TRAFFIC IMPACTS AT RICHLAND JUNCTION CROSSING

Prepared for:

Union Pacific Railroad

Prepared by:

HNTB Corporation

600-108th Avenue NE, Suite 900

Bellevue, WA 98004

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The City of Kennewick proposes to construct an extension of N. Center Parkway from Gage Boulevard on the south to a new at-grade crossing of the railroad tracks near Richland Junction, on the north. The new roadway would connect to a segment of Center Parkway, recently constructed by the City of Richland that extends north to Tapteal Drive. It would be a two-lane minor arterial roadway with a posted speed of 30 mph. The City's engineering studies for the project anticipated the roadway would cross only one set of railroad tracks, but in fact there are four sets of active tracks at the crossing location.

Background

Rail Configuration and Switching Functions

Richland Junction is the interchange point for rail service provided by the Union Pacific Railroad (UPRR), BNSF Railway (BNSF), and Tri City and Olympia Railroad (TCRY), operated by the Port of Benton. The interchange serves switching movements for all rail traffic into and out of the industrial and agricultural areas of Richland and the Department of Energy Hanford site.

The UPRR facilities include the Old Yakima Branch Mainline (UP Main) and a siding (UP Pass), both oriented east-west within the City of Kennewick. The Port tracks extend northwest from Richland Junction about 13 miles into the City of Richland. The Port facilities include a Port Main track, also known as the Government Main, and a Port Pass siding, also known as Government Pass. A series of five switches on these facilities makes switching possible for the interchange of cars among the various railroads. The track configuration and relationship to adjacent roadways are shown on Figure 1.

Only the UP Main track continues to the east as a single track at its overcrossing of Columbia Center Boulevard about 2,000 feet east of Richland Junction, and continues about 19 miles to connect with other UPRR and BNSF lines. The UP Main tracks end about 3,300 feet west of Richland Junction. Along the Port Main, there is an at-grade railroad crossing of Steptoe Street immediately south of its intersection with Tapteal Drive. It is protected with flashing lights and crossing gates.

The existing switching operations at Richland Junction generally occur on weekdays at midday, when TCRY operates over the Port tracks with cars for delivery to UPRR and pickup for Richland and Hanford destinations. UPRR switching generally occurs on weekdays between 9 PM and midnight, when cars from TCRY are picked up and cars left for pick-up the next day by TCRY. Activity includes boxcars, refrigerated boxcars, flatcars, and tanker cars. These cars are routinely parked at the proposed crossing location of Center Parkway, in order to minimize noise impacts to adjacent neighborhoods. BNSF switching occurs either in the early afternoon or early evening.

At the location of the proposed Center Parkway extension, the railroad switching activity by UP crews normally extends about 15 minutes, during which a crossing closure would be required. The midday activity by TCRY would result in a closures totaling about 45 minutes. With the proposed at-grade crossing, the TCRY activity would need to be adapted to reduce the delay to vehicular traffic. No observations were made of BNSF switching or the delays incident to that switching.

