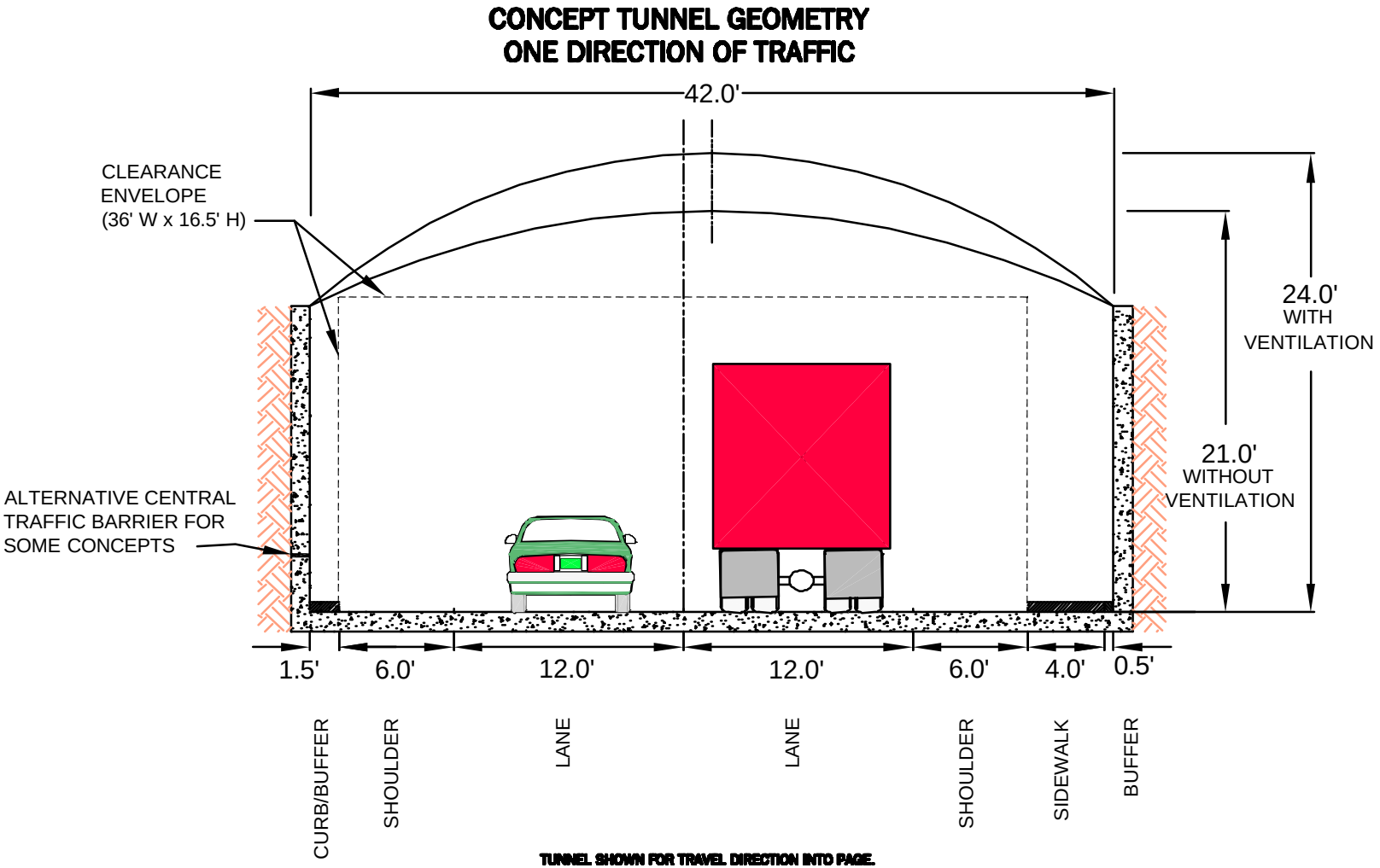
TUNNEL CROSS SECTION



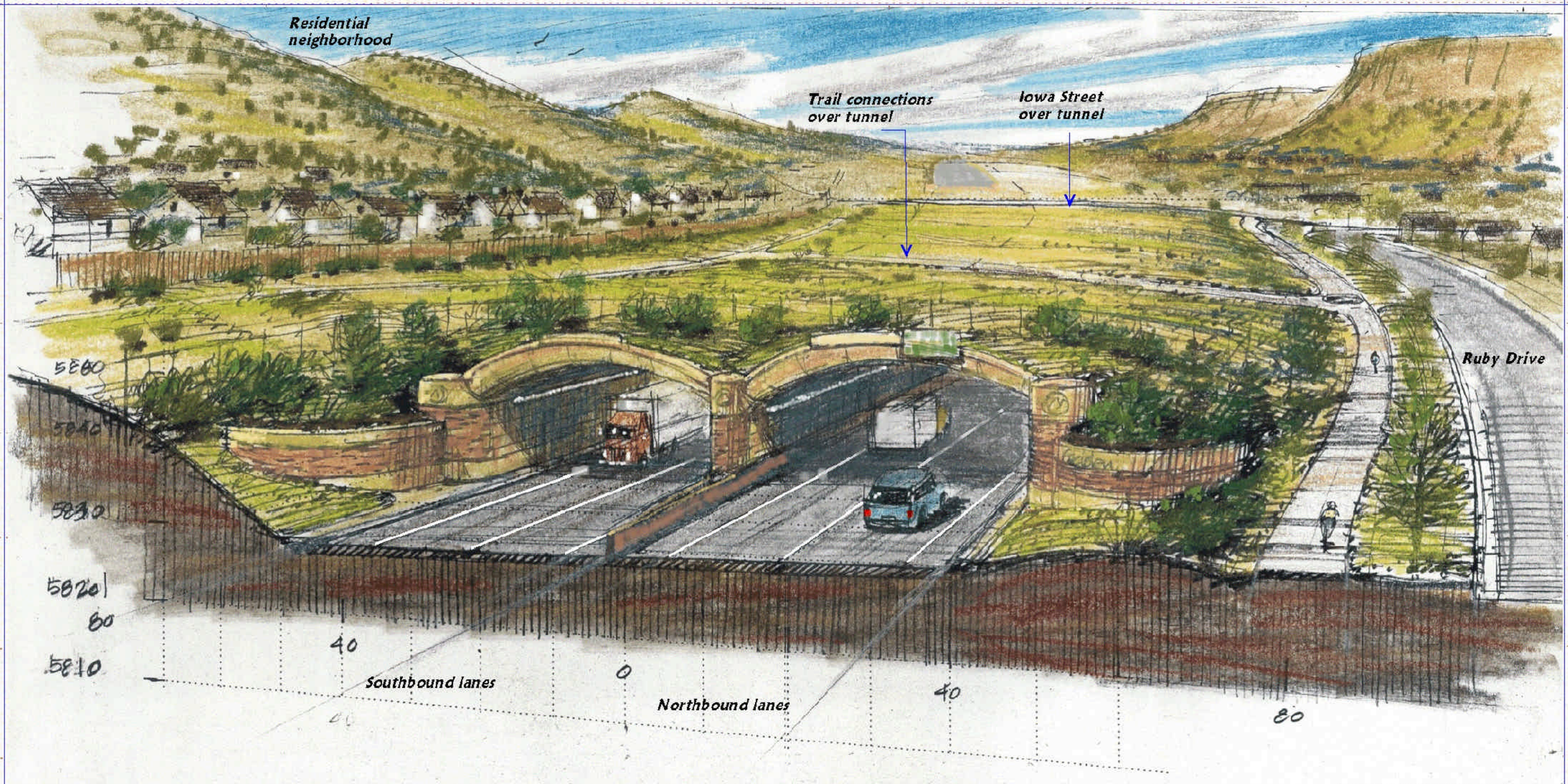


Illustration by Frank Miltenberger 4-18-03

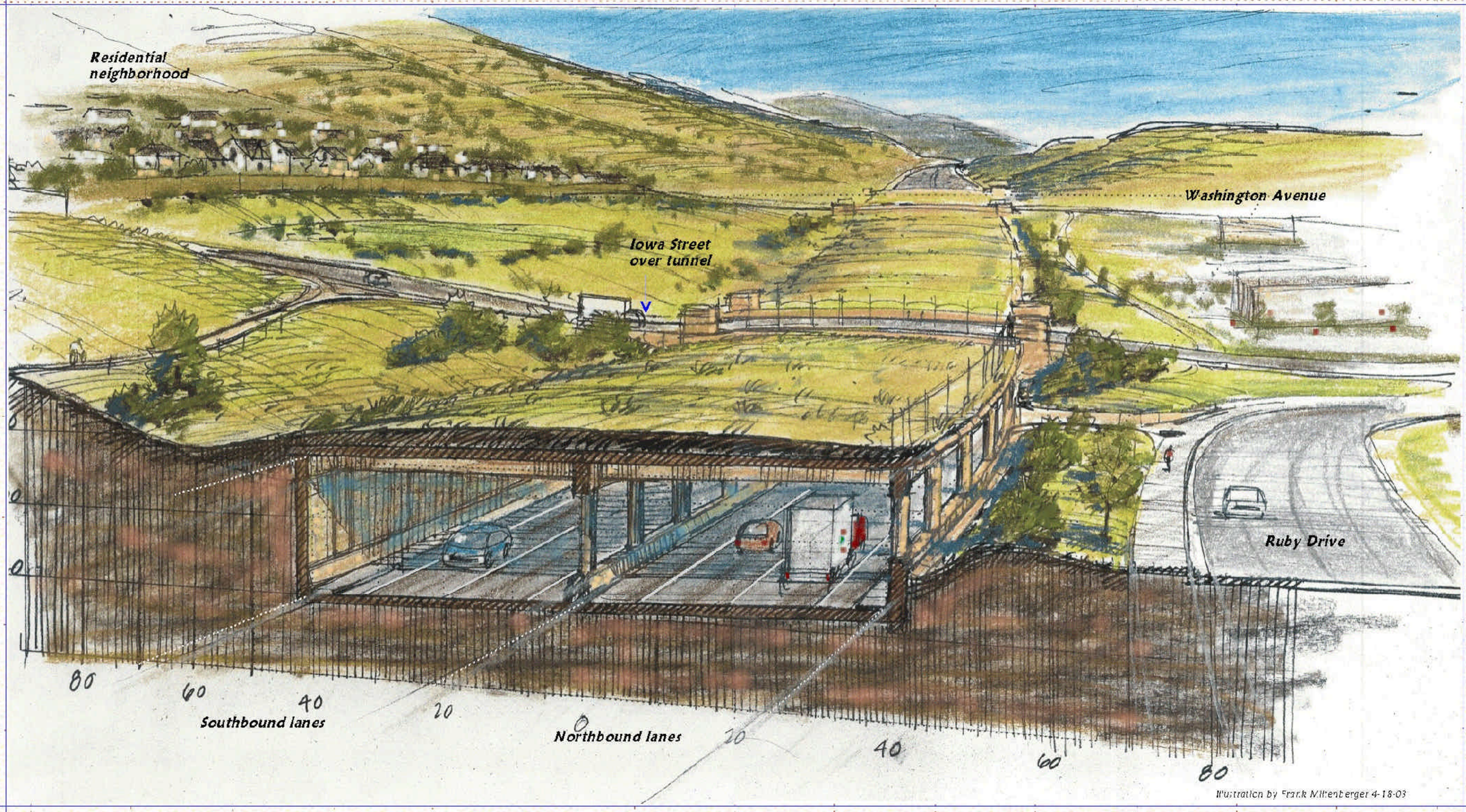
Long Tunnel Alternative

Two 2-lane tunnels separated by structural wall

Sketch concept above depicts a cross section view of a tunnel portal area. This long tunnel alternative would be about 2500 ft in length