previous discussion that shoulder width locations would vary to optimize the alignment based on tunnel geometry (wall locations). The roadway lane widths would be consistent with requirements in both Chapter 2 and the AASHTO Manual.

- Vertical Clearance of 16 feet – All tunnel alternatives would permit truck traffic. The vertical clearance would be consistent with the requirements in both Chapter 2 and the AASHTO Manual. Further, the vertical clearance was developed cognizant of tunnel system needs and most efficient tunnel diameter to accommodate the number of lanes. A lower vertical clearance requirement within both single and twin bore tunnel sections would not have any impact on the selection of the tunnel diameter circular section since the size would be driven by the width of the lanes/shoulders/egress, not the height requirement.
Design criteria used for the tunnel alternatives is as shown to the left. See Appendix G for more details.

Additionally, the alternatives described within this report have been screened against various I-690 options. I-690—specifically within the I-81 ramp zone—has a significant number of non-standard features, ranging from horizontal curvature, line of sight, shoulder width, and others. The tunnel alternatives would be independent of work along I-690 except where otherwise noted. The Red and Blue Alternatives would be implemented with the existing I-690 viaduct or with a reconstructed I-690 that addresses design criteria deficiencies. The Green Alternative would require the existing I-690, while the Orange Alternative would require a reconstructed I-690.

In contrast to the interface with I-690, the Almond Street corridor would be significantly affected by all tunnel alternatives in that portions of the existing I-81 viaduct would be removed and require reconstruction of the street corridor. Further, the tunnel alternatives would all rely consistently on a new Almond Street interchange with I-690 to both facilitate local connectivity to the University Area from points north and west in addition to providing connections to I-690 eastbound from the south and to I-81 southbound from points east via I-690 westbound. All alternatives would include a similar concept to reconstruct the Almond Street corridor and a new I-690/Almond Street interchange. The new interchange would include a combination of flyover ramps, which would seek to replicate the function of the existing Harrison Street ramps. These heavily traveled ramps would be constructed within the median of the reconstructed Almond Boulevard, terminating near Fayette Street. The Green Alternative differs slightly from the other options, which would include maintaining a direct interstate connection from northbound I-81 to eastbound I-690.

Ramp connections would be developed for various alternatives; however, each alignment would offer varying degrees of potential connectivity to I-690 and the local street grid (Table 6). The Green Alternative—with the shortest tunnel—would afford maximum connectivity to I-690 since the alignments would permit viaduct reconstruction, and ramp connections, consistent with the

<table>
<thead>
<tr>
<th>Table 5: Critical Design Elements for Interstate Tunnel Sections</th>
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<table>
<thead>
<tr>
<th>Element</th>
<th>Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Design Speed</td>
</tr>
<tr>
<td></td>
<td>HDM Section 2.7.1.1.A</td>
</tr>
<tr>
<td>2</td>
<td>Lane Width</td>
</tr>
<tr>
<td></td>
<td>HDM Section 2.7.1.1.B</td>
</tr>
<tr>
<td>3</td>
<td>Shoulder Width</td>
</tr>
<tr>
<td></td>
<td>Left Shoulder 4 feet (min) (tunnels)</td>
</tr>
<tr>
<td></td>
<td>HDM Section 2.7.1.1.C, Exhibit 2.2</td>
</tr>
<tr>
<td>4</td>
<td>Horizontal Curve Radius</td>
</tr>
<tr>
<td></td>
<td>HDM Section 2.7.1.1.D</td>
</tr>
<tr>
<td>5</td>
<td>Super-elevation</td>
</tr>
<tr>
<td></td>
<td>HDM Section 2.7.1.1.E</td>
</tr>
<tr>
<td>6</td>
<td>Stopping Sight Distance (Horizontal and Vertical)</td>
</tr>
<tr>
<td></td>
<td>HDM Section 2.7.3.1.F</td>
</tr>
<tr>
<td>7</td>
<td>Maximum Grade</td>
</tr>
<tr>
<td></td>
<td>HDM Section 2.7.1.1.G, Exhibit 2.2</td>
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<tr>
<td>8</td>
<td>Cross Slope</td>
</tr>
<tr>
<td></td>
<td>HDM Section 2.7.1.1.H</td>
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<td>9</td>
<td>Vertical Clearance (above traveled way)</td>
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<tr>
<td>10</td>
<td>Design Loading Structural Capacity</td>
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<tr>
<td>11</td>
<td>Pedestrian Accommodations</td>
</tr>
</tbody>
</table>

| Table 6: Connections to Each Alternative |

* Connection feasible by use of city street grid (Almond Street Corridor)
** Connection could be accommodated by constructing new viaduct ramps (separate from tunnel) (these are optional, but are included in the cost estimate)
DEIS viaduct replacement alternative. The Red Alternative, which would have the longest tunnel, would effectively avoid ramp connections. The Orange and Blue Alternatives would have connectivity.

In addition to the interstate-to-interstate connections, the tunnel alternatives would include various ramps to facilitate local connections. Ramps would be provided at the north portal areas of various alternatives to facilitate access to and from I-81 before entering the tunnel from the southbound direction and subsequent to exiting the tunnel in the northbound direction.

Local road realignment and reconstruction would be necessary. For example, realignment of the Butternut Street bridge is provided within Red and Orange alternatives in order to facilitate other local/interstate ramps. Additionally, the Genant/Bear intersection is realigned under the Blue Alternative. Similarly significant work along the Almond corridor is required to implement the Community Grid. Burt Street is cutoff to provide local access to the Almond Street Corridor from I-81 under all alternatives. Washington and Water Streets are both cutoff to accommodate the Fayette Street Flyover Ramps under all alternatives. The design criteria for arterial roads would be applied for work required in concert with tunnel construction. All tunnel alternatives would rely on a reconstructed Almond Street to provide connectivity to the city street grid and in some cases to certain directions on I-690.

<table>
<thead>
<tr>
<th>TABLE 7: Critical Design Elements for Ramps</th>
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</thead>
<tbody>
<tr>
<td><strong>Element</strong></td>
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<td>1</td>
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<td>11</td>
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</tbody>
</table>

**TABLE 8: Critical Design Elements for Arterial Roads**

| **Element** | **Standard** |
|---|
| 1 | Design Speed | 35 mph |
| 2 | Lane Width | HDM Section 2.7.2.4.A |
| 3 | Lane Width | 11 feet Min. |
| 4 | Shoulder Width | HDM Section 2.7.2.4.B Exhibit 2-4a |
| 5 | Shoulder Width | 0 feet 0 inches/6 feet 0 inches |
| 6 | Shoulder Width | HDM Section 2.7.2.4.C |
| 7 | Shoulder Width | 271 feet Min |
| 8 | Shoulder Width | HDM Section 2.7.2.4.D |
| 9 | Shoulder Width | 4% Max. |
| 10 | Shoulder Width | HDM Section 2.7.2.4.E |
| 11 | Should |

Design criteria tables as applicable to specific alternatives are provided in Appendix H. The tables will detail non-standard features where applicable in addition to confirming that the standards were applied for critical design elements. The existing condition column is blank since the facilities being provided are essentially new.
3.2 GEOTECHNICAL CONDITIONS

3.2.1 SUBSURFACE CONDITIONS

Available information indicates that either a depressed roadway alternative or tunnel alternative would be constructed entirely or partially within the following materials:

- Fill
- Glacial outwash and delta deposits
- Glacial lake deposits
- Shale

The fill would be a product of the development of the city and generally would be derived from the glacial outwash and delta deposits and the glacial lake deposits. In addition to natural soils, older fill could contain various types of obstructions. These obstructions would preclude the use of steel sheetpile for support of excavation (SOE) walls.

The glacial outwash and delta deposits would consist of stratified sands and gravels deposited by flowing glacial melt water or from glacial or post-glacial streams. These deposits would contain cobbles (up to 12 inches across) and small boulders (up to 36 inches across). The cobbles and boulders can include hard and abrasive metamorphic rocks from the Adirondacks or the Canadian Shield. Boulders would preclude installation of sheetpile. All the materials, including hard and abrasive cobbles and small boulders, can be excavated by equipment normally used in slurry wall and secant pile wall construction.

The glacial lake deposits would consist of stratified layers of clay and silt deposited under quiet water conditions. They could contain fine to medium gravel. Both outwash deposits and glacial lake deposits could contain medium to large ice-rafted boulders (between 36 inches and 60 inches across). Although these materials can be penetrated by equipment normally used in slurry wall and secant pile wall construction, removal of such materials would delay excavation and increase cost.

The underlying shale is known to contain noxious and explosive gases and to be subject to high horizontal stresses. The presence of gas would require classification of tunnel excavation as potentially gassy, which would require explosion-proof TBM and ancillary equipment, and increased ventilation to dilute and purge gas.

Groundwater is described as saline, but the degree of salinity is unknown. Saline conditions would affect selection of slurry materials for slurry wall trench excavation and of conditioning agents used in pressurized face TBM excavation. Salinity would also affect concrete mix design for slurry walls, secant pile walls, and permanent structures and corrosion protection of reinforcement used in those structures.

See Appendix D for a more extensive description of subsurface conditions.

3.3 TUNNEL DESIGN & CONSTRUCTION

3.3.1 DEPRESSED ROADWAY, OPEN TUNNEL APPROACH, AND CUT-AND-COVER CONSTRUCTION

Portions of depressed roadway, tunnel approaches, and cut-and-cover tunnels constructed above the groundwater table could be supported by reinforced earth walls or conventional cantilever reinforced concrete retaining walls. Cantilever walls would be constructed within excavations supported by soldier pile and lagging SOE walls.

Roadway structures below the groundwater table would be supported by either slurry wall or secant pile wall SOE walls. The permanent construction of approach structures would either be continuous U-wall type, or would incorporate a roof to improve ventilation, reduce water accumulations and to better resist buoyancy. Cut-and-cover structures would be similar, except with backfill on the roof. The structure would be designed to resist hydrostatic uplift pressures by using self-weight of the structure and the (buoyant) weight of any backfill. Use of tiedowns is precluded by the saline groundwater condition, because the success of corrosion protection measures for tiedowns cannot be confirmed (Figure 20).

Both U-wall structures and cut-and-cover structures constructed within shale would require construction designed to resist lateral movement of shale resulting from stress relief.

See Appendix E for a more extensive discussion of SOE wall types, permanent construction types and buoyancy resistance.

FIGURE 20: Cut-and-Cover Tunnel (with support of excavation system, prior to back-filling)
3.3.2 TUNNEL BORING MACHINE–MINED TUNNEL CONSTRUCTION

Mined tunnels would be constructed by earth pressure balance TBMs. To accommodate two lanes of traffic plus shoulders in each direction, either a single bi-level tunnel can be constructed, or two parallel tunnels. The single tunnel would be approximately 27 feet in diameter. A far more common use on tunnels throughout the country are approximately 44 feet in diameter for two parallel tubes (Figure 21).

Mined tunnels would be designed to resist vertical and horizontal earth pressures and hydrostatic pressures. As discussed for U-wall and cut-and-cover structures constructed within shale, tunnel lining segments would be designed to resist lateral movements of shale resulting from stress relief. Compressible annular grout could be used to reduce the resulting loads on the tunnel. The tunnels would be lined with precast, gasketed liners. Internal structures would be a combination of cast-in-place concrete and precast concrete panels. See Appendix E for a more extensive discussion of mined tunnel design and construction.

3.3.3 CROSS PASSAGE CONSTRUCTION

Cross passages would be required on twin bored tunnel alternatives (see Section 3.5.4). This would conform to the requirements of NFPA 502, and are anticipated to be spaced at 600 feet centers. Some cross passages would be constructed in shale, others would be constructed in soil.

Cross passages in rock would be excavated using one of three possible excavation methods:
- Mechanical excavation
- Excavation by expansive chemical agents placed in drill holes
- Controlled blasting

Excavation crowns would be supported by a combination of rock reinforcement and welded wire fabric to prevent fallout and possible buckling of the rock in the roof as a result of high horizontal stresses. A cast-in-place concrete lining would be constructed within the stabilized excavation.

Cross passages in soil are expected to be constructed in glacial outwash sands and gravels or glacial lake clays. These soils would require stabilization by either jet grouting or ground freezing to permit excavation. The excavation would be supported by the stabilized ground.

A cast-in-place concrete lining would be constructed within the stabilized excavation.

3.3.4 SPOIL (AKA “MUCK”)

Tunneling operations require the removal of large quantities of material starting at the open cuts, through the cut-and-cover operations, the TBM mining operations as well as the cross passages. The considered tunneling options would each generate large total volumes of spoil greater than half a million cubic yards, but the volume would be spread out over the many months of tunneling operations. Efficiently handling, temporarily storing, removing and transporting from the site and disposing of the spoil (also referred to as “muck”) will be key to successful tunneling operations. The project site— with easy access to highways and with several landfills, quarries and sand and gravel operations within 30 miles—suggest that there would be multiple options available for disposal sites.

See Appendix E for more discussion regarding muck disposal.

3.3.5 STRUCTURAL DURABILITY

Saline groundwater conditions and the use of highway deicing salts would require low permeability concrete mixes using low water/cement ratios and pozzolanic additives such as fly ash or blast furnace slag. Corrosion inhibitors such as calcium nitrite could be added to the mix. Concrete cover over exterior and interior reinforcement would need to be at least 3 inches, and potentially more. Epoxy-coated rebar or galvanized rebar should be considered for additional corrosion protection. A cathodic protection system could be cost effective, either to install from the outset, or for electrical continuity of rebar to be provided for potential later retrofitting should corrosion rates become problematic. Waterproofing membranes and design to limit cracking are other important measures. Such precautions are typical in marine environments. See Appendix E for a more detailed discussion on durability and corrosion control.
3.4 VIADUCT DESIGN & CONSTRUCTION

3.4.1 RECONSTRUCTION AND MODIFICATION OF EXISTING I-690 VIADUCT

The existing I-690 viaduct has been documented to have a significant number of non-standard and non-conforming geometric features. Elements such as sight distance, shoulder width, lane width, grades, and ramp spacing are typical features that are either non-standard or non-conforming and have been contributing to safety and level of service issues within the stretch of I-690 from West Street to Almond Street. This section of the interstate—where I-690 was constructed in an “s-slalom” manner where it merges with I-81—is on the viaduct for the entire stretch along with various on- and off-ramps. All alternatives presented in this report have considered both the existing geometry of the viaduct along with the reconstruction of the viaduct required to accommodate the new tunnel alternative.

As described in Chapter 5, all the alternatives selected for further evaluation have some degree of connectivity design elements as it relates to the I-690 viaduct. The baseline assumption for all tunnel alternatives considers the work to reconstruct the I-690 viaduct to address non-standard and non-conforming design elements as an additional option that is not related to the tunnel alternative except where specifically noted otherwise.

Reconstruction of the I-690 viaduct in combination with tunnel construction would offer benefits. The reconstructed viaduct would be designed in a manner to address non-standard and non-conforming features, thus improving both the safety and level of service of the highway and its various ramp connections. Additionally, reconstruction would benefit the constructibility of the tunnel alternative in some cases. Each alternative would have unique impacts on the I-690 viaduct. Many of the alignment alternatives would require I-81 ramps to connect into I-690. In some alternatives, this could require significant reconstruction of I-690, whereas in other local modifications it could be sufficient.

- The Red Alternative would pass underneath the existing viaduct at a depth that would minimize impacts to local sections/spans of the existing viaduct. Local modification or protection could be required for the mainline and adjacent ramps. Reconstruction of the I-690 viaduct to address non-standard and non-conforming issues would depend on the tunnel alternative.

- The Orange Alternative would create a significant conflict with the existing I-690 viaduct since it would locate the portal in a location that would permit I-690 thru traffic to be captured by the tunnel. Significant staging and modifications to existing structure would be required to accommodate this alternative. Reconstruction of the I-690 viaduct would be required to allow construction of this alternative, and would also address other existing deficiencies. Additionally, reconstruction of the I-690 mainline near West Street would provide additional ramp connections between I-690 and I-81.

- The Green Alternative would have little impact on the mainline I-690 viaduct since the tunnel would rise above ground near Washington Street. Significant staging and reconstruction of I-81/I-690 ramps would be required for this alternative. Reframing of existing support structures could be required. Figure 23 shows an example of reframing of the I-84 viaduct in Hartford, Connecticut. On that project, existing crossheads were partially encapsulated inside a new extended crosshead. New columns were located outside the footprint of a new busway being constructed below. Reconstruction of the I-690 viaduct mainline to address non-standard and non-conforming issues would depend on the tunnel alternative.

- The Blue Alternative would replace the West Street interchange, passing through I-690 west of the viaduct; there would be no impact to the existing viaduct.

- As a side benefit, the tunnel alternatives would improve the visual impact of I-690 viaduct on neighboring areas through reconstruction. The elimination of the I-81 viaduct through tunnel construction would eliminate the need for portions of the I-690 viaduct to flyover portions of I-81 to facilitate connections.

- While it would be feasible to partially demolish these unnecessary connections, reconstruction of I-690 could be accomplished in a manner that reduces the overall height of the viaduct in some areas by nearly 15 feet. Aside from Green Alternative, all tunnel alternatives would permit reconstruction of I-690 in a reduced height manner. However, only the Orange Alternative would require this reconstruction.

3.5 TUNNEL SYSTEMS

The specific requirements for the systems and elements necessary to meet the fire protection and life safety goals for any of the tunnel alternatives being considered should be based on the minimum requirements established in National Fire Protection Association (NFPA) 502 Standard for Road Tunnels, Bridges, and Other Limited Access Highways.

The document is a standard and not a legal code requirement unless explicitly called out in the relevant fire code. Most jurisdictions, authorities, and agencies, at a minimum, adopt NFPA 502 as a guideline. NFPA 502 has been followed to develop the requirements for the I-81 tunnel option.