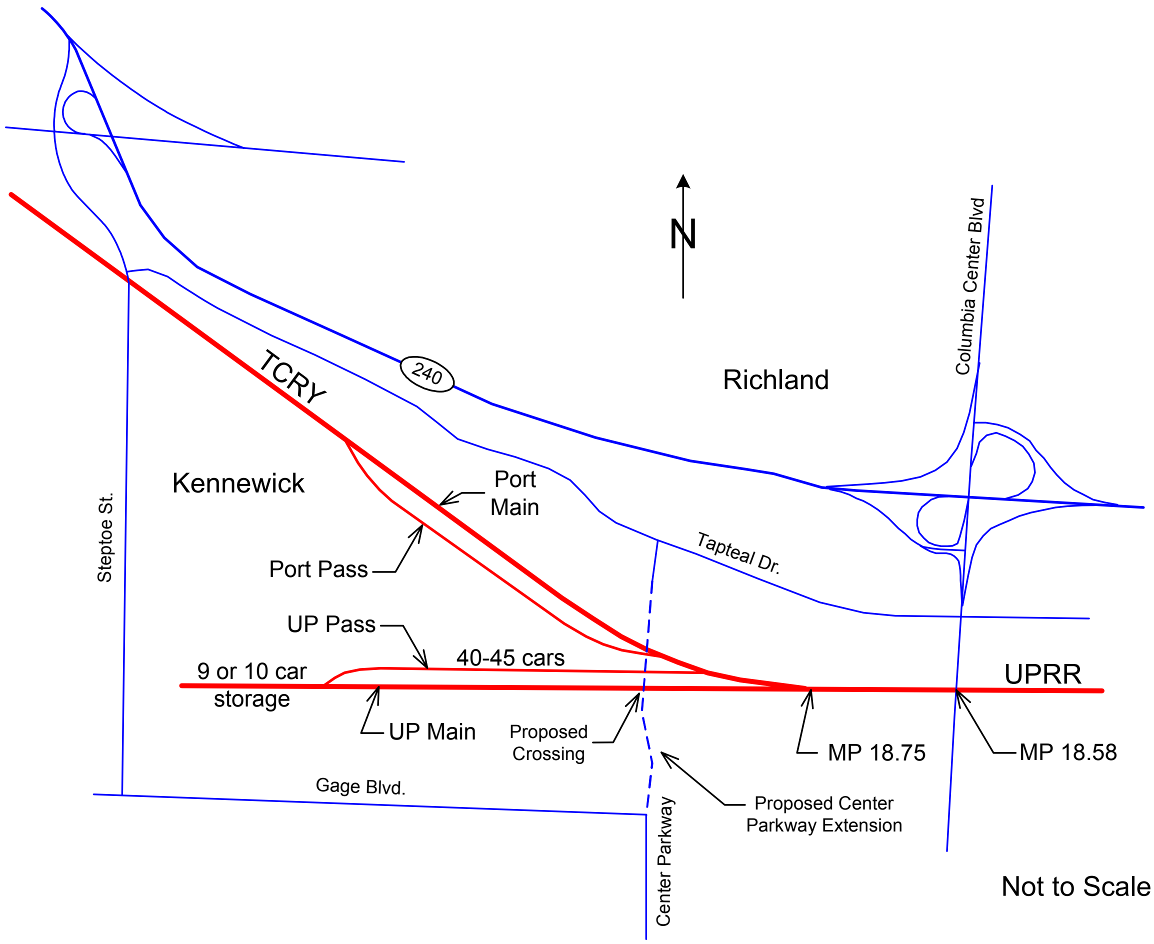


Figure 1 Richland Junction Vicinity Map

Proposed Center Parkway Extension

Design studies for the extension of Center Parkway were conducted during 2002 for the Cities of Kennewick and Richland. The studies included the *N Center Parkway Extension, Gage Boulevard to Tapteal Drive Design Report* (SCM Consultants, Inc, August, 2002), *Center Parkway Extension Rail Plan* (HDR Engineering, Inc, February, 2002), and *Project Traffic Volumes Center Parkway* (Traffic Division Memorandum, April 17, 2002). Center Parkway would be extended across the railroad rights-of-way at Richland Junction. In the City's proposal, the UP Main, UP Pass, and Port Pass tracks would be abandoned and removed, leaving only the Port Main track to serve the various switching movements. Reconstruction of the Port Main tracks would be required to adjust the elevation to conform to the proposed roadway profile at the crossing. The at-grade crossing would be equipped with flashing lights and crossing gates.

Several alignment alternatives were evaluated in the 2002 *Design Report*, with the objective of reducing right-of-way and relocation impacts to adjacent properties. The studies included a design exercise to investigate substitute railroad siding alternatives in the area between Richland Junction and the Columbia Center Boulevard overcrossing.

Traffic forecasts for the Center Parkway extension range from 2,200 vehicles per day (vpd) in the opening year (2003) to 4,250 vpd in the design year (2023). The traffic forecasts accounted for development of the Tapteal Business Center in the City of Richland between SR 240, Steptoe Street, the Port Main rail tracks, and Columbia Center Boulevard. At buildout, business and commercial development of this site would generate an additional 15,955 daily vehicle trips. On the Center Parkway extension, business park traffic would represent about 3,350 vpd of the 2023 total daily traffic.

Purpose of This Report

A series of technical studies have been conducted to evaluate the impacts of the proposed at-grade railroad crossing along the extension of Center Parkway. These studies include assessment of vehicular travel times with and without the extension, safety and geometric analyses of the proposed crossing, and development of alternatives to an at-grade crossing at this location.