extending from south of Iowa Street to north of Washington Avenue. The tunnel is constructed by 'cutting and covering' technique. The alignment should be fairly close to the existing although it would probably be several feet lower in places. This view is looking north, note existing residential neighborhood to the left or west on the foothill slope.

Native landscape would extend down the slope over the tunnel to the commercial area to the east. Bike trail and informal crossings can be made thoughout most of the tunnel length. Fences will required near portal areas shown above. A longer tunnel like this would require an active ventilation system.

FIGURE _____



Long Tunnel with lateral openings: Open Interior.

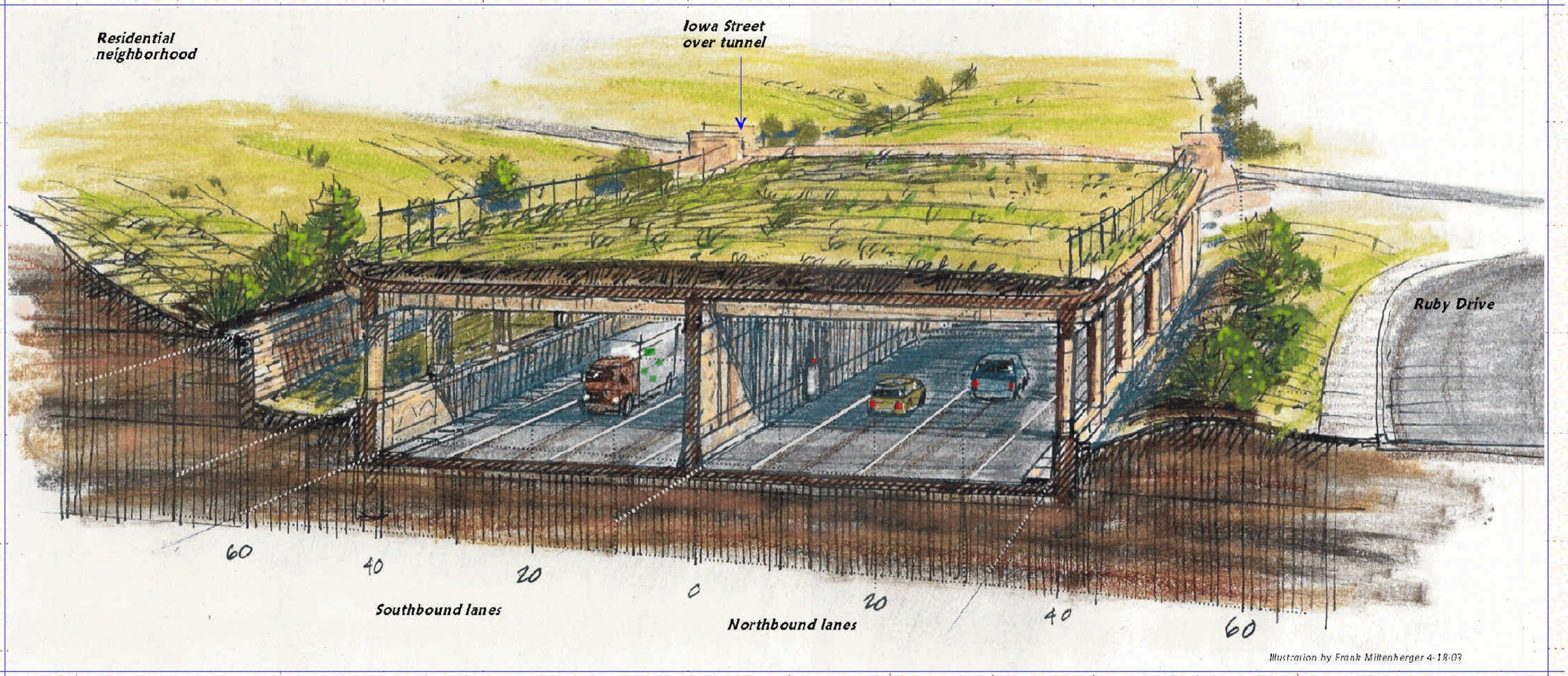
Single 4-lane tunnel with central barrier