Each of the alternative tunnel options being considered for I-81 would require a variety of operational systems and features within the tunnel to support safe traffic operations and to provide the necessary level of fire protection and life safety. The various tunnel systems and features that would be required include the following:

- Tunnel ventilation
- Fixed firefighting system
- Emergency egress
- Tunnel drainage
- Tunnel fire protection
- Electrical system
- Traffic control system
- Tunnel finishes
- Tunnel lighting
- Operations and maintenance

Each of these systems is described in detail in Appendix F, and is summarized in the following sections.

3.5.1 TUNNEL VENTILATION

Ventilation is required for normal operations (management of vehicle emissions) and emergency operations (management of smoke). A key requirement in NFPA 502 is the provision of tenable conditions for egress and facilitation of conditions for firefighting. Achieving these goals relies on ventilation, means of egress and fire control. Ventilation is particularly integral with fire-life safety because it is essential to smoke management.

The likely applicable ventilation options for the various tunnel alternatives being considered herein for I-81 includes a longitudinal system using in-tunnel jet fans (Figure 23), or semi-transverse point exhaust using point exhaust ventilation.
A longitudinal ventilation system using jet fans is considered the most appropriate option for the basis of the four study alternatives because:

- It is the most efficient system for tunnels designed for unidirectional traffic.
- It has the least impact on size of the tunnel compared with options that use exhaust ducts.

Portal emissions and achieving air quality compliance in surrounding areas would be critical with a longitudinal system. For the longer tunnel alternatives, use of a longitudinal ventilation system could cause emission levels from the tunnel portals to exceed allowable levels. An ambient air quality analysis of the emissions from the tunnel portals would be necessary with respect to any sensitive receptors in the surrounding areas near the exit portals. This ambient air quality analysis would need to incorporate the expected tunnel traffic on an hourly basis, the subsequent vehicle emissions, the expected airflow in the tunnel, and the impact of external meteorological conditions.

Emissions from the tunnel portals and achieving air quality compliance would be a critical design matter. If an acceptable level of air quality cannot be achieved then ventilation buildings at each portal could be required to exhaust and disperse vitiated air away from sensitive receptors. In the case of the longer tunnel alternatives, use of a longitudinal ventilation system could cause emission levels from the tunnel portals to exceed allowable levels. In this instance, a ventilation scheme where vitiated air is exhausted just before the exit portal and ejected via a tall vertical stack may be required.

Given the length of the tunnel options being considered, and examples of current practice in similar tunnels, a point exhaust system would likely be needed for the Red, Blue and Green Alternatives, and possibly the Orange Alternative. (At present, it has been assumed that this alternative would not require portal point exhaust.) The necessary ventilation and environmental analysis would be conducted to determine whether a portal point exhaust system would be required, or to determine a suitable air quality management approach. If an exhaust system is required, it would need ventilation buildings to house equipment at both tunnel portals as well as a large vertical stack to discharge vitiated air. Note that jet fans would still be required with or without this point exhaust.

There would be less available vertical clearance for a single bore tunnel with a stacked road deck, especially on the lower deck. The resultant space for the ventilation equipment would tend to be at the sides of the tunnel. Space proofing and ventilation analysis would be required to determine if jet fans can fit into the space. If sufficient space were not available, the space could better serve as a ventilation duct for a point extraction system option since space limitations could still exclude use of jet fans. This would need to be studied at a more detailed design phase. At present, it has been assumed that a ducted exhaust system and supporting building infrastructure would be provided.

### 3.5.2 Fire Protection Systems

Standpipe systems provide a water supply to remote locations within a facility for use by firefighters. Standpipes are considered a manual system that allows firefighters the ability to connect hoses to the system at locations where needed to fight the fire. A dry standpipe system would be appropriate for a road tunnel in Syracuse because of seasonal freezing conditions.

A fixed firefighting system (FFFS) is recommended for the I-81 tunnel alternatives described herein. The most commonly used type of fixed firefighting system for road tunnel application is an open-nozzle deluge type. This type of system would be the least complex and would consist mainly of a water supply system connecting to a series of deluge valves that each would serve to activate the system over only limited section of the tunnel. Upon activation, the deluge valves would allow water to flow through the normally “dry” distribution piping over the roadways and then discharge onto the fire site through the open nozzles. When designed and used properly, an FFFS can greatly reduce the life safety risk and property risk posed by a tunnel fire.

Based on the lengths of the four tunnel alternatives, it is recommended to include both a standpipe system and a fixed firefighting system in any selected alternative.

### 3.5.3 Tunnel Lighting

The tunnel lighting system provides the required illumination so that a motorist can safely navigate and maintain speed while in a tunnel. This objective must be met during daytime, nighttime, and during an emergency. Daylight conditions require high levels of illumination at the entry portal avoiding the “black-hole” effect. Nighttime levels are significantly lower and consistent throughout the tunnel. During an emergency, light levels are maintained at the nighttime level to allow for egress.

It is recommended to use light emitting diode (LED) fixtures throughout the tunnel and egress facilities.

### 3.5.4 Emergency Egress

NFPA 502 establishes emergency egress requirements from road tunnels, which requires emergency exits spaced at a maximum distance of 1,000 feet. For US road tunnels, the spacing requirements are typically closer together, in the order of 600 feet. The minimum egress path width is 44 inches (3.7 feet). Fire rated doors are required to separate the egress pathway from the tunnel. Sliding egress doors are typically used for cross passageways to allow for bidirectional egress travel. Suitable emergency signage, lighting, and pressurization are also required.

Access to the emergency exits would be provided at roadway level. Many road tunnels also provide a walkway for maintenance and responder access. This walkway is typically elevated 2 feet to 3 feet above the roadway with a handrail and a width in the order of 3 feet to 4 feet. It is proposed to provide such a walkway in the I-81 tunnels.

Options for the arrangement of emergency exits in road tunnels varies, based primarily on the tunnel configuration. For the tunnel alternatives considered herein, the following are the most likely options for emergency egress:

- In a single bore stacked tunnel, each roadway level can provide an egress pathway to safety in the other (non-incident) traffic level. To accommodate for this, stairway egress connections between the two traffic levels would be necessary. The stairways can be configured within the ancillary space at the side of the bore. In these cases, areas for wheelchairs or non-ambulatory persons would be required.
- In a twin bore version, twin parallel bores are placed adjacent to each other, with mined cross passages provided between them at intervals. If the twin bores cannot be constructed at the same level, short lengths of stairs would be required. In these cases, areas for wheelchairs or non-ambulatory persons would be required.
3.5.5 TUNNEL FINISHES AND FIXED SIGNAGE

Tunnel finishes, which are further described in Appendix F, typically coordinate with various roadway and tunnel elements, including lighting, architectural appearance, cleaning, and fireproofing.

Fixed signage other than highway signage directs motorists, maintenance workers and first responders to emergency exits, cabinets, standpipe valves and similar elements.

3.5.6 ELECTRICAL SYSTEMS

Each of the tunnel alternatives identified herein for the I-81 corridor through Syracuse would require a variety of electrical systems to support safe traffic operation. The required installation methods and performance criteria of these various electrical systems for road tunnel application have been generally defined in within applicable codes and standards including NFPA 502 and the National Electrical Code. The required tunnel electrical systems include the following:

- Power distribution
- Fire alarm and detection
- Emergency communications
- Security
- Supervisory control and monitoring (SCADA)

3.5.7 TRAFFIC CONTROL

Roadway tunnels are required by NFPA 502 to be provided with a means to control traffic within the tunnel, as well as traffic on the approach roadways leading into and out of the tunnel. A separate tunnel drainage system, designed to be independent of inflow from sources outside the tunnel, is required to collect and discharge water and effluents generated within the tunnel. These effluent flows result from tunnel washing, use of fire suppression systems, vehicle carryover, and some groundwater seepage.

The tunnel drainage system must also be designed and equipped to accommodate a potential fuel spill.

The profile of the selected tunnel alignment would dictate the location of the tunnel drainage pumping station since the drainage collection would need to occur at the lowest point in the roadway profile.

The stormwater collected at the tunnel portals is considered to be clean and therefore does not require special treatment prior to discharge. However, the tunnel drainage effluent could require some form of pre-treatment prior to discharge depending on local permitting requirements.

3.5.8 DRAINAGE

Tunnel drainage systems normally consist of two independent systems: a stormwater control system and a tunnel drainage system.

Stormwater control systems are required at the tunnel portals to intercept stormwater flows that accumulate on the open approaches and transition roadways leading into and out of the tunnel. A separate tunnel drainage system, designed to be independent of inflow from sources outside the tunnel, is required to collect and discharge water and effluents generated within the tunnel. These effluent flows result from tunnel washing, use of fire suppression systems, vehicle carryover, and some groundwater seepage.

The tunnel drainage system must also be designed and equipped to accommodate a potential fuel spill.

3.5.9 OPERATION AND MAINTENANCE

A dedicated and well planned tunnel operations and maintenance program is necessary to ensure a safe, well maintained, and reliable tunnel facility that maximizes public safety and roadway availability. Each of the various tunnel alternatives discussed in this report has an inherent requirement for a tunnel Operations and Maintenance Plan that fully considers the future operations and maintenance needs of the facility and adequately identifies all ancillary facilities, operating systems, infrastructure, staffing, maintenance equipment, and related items necessary to operate and maintain the facility.

Ancillary facilities that would be required to support operation of the tunnel alternatives considered herein would include provision of an operation and control center for tunnel operations staff who would be responsible for the operation and monitoring of the mechanical, electrical, and traffic control systems on a 24/7/365 basis.

Maintenance related facilities could include maintenance shops, garage facilities, and other storage spaces to house equipment and spare parts that are needed to maintain the tunnel. Appropriate maintenance requires a mix of personnel, including electricians, mechanics/millwrights, and general maintenance staff to maintain the facilities and various systems, support traffic control measures and respond to traffic incidents.

A significant level of planning and coordination is required to operate and maintain a major road tunnel facility. An Operations and Maintenance Plan consists of the various incident and emergency management plans, maintenance management plans, and operational procedures determined to be necessary for safe and efficient operation and maintenance of the tunnel facility.

During the planning and feasibility stage of a major urban road tunnel project such as the I-81 corridor it is important to consider the Operations and Maintenance Plan so the project design accounts for all of the facilities, infrastructure and other items needed to support the operation of the facility. The development of a Concept of Operations Report serves as the first step to developing the basis of the Operations and Maintenance Plan. The Concept of Operations Report provides a basic understanding of how the facility must function in relation to the overall road network and identifies the individual agencies, entities and other stakeholders dependent on the overall successful operation of the facility. The Concept of Operations Report summarizes the key decisions and operating policies established during the planning and design phases of a road tunnel project, and also serves as a basis to develop the actual operating procedures to be implemented within the Operations Plan portion of the Operations and Maintenance program.

3.6 CONSTRUCTION STAGING AREAS

Various construction staging areas would be required for materials, equipment, and personnel. The location of these areas would depend on various factors, including the availability of open space (or usable space), proximity to the work, ease of access for trucks, and distance from residential neighborhoods. Temporary easements would be required for staging areas located on private property.

The main construction staging areas are generally expected to be as follows:

- Southern tunnel portal
- Northern tunnel portal
- I-81 viaduct demolition and Almond Corridor reconstruction
- I-690 reconstruction (primarily for the Orange Alternative)
- West Street (Blue Alternative only)

One of the portal staging areas would be used to launch the TBM, handle bored tunnel spoils, and store precast tunnel segments. In general, this is expected to be the southern portal, but could be at the northern portal for the Blue Alternative due to greater availability of space.

Most staging areas would require parking areas for the main contractor and subcontractors, construction manager, and NYSDOT. Office trailers, change house, warehouses, electrical substation, mechanical/electrical shops, and equipment storage yard are likely to be required. The TBM launch site would require segment storage, crane, muck storage piles/silos, truck waiting/turnaround area plant. Portal staging areas would, most likely, require space for hoisting and storing rebar cages. Staging areas would likely be close to residences or businesses. They would require fences, silt control fences, wheel wash facilities, noise barriers, security, and lighting. Location maps of potential staging areas for each option are shown in Appendix E.
3.7 UTILITIES

Utility investigation and identification would be important to the design phases of this project. Maintaining active utility services without community disruption would be a crucial component. Cut-and-cover structures would have particular impact on utilities, requiring re-routing and alternative utility connections. Maintaining the major utilities around the university steam plant would be a significant requirement.

Preliminary utility investigations have identified some of the major utilities at the portals, and along Almond Street. These are described in Appendix J, and are summarized for each alignment in the following sections.

3.8 PROPERTY IMPACTS

3.8.1 OVERVIEW

Reconstructing an interstate highway through an urban area results in property impacts. A goal of this study is to minimize those impacts. This has been achieved by various methods, including selecting tunnel alignments and profiles that avoid structures, and using TBMs where possible. Cut-and-cover structures and tunnel approach structures would be located to minimize impact to existing buildings. Potential property impacts arising from the four alternatives have been identified, as described below, and summarized in Appendix J.

3.8.2 CUT-AND-COVER/OPEN-CUT TUNNELS

Where possible, tunneling would use TBM technology to minimize surface disruption. However, where the tunnel becomes shallower than approximately half the tunnel diameter, TBM tunneling is no longer feasible, so cut-and-cover construction would be required, which would require structure surfaces within the path of the cut-and-cover tunnel to be removed. While it is technically feasible to move some buildings, this is an extreme measure that is rarely enacted.

3.8.3 BORED TUNNELS

Large diameter TBMs, such as those proposed for the I-81 project, generally provide excellent control of surface settlement. All projects reviewed (Appendix N, and others) generally maintained surface settlement to less than half an inch. Settlement would likely be sufficiently small to be unmeasurable along much of the alignment. There could be occasional areas where larger settlement occurs, which could be significantly larger. Larger settlement could arise from encountering unexpected ground conditions or manmade obstruction, TBM breakdown, or operator error. Larger settlements are typically more common near the start of a tunnel drive during the “learning curve” from operating the TBM. Where alignments pass through a mixed face of rock and soil, higher settlements could occur. Tunneling though shale should present a low risk of settlement provided that shale is present above the crown.

Existing structures above or adjacent to the tunnel drives would need to be individually evaluated to determine the sensitivity to settlement. Most buildings can tolerate some settlement. However, historical structures, tall brick or stone structures, and structures with sensitive equipment (such as hospitals) could have a low displacement tolerance.

The proposed alignment alternatives would avoid tall buildings and sensitive structures, where possible.

Sensitive structures can be protected in a number of ways, including structural modifications, structural underpinning, ground treatment (such as jet grouting), cutoff walls (such as secant pile walls installed between the path of the TBM and the structure), and compensation grouting (where grout is injected below a structure through an array of pipes to intercept displacement before it reaches the structural footings). These measures are generally expensive, and the cost of such protective works must be weighed against the risk and impact of settlement.

3.8.4 METHODOLOGY FOR ASSESSMENT OF PROPERTY IMPACTS

The methodology to assess property impacts for each alternative consisted of the following:

- Determine the limits of property impacts associated with each alternative.
- Identify the affected parcels.
- Collect affected parcels data.

- Create impact assessment
- Value Assessment of Impacted properties

Appendix J presents additional detail on the methodology. A table summarizing the land use of all affected properties, under each of the four alternatives is provided in Chapter 5. Each table provides estimated needs for easements, partial fee acquisitions, and full fee acquisitions and estimates the costs for total fee takings per alternative.

- Temporary Easements
- Permanent Easements

- Additional temporary easements would be required during construction for offices, storage, and laydown areas.

- Permanent Easements would be required for mined tunnels, cut-and-cover tunnels, open approach excavations and depressed roadways. These are primarily expected in areas where the bored tunnel would be located at significant depth.

- Partial Fee Acquisitions would be required for cut-and-cover impacts that would significantly affect the future use of the property.

- Full Fee Acquisitions would be required where the amount of taking would essentially render the remaining property without value, at least during construction. This would occur in areas of cut-and-cover construction or above-grade construction, and would include areas where tunnel construction requires demolition of an occupied structure.

3.8.5 CONSTRAINTS IMPOSED BY THE COMPLETED TUNNEL ON FUTURE DEVELOPMENT

The tunnel project would allow the existing viaduct structures to be demolished, removing a divisive barrier from the heart of Syracuse. Urban renewal around the Almond Street corridor is anticipated, with the potential for numerous new structures to be constructed. However, the Red, Orange and Green Alternatives would require tunnels to be constructed under these developable lots. The Blue Alternative would also pass under developable lots to the north, south and west of downtown. The tunnel would impose some constraints on future development, due to restrictions on foundation depth and due to the weight of the buildings acting on the tunnel structure.

As described in Appendix J, preliminary analyses have been performed to assess the impact of overbuild on bored tunnels. Spread footings and piled foundations were assessed, using simplified analytical methods. The analyses examined stress increases on the tunnel due to new construction above. It was assumed that the tunnel would be designed to accommodate a 30 percent increase in stress due to future overbuild.

It is estimated that two-story buildings would have essentially no impact on the tunnel. For soft ground, it is estimated that if the crown of the tunnel were 30 feet below grade, a five-story building could be constructed on spread footings. At 40 feet cover, the permissible building height would increase to ten-stories, and at 60 feet cover, 20-story builds would be permissible.

Where the tunnel is entirely within rock, piled foundations are assumed to transfer loads to the pile tips. Ten-story buildings could be constructed where the crown of the tunnel is at least 36 feet below the surface and 16 feet below the pile tips founded on rock. Twenty-story buildings could be constructed where the crown of the tunnel is at least 66 feet below the surface and 46 feet below pile tips founded on rock. If the tunnel is deeper, the influence of a building on the tunnel would be reduced.

If buildings are required above or adjacent to the tunnel, and the load on the tunnel would be too great, longer piles could be sleeved to below the invert of the tunnel. Transfer beams or trusses could be required within the building to offset load paths from the superstructure to the foundations.