Vehicular Traffic Circulation

Traffic Volumes and Patterns

The design parameters and assumptions for the Center Parkway extension were documented in the 2002 *Design Report*. The stated purpose of the extension project is to provide a convenient route between Gage Boulevard and Columbia Center Boulevard, and to provide a direct route to access SR 240 (*Design Report* p 3). The project would reduce traffic volumes on adjacent streets (*Design Report* p 7), where congestion would develop without the project.

The traffic forecasts for the project are depicted on Figures 3b (2003) and 3c (2023) of the *Design Report*. For 2023, the report indicates that daily traffic volume on Columbia Center Boulevard and on Tapteal Drive would each be reduced by 2,000 vpd with the project, compared to conditions without the project. Similarly, volumes on Steptoe Street south of Tapteal Drive would be reduced about 700 vpd with the project, and about 650 vpd on Steptoe Street north of Tapteal Drive. Traffic volume increases are forecasted for Gage Boulevard and existing segments of Center Parkway to the south.

On further analysis, the traffic volume differences shown in these figures are composed entirely of trips associated with development of the Tapteal Business Park. They reflect the use of the Center Parkway extension for trips between the business park and areas to the south and west. In the April 17 Traffic Division Memorandum, reference is made to the “3,350 vpd using the extension…to/from the Tapteal area,” matching exactly the total diversion from parallel routes of 2,000+700+650 vpd discussed above.

The 2023 daily volume of 4,250 vpd projected to use the Center Parkway extension thus consists of the 3,350 business park trips and 900 trips associated with existing uses adjacent to the proposed roadway. None of the diverted trips using the Center Parkway extension would connect to SR 240. This pattern indicates that the benefits of the extension accrue only to business park traffic, and contradicts the claim that access to and from SR 240 is being improved by the project.

Access to and from SR 240 would not improve with the Center Parkway extension because the awkward configuration of the intersection of Columbia Center Boulevard and Tapteal Drive prevents direct movements for most turning routes. Instead, traffic must use a circuitous loop route that overcrosses Columbia Center Blvd using Yellowstone Avenue. Traffic on southbound Columbia Center Blvd from westbound SR 240 must turn left across northbound traffic at an unsignalized intersection onto the Tapteal Loop to reach Tapteal Drive and Center Parkway. Similarly, eastbound traffic on Tapteal Drive must use the Tapteal Loop to cross above Columbia Center Blvd, and then make a right turn to reach the SR 240 interchange. These features diminish the potential benefit of the Center Parkway extension for users of SR 240.

Travel Time Analysis

The 2002 Design Report included forecasts of traffic volume using the roadway routes in the project vicinity, but no documentation was provided regarding travel times for vehicles using the competing routes. Travel times among competing routes determine the propensity of motorists to select one route over another. A series of field studies were conducted on October 19-20, 2005 to estimate travel times for conditions without and with the proposed Center Parkway extension.

Travel time samples were collected for four different routes that might derive benefit from the use of Center Parkway:

- between SR 240 (West) and Gage Blvd at Center Parkway,
- between SR 240 (East) and Quinalt Street at Center Parkway
- between the proposed Tapteal Business Park and destinations south of the project area (south to Quinalt Street)
- between the proposed Tapteal Business Park and areas west of the project vicinity (west to Gage Blvd or Columbia Park Trail)

The four route pairs are shown on Figures 2 through 5. Travel time observations were conducted in both directions of travel during PM peak hours. Delay at intersections was included in the travel time measurements. For trips using the proposed Center Parkway extension, travel time was estimated using a 28 mph average speed.

The travel time analysis with the proposed roadway extension also includes an estimate of the crossing delay at the proposed at-grade railroad crossing. No such estimates are provided in the City's design studies for this delay parameter. Based on current usage, crossing delays would be encountered by about ¾ of vehicles using Center Parkway at the noon hour, and by about ¼ of vehicles using the extension during the 9-10 PM hour. Total crossing delay would reach 21 vehicle-hours daily in 2003 and 41 vehicle hours daily in 2023. By 2023, the railroad crossing delay would average about 35 seconds per vehicle. During weekday noon hour conditions, crossing delay would average 5.6 minutes per vehicle, and 1.8 minutes per vehicle during the 9-10 PM hour. The daily average railroad crossing delays for 2023 were added to travel times on the Center Parkway extension to estimate the impacts of the train activity on vehicular traffic. Delays attributable to BNSF switching were not evaluated in the analysis.