This cross section sketch view is looking north just south of Iowa Street. Note the Iowa Street bridge in the middle ground, and the residential neighborhood to the left. This alernative is also a continuous 2500 ft long tunnel with generous openings on the east side for ventilation. A native landscape of grasses and wildflowers extends from the natural uphill slope across the top of the structure.

Because of the fences required at roof edges, these alternatives would have a more limited connectivity across the corridor. Note that emergency pedestrian egress will be needed at a few locations.

Tree and shrub planting can be used at edges to soften view of structure for surrounding neighborhoods.

FIGURE _____



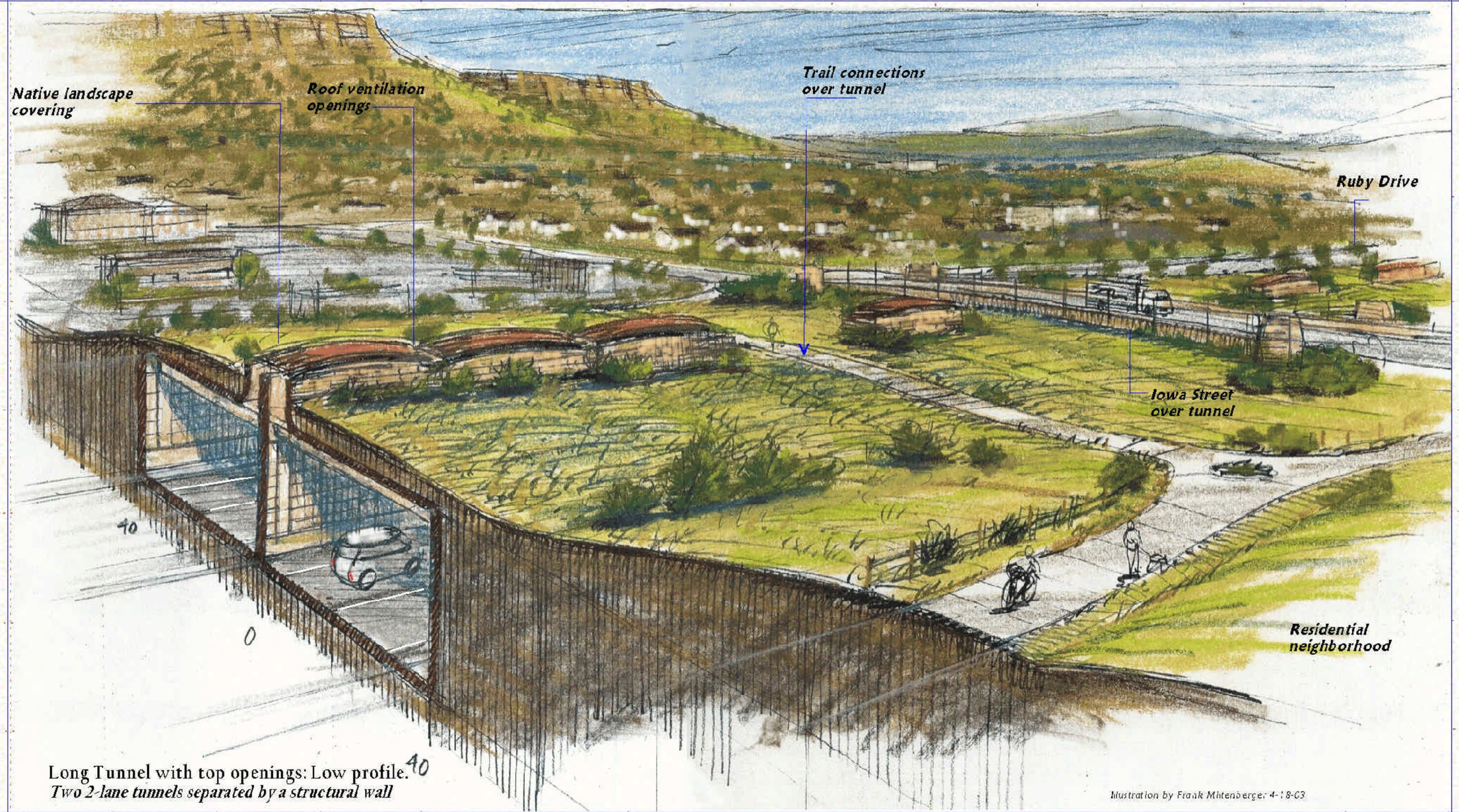
Long Tunnel with lateral openings: Split Interior