Cut-and-cover structures could be designed to accommodate overbuild structures of 10 or 20 stories, or more. This can generally be accomplished with minimum premium because if soil is removed from the roof (to create basements), the weight reduction would offset the increase in weight due to superstructure loads. Clearly, the impact of load on individual footings, buoyancy during construction, and other conditions would need to be evaluated.

Indications of potential significance of these overbuild constraints for each of the four tunnel alternatives are provided later in this report.
4 COMMUNITY GRID CONSIDERATIONS

4.1 BACKGROUND AND PURPOSE

The Almond Street corridor and its intersecting streets would need to be reconstructed under any of the tunnel alternatives investigated in this study. This corridor is very important to the City of Syracuse and the region since it serves local and interstate traffic and provides connections to anchor institutions, commercial uses and other major employers in downtown Syracuse. It is also a highly visible component of the I-81 Project in downtown Syracuse (as opposed to the subgrade tunnel), and therefore requires more attention with respect to aesthetics and interaction with adjacent land uses.

The I-81 Viaduct Project Scoping Report looked at two alternatives that examined converting the Almond Street corridor into a major urban arterial. The Community Grid Alternatives are CG-1 (Boulevard) and CG-2 (Almond Street and Other Local Street(s)). CG-1 was dismissed for further study due to concerns about concentration of traffic flow along one corridor. CG-2 was recommended for further consideration in the DEIS as an alternative that optimizes the use of existing streets and disperses traffic through the network.

The community grid discussed in this Independent Feasibility Study was derived from the community grid concept defined in the DEIS. It is a separate set of interventions recommended for surface streets in downtown Syracuse to improve connectivity and mobility under each tunnel alternative. The community grid is of particular importance when discussing the replacement of a segment of I-81 with a tunnel, because a tunnel would limit the number of feasible connections that could be made between the highway and surface streets. The community grid would play the role of redirecting traffic and providing access at new locations.

The addition of a tunnel and the removal of existing viaducts in downtown Syracuse would change the traffic dynamics between interstate highways and local destinations. The general makeup of the vehicular demand would include local to local, local to regional, and regional to local trips. Various alternatives could have an impact on the percentage of each of these categories, but generally all three would need to be accommodated. A set of community grid recommendations for each tunnel alignment is an essential component of the discussion of an alternative.

Replacing the I-81 viaduct with a tunnel would allow the surface street network to operate more efficiently in some areas. This is especially true where local streets that were previously severed by the elevated highway infrastructure could be reconnected. New pedestrian and bicycle crossing could be incorporated and access would be improved. A more efficient urban street system would then take shape, allowing greater distribution of vehicular traffic, new route opportunities for pedestrians and bicyclists, and an upgrade of existing corridors such as Almond Street and Erie Boulevard. These roadway upgrades include eliminating non-standard intersections, increasing capacity, and eliminating existing bottlenecks like the ramp interchange at Harrison Street.

Removing the I-81 viaduct would free a large amount of land within the existing right-of-way for potential redevelopment and street improvements, including pedestrian and bicycle infrastructure, transit facilities, landscape, and street furniture. As a physical and visual barrier, the viaduct has likely constrained the development potential for properties adjacent to the structure. The land use pattern could evolve over the long term by removing the viaduct and introducing more connectivity.

4.2 GUIDING PRINCIPLES

The following principles were developed to guide the development of community grid design concepts. They are a series of goals and objectives that state priorities related to urban design and traffic considerations along the Almond Street corridor, which were derived from the I-81 Viaduct Scoping Report, studies by the American Institute of Architect’s New York chapter, and best practices in urban design and traffic engineering.

- Improve connectivity for motorized and non-motorized traffic.
- Enhance system capacity in absorbing and dispersing traffic.
- Minimize turn prohibitions and provide adequate turn lanes.
- Increase the number of through lanes where necessary.
- Incorporate coordinated signals for optimal corridor progression (continuous flow of traffic at target speed).
- Provide equal accessibility to pedestrian, bicycles and cars:
  - Design signal timings to provide sufficient pedestrian crossing time.
  - Manage speed for increased safety.
  - Provide parking opportunities.
  - Incorporate bicycle lanes where feasible.
  - Minimize pedestrian crossing distance.
- Maximize economic development potential:
  - Maximize development potential.
  - Restore the urban grid to the extent possible.
  - Maximize land disposition opportunities.
  - Minimize property impacts.
  - Provide attractive streetscapes.

In addition to connectivity improvements, the reconstruction of the Almond Street corridor could substantially influence future economic development and urban design improvements in downtown Syracuse. Therefore, it was important to identify community grid treatments that restore urban block patterns and support urban land assembly and redevelopment. Equally important was maximizing the opportunity to free up land currently occupied by transportation infrastructure for disposal by the state.

The removal of existing interstate ramps would require vehicles destined for the central business district to divert their trip at least partially away from the highway system and instead use the surface street network to get to and from their destinations. Therefore, the community grid must be designed so that it could process this additional traffic demand. Typical treatments include turn lanes at major intersections and additional lanes to process throughput. Signal timing is also a critical component of the community grid. Allowing for the major street approaches to benefit from corridor progression while balancing the needs of side streets and pedestrian crossing times was a major goal in developing community grid options.
4.3 COMMUNITY GRID OPTIONS

4.3.1 APPROACH

Several design options were developed based on different priorities, such as optimizing mobility, increasing pedestrian accessibility, and maximizing redevelopment opportunity. These design options were then assessed with each tunnel alternative for their applicability and success in achieving urban design and traffic objectives.

4.3.2 KEY DESIGN AREAS

The most significant impact to the surface street network would occur along the existing viaduct between the south portal and I-690. In all the tunnel alternatives, significant change would be made to the connections between the southern I-81 and downtown (existing entrance and exit at Adams Street), the southern I-81 and I-690, and downtown and the northern I-81 (existing entrance and exit at Harrison Street). Removing the existing I-81 viaduct would also physically affect Almond Street by daylighting the corridor and opening up a large amount of space within the existing right-of-way. This would lead to reimagining and reconstructing the Almond Street corridor. Therefore, the community grid options would focus on the area south of I-690 and north of the south portal.

For purposes of this study, the community grid is divided into three focus areas (from south to north):

- 1. South Tunnel portal
- 2. Almond Street corridor
- 3. I-690/I-81 Connection to downtown Syracuse

The north portal area is not discussed here as a focus area for community grid consideration, since in most cases the north portal affects surface streets outside of the downtown. In each tunnel alternative, existing ramp connections between the northern I-81 and surface street would be accommodated with minor modifications. There would be little impact to the local street network or traffic pattern around the north portal area. The relocation or reconfiguration of connections near the north portal are discussed in Chapter 5 with each tunnel alternative.

The following sections discuss potential community grid design options for each of the key areas and their general application to different tunnel alternatives. Chapter 5 then ties the specific community grid design recommendations and implications to each tunnel alternative for a more comprehensive comparison between each alternative.

FOCUS AREA A: SOUTH TUNNEL PORTAL

The community grid design in the south tunnel portal area would include I-81 on- and off-ramps and modifying or closing existing surface streets caused by vertical street clearance requirements of these ramps. Another design focus would be configuring the first at-grade intersection after the ramps have touched down and merged into Almond Street (Figure 29).

The explored option related to the South Tunnel Portal confluence with the Almond Street corridor is described in detail below. This design could be combined with any tunnel alternative and I-690/I-81 interchange scenario.

As a tunnel begins its descent underground, ramps would be built to connect I-81 to the surface street grid by curving in close near the U-wall and touching down at Almond Street. The first signalized intersection would be located at Taylor Street. Optionally, turns from Almond Street could be prohibited south of East Adams Street to provide maximum capacity to the I-81 through movements. In this scenario, there would also be an opportunity to reconnect Monroe Street and expand the local surface street grid.

Martin Luther King Boulevard and Burt Street would be maintained under the new connection ramps. Van Buren Street would be realigned along the descending ramp to continue providing local access.

The connection between the south portal and Almond Street would be a transition zone between a highway and an urban street environment. The design of this segment should incorporate traffic calming and signage to help alert drivers to adjust their speed.

The first at-grade intersection could be designed as a gateway to downtown Syracuse with landscape features. Multiple exit lanes from the southern I-81 would enter this intersection from the south. Depending on the tunnel alternative, the number of lanes exiting from I-81 would range from one to three lanes. Turn lane(s) would be needed to help disperse traffic to the east-west cross-street. The intersection would be treated with features to facilitate traffic calming and safe pedestrian and bicycle crossing.

FIGURE 29: Community Grid Focus Areas
The specific configuration of this gateway intersection is discussed in Chapter 5 with each tunnel alternative.

FOCUS AREA B: ALMOND STREET CORRIDOR

The existing Almond Street corridor marks the eastern boundary of downtown Syracuse. It is one of the few undisrupted north-south thoroughfares in the eastern portion of the city. Under the scenario that I-81 would be relocated in a tunnel, the future Almond Street would become a more important corridor from both transportation and economic development perspectives.

A key component of the Almond Street corridor is the intended traffic distribution to local streets. In each tunnel alternative, Almond Street would play the role of a collector and distributor as well as a local street that serves surrounding properties.

Each of the explored options related to the Almond Street corridor in downtown Syracuse are described in detail below. All options can be combined with any tunnel alternative and I-690/I-81 interchange scenario.

- An Almond Street Boulevard that incorporates a frontage roadway would help separate vehicles making short distant trips from those making longer distance trips. Left turns would be prohibited from the frontage road, but all turns would be allowed from the mainline. Signalizing each intersection could be a challenge given the closely spaced intersections that would be formed along each side street as a result of the frontage road. The frontage road intersections themselves could be signalized or stop controlled. To provide additional capacity, it could be possible to grade separate one or more of the major intersections like Erie Boulevard to allow the bulk of the north-south traffic to flow unimpeded past primary east-west roadways; however, this would negatively affect adjoining crossstreets and properties. Each median between the frontage street and the mainline would be designed with a multiuse path and a tree-lined landscape strip. The pedestrian refuge on these medians at the intersection would reduce crossing distance (figure 30).

- A more traditional and streamlined option incorporates Almond Street as a consolidated roadway with turn lanes at each intersection and varying number of lanes in each direction, depending on the anticipated traffic volume. Compared to the boulevard option, this option would have a narrower typical cross-section and leave more width to the sidewalk and curbside public space.

Grade-separated intersections could also be used in this scenario to gain additional throughput along the Almond Street corridor; however, this could be unfavorable from an urban design perspective (figure 31).

- A Hybrid Option that combines the two configurations mentioned above could be applied depending on the anticipated traffic volume of the tunnel alternative being studied. The boulevard cross-section could be applied to the southern portion of Almond Street near the connection ramps from the south tunnel portal, and the consolidated roadway cross-section could be applied to the northern portion of Almond Street where local access takes priority over traffic making long distance trips.

The application of the design options above are further discussed under each tunnel alternative in Chapter 5.

Figure 32 and Figure 33 show existing conditions and a rendered perspective of Almond Street at E. Genesee Street, respectively. Figure 34 and Figure 35 show existing conditions and rendered perspective of Almond Street at Water Street, respectively.
I-690 is an important connection between I-90 and the western suburbs of Syracuse. It also provides an alternative access route to and from southern I-81. Removing the I-81 viaduct would also remove the existing ramps that connect I-81 with I-690. Some of the I-690 connection ramps are more heavily used than others, and opportunities do exist to reroute a fraction of the traffic to other highways. The heaviest movements occur on the ramps connecting I-690 eastbound (EB) to I-81 southbound (SB) and I-81 northbound (NB) to I-690 westbound (WB). This is because access to downtown Syracuse from the northwest region is provided by these ramps coupled with the Harrison Street interchange. Options were explored to create new connections between I-690 and a new community grid in order to maintain access to downtown and the major trip generators located there.

Each of the explored options related to the I-690/I-81 connection to downtown Syracuse, coupled with the community grid design are described in detail below. The following design options except for the No Build Alternative accommodate all four connections between existing southern I-81 and I-690 through existing and proposed Almond Street and I-690 connections. All options can be combined with any tunnel alternative.

- A Single Point Urban Interchange (SPUI) would allow for a full interchange between I-690 and Almond Street using a single signalized intersection. Right turns would be made at unsignalized slip ramps separated from the main intersection. Pedestrian signals could be installed at the slip ramps consistent with previous NYS DOT application at I-87 Exit 6. This configuration would relocate both the existing I-690 WB off-ramp to Townsend Street and the McBride Street on-ramp to I-690 EB ramp while creating two new ramps on Almond Street that provide access from I-690 EB to I-690 WB (Figure 38). This type of interchange would help distribute traffic throughout the surface street grid more so than a full interchange on Almond Street and could help prevent an excessive amount of vehicular volume from turning Almond Street into a very large multi-lane arterial. The split diamond interchange would limit the number of highway access points on Almond Street, which would increase pedestrian comfort and safety. The four existing ramps between the southern I-81 and I-690 would also be removed under this scenario.

- Another option would incorporate Fayette Flyover Ramps that connect I-690 to Almond Street, with a touchdown point of approximately Fayette Street. This option would create two new ramps in approximately the same location as the current ramps that connect I-690 EB to I-81 SB and I-81 NB to I-690 WB. The ramps would provide grade separation at Erie Boulevard, with significant benefits for traffic flow compared with the other options. However, the flyover ramps would continue to affect properties that are currently affected by existing ramps between southern I-81 and eastern I-690. The ramp structure would continue to be a physical and visual barrier. Fayette Street and the Fayette-Almond Street intersection would need to be reconfigured to accommodate traffic to and from the flyover ramps. However, pedestrian and bicycle traffic on Almond Street are less likely to be directly affected (Figure 39, Figure 40).

- It is assumed that the existing I-690 WB to I-81 SB and I-81 NB to I-690 EB ramps would be removed. Traffic that currently uses the I-81 ramps to reach downtown would divert to through other exits, such as at Townsend Street and McBride Street. The Fayette Flyover Ramps have been selected as the option for including in the cost estimate of each tunnel alternative.

- No additional interstate connectivity is also considered as an option. The existing I-690 WB off-ramp to Townsend Street and the McBride Street on-ramp to I-690 EB ramp would be retained, but no new ramps would be built. Instead, drivers looking to access I-690 or the Almond Street corridor would rely heavily on the few east-west corridors in the downtown area such as Erie Boulevard or the East Adams Street/Harrison Street one-way couple. This option would remove existing overhead ramp structures without introducing any new connection in this area. From an urban design perspective, this option would minimize physical constraints created by any highway structure and create more opportunity for filling the gap of urban fabric between downtown and eastern Syracuse.

See Appendix A and Appendix C for further information on the Fayette Flyover Ramps.
5 ALTERNATIVES

5.1 ALTERNATIVES CONSIDERED

Seven tunnel alternatives with various sub-options were considered. Highways in tunnels are “out of sight and out of mind,” compared with elevated, at-grade, or depressed alternatives. Removing some of the existing highway viaducts from the urban landscape and placing highways in tunnel would create conditions that promote urban renewal. However, for traffic to descend into a tunnel from a viaduct or other highway, a transition structure is required with sections that are either elevated, at-grade, or depressed. Minimizing any negative impact of these transition sections on downtown Syracuse while achieving the objectives for traffic flow were key considerations during the Independent Feasibility Study.

The two applicable tunneling methods would be cut-and-cover and bored tunneling. Bored tunnels would be constructed using TBMs. These machines can be operated to result in negligible settlement at the ground surface, which can allow tunnels to be constructed under existing buildings, streets and other infrastructure with minimal disturbance.

The bored tunnel alternatives were considered as either a single bi-level tunnel, or twin bored parallel tunnels. The general merits of each method are discussed in Section 3.3. Specific differences relative to each alternative are discussed in the following sections and in Appendix E.

Cut-and-cover tunneling involves excavating a trench that is wider than the highway. This requires most existing features within the footprint to be removed, which limits its potential in urban areas. Upon completion, the land over the tunnel roof can be redeveloped. Cut-and-cover tunnel alternatives were studied along the existing interstate corridors and on certain nearby city streets. Limited additional sections of cut-and-cover tunnel were studied where such tunnels would be required for transitions into bored tunnels. In the following descriptions, the shallowest parts of the tunnel approaches are described as open-cut (which is equivalent to a depressed highway). These open-cut sections could be covered, with roofs extending above ground level, depending on the requirements for ventilation, snow removal and other considerations.

Two depressed highway alternatives were examined, both along the existing I-81 corridor. Depressed highways are structurally similar to cut-and-cover tunnels, but have no roof and could be at a shallower depth. The long-term impact on the urban landscape is typically worse than cut-and-cover tunnels since the highway trench reduces connectivity between neighborhoods, especially if the highway is too shallow to allow the existing street pattern to be maintained.

Each alternative includes a community grid. The community grid includes enhancements to streets along the existing I-81 corridor and elsewhere. All the alternatives have fewer connections between the interstates and the city streets than presently exist. The enhanced street grid would allow for local flow of traffic and connectivity.

The southern end of all tunnel alternatives would be at a similar location, close to where I-81 crosses over Martin Luther King East (Figure 40 and Figure 41). This location would be south of the existing I-81 viaduct, and would have sufficient adjacent space within which to construct transition structures to ramp traffic into a tunnel. At this point, traffic would either flow into a tunnel, or diverge on the community grid by following the current alignment of I-81, passing over Martin Luther King East and the railroad before ramping down to street level.

FIGURE 41: Composite Highway Alignments

FIGURE 42: Feasible Build Alternatives Map
The northern end of each alternative would vary considerably, with different alignment alternatives having clear advantages and disadvantages, as discussed below. A major consideration was whether to have interstate connectivity between I-81 and I-690, or for an I-81 tunnel to bypass I-690 completely, with a tunnel portal further north.