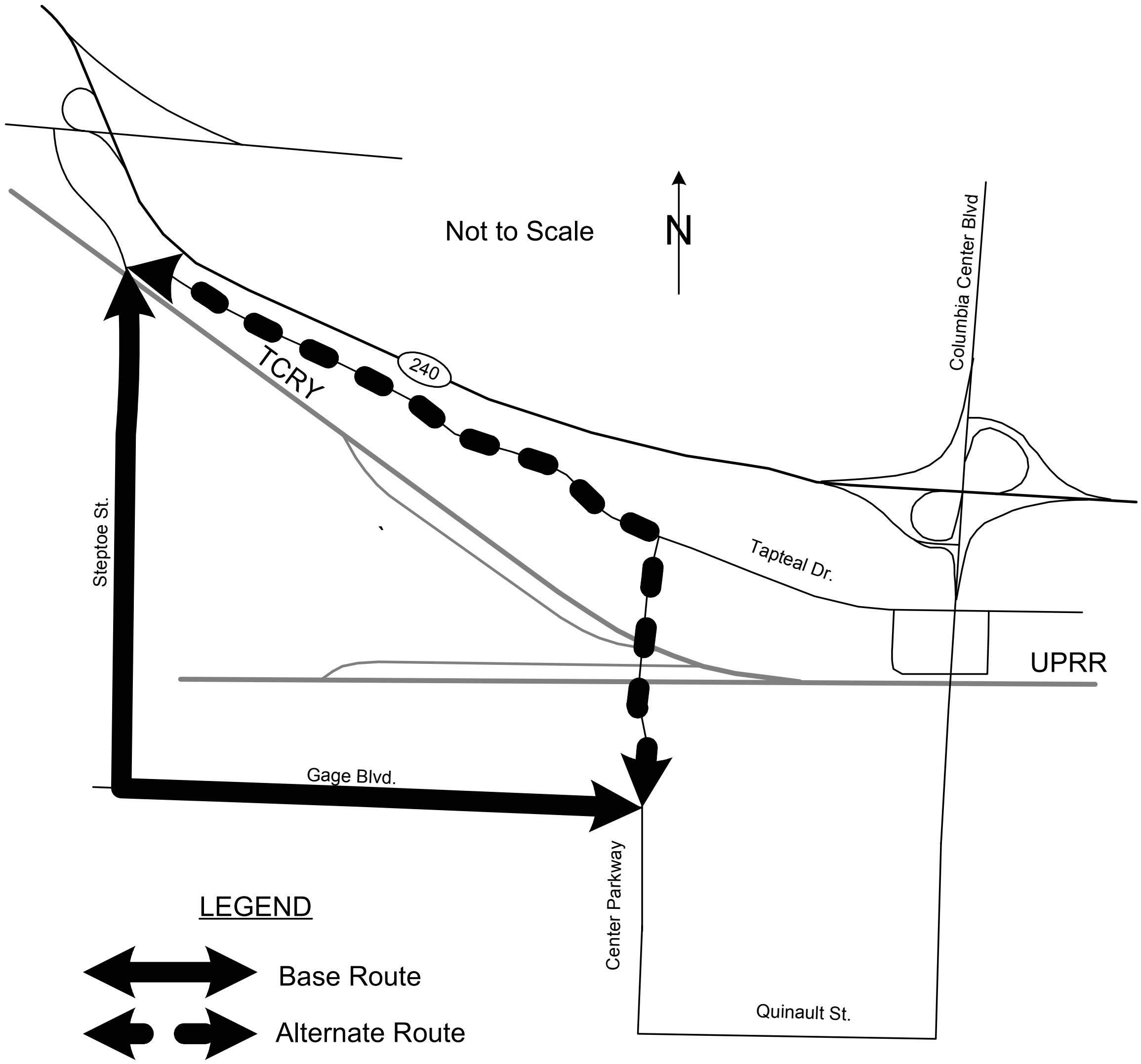


Figure 2 SR 240 Access To/From West

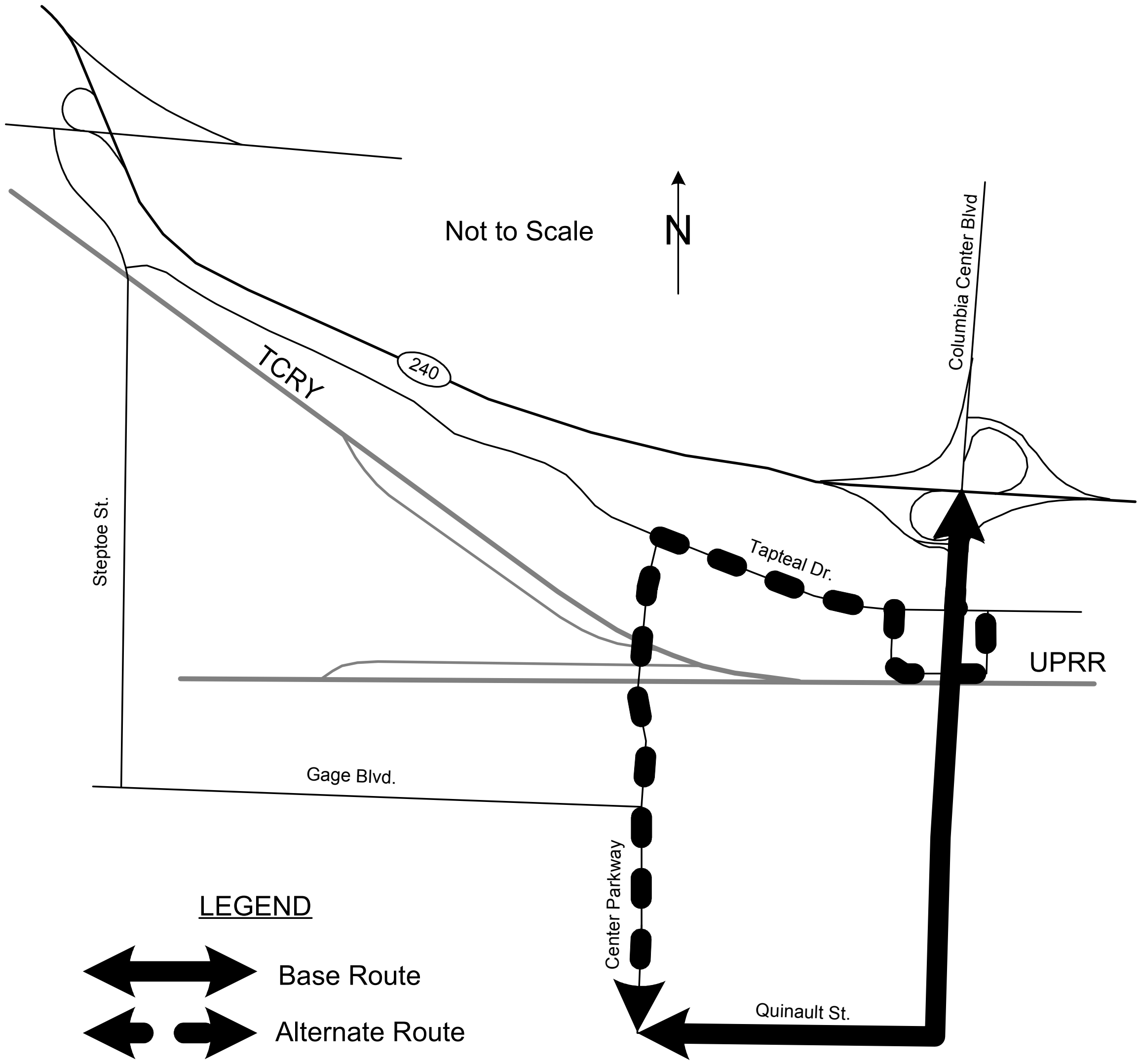


Figure 3 SR 240 Access To/From East

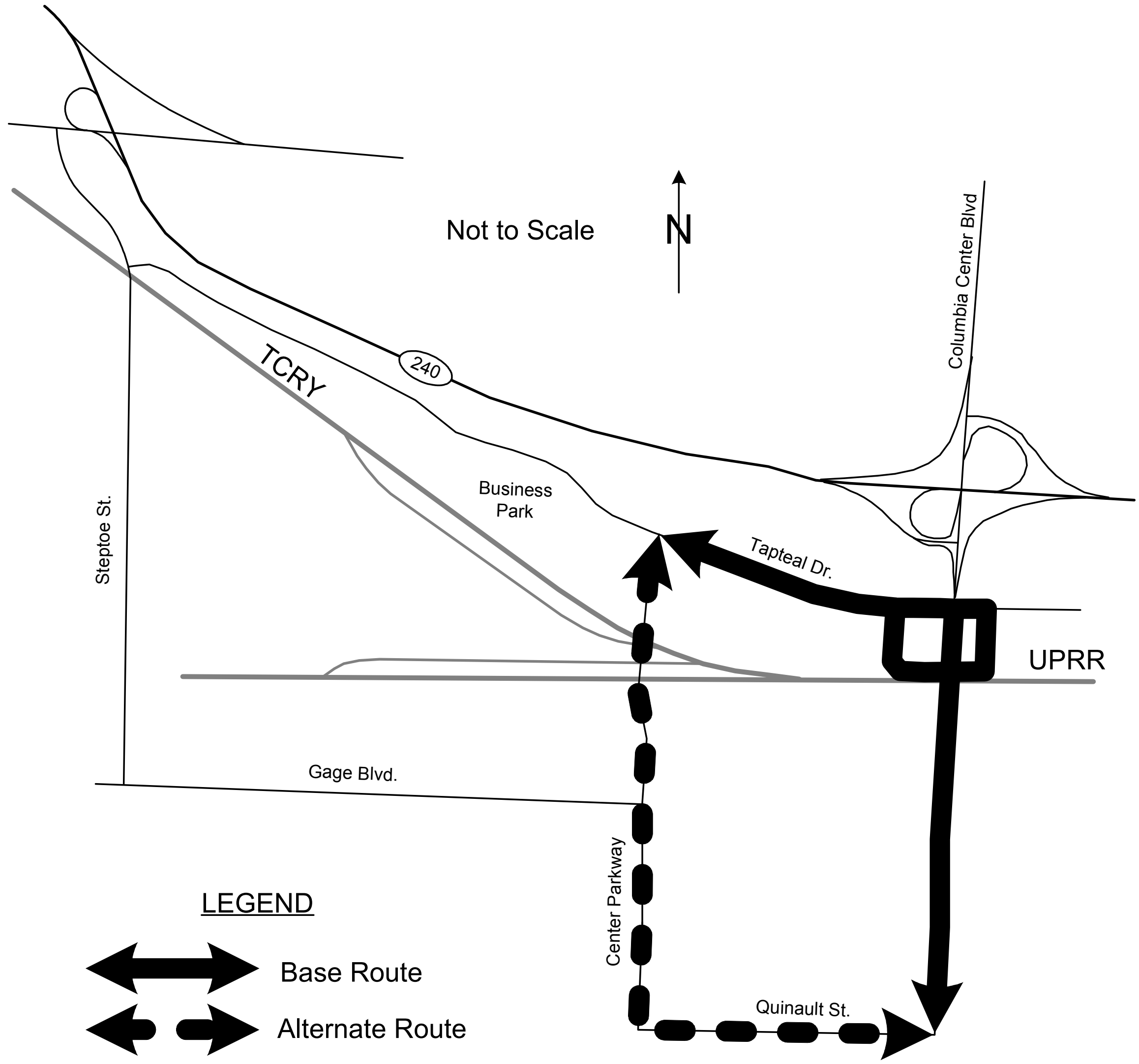


Figure 4 Business Park Access To/From South

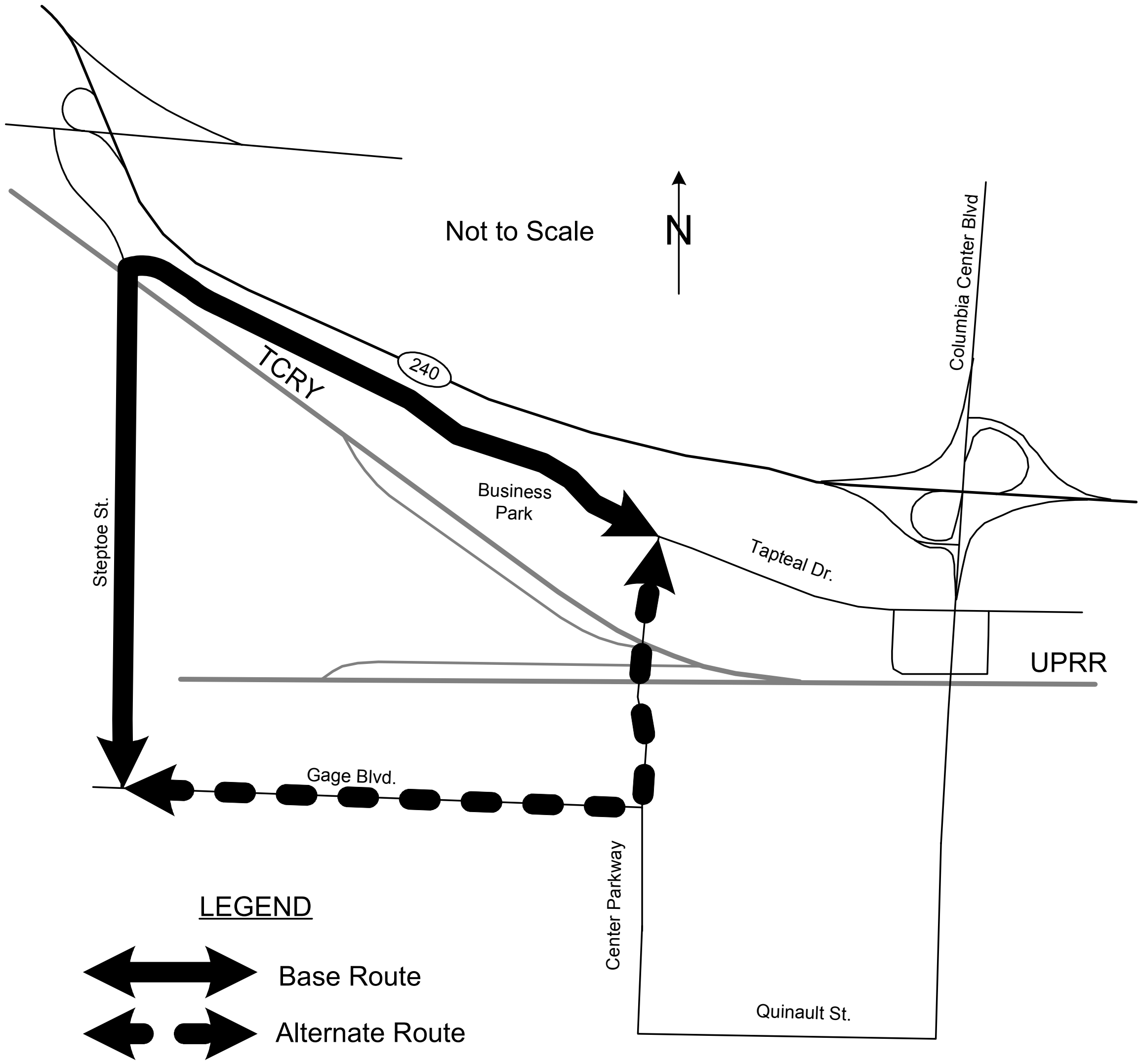


Figure 5 Business Park Access To/From West

The results of the travel time analyses are shown on Table 1. To and from the west on SR 240 travel times are within 5 seconds using the base and alternative routes. The Center Parkway extension would not provide a travel time advantage for trips destined to the Gage/Center intersection vicinity. The apparent reason is higher posted speeds of 35 to 40 mph