Single 4-lane tunnel with a structural wall

This cross section sketch view is looking north just south of Iowa Street. This alternative is another variation of the tunnel with lateral openings idea. It differs from the other similar alternative in that there are opening on both east and west sides and has a solid structural wall separating north and southbound lanes. This is also a continuous 2500 ft long tunnel. The roof or top also has a native landscape of grasses and wildflowers and fences at edges.

Tree and shrub planting can be used at edges to soften view of structure for surrounding neighborhoods. Sound eminating from the west side may make this alternative less desirable.

FIGURE _____

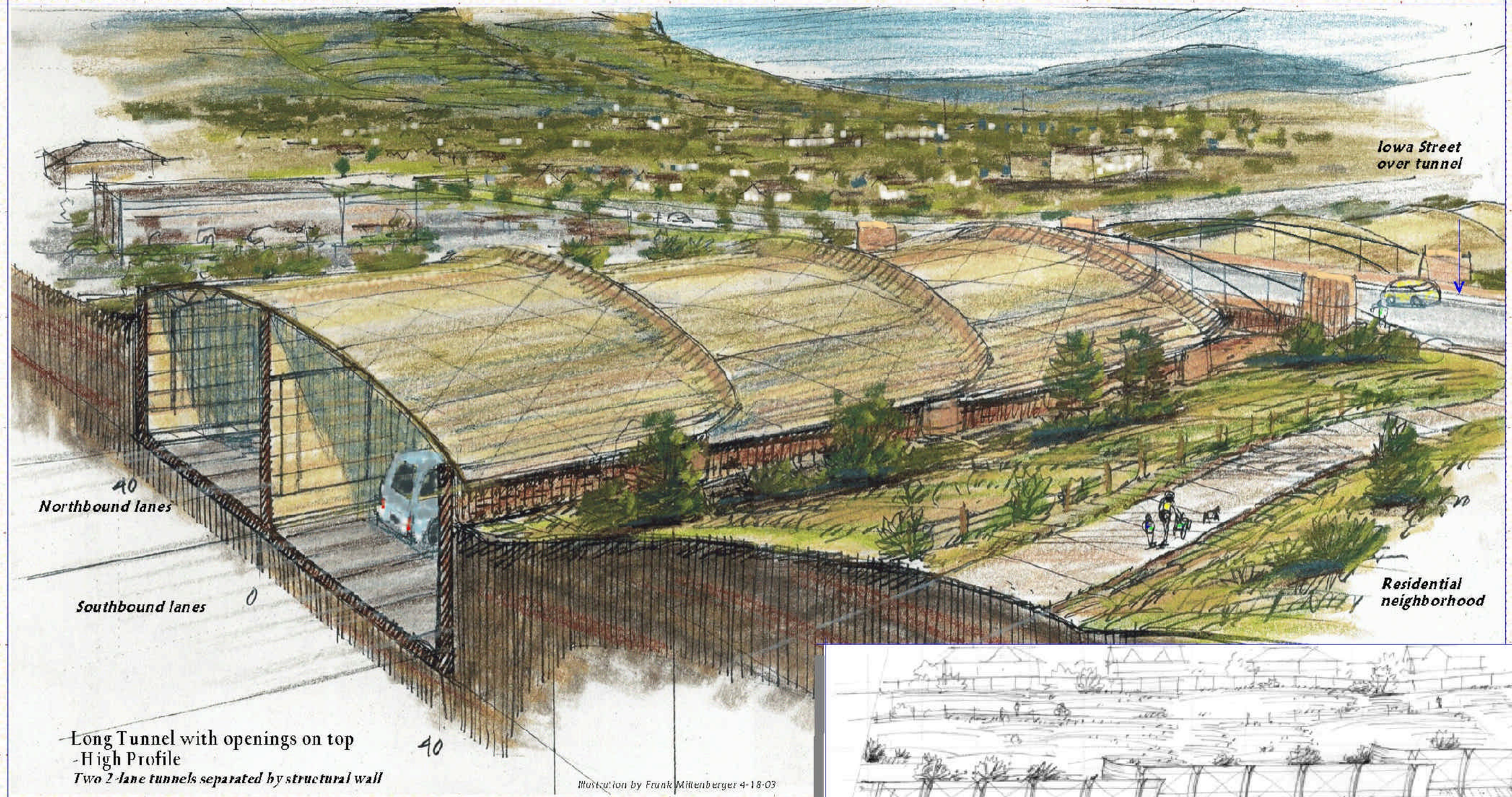


Long Tunnel with top openings: Low profile.
Two 2-lane tunnels separated by a structural wall

This concept, like the high profile alternative, also has roof openings for ventilation. This row of openings is centered over the dividing wall to ventilate each side of the tunnel. The remaining roof like most other alternatives is covered with native landscape. The ventilation features must protrude several feet above the adjacent ground surface and have a roof covering. Consequently these become rather conspicuous community architectural features.

While not as obvious as the high profile alternative it will require some studies and iterations to achieve the most desirable approach.
Otherwise this concept has many of the connectivity advantages and sound mitigation virtues of the more conventional long tunnel alternative.

FIGURE _____



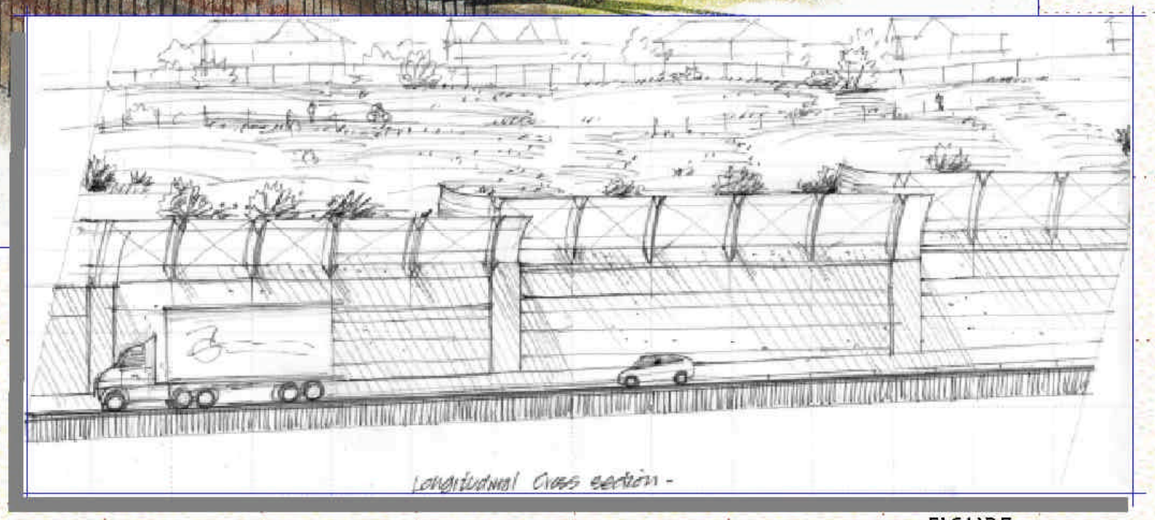
Long Tunnel with openings on top
- High Profile