After developing the two depressed highway alternatives and seven tunnel alternatives, an initial screening was conducted. All depressed highways were eliminated from further study, and the Yellow, Green B, and Purple tunnel alternatives were dismissed (see section 5.2). Therefore the Red, Orange, Green, and Blue Alternatives, which all provide distinct and unique features, were chosen for further study.

Table 9 shows the length of each alternative.

### 5.2 ALTERNATIVES ELIMINATED FROM FURTHER STUDY

The following alternatives were examined but eliminated from further study. Table 10 provides a summary. Appendix M provides additional information, listed by advantages and disadvantages, and fly-through descriptions of the alignments.

#### 5.2.1 YELLOW ALTERNATIVE

The Yellow Alternative was a cut-and-cover tunnel that would be located on the same alignment as the existing I-81 viaduct, along Almond Street. An alignment within the Almond Street corridor is the only potentially viable alignment for a cut-and-cover tunnel, without major property takings. However, even this corridor construction would have to contend with street traffic, I-81 traffic, the I-81 viaduct, utilities and adjacent businesses and residences. The cost and disruption associated with cut-and-cover work along Almond Street/I-81 were the primary reasons for eliminating this options from further study.

#### 5.2.2 GREEN B ALTERNATIVE

The Green B Alternative was generally aligned immediately east of the I-81 viaduct. From the southern limit, adjacent to Martin Luther King East, it was identical in plan alignment to the Green Alternative until East Fayette Street. It deviated from the Green Alternative by continuing northward to a similar north portal as the Red Alternative.

A single double-deck tube was considered preferable to twin tunnels due to the physical constraints along Almond Street.

The tunnel would have been functionally identical to the Red Alternative, but would have had higher construction risk, passing under more properties and close to others. The Red Alternative is a similar “base” cost but with a lower risk of delay and cost increases. For this reason, Green B Alternative was eliminated from further study.

#### 5.2.3 PURPLE ALTERNATIVE

The Purple Tunnel Alternative demolished both the I-81 and I-690 viaducts, and replaced them with tunnels. This would have freed surface space for development and would have improved livability.

The I-81 tunnel would have been somewhat similar to the Red Alternative, and would have been constructed by TBM until Genesee Street. For the I-690 tunnel, cut-and-cover construction would have been required to accommodate the number of traffic lanes. A complicated series of cut-and-cover interchanges would have been required to achieve interconnections between I-81 and I-690.

This option was eliminated from further study, primarily due to the cost. The I-690 section alone could have cost 2 to 3 times the cost of the I-81 options carried forward. Overall project costs could have been 3 to 4 times more than focusing on I-81 alone. Furthermore, the disruption to

### TABLE 9: Feasible Build Alternatives - Lengths (miles)

<table>
<thead>
<tr>
<th>Alternative</th>
<th>Bored Tunnel Length (one way)</th>
<th>Open/Covered Cut Length (south)</th>
<th>Open/Covered Cut Length (mid)</th>
<th>Open/Covered Cut Length (north)</th>
<th>Total Length (one way)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Red</td>
<td>1.6</td>
<td>0.3</td>
<td>0.4</td>
<td>2.3</td>
<td></td>
</tr>
<tr>
<td>Orange</td>
<td>1.6</td>
<td>0.4</td>
<td>0.2</td>
<td>1.7</td>
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<tr>
<td>Green</td>
<td>0.8</td>
<td>0.3</td>
<td>0.2</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Blue</td>
<td>1.2+0.4</td>
<td>0.3</td>
<td>0.3</td>
<td>2.7</td>
<td></td>
</tr>
<tr>
<td>Yellow</td>
<td>—</td>
<td>—</td>
<td>0.5</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Green B</td>
<td>1.7</td>
<td>0.2</td>
<td>0.2</td>
<td>2.1</td>
<td></td>
</tr>
<tr>
<td>Purple</td>
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</tr>
<tr>
<td>Short</td>
<td>—</td>
<td>0.4</td>
<td>—</td>
<td>0.4</td>
<td></td>
</tr>
<tr>
<td>Long</td>
<td>—</td>
<td>0.6</td>
<td>—</td>
<td>0.6</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 10: Eliminated Alternatives – Lengths (miles)
traffic and people during construction would have been more widespread and would have lasted much longer.

5.2 SHORT DEPRESSED HIGHWAY ALTERNATIVE

The Short Depressed Highway Alternative would have aligned along the same alignment as the existing I-81 viaduct. I-81 northbound would have had a bridge over the railroad, descending into a depressed highway. It would have risen to meet the I-690 ramps.

The purpose of examining this alternative was to determine the shortest practical depressed highway. However, this alternative was too short. It would have started and ended at a viaduct, and except for one cross-street (Adams), all other cross-streets would have been permanently blocked due to the highway either ramping down or ramping up.

- This option was eliminated from further study, primarily due to the required permanent closure of multiple city streets.

5.2.5 LONG DEPRESSED HIGHWAY ALTERNATIVE

The Long Depressed Highway was an open-cut depressed highway that would have followed the existing I-81 alignment. Compared with the Short Depressed Highway Alternative, this alternative would have remained at the full depth long enough for most transverse city streets to remain open. Community grid at street level would have been maintained by splitting Almond Street northbound and southbound, and cantilevering each direction over I-81 (see Appendix E).

- This option was eliminated from further study for two principal reasons: the requirement for an extended closure of I-81 during construction, and because the resulting depressed highway, ramps and viaducts would have perpetuated the division between the university area and the downtown area.

5.3 FEASIBLE BUILD ALTERNATIVE RED

5.3.1 GENERAL OVERVIEW

The Red Tunnel Alternative would be generally aligned west of the existing I-81 viaduct, along South Townsend Street (see Figure 43).

It would start south of the Martin Luther King East overpass and trend to the northwest. An open-cut would transition to a cut-and-cover tunnel immediately south of Martin Luther King East. Twin bored tunnels would pass to the west of the Syracuse University Steam Station & Chilled Water Plant. The tunnels would generally follow South Townsend Street, passing below private residences and private parking lots in some areas. The tunnel would then strike northwest to align with State Street, passing below various private properties near Washington Street and Water Street. The tunnel would pass under I-690 with no interconnections, at sufficient depth to avoid the existing piles (see profiles in Appendix E). Based on record drawings, the I-690 piles would extend 53 feet below grade and the crown of the tunnel would be approximately 80 feet deep. The tunnel would then follow North State Street before deviating to the west to rejoin I-81 at a new intersection north of Butternut Street.

Twin tube tunnels are recommended rather than a single bi-level tunnel. Twin bored tunnels provide greater flexibility at the portals, and shorter cut-and-cover approaches (since the smaller diameter tunnels require less cover). However, the out-to-out width of twin tunnels would be approximately 110 feet, which would be wider than Townsend Street. More private property easements would therefore be required. It would also require mining under additional buildings compared with a single larger tunnel, which would increase risk.

Advantages of Red Alternative
- Bypasses Syracuse University Steam Station & Chilled Water Plant
- Favorable geometry for a tunnel mining portal south of the railroad
- Avoids risk of tunnelling under I-81 (potentially encountering piles, or requiring traffic shutdowns)
- Has negligible impact on I-690
- Construction costs are relatively low compared to the other alternatives
- Simpler construction staging compared to Orange

FIGURE 43: Red Alternative Map
and Blue alternatives
- Improvements to I-690 are independent of this alternative.
- Disadvantages of Red Alternative
  - Does not provide a direct interconnection with I-690
  - Passes under private land
  - Passes under buildings, such as on Fayette St, N State St and N Salina Street
  - Construction of northern tunnel approaches would be disruptive to I-81 traffic and would result in a temporary reduction to two lanes for each direction approximately between Butternut St and Spencer Street.

5.12 HIGHWAY DESIGN

TUNNEL TRAFFIC

Traffic demand in the tunnel would be the lowest of all alternatives. Given the elimination of all connections between I-81 and I-690, the bulk of the drivers using the existing interchange would exit from the highway system prior to entering the tunnel and use the local surface street grid to access the downtown area. Anticipated traffic volumes would range from 300 vehicles per hour (vph) during the AM peak hour in the northbound direction to approximately 1,250 vph during the PM peak hour in the southbound direction. (For details on traffic volumes see Appendix C-3 of the DEIS.)

5.13 COMMUNITY GRID

FOCUS AREA A: SOUTH TUNNEL PORTAL

The south tunnel portal would be connected to Almond Street via on- and off-ramp structures from the I-81 mainline, and first tie in at-grade at Taylor Street. This connection would require the closure of Burt Street due to vertical clearance requirements. Martin Luther King East/Renwick Avenue would be maintained. The existing segment of Almond Street south of Taylor Street would be converted to a one-way northbound frontage road, providing connections between Van Buren Street, Burt Street, and Taylor Street on the east side of Almond Street. A two-way bicycle track would be located adjacent to the general purpose travel lane and would provide direct bicycle connections from Almond Street to Van Buren Street and the Syracuse University campus.

FOCUS AREA B: ALMOND STREET CORRIDOR

The Almond Street corridor—generally defined as Almond Street between the south tunnel portal and I-690—would have a right-of-way of up to approximately 150 feet. It would range between two and three general purpose travel lanes in each direction, with designated curbside bicycle lanes and 15-foot sidewalks on the east and west sides of the street. Where possible, parallel on-street parking would be provided for convenience and to slow traffic. To mitigate Almond Street’s wide cross-section and provide a visual buffer from potentially high traffic volumes, side and center medians would be constructed, which would provide area for substantial tree planting and canopy, add aesthetic interest, physically separate travel lanes, and provide green space. A side median with adjacent northbound frontage road would be constructed adjacent to Syracuse Housing Authority’s Pioneer Homes between Taylor Street and Adams Street. A wide center median would be constructed north of Adams to I-690. In combination, these improvements would make Almond Street a heavily landscaped urban boulevard, and a walkable, multimodal “Complete Street.” All intersecting streets along the Almond Street corridor would remain unchanged in terms of travel lane assignment and cross-sectional configuration.

Under this alternative there would be residual state-owned right-of-way currently occupied by I-81 viaduct and ramps not required for the reconstruction of Almond Street. This freed up land—most notably on block frontages westerly adjacent to Almond Street—could be redeveloped by others if the state decided to dispose of the property.

FOCUS AREA C: I-690/I-81 CONNECTION TO DOWNTOWN SYRACUSE

Focus Area C generally refers to the area north of Fayette Street where new on- and off-ramps would be constructed under the Red Alternative to provide grade-separated access to I-690 from the Almond Street corridor. Providing a direct local-to-interstate connection is critical to maintaining acceptable levels of service in downtown Syracuse. To provide this connection from the north end of Almond Street, on- and off-ramps would begin and end in a wide center median at Almond Street’s intersection with Fayette Street, and ascend north and west toward downtown.

Assumptions:
1. Closure of I-81 NB to I-690 EB Ramp
2. Closure of I-690 WB to I-81 SB Ramp
3. Closure of I-81 NB to I-690 WB Ramp
4. Closure of I-690 EB to I-81 SB Ramp
5. Two-Lane Tunnel

TABLE 11: Weekday Peak Hour Tunnel Traffic (vph): 2050 Build – Red Alternative

<table>
<thead>
<tr>
<th>Weekday AM Peak Hour</th>
<th>Weekday PM Peak Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Volume (vph)</td>
<td>Estimated Level of Service</td>
</tr>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>B</td>
</tr>
</tbody>
</table>

| Assumptions         |                      |
|----------------------|                      |
| 1.                    | Closure of I-81 NB to I-690 EB Ramp |
| 2.                    | Closure of I-81 SB to I-81 WB Ramp |
| 3.                    | Closure of I-690 EB to I-81 SB Ramp |
| 4.                    | Closure of I-690 WB to I-81 SB Ramp |
| 5.                    | Two-Lane Tunnel      |
over Washington Street, Water Street, and Erie Street, ultimately tying in to eastbound and westbound I-690. This would necessitate the closure of Washington Street and Water Street due to vertical clearance requirements. Almond Street would continue as two lanes in each direction with wide sidewalks and bicycle lanes north of the I-690 ramps to Burnet Avenue where Almond Street narrows to a four-lane cross-section with no center median.

The closure and demolition of existing ramps form I-81 to I-690 and the introduction of new ramp connections from Almond Street to I-690 envisioned as part of the Red Alternative would provide a substantial amount of residual state-owned land for potential disposal north of Fayette Street between McBride Street and Almond Street.

Figure 46 and Figure 47 show existing conditions and a rendered perspective of Almond Street at Jackson Street, respectively.

5.3.4 GEOTECHNICAL CONDITIONS

Based on limited available geotechnical information, ground conditions for the Red Alternative appear to be favorable for closed mode TBM construction. The portals of the bored tunnels have been located so that most of the tunneling would be in the bedrock (shale). (Appendix D provides anticipated geotechnical profiles.) However, limited geotechnical information from the area of the university steam plant (near the south portal) indicates that rock could dip to the west, resulting in some mixed face tunneling. Settlement above the tunnel should be low, but mixed face conditions are less favorable than a full face of rock.

5.3.5 TUNNEL DESIGN & CONSTRUCTION

The Red Alternative tunnel would consist of a twin bore carrying I-81 traffic through downtown Syracuse. Beginning south of Syracuse University, the tunnel would start in a cut-and-cover section for approximately 700 feet. This portion of the mainline construction would be constructed under MLK Boulevard, thus allowing it to remain open, while the Almond Connector ramps would be constructed above the existing street crossing. The twin bore would continue for approximately 10,000 feet. Within this section, the tunnel would descend to roughly 80 feet below grade at a slope of 4%. The bulk of the tunnel bore would be 80 feet below grade before ascending at 6% grade within I-81 right-of-way north of I-690. The tunnel section would continue in a cut-and-cover section for another 700 feet, tying to the existing I-81 alignment north of Spencer Street. The design speed for this option would be 50 mph. The minimum horizontal curvature for this option would be 2,269 feet, greater than that required by design criteria, although the necessary minimum to provide the sight distance requirement for vehicles traveling 50 mph in the tunnel. The shoulder widths within the tunnel section would be a non-standard design feature. Due to the diameter of the bore, shoulders of 4 feet would be provided on the left and right sides adjacent to the 12-foot lanes. Each bore would contain two 12-foot lanes and two 4-foot shoulders to convey traffic southbound and northbound along I-81. Shoulders would transition to 10 feet once outside of the bored tunnel structure.

The Red Alternative includes the following interstate connections:
- I-81 SB to I-690 EB – new ramp on viaduct
- I-690 WB to I-81 NB – new ramp on viaduct

There would be an option to provide two additional interstate connections, independent from the tunnel construction from I-690EB to I-81NB, from I-81SB to I-690WB. Although elimination of select local access would be required to accommodate these movements.

The Red Alternative would include reconstructing Almond Street into a boulevard, constructing a new interchange at Almond Street/I-690, and various traffic operational improvements throughout the street grid. The street grid would be required to complete several other movements:
- I-81 NB to I-690 WB – must use new Almond Street/I-690 interchange (Fayette Street Flyover)
- I-81 NB to I-690 EB – must use new Almond Street/I-690 interchange
- I-690 WB to I-81 SB – must use new Almond Street/I-690 interchange
- I-690 EB to I-81 SB – must use new Almond Street/I-690 interchange (Fayette Street Flyover)

Separate from the actual tunnel construction, this alternative would construct two viaduct ramps extending from the western leg of I-690 to Fayette Street. These viaduct ramps would replace the existing Harrison Street ramps, which were heavily used, and permit the Erie Boulevard/Almond Street intersection to be at-grade. Local connectivity would be maintained with the Red Alternative in that access to the local street grid would be provided at the I-690/West Street interchange, new I-690/Almond Street interchange, and new local ramps located near the north portal at Hickory (to I-81 NB), Clinton (from I-81 SB), and Taylor (to I-81SB and from I-81 NB). Local streets would be marginally affected with permanent closures expected at Martin Luther King East and Burt Street near the south portal. Additionally, Water and Washington Street would be closed to through traffic across Almond Street as a result of the Fayette Street flyover ramps.

The Red Alternative would pass beneath I-690 in a manner that would minimize disruption to the existing structure. Further, any work on the geometric deficiencies for I-690 could be performed independent of the Red Alternative.

5.3.6 VIADUCT DESIGN & CONSTRUCTION

The Red Alternative would avoid impacts to the existing I-690 due to the new I-81 tunnel bypassing the interchange completely at a sufficient depth to avoid existing pile foundations. New and replacement bridges would be of standard construction—such as reinforced concrete deck on steel or concrete girders and concrete piers—unless circumstances require a different approach. Under this alternative, a new connection would be created with a new elevated ramp from I-690 EB to I-81 NB, which could be
built with little to no impact to the existing I-690. Another new partially elevated ramp would directly connect I-81 SB to I-690 WB, while the existing connections of I-81 SB to local streets and the West Street arterial would be maintained. The existing Butternut Street bridge would be removed and replaced with a new structure north of the existing to accommodate the new connections. The existing Spencer Street bridge would also be replaced to accommodate the widened I-81 roadway at this location. The widening would be necessary to accommodate the proposed I-81 emerging tunnel roadways, the new I-690 connecting ramps and the existing connecting ramps to I-690 EB and from I-690 WB, as they merge into existing I-81 at-grade. The existing I-81 bridge over N. Salina Street could also be replaced to accommodate a new alignment for the existing I-690 connecting ramp roadways to remain. The existing viaducts and interchange could be maintained during construction with limited impacts outside of the staged construction area required near the north portal north of Butternut Street, as noted in Section 5.3.8. The existing I-81 viaducts could be removed once the new I-81 tunnel is in service. Drawings for a potential construction sequence of the northern end of the project are included in Appendix E (showing tunnel elements only, with approximated roadway alignments).

At the southern end of the project, the proposed I-81 roadway and tunnel could be built independently and would avoid affecting the existing I-81 entirely. Drawings for a potential construction sequence of the southern end of the project are included in Appendix E. The same would be true for the new ramp over the existing railroad, which would lead to the newly constructed community grid for downtown Syracuse.