along Gage Blvd and Steptoe Street, compared to 30 mph along Tapteal Drive and proposed for Center Parkway. For trips to and from the east on SR 240, travel times using the Center Parkway extension would match those on the base route for trips to the east, but would require up over 1 ½ minutes longer for trips from the east, compared to the base route. Trips on the alternative route would be required to use the Tapteal Loop in both directions of travel.

Table 1 State Route 240 Access Routes

Tour	Route	Base			Alternative		
		Length (mi)	Travel Time (sec)	Speed (mph)	Length (mi)	Travel Time (sec)	Speed (mph)
1	From West	1.2	145.3	31	1.0	150.7	32
2	To West	1.2	143.8	32	1.0	147.9	33
3	From East	1.0	135.0	27	1.4	245.7	24
4	To East	1.0	243.3	18	1.4	241.5	23

Travel time estimates for routes serving the business park are shown on Table 2. For business park trips oriented to and from the south, the extension of Center Parkway results in lower travel times than on the competing parallel route, saving about 1 to 1 ½ minutes. Business park trips to and from the west, however, would encounter travel time within 8 to 9 seconds on both routes.

Table 2 Business Park Access Routes

Tour	Route	Base			Alternative		
		Length (mi)	Travel Time (sec)	Speed (mph)	Length (mi)	Travel Time (sec)	Speed (mph)
1	From South	1.1	182.1	22	0.9	148.8	28
2	To South	0.9	132.9	23	0.9	149.1	28
3	From West	1.3	136.9	35	0.9	144.8	29
4	To West	1.3	148.3	32	0.9	157.6	26

Railroad Crossing Safety

The introduction of an at-grade highway-railway crossing in an urban arterial setting can be expected to generate a menu of conflicts that will result in train/car collisions. Common conflicts at crossings of multiple crossings are running around crossing gates, collisions with a second train, and pedestrian or bicycle collisions with trains. Railroad operators and communities nationwide have been involved in programs to close or consolidate at-grade crossings for many years. The State of Washington has aggressively pursued grade separation of offending at-grade crossings over the last decade.