Two 2-lane tunnels separated by structural wall

Illustration by Frank Miltenberger 4-18-03

This sketch view , is looking southeast from the slope above the roadway. This concept utilizes an architectural roof to cover the roadway instead of earth. The example at right utilizes a stepped roof with openings for ventilation. This particular roof material might be translucent to aid in lighting the roadway below. An architectural roof would likely be considerably less expensive than an earthen roof because of the lighter structural requirements.

The architectural treatment of the roof becomes a community architecture issue. This structure would be prominent local feature and would require some investigation into the appropriate materials and configurations for maximum acceptance.



RIGHT- Longitudinal cross section of architectural roof alternative. Note the stepped, overlapping roof segments with openings for ventilation.

FIGURE _____

Two short tunnels alternative

Two tunnels connected with an open section

This birds eye view is looking north at the 'two short tunnels concept'. A tunnel shorter than 800 feet in length does not require an active mechanical ventilation system as do longer tunnels. This concept has two 800 ft tunnels with an 800 ft long opening between. Depicted here is the opening starting on the north side of Iowa Street and extending toward the Washington Avenue area. The tunnel portion is similar to the first long tunnel concept and is covered with soil and native type landscape. The opening is a sort of a roadway canyon with tall retaining walls on both sides. Sound barriers may also be needed along the top of the west side to augment the sound attenuation.