The Red Alternative would not require reconstruction of I-690, meaning the non-standard features of the viaduct would not be improved upon. However, by eliminating the existing I-81 viaduct and replacing the existing connections between I-690 and I-81, the final proposed geometry would allow future improvements of I-690. This would include lowering the existing flyovers and the ability to realign the westbound and eastbound roadways so that they would be adjacent to each other, reducing I-81’s footprint on the city and allowing for further land development.

As most of the existing bridges and viaducts would be supported by piers, it can be assumed that the new bridges, viaducts, and ramps would also be supported by piers. In some locations, new foundations could be seated on the top of the tunnel roof or lining, such as the flyover ramp near Spencer Street, to avoid overly long spans.

### 5.3.7 TUNNEL SYSTEMS

Tunnel systems would be similar for the Red, Orange and Blue Alternatives’ tunnel options and would generally vary only by the quantity of equipment required. For instance, with jet fans spaced at 500 linear feet and installed in pairs would require 96 fans. A ventilation building may be required at each portal with paint exhaust to remove vitiated air and discharge it at high velocity above the ground level. Given the length of this option, it would be unlikely that an environmental assessment of air quality would eliminate the need for a ventilation building and allow ventilation with jet fans alone. However, environmental air quality assessment would still be necessary to confirm operational requirements.

Egress passages between the bores, spaced at about 600 linear feet, would number approximately 18 to 19. Other systems such as electrical, drainage and fire protection, finishes, controls and ITS, would scale in quantity based on the tunnel length.

### 5.3.8 CONSTRUCTION STAGING

Many of the proposed structures under this alternative could be built with limited impact to the existing structures and roadways with simple construction staging. This includes the new ramps from I-690 to I-81 over North Salina Street and from I-81 to I-690 over North Franklin Street. Demolition of the existing I-81 at the interchange could be performed once the tunnel is complete and open to traffic, with limited impacts to the existing I-690. Some structures carry traffic for both I-690 and to be demolished I-81 ramps. These structures would require modifications, which could be performed with the staged construction, but the impacts to traffic during these operations would be very limited, since they would no longer carry the combined traffic of I-81 and I-690.

The existing Spencer Street bridge carries two lanes of traffic, one in each direction, and is accessible to pedestrians via sidewalks on each side of the roadway. Replacing the existing structure would keep the existing structure geometry and the existing features, where appropriate. Despite the single-lane usage of the structure, it would be wide enough to accommodate two lanes per direction, which would allow staged construction to be used to limit impacts to the traveling public. The new Butternut Street bridge could be built without affecting the existing structure and would opened to the public before demolishing the existing structure.

### 5.3.9 UTILITIES

Utility impacts for this alternative would be present at the south and north portals. Additional impacts would be expected within the Almond Boulevard reconstruction zone, although these utilities would be readily located within the work zone. Major relocations would be expected for utilities affected by the north and south portals since relocation would typically be needed outside the portal zone.

Utilization investigation and identification would be important to the design consideration phases of this project, and would help in determining what alignments would be further studied and what alignment options could be eliminated. Along the I-690 and I-81 viaducts as they approach the city’s inner limits, ground space below would either function as a highway interchange such as at the north end of I-81, or would be consumed by vegetation with side streets connecting neighborhoods to the Syracuse University campus at the south end of I-81. These less populated areas would allow for portal points to be further considered as areas of entries and egress into the alternative alignments discussed.

The community grid area along I-81 between the northern constraint of Erie Boulevard and the southern constraint of Martin Luther King East shares a variety of residential housing, student housing facilities, small business, large business, medical facilities, educational facilities and large industrial facilities. Maintaining active utility services without community disruption would be a crucial component at the time of the design consideration phase of this connective corridor between the eastern portion of the inner city to the Syracuse University campus area and medical facilities. This should ensure that the revitalization of this area will have a positive impact on the community as well and improving traffic flow and pedestrian access.

### 5.3.10 PROPERTY IMPACTS

A property impact analysis was prepared for the various alternatives. The efforts required under this property analysis task included the following:

- Determining the limits of property impacts associated with each alternative.
- Identifying the affected parcels.
- Collecting affected parcels data.
- Assessing impact.
- Assessing value of affected properties.

Assumptions and the methodology used to determine the impacts are summarized in Section 3 while backup documentation and maps relative to each alternative is shown in Appendix J.

### TABLE 12: Property Takings: Red Alternative

<table>
<thead>
<tr>
<th>Property Impact Classification by Land Use</th>
<th>Commercial</th>
<th>Residential</th>
<th>Industrial</th>
<th>Vacant</th>
<th>Parks</th>
<th>Public Services</th>
<th>Comm. Services</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Fee Taking</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>7</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Full Fee Taking</td>
<td>12</td>
<td>6</td>
<td>0</td>
<td>11</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Permanent Easement</td>
<td>53</td>
<td>4</td>
<td>0</td>
<td>18</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>0</td>
</tr>
</tbody>
</table>

Site specific utility impacts for this alternative are shown in Appendix I.
Thirty (30) Full Fee Takings are projected for this option. The Full Fee Takings include seventeen (17) properties containing building that will require demolition. The remaining thirteen (13) properties are either vacant or have uses that do not require buildings (i.e. parking lot). The above described takings were used to develop estimates for property acquisition costs.

5.3.11 DEVELOPMENT CONSTRAINTS

The future construction of buildings directly above the Red Alternative tunnel would be minimally constrained by the allowable depth of footings/piles and the allowable weight of buildings (Appendix J). The south end of the tunnel would be in a residential area where future development of buildings greater than five stories tall would be unlikely. Buildings of this size could likely be constructed above both the tunnel with no adverse impact.

The Red Alternative would pass relatively close to downtown, under developable land along Townsend Street and State Street. The depth to the crown of the tunnel would be typically around 80 feet, and the tunnel would be expected to be in rock, which should result in little or no constraint on future high rise development (geotechnical profiles, Appendix D). The cut-and-cover tunnel near the north portal would be situated directly below the reconstructed I-81 highway.

5.4 FEASIBLE BUILD ALTERNATIVE ORANGE

5.4.1 GENERAL OVERVIEW

The Orange Alternative would be aligned immediately west of the I-81 viaduct (Figure 48). It would start south of Martin Luther King East and continue due north in a cut-and-cover tunnel, passing under both Martin Luther King East. A TBM launch wall would be constructed just south of the South McBride Street and Van Buren Street Intersection. The TBM tunnels would be mined under vacant space at the Syracuse University steam station and chilled water plant. To avoid the risk of encountering piles (from previously demolished buildings), a cut-and-cover tunnel method could be used, which could disrupt operations and could require multiple utilities to be rerouted or supported.

The bored tunnels would continue under Taylor Street, pass under the Pioneer Homes housing project, and then continue parallel to I-81. It would pass under both the parking lot of the Upstate University Medical Center and the parking structure for Madison Towers. An alternative alignment would be under the I-81 viaduct, which would avoid private properties, but the risk of encountering a pile (from the I-81 viaduct) could increase.

At East Genesee Street, the tunnel would head to the northwest, passing under private land and various low-rise buildings. The bored tunnel would end at Erie Boulevard, transitioning to a cut-and-cover tunnel. The at-grade parking lots in this area could potentially be acquired to make an efficient reception/launch site for the bored tunnels.

North of Erie Boulevard, cut-and-cover construction would be used, with the I-690 viaducts being being underpinned and support structures reconstructed as required. To achieve connections from I-81 NB to I-81 NB and to I-690 WB, extensive reconstruction of I-690 would be required. This would include reconstructing much of the existing viaduct, which would enable existing geometric deficiencies to be remedied.

- Advantages of Orange Alternative
  - Enables connections to I-690
  - Relatively short tunnel
  - Improvements to I-690’s currently non-conforming features would be inclusive for this alternative
  - Open view under new I-690 viaduct compared to existing wide viaduct.

- Disadvantages of Orange Alternative
  - Passes under unused space at Syracuse University steam station and chilled water plant, with risk of encountering abandoned piles and need to protect sensitive utilities.
  - Passes under private land
  - Passes under multi-story parking structure for Madison Towers
  - Tunnel could limit future development requiring piles, such as on Townsend Street between Washington Street and Water Street.
  - Construction of northern tunnel approaches would

![FIGURE 48: Orange Alternative Map](image)
be disruptive to I-690 traffic, requiring temporary connections and structures to divert traffic around the tunnel portal area.

- Complex staging would be needed to build proposed structures around the existing viaducts, resulting in difficult construction.
- Requires temporary supports or reframe of piers for a large section of existing I-690 due to the cut-and-cover area underneath the I-690 and its connections.
- Would require modifications to the existing West Street and I-690 interchange to accommodate new I-690 WB alignment.

For the Orange Alternative, twin tube tunnels are recommended rather than a single bi-level tunnel. Twin bored tunnels would provide greater flexibility at the portals, and shorter cut-and-cover approaches (since the smaller diameter tunnels require less cover). However, the out-to-out width of twin tunnels would be approximately 110 feet, which would increase the risk of encountering piles under the steam plant (see below and Appendix E). Also, more private property easements would be required.

5.4.2 HIGHWAY DESIGN

TUNNEL TRAFFIC
Traffic demand in the tunnel would be higher than in the Red Alternative. The elimination of the I-81 NB ramp to I-690 WB and the I-690 WB ramp to I-81 SB would still place a large number of vehicles on the local surface street grid since many drivers use these connections to go to and from the Harrison Street ramps use these connections. Anticipated traffic volumes would range from 1,200 vph during the AM peak hour in the northbound direction to approximately 2,050 vph during the PM peak hour in the southbound direction. (For details on traffic volumes see Appendix C-3 of the DEIS.)

5.4.3 COMMUNITY GRID

FOCUS AREA A: SOUTH TUNNEL PORTAL
The south tunnel portal would be connected to Almond Street via on- and off-ramp structures from the I-81 mainline, and first tie in at-grade at Taylor Street. This connection would require the closure of Burt Street due to vertical clearance requirements. Martin Luther King East/Renwick Avenue would remain open. The existing segment of Almond Street south of Taylor Street would be converted to a one-way northbound frontage road, providing connections between Van Buren Street, Burt Street, and Taylor Street on the east side of Almond Street. A two-way bicycle track would be located adjacent to the general purpose travel lane and would provide direct bicycle connections from Almond Street to Van Buren Street and the Syracuse University campus.

FOCUS AREA B: ALMOND STREET CORRIDOR
The Almond Street corridor—generally defined as Almond Street between the south tunnel portal and the I-690—would have a right-of-way of up to approximately 150 feet. It would range between two and three general purpose travel lanes in each direction, with designated curbside bicycle lanes and 15-foot sidewalks on the east and west sides of the street. Where possible, parallel on-street parking would be provided for convenience and to slow traffic. To mitigate Almond Street’s wide cross-section and provide a visual buffer from potentially high traffic volumes, side and center medians would be constructed, which would provide area for substantial tree planting and canopy, add aesthetic interest, physically separate travel lanes, and provide green space. A side median with adjacent northbound frontage road would be constructed adjacent to Syracuse Housing Authority’s Pioneer Homes between Taylor Street and Adams Street. A wide center median would be constructed north of Adams Street to I-690. In combination, these improvements would make Almond Street a heavily landscaped urban boulevard and a walkable, multimodal “Complete Street.” All intersecting streets along the Almond Street corridor would remain unchanged in terms of travel lane assignment and cross-section configuration.

Under this alternative, there would be residual state-owned rights-of-way currently occupied by the I-81 viaduct and ramps not required to reconstruct Almond Street. This freed up land—notably on block frontages westerly adjacent to Almond Street—could be redeveloped by others if the state decided to dispose of the property.

FOCUS AREA C: I-81/I-690 CONNECTION TO DOWNTOWN SYRACUSE
Focus Area C generally refers to the area north of Fayette Street where new on- and off-ramps would be constructed under the Orange Alternative to provide grade-separated access to I-690 from the Almond Street corridor. Providing a direct local-to-interstate connection would be critical

![FIGURE 49: Orange Alternative North Portal](image)

![FIGURE 50: Almond Street and Cedar Street (Rendered Perspective)](image)

TABLE 13: Weekday Peak Hour Tunnel Traffic (vph): 2050 Build – Orange Alternative

<table>
<thead>
<tr>
<th>Volume (vph)</th>
<th>Northbound</th>
<th>Southbound</th>
<th>Northbound</th>
<th>Southbound</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday AM Peak Hour</td>
<td>1,194</td>
<td>1,721</td>
<td>1,497</td>
<td>2,049</td>
</tr>
<tr>
<td>Weekday PM Peak Hour</td>
<td>1,721</td>
<td>1,194</td>
<td>2,049</td>
<td>1,497</td>
</tr>
</tbody>
</table>

Assumptions:
1. Closure of I-81 NB to I-690 EB Ramp
2. Closure of I-690 WB to I-81 SB Ramp
3. Two-Lane Tunnel
to maintaining acceptable levels of service in downtown Syracuse. To provide this connection from the north end of Almond Street, on- and off-ramps would begin and end in a wide center median at Almond Street’s intersection with Fayette Street, and ascend north and west toward over Washington Street, Water Street, and Erie Street, ultimately tying in to I-690 EB and WB. This would necessitate the closure of Washington Street and Water Street due to vertical clearance requirements. Almond Street would continue as two lanes in each direction with wide sidewalks and bicycle lanes north of the I-690 ramps to Burnet Avenue where Almond Street would narrow to a four-lane cross-section with no center median.

The closure and demolition of existing ramps from I-81-to-I-690 and the introduction of new ramp connections from Almond Street to I-690 ramp connections envisioned as part of the Orange Alternative would provide a substantial amount of residual state-owned land for potential disposal north of Fayette Street between McBride Street and Almond Street.

### 5.4.4 Geotechnical Conditions

Based on limited available geotechnical information, ground conditions for the Orange Alternative appear to be favorable for closed mode TBM construction. The portals of the bored tunnels would be located so that most of the tunneling would be in the bedrock (shale). (Appendix D contains the anticipated geotechnical profiles.) However, limited geotechnical information from the area of the university steam plant (near the south portal) indicates that rock could be lower than under the existing I-81 viaduct, resulting in some mixed-face tunneling. Settlement above the tunnel should be low, but mixed face conditions would be less favorable than a full face of rock.

### 5.4.5 Tunnel Design & Construction

The Orange Tunnel would consist of a twin bore carrying I-81 and I-690 traffic through downtown Syracuse. Beginning south of Syracuse University, the tunnels would begin in a cut-and-cover section for approximately 1,100 feet, beginning south of Martin Luther King East / Renwick. This portion of the construction would run under the Martin Luther King Boulevard crossing while the Almond Street Ramps would be elevated above the existing roadway crossing. The twin bore would continue approximately 5,400 feet. Within this section, the tunnel would descend to roughly 80 feet below grade at a slope of 4%. The bulk of the tunnel bore would be 80 feet below grade prior to ascending at 6% grade within the I-81 right-of-way north of Erie Boulevard. The tunnel section would continue in a cut-and-cover section for another 700 feet, tying to the existing I-81 alignment north of James Street. The design speed for this option would be 50 mph. The minimum horizontal curvature for this option would be 2,269 feet, which would be greater than that required by design criteria, although the minimum necessary to provide the sight distance required for vehicles traveling 50 mph in the tunnel. The shoulder widths within the tunnel section would be a non-standard design feature. Due to the diameter of the bore, shoulders of 4 feet would be provided on left and right sides adjacent to the 12 feet lanes. Each bore would contain two 12-foot lanes and two 4-foot shoulders to convey traffic both southbound and northbound along I-81. Shoulders would transition to 10 feet once outside of the bored tunnel structure. The Orange Alternative would include the following interchange connections:

- I-81 SB to I-690 EB – new ramp on viaduct
- I-81 NB to I-690 WB – new ramp on viaduct
- I-690 EB to I-81 SB – new ramp on viaduct
- I-690 WB to I-81 NB – new ramp on viaduct

There would be an option to provide two additional interstate connections, independent from the tunnel construction: from I-690 EB to I-81 NB, from I-81 SB to I-690 WB. Although elimination of select local access would be required to accommodate these movement.

The Orange Alternative would reconstruct Almond Street into a boulevard—similar to all other alternatives—construct a new interchange at Almond Street/I-690, and various traffic operational improvements throughout the street grid. The street grid would be required to complete several other movements including the following:

- I-81 NB to I-690 EB – must use new Almond Street/I-690 interchange
- I-690 WB to I-81 SB – must use new Almond Street/I-690 interchange

Separate from the actual tunnel construction, this alternative would construct two viaduct ramps extending from the western leg of I-690 to Fayette Street. Working in combination with Almond Street’s intersection, these viaduct ramps would replace the existing Harrison Street ramps, which were heavily used, and permit the Erie Boulevard/Almond Street intersection to be at-grade. Local connectivity would be maintained with the Orange Alternative in that access to the local street grid would be provided at the I-690/West Street interchange, new I-690/Almond Street interchange, and new local ramps located near the north portal at Hickory (to I-81 NB), Clinton (from I-81 SB), and Taylor (to I-81 SB and from I-81 NB). Local streets would be marginally affected with permanent closures expected at Burt Street near the south portal. Willow Street would be cut off near the northern portal while cross-streets would be maintained since the alignment would be on a structure passing above the street grid at that point. This would be consistent with the existing alignment. Additionally, Water Street and Washington Street would be closed to through traffic across Almond Street as a result of the Fayette Street flyover ramps.

The Orange Alternative would be extremely disruptive to the existing I-690 corridor substructures. The baseline alternative could be implemented with either the existing alignment or a reconstructed alignment, which would address the existing geometric deficiencies. Addressing the existing deficiencies in combination with the Orange Alternative would improve the overall constructability of the northern portal area.

### Protection of Structures

Under this alternative, the cut-and-cover operations would greatly affect the existing I-690 structures. To adequately protect the existing structures and maintain traffic during construction, refinancing and/or underpinning existing roadway supports and using temporary piers would need to be incorporated. The limited space between the existing and proposed structures would result in complex detailing, and it would be expected to be difficult to construct while protecting the existing structures. Besides the difficulties surrounding the area where the cut-and-cover operations would be, many of the proposed structures would overlap in some cases, which would require either staging to use portions of the existing structure or temporary connections and flyovers to divert I-81 traffic around the tunnel construction zone to avoid overly complex staging. Temporary sharing as well as excavation support would
be required for existing structures/embankment at the tunnel cut-and-cover, and open-cut areas.

5.4.6 VIADUCT DESIGN & CONSTRUCTION

New and replacement bridges would be a standard construction of reinforced concrete deck on steel or concrete stringers and reinforced concrete piers, unless circumstances require a different approach. I-690 WB and EB would be realigned and improved with new structures through the existing interchange area since the existing interchanges could remain open to traffic during construction. The new structures could need to be built as flyovers to avoid conflicting with active roadways and affecting the traveling public. The proposed structures would have many constraints in its design due to the close proximity of the existing and proposed structures. This alternative would include improvements to the existing non-standard features of I-690 WB and EB due to the new viaduct being built to permanently replace the existing. A new ramp with a flyover would replace the existing connection from I-81 NB to I-690 WB. Another new ramp would connect I-81 SB to I-690 EB. The existing ramps connecting the West Street arterial and I-690 would be rebuilt under to accommodate the new alignment of I-690 WB. The existing Butternut Street bridge would be removed and replaced with a new structure north of the existing to accommodate the new connections.

Under the Orange Alternative, one complex area that would need special emphasis would be the proposed I-690 EB over the existing I-81. This would be above the cut-and-cover area for approximately 300 feet. Protection of structures and construction staging would be critical for this area of the Orange Alternative.

5.4.7 TUNNEL SYSTEMS

Tunnel systems would be similar for then Red, Orange and Blue Alternatives’ tunnel options and would generally vary only by the quantity of equipment required. For instance, with jet fans spaced at 500 linear feet and installed in pairs, this alternative would require 64 fans. A ventilation building may be required at each portal with point exhaust to remove vitiated air and discharge it at high velocity above the ground level. This would be the shortest of all the bored tunnel options, and there would be a possibility that an environmental assessment of air quality would eliminate the need for a ventilation building and allow ventilation with jet fans alone. However, environmental air quality assessment would still be necessary to confirm operational requirements.

Egress passages between the bores, spaced at about 600 linear feet, would number approximately 13 to 14. Other systems such as electrical, drainage and fire protection, finishes, controls and ITS, would scale in quantity based on the tunnel length.

### CONSTRUCTION STAGING

The Orange Alternative would have the most complicated staging of the feasible build alternatives largely due to the cut-and-cover operations taking place within the most congested area of the I-81 and I-690 interchange. Limited space within this area means proposed structures would need to be built around the existing structures and would require staging in some cases to tie the proposed into existing and vice versa. In many of these cases, the staging would result in traffic diversions using temporary structures, until the proposed tunnel is open to traffic. Maintaining the existing interchange while building the proposed structures could be accomplished but would be a challenge and could prolong construction operations. Staging and construction would be simplified if a portion of I-81 through traffic can be temporarily diverted to I-481 and I-90 during construction.

One possible staging approach to get the tunnel operational and connected to I-81 at the northern terminus would be as follows:

- Build a flyover ramp from I-81 NB to the ramp from I-690 WB to I-81 NB. Provide temporary widening as necessary to accommodate projected traffic volumes.
- Build a connection ramp from I-81 SB (just south of the I-690 WB flyover bridge) to I-690 EB. Provide widening of the elevated viaduct as necessary to accommodate projected traffic volumes and provide length for the weaving for I-81 SB traffic entering on the left to exit on the right for the ramp back onto I-81. A flyover connection could also be considered to avoid the weaving.
- Divert all I-81 through traffic to temporary connections NB and SB.
- Build the tunnel cut-and-cover and open-cut portions, providing temporary shoring to the I-690 EB viaduct.
and make the tunnel connections to existing I-81 roadways.

- Open I-81 traffic through the new tunnel, allowing for removal of the I-81 structures, allowing for the other improvements, specifically realigning I-690 through the intersection.

The existing ramps connecting I-690 and the West Street arterial would be replaced to accommodate the new alignment of I-690 EB and WB. Since this would be a major connection, it would need to be replaced via staged construction, which could temporarily reduce each of the ramp roadways to a single lane. In some instances, the existing piers could be used for the new structures. The new alignment of I-690 WB would also be expected to replace the I-690 over Onondaga Creek, which would also require a staged construction while limiting impact to traffic. The I-690 WB over Onondaga Creek, which leads to the connection for West Street, as well as a new connection ramp from I-81 SB to I-689 WB would require special attention since the ramp structure replacement would be coordinated and developed with the I-690 WB bridge replacement.

Under this alternative, the existing connections for I-81 NB to I-690 EB and for I-690 WB to I-81 SB would be permanently removed and replaced with a community grid connection to Almond Street. The proposed I-690 EB on the eastern side of the project site would be tied into the existing I-690 EB via staged construction. During this time, there would be at least a one lane reduction, and initial expectations are for the construction to be completed in at least three stages.

5.4.9 UTILITIES

Utility impacts for this alternative would be present at the north and south portals. Additional impacts would be expected within the Almond Boulevard reconstruction zone although these utilities would be readily located within the work zone. Major relocations would be expected for utilities affected by north and south portals since relocation would typically be needed outside the portal zone.

Utility investigation and identification would be important to the design consideration phases of this project, and would help determine what alignments would be further studied and what alignment options could be eliminated.

The Syracuse University steam station and chilled water plant would be located close to the southern portal. Numerous steam pipes, chilled water lines and high voltage cables would be tunneled beneath on Hurt Street, East Taylor Street, and within the plant.

Along the I-690 and I-81 viaducts as they approach the city’s inner limits, ground space below either would function as a highway interchange (such as at the north end of I-81) or would be consumed by vegetation with side streets connecting neighborhoods to the Syracuse University campus at the south end of I-81. These less populated areas would allow for portal points to be further considered as areas of entries and egress into the alternative alignments discussed.

The community grid area along I-81 between the northern constraint of Erie Boulevard and the southern constraint of Martin Luther King East shares a variety of residential housing, student housing facilities, small business, large business, medical facilities, educational facilities, and large industrial facilities. Maintaining active utility services without community disruption would be a crucial component at the time of the design consideration phase of this alternative. The inner city to the Syracuse University campus area and medical facilities. This should ensure that the revitalization of this area would have a positive impact on the community as well and improving traffic flow and pedestrian access.

Site-specific utility impacts for this alternative are shown in Appendix I.

5.4.10 PROPERTY IMPACTS

A property impact analysis was prepared for the various alternatives. The efforts required under this property analysis task included the following:

- Determining the limits of property impacts associated with each alternative.
- Identifying the affected parcels.
- Collecting affected parcels data.
- Assessing impacts.

Assumptions and the methodology used to determine the impacts are summarized in Section 3 while backup documentation and maps relative to each alternative are shown in Appendix J.

Twenty two (22) Full Fee Takings are projected for this option. The Full Fee Takings include twelve (12) properties containing building that will require demolition. The remaining ten (10) properties are either vacant or have uses that do not require buildings (i.e., parking lot). The described takings were used to develop estimates for property acquisition costs.

5.4.31 DEVELOPMENT CONSTRAINTS

The future construction of buildings directly above the Orange Alternative tunnel would be minimally constrained by the allowable depth of footings/piles and the allowable weight of buildings (Appendix J). The south end of the tunnel, south of the railroad, would be in a residential area where future development of buildings greater than five stories tall would be unlikely. Buildings of this size could likely be constructed above the tunnel with no adverse impact.

Immediately north of the railroad, the alignment would pass through the university’s steam plant. If future industrial development is anticipated on this site, it should be preferred to construct the tunnel as a cut-and-cover tunnel that could be designed for future overbuild loads (rather than the currently shown bored tunnel, which would be suitable for low-rise overbuild).

The Orange Alternative would pass east of downtown under developable land near McBride Street and Townsend Street. The depth to the crown of the tunnel would be typically around 80 feet, and the tunnel would be expected to be in rock, which should result in little or no constraint on future high rise development (geotechnical profiles, Appendix D). The cut-and-cover tunnel on both sides of Erie Boulevard, near the north portal, could be designed for future overbuild at a moderate cost premium.
5.5 FEASIBLE BUILD ALTERNATIVE GREEN

5.5.1 GENERAL OVERVIEW

The Green Alternative would be aligned immediately east of the I-81 viaduct (see Figure 51).

The Green Tunnel Alternative would start in the south, south of to Martin Luther King East, and would bend to the east to clear the existing I-81 alignment immediately south of the railroad. The southern end of the bored tunnel would be close to this location. To achieve this geometry, reverse curves would be required on both the through tunnel and ramp leading to the community grid (see Appendix-A).

A single bi-level tunnel would be recommended due to the restricted width of available space between the piles of the I-81 viaduct (to the west) and the Crowne Plaza Hotel and hospital buildings (to the east).

From the south portal, the bored tunnel would pass under the Pioneer Homes housing project and immediately adjacent to the Upstate Medical University Hospital, and beneath the I-81 northbound off-ramp to Adams Street (see drawing in Appendix “Green Alignment – Bored Tunnel at Monroe St”). The crown of the tunnel would be expected to be below the tip of existing piles of I-81 Ramp I (northbound to Adams) and Ramp III (northbound from Harrison). Some piles would be steel and others battered cast-in-place piles. The risk of encountering piles would need to be reviewed in detailed design, a deeper tunnel alignment could be adopted to reduce the risk.

The northern portal would be located within the footprint of Almond Street, resulting in traffic disruption and utility relocations. The bored tunnel would be very shallow in this location (see profile in Appendix E) requiring special measures to restrain the TBM from becoming buoyant.

The bored tunnel would end at East Fayette Street. The at-grade parking lots in this area would be acquired to make an efficient reception/launch site for the bored tunnel (Appendix E), in addition to being necessary for future viaduct ramp construction. Areas adjacent to future ramps remaining from the acquisition could be leased/sold back to interested developers for parking or other suitable uses.

A cut-and-cover tunnel would turn westward to connect into the ramps of the existing I-81 viaduct. Connections from I-81 NB to both I-690 WB and I-81 SB would be maintained along with the reverse flows. A ramp for I-81 NB to I-690 EB would be constructed while no reverse ramp would be included. Some underpinning and reconstruction of I-690 would be required.

Advantages of Green Alternative:
- Enables connections to I-690, while limiting modifications to the existing I-690 roadways and structures
- Relatively short tunnel
- Requires less reconstruction of I-690 than the Orange Alternative
- Generally passes under public land
- Avoids Syracuse University Steam Station & Chilled Water Plant

Disadvantages of Green Alternative:
- Confined geometry throughout
- Requires permanent closure of Water Street, Washington Street and East Fayette Street
- Passes close to foundations of hospital and Crowne Plaza Hotel
- I-690 WB to I-81 SB connection would be permanently removed
- Special buoyancy control measures would be required for the bored tunnel
- Risk of encountering piles from I-81 viaduct and ramps
- Steeper tunnel (6%), at the southern portal, compared with other options (4%)
5.5.2 HIGHWAY DESIGN

TUNNEL TRAFFIC

Traffic volumes in the tunnel would be the highest of all alternatives. All connections between I-81 and I-690 would remain, but the Harrison Street ramps would still be eliminated, requiring some drivers to use the local surface street grid to access the downtown area. Anticipated traffic volumes would range from 2,030 vph during the AM peak hour in the northbound direction to approximately 2,050 vph during the PM peak hour in the southbound direction. (For details on traffic volumes see Appendix C-3 of the DEIS.)

5.5.3 COMMUNITY GRID

FOCUS AREA A: SOUTH TUNNEL PORTAL

The south tunnel portal would be connected to Almond Street via on- and off-ramp structures from the I-81 mainline and first tie in at-grade at Taylor Street. This connection would require the closure of Burt Street due to vertical clearance requirements. Martin Luther King East/Renwick Avenue would remain open. The existing segment of Almond Street south of Taylor Street would be converted to a one-way northbound frontage road, providing connections between Van Buren Street, Burt Street, and Taylor Street on the east side of Almond Street. A two-way bicycle track would be located adjacent to the general purpose travel lane and would provide direct bicycle connections from Almond Street to Van Buren Street and the Syracuse University campus.

This ramp connection would be constructed directly above the cut-and-cover tunnel portal, requiring the tunnel to be completed before construction of the ramp.

FOCUS AREA B: ALMOND STREET CORRIDOR

The Almond Street corridor—generally defined as Almond Street between the south tunnel portal and I-690—would have a right-of-way of up to approximately 150 feet. It would range between two and three general purpose travel lanes in each direction, with designated curbside bicycle lanes and 15-foot sidewalks on the east and west sides of the street. Where possible, parallel on-street parking would be provided for convenience and to slow traffic. To mitigate Almond Street’s wide cross-section and provide a visual buffer from potentially high traffic volumes, side and center medians would be constructed, which would provide area for substantial tree planting and canopy, add aesthetic interest, physically separate travel lanes, and provide green space. A side median with adjacent northbound frontage road would be constructed adjacent to Syracuse Housing Authority’s Pioneer Homes between Taylor Street and Adams Street. A wide center median would be constructed north of Adams Street to I-690. In combination, these improvements would make Almond Street a heavily landscaped urban boulevard, and a walkable, multimodal “Complete Street.”

Most intersecting streets along the Almond Street corridor would remain unchanged in terms of travel-lane assignment and cross-section configuration. However, this alternative would divert Almond Street to McBride Street at Genesee Street to provide continued north-south connectivity while avoiding the north tunnel portal located north of the intersection with Genesee Street. To accommodate the north tunnel portal, Fayette Street, Washington Street, and Water Street would be closed.

Under this alternative, there would be residual state-owned rights-of-way currently occupied by I-81 viaduct and ramps not required for the reconstruction of Almond Street. This freed up land, most notably on block frontages westerly adjacent to Almond Street, could be redeveloped by others if the state decided to dispose of the property.

FOCUS AREA C: I-690/I-81 CONNECTION TO DOWNTOWN SYRACUSE

Focus Area C generally refers to the area north of Fayette Street where new on- and off-ramps would be constructed under the Green Alternative to provide grade-separated access to I-690 from the Almond Street corridor. Under the Green Alternative, the I-81 north tunnel portal would also be in this location and aligned in the center of the existing Almond Street right-of-way north of Fayette Street. This would require closing Fayette Street, Washington Street, and Water Street and realigning Almond Street west to McBride Street to maintain north-south connectivity. The Almond Street/McBride Street realignment would continue as two lanes in each direction with wide sidewalks and bicycle lanes north of the I-690 ramps to Erie Boulevard, where Almond Street/McBride Street narrows to a four-lane cross-section with no center median.

Providing a direct local-to-interstate connection would be critical to maintaining acceptable levels of service in downtown Syracuse. To provide this connection from the

FIGURE 52: Green Alternative North Portal
The Green Tunnel would consist of a single bore carrying I-690/Almond Street interchange, and includes the Fayette Street flyover ramps. Maintenance of the local ramps located near the north portal at Hickory (to I-81 NB), Clinton (from I-81 SB), and Taylor (to I-81 SB and from I-81 NB). Local streets would be significantly affected with permanent closures expected at Burt Street near the south portal. Martin Luther King East and Renwick will remain open. Water Street and Washington Street would be cut off near the northern portal due to limited vertical clearance from the tunnel mainline and local ramp viaduct structures as would be a portion of Almond Street, which would be relocated to avoid the ascending tunnel/viaduct at Fayette. Street would be cut off due to the ascending single bore tunnel.

The Green Alternative would be completely independent from the work to correct the existing I-690 geometric deficiencies. The baseline alternative could be implemented with either the existing alignment or a reconstructed alignment, which would address the existing geometric deficiencies.

**PROTECTION OF STRUCTURES**

Under the Green Alternative, the construction of the proposed ramps between I-81 and I-690 would interfere with an existing pier at the existing I-690 structure over Townsend Street. To protect this structure, reframing of the existing piers and temporary supports would be necessary. In this case, the existing structure could be replaced ‘where necessary, before construction operations. During construction, the contractor would need to take care that operations and equipment would not be in danger of damaging existing structures. Although the existing and proposed structures would be within close proximity as laid out by the Green Tunnel Alternative alignments, this type of construction would not be uncommon and could be accomplished in a manner that safely protects the existing structures.

At the southern end of the project, the proposed I-81 roadway approach to the Alternative tunnel could be built independently and would avoid affecting the existing I-81 traffic system. The southern end of the viaduct, where tunneling begins, a new structure would be built over the railroad. This new structure would not affect the existing structure and would be tied into the community grid when open to traffic. Since most of the existing bridges and viaducts would be supported by piles, it can be assumed that the new bridges, viaducts, and ramps would also be supported by piles.

**5.5.5 TUNNEL SYSTEMS**

The Green Alternative with its single bi-level tunnel would be unique with respect to other alternatives for the tunnel systems design, particularly ventilation and egress. An exhaust duct is recommended for this alternative, with operable dampers spaced every 300 feet (approximately 88 dampers needed). A ventilation building may be needed at each end of the tunnel to house equipment for ventilation, including exhaust fans. Jet fans would primarily evaluate the tunnel’s impacts on the surrounding soil and existing foundations, and thus the need for temporary draining or reframing the viaduct to maintain traffic during construction.
be needed for air balance control, rather than primary ventilation. With jet fans spaced at 1,000 linear feet and installed in pairs, the fan estimate for this alternative would require 32 fewer fans than other alternatives. Ventilation could be operated in normal conditions for this alternative to minimize discharge of vitiated air at the portals. An environmental assessment of air quality for this alternative would still be necessary to confirm operational requirements.