Contrasting light changes and changing roadway surface conditions are a disadvantage to this alternative.

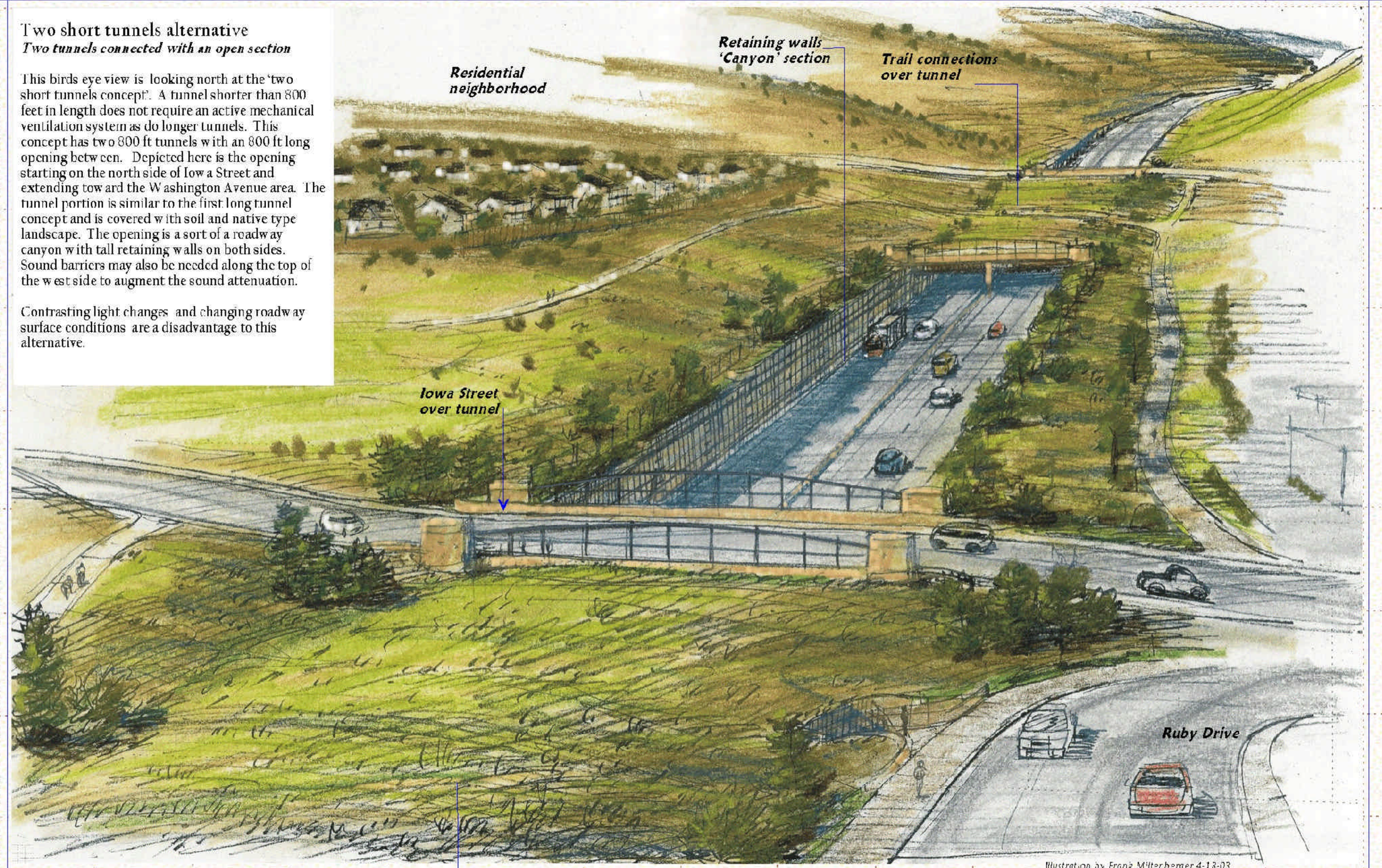


FIGURE _____

EVALUATION OF TUNNEL CONCEPTS

TABLE 1: OPERATIONAL AND USER SAFETY ISSUES AND COSTS

Concept	Description	Concept Variations	Interior Dimensions (W x H in feet)	Operational and User Safety Issues				Relative Costs	
				Ventilation	Emergency Egress	Lighting	Road Surface Safety	Capital	Operation and Maintenance
			See Note 3	See Note 4	See Note 5	See Note 6	See Note 7	See Note 8	See Note 9
1	**Long Tunnel with Active Ventilation**		85' x 24' Total		Assumed several cross-passages	Moderate to high level	Minor - de-icing at portals		
2 ★	**Long Tunnel with Lateral Openings** See Notes 1a and 1b	**Open Interior**	85' x 21' Total	Designed to avoid	Assumed several exits to the outside on east only	Moderate level - openings provide some light	Moderate - de-icing at portals plus moderate rain and blowing snow at openings	High	Medium - primarily for lighting
		Split Interior	85' x 21' Total	Designed to avoid	Assumed several cross-passages				
3 ★	**Long Tunnel(s) with Top Openings** See Notes 2a and 2b	**Low Profile**	85' x 21' Total	Designed to avoid	Assumed several cross-passages	Moderate to high level	Minor - de-icing at portals plus minor rain and blowing snow at openings	High	Medium - primarily for lighting
		High Profile	42' x 21' Per Direction	Designed to avoid	Assume several exits to the outside	Moderate - function of roof material		Medium - due to cheaper roof	
4	**Two Short Tunnels**		85' x 21' Total	Assumed not required	Probably one cross-passage per tunnel		Difficult - snow storage for connecting section, de-icing at least at portals, and changing driving conditions.	Lowest - short tunnel sections	Medium - primarily for lighting

★ Indicates a preferred concept

Indicates a highly adverse characteristic of the concept

Notes:

1a Single 4-lane tunnel with low central traffic barrier, and with openings and egress exits only on one side.
1b Single 4-lane tunnel with central wall, openings on both sides, and egress through central wall.
2a Road elevation significantly below existing ground surface with concrete roof and landscaping above
2b Road elevation near existing ground surface with architectural roof raised above ground surface
3 Total indicates width of structure in both directions including 4 lanes and center divider
4 Based on assessment of need for active ventilation
5 Based on method of egress or refuge during life threatening emergencies
6 Lighting needed for all concepts. Evaluation based primarily on overall level of lighting and secondarily on variation in lighting level.
7 Based on the impact of weather and meteorological conditions on the condition and safety of the road surface
8 Based on the relative cost of the initial capital investment for tunnel concepts, and not necessarily relative to an open road
9 Based on the relative annual cost of operation and maintenance, especially power for ventilation and lighting.

EVALUATION OF TUNNEL CONCEPTS

TABLE 2: COMMUNITY ISSUES