Egress would be provided between the levels by connecting fire-rated stairways spaced at about 600 linear feet, approximately 10 to 11. Holding areas for non-ambulatory people would be required. Other systems such as electrical, drainage and fire protection, finishes, controls and ITS, would scale in quantity based on the tunnel length.

5.5.8 CONSTRUCTION STAGING

The Green Alternative would have less complex staging than the Orange Alternative and could be done with limited impacts to traffic. The new I-81 NB to I-690 EB ramp would be built adjacent to the existing alignment to start, and then would be tied into the existing alignment as it enters I-690 EB. This could be done with staged construction. Since the existing ramp would be on one lane with shoulders on each side, the staged construction in this area would have negligible impact on traffic. At this time, the tunnel could be open to traffic for using I-81 NB as a connection to I-690 EB, while the existing viaduct could remain open for the remaining connections. The existing I-81 NB to I-690 EB could be removed to eliminate its obstruction to the proposed I-81 ramps. With both the existing I-81 NB to I-690 EB and I-690 WB to I-81 SB removed, the proposed I-81 NB ramp could be built with no obstructions adjacent to and north of the existing ramp and tied into the existing roadways where feasible, using typical localized staging. Upon completing the new I-81 NB ramp, the existing ramp could be demolished. With the existing I-81 NB demolished, the new I-81 SB ramp could be built and tied into the existing structure. Finally, the new I-690 EB to I-81 SB ramp could also be tied into the existing ramp structure with limited staged construction. With all proposed structures in place, the remaining existing structures could be removed.

After removing the existing structure, the southern connection from I-81 to Almond Boulevard would be constructed, on top of the tunnel.

5.5.9 UTILITIES

Utility impacts for this alternative would be present at the south and north portals. Additional impacts would be expected within the Almond Boulevard reconstruction zone, although these utilities would be readily located within the work zone. Major relocations would be expected for utilities affected by north and south portals since relocation would typically be needed outside the portal zone.

Utility investigation and identification would be important to the design consideration phases of this project, and would help in determining what alignments would be further studied and what alignment options could be eliminated. Along the I-690 and I-81 viaducts as they approach the city’s inner limits, ground space below would either function as a highway interchange (such as at the north end of I-81) or would be consumed by vegetation with side streets connecting neighborhoods to the Syracuse University Campus at the south end of I-81. These less populated areas would allow for portal points to be further considered as areas of entries and egress into the alternative alignments discussed.

The community grid area along I-81 between the northern constraint of Erie Boulevard and the southern constraint of Martin Luther King East shares a variety of residential, student housing facilities, small business, large businesses, medical facilities, educational facilities and large industrial facilities. Maintaining active utility services without community disruption would be a crucial component at the time of the design consideration phase of this connective corridor between the eastern portion of the inner city to the Syracuse University campus area and medical facilities. This should ensure that the revitalization of this area would have a positive impact on the community as well as improving traffic flow and pedestrian access.

Appendix I shows site-specific utility impacts for this alternative.

5.5.10 PROPERTY IMPACTS

A property impact analysis was prepared for the various alternatives. The efforts required under this property analysis task included the following:

- Collecting affected parcels data
- Assessing impact
- Assessing value of affected properties

The assumptions and methodology used to determine the impacts are summarized in Section 3 while backup documentation and maps relative to each alternative is shown in Appendix J.

Six (6) Full Fee Takings are projected for this option. The Full Fee Takings include two (2) properties containing buildings that will require demolition. The remaining four (4) properties are either vacant or have uses that do not require buildings (i.e. parking lot). The described takings were used to develop estimates for property acquisition costs.

5.5.11 DEVELOPMENT CONSTRAINTS

The future construction of buildings directly above the Green Alternative tunnel would be minimally constrained by the allowable depth of footings and the allowable weight of buildings (Appendix J). The south end of the tunnel, near the railroad, would be in a residential area where future development of buildings greater than five stories tall would be unlikely. Buildings of this size could likely be constructed above the tunnel with no adverse impact.

The rest of the alignment would run directly below Almond Street, so future development directly above the bored tunnel or north portal cut-and-cover would be unlikely.

### TABLE 15: Weekday Peak Hour Tunnel Traffic (vph): 2050 Build – Green Alternative

<table>
<thead>
<tr>
<th></th>
<th>Weekday AM Peak Hour</th>
<th>Weekday PM Peak Hour</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Northbound</td>
<td>Southbound</td>
</tr>
<tr>
<td>Volume (vph)</td>
<td>2,031</td>
<td>1,721</td>
</tr>
<tr>
<td>Estimated Level of Service</td>
<td>C</td>
<td>B</td>
</tr>
</tbody>
</table>

Assumptions:
1. Closure of I-690 WB to I-81 SB Ramp
2. Two-Lane Tunnel
### 5.6 FEASIBLE BUILD ALTERNATIVE BLUE

#### 5.6.1 GENERAL OVERVIEW

As analyzed for this feasibility study, the Blue Tunnel Alternative would be aligned southwest of downtown Syracuse, and would connect into West Street close to the interchange with I-690. It would include two separate sections of tunnel: Martin Luther King East to West Street, and West Street to near Destiny Mall (Figure 53).

The Blue Alternative would start south of Martin Luther King East and would trend to the northwest. A cut and cover tunnel would transition to a bored tunnel near South McBride Street. A TBM launch shaft would be located south of the Van Buren and South McBride Street intersection. The bored tunnels would pass under the railroad, and stay west of the Syracuse University steam station & chilled water plant.

The tunnels would pass under the southwest corner of the Pioneer Homes housing project, Roessler Park, and low-rise buildings on South Warren Street. The tunnel would continue under the railroad and Onondaga Creek, and would pass to the south of the parking lot for the Museum for Science and Technology, which overlies water storage tunnels that comprise the Clinton CSO Facility. The tunnels would re-cross both the creek and the railroad as they approach West Street.

The bored tunnel would transition to cut-and-cover at West Fayette Street. The existing interchanges at Erie Boulevard and I-690 would require significant reconstruction. A connection with I-690 would be constructed. Significant open-cut excavation would be required during construction, but the finished condition above the cut-and-cover structures at West Street would be substantially the same as today. Northbound off-ramps and southbound on-ramps would provide connections to I-690 and city streets.

The bored tunnel would re-commence south of I-690, continue north under low-rise buildings, and pass east of the Inner Harbor. The tunnel would daylight and rise onto a viaduct to span over Bear Street and the Inner Harbor. The tunnel would daylight and continue north under low-rise buildings, and pass east of The bored tunnel would re-commence south of I-690, provide connections to I-690 and city streets. Northbound off-ramps and southbound on-ramps would be provided for convenience and to slow traffic. To mitigate Almond Street’s wide cross-section and provide a visual buffer from potentially high traffic volumes, side and center medians would be constructed, which would provide area for substantial tree planting and canopy, add aesthetic interest, physically separate travel lanes, and provide green space. A side median with adjacent northbound frontage road would be constructed adjacent to Syracuse Housing Authority’s Pioneer Homes between Taylor Street and Adams Street. A wide center median would be constructed north of Adams to I-690.

In combination, these improvements would make Almond Street a heavily landscaped urban boulevard, and a walkable, multimodal “Complete Street.” All intersecting streets along the Almond Street corridor would remain unchanged in terms of travel lane assignment and cross-sectional configuration.

#### 5.6.2 HIGHWAY DESIGN

##### TUNNEL TRAFFIC

Traffic volume in the tunnel would be somewhere between the 5.6.3 COMMUNITY GRID

The south tunnel portal would be connected to Almond Street via on- and off-ramp structures from the I-81 mainline, and first tie in at-grade at Taylor Street. This connection would require the closure of Burt Street due to vertical clearance requirements. Martin Luther King East/Renwick Avenue would remain open. The existing segment of Almond Street south of Taylor Street would be converted to a one-way northbound frontage road, providing connections between Van Buren Street, Burt Street, and Taylor Street on the east side of Almond Street. A two-way bicycle track would be located adjacent to the general purpose travel lane and would provide direct bicycle connections from Almond Street to Van Buren Street and the Syracuse University campus.

#### FOCUS AREA B: ALMOND STREET CORRIDOR

The Almond Street corridor, generally defined as Almond Street between the south tunnel portal and I-690, would have a right-of-way of up to approximately 150 feet. It would range between two and three general purpose travel lanes in each direction, with designated curbside bicycle lanes and 15-foot sidewalks on the east and west sides of the street. Where possible, parallel on-street parking would be provided for convenience and to slow traffic. To mitigate Almond Street’s wide cross-section and provide a visual buffer from potentially high traffic volumes, side and center medians would be constructed, which would provide area for substantial tree planting and canopy, add aesthetic interest, physically separate travel lanes, and provide green space. A side median with adjacent northbound frontage road would be constructed adjacent to Syracuse Housing Authority’s Pioneer Homes between Taylor Street and Adams Street. A wide center median would be constructed north of Adams to I-690.

In combination, these improvements would make Almond Street a heavily landscaped urban boulevard, and a walkable, multimodal “Complete Street.” All intersecting streets along the Almond Street corridor would remain unchanged in terms of travel lane assignment and cross-sectional configuration.

<table>
<thead>
<tr>
<th>Property Impact Classification by Land Use</th>
<th>Commercial</th>
<th>Residential</th>
<th>Industrial</th>
<th>Recreat</th>
<th>Parks</th>
<th>Public Services</th>
<th>Comm. Services</th>
<th>Unknown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Partial Fee Taking</td>
<td>6</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Full Fee Taking</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Permanent Easement</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>3</td>
<td>5</td>
<td>0</td>
</tr>
</tbody>
</table>

TABLE 16: Property Takings: Blue Alternative
Under this alternative, there would be residual state-owned rights-of-way currently occupied by I-81 viaduct and ramps not required to reconstruct Almond Street. This freed up land, most notably on block frontages westerly adjacent to Almond Street, could be redeveloped by others if the state decided to dispose of the property.

5.6.4 GEOTECHNICAL CONDITIONS

Geotechnical information along the Blue Alternative alignment is limited. At West Street/I-690, available boring logs encountered no rock to depths of 100 feet. It is assumed that the whole alignment would be either in soft ground (soil) or potentially in mixed face. In either case a pressurized face FPM tunneling machine is proposed, which would be suitable for these conditions (see Appendix E).

The depth of rock at the West Street cut-and-cover structures is unknown but has been assumed as 100 feet. A similar depth has been assumed for the north portal. For cost estimating purposes support of excavation walls have been extended to this depth. If future geotechnical boring programs determine that rock would be significantly deeper, the cost of the support walls would increase, and it could be necessary to install a jet grout invert plug.

5.6.5 TUNNEL DESIGN & CONSTRUCTION

The Blue Alternative would run westerly of all others, essentially replacing the West Street interchange with a new limited movement highway interchange. Local connections at West Street would then be implemented farther east of West Street. The Blue Alternative evaluated both twin bored and single bore options. The twin bore option is preferred since it would provide better highway connections at West Street.

The Blue Alternative tunnel would consist of a twin bored carrying I-81 and I-690 traffic through downtown Syracuse. This alignment would be the longest in-tunnel length and would include two bored sections with an intermediate cut-and-cover section in the middle that facilitates connections to I-690. Beginning south of Syracuse University, the roadway would be realigned leading to the beginning of tunnel construction via cut-and-cover. The single bore would continue for approximately 4,100 feet. Within this section, the tunnel would descend to roughly 80 feet below grade at a slope of 4%. The bulk of the tunnel bore would be 80 feet below grade prior to ascending at 6% grade to a cut-and-cover section at West Street. Moving north roughly 1,300 feet, the tunnel would be constructed using cut-and-cover methods, which would permit the various I-690 ramps to merge into I-81. North of this cut-and-cover section, a second bored alignment would be designed leading farther north again descending Fay Street, again descending Onondaga Creek and I-690 to 80 feet below grade. The second bored section would finish at 5,500 feet just south of the Solar Street/Court Street intersection. The tunnel section would continue in a cut-and-cover section for another 500 feet, before rising on viaduct to flyover existing Bear Street and I-81 Southbound. Significant realignment of Genant Street including a new intersection at Bear Street is required. The design speed for this option would be 50 mph. The minimum horizontal curvature for this option would be 1,500 feet, greater than that required by design criteria, although the minimum necessary to provide the sight distance requirement for vehicles traveling 50 mph. Non-standard shoulder widths would be provided within the tunnel section, which would transition to compliant widths outside the actual tunnel construction. Due to the diameter of the bore, shoulders of 4 feet would be provided on both left and right sides adjacent to the 12-foot lanes. Each bore would contain two 12-foot lanes and two 4-foot shoulders to convey traffic both southbound and northbound along I-81.

The Blue Alternative includes the following interstate connections:

- I-81 SB to I-690 EB – existing ramp on viaduct. I-81 would be maintained through several connections to I-690 that would not be facilitated by the new tunnel.
- I-81 NB to I-690 WB – new ramp from tunnel cut-and-cover area
- I-81 NB to I-690 EB – new ramp from tunnel cut-and-cover area
- I-690 EB to I-81 SB – new ramp from tunnel cut-and-cover area
- I-690 WB to I-81 NB – existing ramp on viaduct

The option exists to provide a connection from I-81 SB to I-690 WB. This work would be completely independent of the Blue Alternative work since it would not interfere or affect the tunnel construction.

The option exists to provide a connection from I-690 EB to I-81 NB. This work would be completely independent of the Blue Alternative work since it would not interfere or affect the tunnel construction. However, inclusion of this ramp would be on structure and require modification to the city street grid to facilitate. The Blue Alternative includes reconstructing Almond Street into a boulevard, similar to all other alternatives, along with demolishing the existing viaduct from nearly Washington Street to Burt Street. The construction of a smaller limited interchange at Almond Street/I-690 and various traffic operational improvements throughout the street grid would be required to replace the local street access lost by eliminating the Harrison Street ramps. However, the existing viaduct could be maintained in the Blue Alternative to permit a reconstructed set of Harrison Street ramps to be included within the Green Alternative. The street grid would be required to complete several other movements:

- I-690 WB to I-81 SB – must use new Almond Street/I-690 interchange

Separate from the actual tunnel construction, this alternative would include constructing two viaduct ramps that would extend from the western leg of I-690 to Fayette Street.
FIGURE 54: Blue Alternative Map

FIGURE 55: Blue Alternative North Portal

FIGURE 56: Blue Alternative – West Street

ALTERNATIVES

- Study Area
- Tunnel
- Tunnel Portal
- Blue Alternative

FIGURE 54: Blue Alternative Map
Working in combination with the Almond Street/I-690 interchange, these viaduct ramps would replace the existing Harrison Street ramps, which were heavily used, and permit the Erie Street/Almond Street intersection to be at-grade.

Local connectivity would be significantly altered in the Blue Alternative. While this option would provide a new interchange at I-690/Almond Street, the interchange at West Street would be effectively removed. Genesee Street would be maintained along with constructing a new north-south West Street above the cut-and-cover tunnels to Erie Boulevard. Access to the local street grid would be maintained and provided at the I-690/West Street interchange, modified I-690/Almond Street interchange, and includes the Fayette Street flyover ramps. Maintenance of the local ramps located near the north portal at Hickory Street (to I-81 NB), Clinton Street (from I-81 SB), and Taylor Street (to I-81 SB and from I-81 NB). Additionally, an off-ramp from I-90 EB would be designed to Salina Street while an on-ramp to I-90 WB begins at Clinton Street. Local streets would be marginally affected with permanent closures expected at Burt Street near the south portal in addition to Water Street and Washington Street to accommodate the Fayette Street ramps.

The Blue Alternative would be completely independent from the work to correct the existing I-690 geometric deficiencies. However, the new tunnel would eliminate various ramp connections in the I-690/I-81 merge area that would ultimately reduce the overall structure height should that section be reconstructed. The baseline option could be implemented with either the existing alignment or a reconstructed alignment, which would address the existing geometric deficiencies.

**VIADUCT DESIGN & CONSTRUCTION**

The Blue Alternative would align the I-81 tunnel to the west toward West Street, and would come to ground level to allow for connections to the West St and I-690 interchange, before continuing underground. At the northern end, the tunnels would reach existing grade just past the intersection of Solar Street and Court Street. A new bridge would be needed to bring traffic above Bear Street, a major roadway carrying traffic going to and from Destiny USA Mall, I-690, and existing I-81. New and replacement bridges would be of standard construction, such as reinforced concrete deck on steel or concrete girders and concrete piers, unless circumstances require a different approach. A portion of the existing I-81 would remain under this alternative, to the north of the existing interchange. At the southern end of the project, the proposed I-81 roadway and tunnel could be built independently and would avoid affecting the existing I-81 entirely. The same would be true for the new ramp over the existing railroad, which would lead to the newly constructed community grid for downtown Syracuse.

The replacement of I-690 WB and EB could be performed after completing the tunnel’s construction and the removal of existing I-81 connections. The new I-690 would be built using a combination of newly constructed and existing roadways, but could be accomplished via staging while limiting impacts to traffic.

**PROTECTION OF STRUCTURES**

Under the Blue Alternative, the existing I-690 and I-81 interchange would be avoided and the existing structures in this area would not be affected during construction. The existing Erie Boulevard over West Street Bridge would overlap with the cut-and-cover area of the project and would be affected greatly by construction operations and would need replacement. Traffic would need to be diverted while cut-and-cover operations are in progress. The West Street and I-690 connections would need replacement ramps built, with reframing possible where proposed alignments would overlap with the existing, such as where the proposed West Street to I-690 WB ramp would overlap with the existing I-690 WB to West Street SB ramp. The replacement of I-690 WB and EB could be performed after the completion of the tunnel’s construction and the removal of existing I-81 connections. The new I-690 would be built using a combination of newly constructed and existing roadways, but could be accomplished via staging while limiting impacts to traffic.

**TUNNEL SYSTEMS**

Tunnel systems would be similar for the Red, Orange and Blue Alternatives and would generally vary only by the quantity of equipment required. For instance, with jet fans spaced at 500 linear feet and installed in pairs, this alternative would require 104 fans. A ventilation building may be required at each portal with point exhaust to remove vitiated air and discharge it at high velocity above the ground level. Given the length of this alternative, it is unlikely that an environmental assessment of air quality for this alternative would eliminate the need for a ventilation building and allow ventilation with jet fans alone. Environmental air quality assessment would still be necessary to confirm operational requirements.

Egress passages between the bores, spaced at about 600 linear feet, would number approximately 21 to 22. Other systems such as electrical, drainage and fire protection, finishes, controls and ITS, would scale in quantity based on the tunnel length.
CONSTRUCTION STAGING

For the Blue Alternative, staged construction would be needed primarily for the newly constructed I-690 roadways and structures. The new alignments would take advantage of the existing roadways and bridges to allow for staged construction with limited impacts to traffic. The West Street NB to I-690 WB ramp and the West Street NB to I-690 EB would need to be replaced to accommodate the new alignments of I-690, which could be accomplished with localized staging. Some aspects of these structures could be built independently without affecting traffic in any way, such as the proposed West Street NB to I-690 EB, which would have a portion of the structure over currently unused land.

The north end of the project limits would also have limited staging areas. A new exit roadway from I-81 SB to Bear Street could be constructed and opened to traffic prior to the construction of the I-81 over Bear Street bridges. Since these structures would also cross a portion of the existing I-81 traffic would be maintained via staging using a portion of the existing roadways and using widened roadways as necessary.

UTILITIES

Utility impacts for this alternative would present at the south portal, West Street, and north portal. Additional impacts would be expected within the Almond Boulevard reconstruction zone although these utilities would be readily located within the work zone. Major relocations would be expected for utilities affected by north and south portals since relocation would typically be needed outside the portal zone.

Utility investigation and identification would be important to the design consideration phases of this project, and would help in determining what alignments would be further studied and what alignment options could be eliminated. Along the I-690 and I-81 viaducts as they approach the city’s inner limits, ground space below would either function as a highway interchange (such as at the north end of I-81) or would be consumed by vegetation with side streets connecting neighborhoods to the Syracuse University campus at the south end of I-81. These less populated areas would allow for portal points to be further considered as areas of entries and egress into the alternative alignments discussed.

Significant utility relocations would be anticipated at West Street, as noted in Appendix I.

The community grid area along I-81 between the northern constraint of Erie Boulevard and the southern constraint of Martin Luther King East shares a variety of residential housing, student housing facilities, small business, large business, medical facilities, educational facilities and large industrial facilities. Maintaining active utility services without community disruption would be a crucial component at the time of the design consideration phase of this connective corridor between the eastern portion of the inner city to the Syracuse University Campus area and medical facilities. This should ensure that the revitalization of this area would have a positive impact on the community as well as improving traffic flow and pedestrian access.

Appendix I shows site-specific utility impacts for this alternative.

PROPERTY IMPACTS

A property impact analysis was prepared for the various alternatives. The efforts required under this property analysis task included the following:

- Determining the limits of property impacts associated with each alternative
- Identifying the affected parcels
- Collecting affected parcels data
- Assessing impacts
- Assessing value of affected properties

Assumptions and methodology utilized to determine the impacts are summarized in Section 3, while backup documentation and maps relative to each alternative is shown in Appendix J.

Fifty two (42) Full Fee Takings are projected for this option. The Full Fee Takings include twenty two (22) properties containing building that will require demolition. The remaining twenty (20) properties are either vacant or have uses that do not require buildings (i.e. parking lot).

The described takings were used to develop estimates for property acquisition costs.

DEVELOPMENT CONSTRAINTS

The future construction of buildings directly above the Blue Alternative tunnel would be somewhat constrained in some areas by the allowable depth of footings/piles and the allowable weight of buildings (Appendix J). The south end of the tunnel, south of the railroad, would be in a residential area where future development of buildings greater than five stories tall is unlikely. Buildings of this size likely could be constructed above both the tunnel with no adverse impact.

The crown of the bored tunnel would be generally around 50 feet deep, but slightly shallower close to the portals. It would be anticipated that this tunnel would be primarily in soil, with some areas of mixed face comprising soil and rock (geotechnical profiles, Appendix D).

The Blue Alternative would pass south and west of downtown. It would pass under developable land near Clinton Street and Salina Street. The height of new development would likely be limited to approximately 10 stories on shallow footings. Further analysis would be required to determine whether settlement of buildings of this approximate height would be acceptable if piles were used.
5.7 CAPITAL COST ESTIMATION

This study looked at building tunnel alternatives set in an urban environment to replace the aging I-81 viaduct section in downtown Syracuse. Successfully delivering one of these alternatives would present many challenges to overcome in the design and construction of the facilities and engage many trades and equipment and construction materials. In developing the cost estimate for each alternative, the work was broken into different areas:

- Tunneling and Heavy Civil work – This includes the major work excavations for the cut and the cut-and-cover transitions to the mining portal, major reinforced concrete work for the cut-and-cover tunnels, the TBM drive(s), handling and disposal of muck, along with the placement of precast concrete segmental liners for the tunnel, and the temporary power, draining pumps and ventilation needed to work underground.
- Ventilation and Fire-Life Safety Systems – This work includes the permanent ventilation fans and equipment, fire protections, final tunnel drainage, lighting and finishes and special systems in the tunnel.
- Bridges & Ramps (new, temporary and demolishing portions of existing viaduct) – The cost estimate was prepared by calculating the quantities for each alternative on a square-foot basis for the different types of bridge, ramps, temporary structures, underpinning/temporary support of existing structures as well as the portions of the existing viaduct to be demolished.
- Civil Highway and Miscellaneous – This cost estimate includes all the pavement, roadway construction, surface drainage, concrete barriers, guide rails, lighting, signs, landscaping, and utilities for each alternative.
- Right-of-Way and Property Easement – This cost estimate accounts for the permanent ventilation fans and equipment, fire protections, final tunnel drainage, concrete barriers, guide rails, lighting, signs, landscaping, and utilities for each alternative.
- Soft Costs (project management/construction management and support, design services, geotechnical exploration program, procurement services, legal, public outreach, etc.) – This estimate accounts for costs associated with successfully delivering a large multi-year project in an urban area.
- Escalation and Risk Reserve – This cost estimate accounts for escalation and a risk reserve associated with successfully delivering a large multi-year project in an urban area.

Table 19 provides the total estimated project costs for each alternative. Please see Appendix K for more details.

5.8 CONSTRUCTION SCHEDULE

Each of the tunnel alternatives considered in this study would be a multi-year project. The project could be packaged to be delivered as a conventional design-build or as a design-build or other alternative delivery process. Regardless of the delivery method, there would be a minimum of two to half three years of design development and geotechnical exploration needed before any construction could begin. In addition, all needed property rights-of-way and perpetual underground easements must be identified and acquired—a considerable effort by itself. The geotechnical investigation would be needed to inform the tunnel design as well as provide the input to guide the design and manufacture of the project-specific TBM. Once design is complete, construction could commence, which could take five to seven years, depending on the alternative and what time of year construction would start.

The design, manufacture, and delivery of a TBM typically takes a year. It should be noted that for a single bore large diameter TBM another three to six months could be required. During this TBM procurement time, the contractor could mobilize, begin temporary construction to support MOT operations, and excavate the cut-and-cover transition tunnel area and prepare the portal where TBM mining would begin. The TBM operations would start out slowly to let the operator learn how the TBM operates and how the ground responds—this would be the learning curve period. Efficiency increases as mining progresses. It would be assumed that only one TBM would be used for the twin tunnel alternatives, so once the machine mines the first tunnel (taking between eight to eleven months, depending on the length of the tunnel), it would break through and undergo an approximately three-month period of maintenance and configuration to bore the second tunnel. The second tunnel would have a similar duration as the first, but would typically go a little faster.

After the tunnels are complete, the work would shift to installing the roadway surfaces, the permanent ventilation system, and other fire-life safety systems and equipment. This effort would take over a year and significantly longer for the large single bore tunnel with stacked roadways.

As the tunnel fit-out nears completion, the contractor could shift his work efforts to building new ramps and connecting roadways, tying into the existing network. After the tunnel is ready and the connections made, traffic could shift into the new tunnels. The contractor could then begin demolishing and removing the old viaduct structure. Duration would be governed by the amount of viaduct being demolished. Once demolition is well under way, the final work of reconstructing Almond Street could begin to finish up the project.

In summary, the project schedule to deliver a tunnel option would require about 9 years.

A comparative schedule was prepared for each alternative (Table 20).

These schedules would be only preliminary and based on the identified scope of work and subject to adjustments based on results of geotechnical explorations, design development, and risk analysis. Typical project schedules for each alternative are presented on Figure 56 through Figure 59.

<table>
<thead>
<tr>
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Table 19: Alternatives Project Capital Cost Estimation

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<td>9 years</td>
<td>9.2 years</td>
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</table>

Table 20: Total Project Schedule by Alternative
FIGURE 57: Red Tunnel Alternative Construction Schedule

- **Design & Geotechnical Exploration**
- **Procurement(s)**
- **Acquire ROW & Perpetual U/G Easements**
- **Construction**
- **Mobilization, Utilities, MOT, Portal Construction**
- **TBM Procurement**
- **Assemble TBM**
- **Mine First Tunnel**
- **TBM Maintenance-Set Up For**
- **Mine Second Tunnel**
- **Install Tunnel Finishes, Cut & Cover Concrete**
- **New Bridges, Ramps**
- **Connection Roadways**
- **Demolish Existing Viaduct**
- **Reconstruct Almond St.**

YEAR 1:
- Q3: Design & Geotechnical Exploration
- Q4: Procurement(s)
- Q1: Acquire ROW & Perpetual U/G Easements
- Q2-Q4: Construction

YEAR 2:
- Q1: Mobilization, Utilities, MOT, Portal Construction
- Q2: TBM Procurement
- Q3: Assemble TBM
- Q4: Mine First Tunnel

YEAR 3:
- Q1: TBM Maintenance-Set Up For
- Q2: Mine Second Tunnel
- Q3-Q4: Install Tunnel Finishes, Cut & Cover Concrete

YEAR 4:
- Q1-Q4: New Bridges, Ramps
- Q1-Q2: Connection Roadways
- Q3-Q4: Demolish Existing Viaduct

YEAR 5:
- Q1-Q4: Reconstruct Almond St.

YEAR 6:
- Q1-Q4: Design & Geotechnical Exploration
- Q1-Q2: Procurement(s)
- Q3: Acquire ROW & Perpetual U/G Easements
- Q4: Construction

YEAR 7:
- Q1-Q4: Mobilization, Utilities, MOT, Portal Construction
- Q1-Q2: TBM Procurement
- Q3: Assemble TBM
- Q4: Mine First Tunnel

YEAR 8:
- Q1-Q4: TBM Maintenance-Set Up For
- Q1-Q2: Mine Second Tunnel
- Q3-Q4: Install Tunnel Finishes, Cut & Cover Concrete

YEAR 9:
- Q1-Q4: New Bridges, Ramps
- Q1-Q2: Connection Roadways
- Q3-Q4: Demolish Existing Viaduct
- Q1-Q2: Reconstruct Almond St.
<table>
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<th>YEAR 1</th>
<th>YEAR 2</th>
<th>YEAR 3</th>
<th>YEAR 4</th>
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<th>YEAR 6</th>
<th>YEAR 7</th>
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<td>Q2</td>
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<td>Q4</td>
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<td>Q2</td>
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<td>Install Tunnel Finishes, Cut &amp; Cover Concrete</td>
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<td></td>
<td>Demolish Existing Viaduct</td>
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<td>Reconstruct Almond St.</td>
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</table>

**FIGURE 58:** Orange Tunnel Alternative Construction Schedule
FIGURE 59: Green Tunnel Alternative Construction Schedule
FIGURE 60: Blue Tunnel Alternative Construction Schedule
5.9 OPERATION & MAINTENANCE (O&M) COST ESTIMATION

5.9.1 TUNNEL SYSTEMS – OPERATIONS AND MAINTENANCE COST + REPLACEMENT COST

Life-cycle costs for tunnel systems are broken into three major categories:

- Initial Construction cost
- Operations and Maintenance cost
- Replacement cost

Costs have been estimated based on previous project experience. Operations and maintenance cost and replacement cost were estimated on a net present value basis over a 50 year life-cycle. Replacement cost relates to items that could require replacement during the assumed life-cycle. System replacement periods vary from 15 years (lighting) to 50 years (finishes).

The construction cost of tunnel systems is included in the estimated total construction cost.

Table 21 presents the present value of operations and maintenance cost plus the replacement cost for tunnel systems, over 50 years.

**TABLE 21: Alternatives Project Operations and Maintenance Cost Estimation**

<table>
<thead>
<tr>
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<td>$359 M</td>
<td>$295 M</td>
<td>$606 M</td>
</tr>
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</table>
6 KEY FINDINGS & CONCLUSIONS

The original study scope anticipated developing two tunnel alternatives and two depressed highway alternatives—all with and without community grid improvements. The existing interstate system in downtown Syracuse of I-81 and I-690 are largely on viaduct structures. The key challenge was taking the elevated I-81 highway and putting it underground, but trying to re-establish connections with I-690 that would remain elevated. The team briefly considered putting both interstates underground, but trying to establish an underground interchange was quickly determined to not be a feasible alternative due to constructability issues, property required, as well as high cost. Eight alignment alternatives were initially developed of which four were selected to be examined in greater detail. As the Independent Feasibility Study progressed, the study team came to consensus on the following points:

- The depressed highway alternatives did not meet the goals of the study at all, and in fact were seen to be detrimental to the city. These alternatives would further divide neighborhoods and close off more local streets. Therefore, depressed highway alternatives are not recommended.
- Community grid improvements would be integral to each alternative that was studied further. It is not recommended to consider a tunnel alternative without community grid improvements.

Therefore, the Independent Feasibility Study shifted to examine in greater detail four tunnel alternatives, each with community grid improvements. These tunnel alternatives would have different northern portals and roadway connections that would provide distinct choices and unique features as to the advantages and disadvantages.

Table 22 illustrates how the four alternatives meet the study goals and objectives. Table 23 provides an overall comparative rating for each of the studied alternatives.

It would be technically feasible to design and construct a tunnel alternative that meets the study goals and improve the transportation system in Syracuse Metropolitan Area.

The study team recommends that the Orange Alternative be considered for further study as a viable tunnel alternative. The tunnel portion would be relatively short compared to other alternatives and the north portal would be near the existing I-81 and I-690 interchanges. This alternative also reconstructs and re-configures significant portions of I-690 to make better connection to I-81 coming out of its tunnel, which drives the cost higher than other alternatives, but provides more benefits as shown in the Alternative Comparison Matrix.

It would be noted that comparing the tunnel alternative to the rebuild of the viaduct alternative, the community grid alternative, or the No Build Alternative would be beyond the scope of this study.
<table>
<thead>
<tr>
<th>GOALS</th>
<th>OBJECTIVES</th>
<th>CRITERIA</th>
<th>RED</th>
<th>ORANGE</th>
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<tr>
<td>Improve safety and create an efficient regional and local transportation system within and through greater Syracuse</td>
<td>Improve interstate geometry</td>
<td>Decommission aging viaduct structure(s)</td>
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<tr>
<td></td>
<td></td>
<td>Maintain I-81 interstate status, with interstate highway standards</td>
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<tr>
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<td>Correct non-conforming highway geometry on I-81 and I-690</td>
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<tr>
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<td></td>
<td>Improve mobility</td>
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<td>Maintain or enhance interstate-to-interstate connections</td>
<td>Maintain I-81 through moves on interstate highway</td>
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<td>Minimize capital cost</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Minimize operations, maintenance and repair costs</td>
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<tr>
<td></td>
<td></td>
<td>Replace infrastructure that has limited remaining service life and high maintenance</td>
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<tr>
<td></td>
<td></td>
<td>Utilize existing transportation infrastructure that has decades of remaining service life</td>
<td></td>
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</table>
### Goals

Provide transportation solutions that enhance the livability, visual quality, sustainability, and economic vitality of greater Syracuse.

### Objectives

**Enhance livability of the surrounding area**

- Minimize use of elevated or depressed highways
- Minimize disruption to the local street grid, including street closures and altering the vertical or horizontal geometry of local streets
- Enhance north-south and east-west connectivity on local streets
- Maintain and improve access to transit services
- Maximize opportunities for land development
- Enhance pedestrian and bicycle accessibility, experience and safety
- Preserve historic buildings and structures
- Enhance the visual character and streetscape of impacted local streets

**Minimize adverse environmental impacts**

- Minimize noise, vibration and dust during construction
- Minimize traffic impacts to interstate highways during construction
- Minimize traffic impacts to local streets during construction
- Minimize residential displacements
- Minimize community facility displacements
- Minimize commercial displacements
- Minimize impacts to Onondaga Creek

### Criteria

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<td>Minimize use of elevated or depressed highways</td>
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<td>Minimize disruption to the local street grid, including street closures and altering the vertical or horizontal geometry of local streets</td>
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<td>Maintain and improve access to transit services</td>
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<td>Preserve historic buildings and structures</td>
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<td>Minimize noise, vibration and dust during construction</td>
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<td>Minimize traffic impacts to interstate highways during construction</td>
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<td>Minimize residential displacements</td>
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<td>Minimize community facility displacements</td>
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<td>Minimize commercial displacements</td>
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<td>Provide transportation solutions that enhance the livability, visual quality, sustainability, and economic vitality of greater Syracuse</td>
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