Concept	Description	Concept Variations	Exterior Aesthetics	Ground Surface Mobility		Noise Abatement	
				Community Connectivity	Access Restrictions	Roadway	Mechanical Ventilation
			See Note 3	See Note 4	See Note 5	See Note 6	See Note 7
1	**Long Tunnel with Active Ventilation**		- 1 - Most desireable	Best - unlimited	Best - no restrictions except at portals	Best - high noise reduction for many homes	Moderate - Fan noise can be controled with the choice of fan type and sound attenuation devices
2 ★	**Long Tunnel with Lateral Openings** See Notes 1a and 1b	**Open Interior**	- 2 -	Moderate to high - restrictions on east side only	Moderate - restrictions at portals and east side	Moderate to good - noise from ventilation openings can be directed away from noise sensitive areas	Not applicable
		Split Interior	- 4 -	Moderate - some restrictions on both sides.	Moderate - restrictions at portals and both sides	Moderate to bad - noise emanates from both sides	Not applicable
3 ★	**Long Tunnel(s) with Top Openings** See Notes 2a and 2b	**Low Profile**	- 4 -	High - some restrictions above tunnel at vents	Slight to moderate - restrictions at portals and vents	Moderate - less open area for required for ventilatin because openings located at tunnel crown	Not applicable
		High Profile	- Not Ranked - See Note 8	Worst - access is limited with significant restrictions	Worst - highly restricted	Moderate to poor - less open area, but may provide limited noise reduction if architectural roof is light weight material	Not applicable
4	**Two Short Tunnels**		- 3 - Combination of desireable and undesireable	Overall medium - combination of unlimited and restricted	Overall moderate to poor - restrictions at portals and open section		Not applicable

★ Indicates a preferred concept

Indicates a highly adverse characteristic of the concept

Notes:

1a Single 4-lane tunnel with low central traffic barrier, and with openings and egress exits only on one side.
1b Single 4-lane tunnel with central wall, openings on both sides, and egress through central wall.
2a Road elevation significantly below existing ground surface with concrete roof and landscaping above
2b Road elevation near existing ground surface with architectural roof raised above ground surface
3 Relative ranking for tunnel concepts according to degree of visible absorption into landscape, with lowest number (highest rank) corresponding to greatest visual absorption. All concepts are significantly better than open roadway.
4 Based on the freedom for people to move across the highway thereby connecting the community, and ability to use the land over and in the vicinity of the highway.
5 Based on degree of restrictions to access in the vicinity of the highway such as fencing at the portals.
6 Based first on the level of noise generated from traffic on the roadway and second on the difficulty of mitigation.
7 Based first on the level of frequency of the noise generated from ventilation and second on the difficulty of mitigation.
8 Roof is prominent architectural feature and the aesthetics depend on community acceptance.