The 2002 *Design Report* claims at several points to have considered safety among the criteria for selection of the preferred design for the Center Parkway extension (pp ES-1, 1, 12 and 30). No quantitative data concerning accident numbers or rates in the project area was presented by the City. Installation of flashing lights and crossing gates is recommended to serve the single remaining rail track considered in the design.

A useful tool for estimating railroad-highway conflicts at at-grade crossings can be found in the *Rail-Highway Crossing Resource Allocation Procedure*, developed cooperatively by the Federal Railroad Administration (FRA) and Federal Highway Administration in 1987. It provides an accident model for estimating the number of collisions to be expected for at-grade railroad crossings, based on levels of vehicular traffic, character, type, and speed of train traffic, and type of crossing protection. This model was used to estimate the annual number of accidents that would be associated with an at-grade crossing along the proposed Center Parkway extension.

The accident prediction model was applied for three distinct scenarios of vehicle/rail interaction in the Center Parkway corridor:

- Crossing of the four active tracks with today's pattern of railcar switching (2003 and 2023)
- Crossing of the four active tracks with additional train crossings attributable to revised patterns railcar parking and switching needed with the at-grade crossing (2003 and 2023)
- Crossing of the four active tracks with increased vehicular and train traffic (2023 design year only)

The switching movements at the existing railroad operation produce an average of six train crossings daily of the UP tracks and an average of ten train crossings daily of the Port tracks, including BNSF switching movements. With an at-grade crossing, railcars must be parked at least 250 feet from the roadway edge, and will be split into two sets of cars for parking, or parked further west. As a result, additional switching movements will be required to re-assemble these cars for transport. With the at-grade crossing, it is estimated that train activity would increase to an average of eight train crossings daily on the UP tracks and an average of twelve train crossings daily on the Port tracks.

In the third scenario, train activity was increased to reflect the potential for increased rail freight volume and usage of Richland Junction. Train activity would reach ten train crossings daily on the UP tracks and fourteen train crossings daily on the Port tracks. In addition, vehicular traffic would increase to 5,500 vpd on Center Parkway in this scenario, as suggested in testimony of the City Traffic Engineer.

Table 3 Accident Prediction Model Results

Scenario	Crossing	Analysis Year	Accidents Per Year	Total Accidents Per Year for Both Crossings
Baseline	UPRR	2003	0.03	0.06
	Port	2003	0.03	
	UPRR	2023	0.03	0.06
	Port	2023	0.03	
Reduced Siding Area	UPRR	2003	0.03	0.06
	Port	2003	0.03	
	UPRR	2023	0.04	0.07
	Port	2023	0.03	
Increased Activity	UPRR	2023	0.04	0.07
	Port	2023	0.03	

The results of the accident prediction model for the proposed Center Parkway crossing are shown on Table 3. With the revised switching operations, the at-grade crossing can be expected to produce 0.06 accidents annually in the 2003 opening year, increasing to 0.07 accidents annually by the 2023 design year. In the scenario with increased train and vehicular activity, the number of accidents would remain at 0.07 accidents annually by 2023.

Although the average accident figures predicted by the FRA model are very low, they can properly be viewed as accidents which are avoidable in the absence of the proposed at-grade crossing. The addition of a new at-grade railroad crossing is inappropriate in circumstances where the public benefit of the Center Parkway extension cannot be conclusively demonstrated.

Railroad Crossing Geometrics

The proposed Center Parkway extension alignment was designed by the City on the assumption that three of the existing railroad tracks at Richland Junction would be removed, and that only the Port Main track would remain. The abandonment and removal of existing tracks would be problematic for railroad switching operations and car storage. For this reason, we performed an independent design study to determine the roadway profile of a crossing that accommodates all four existing tracks.

Top-of-rail elevations were obtained from records furnished by the City to UPRR for the proposed location of the Center Parkway extension. The rail centerlines for each set of tracks are generally 15 to 16 feet apart, with about 200 feet between the UP and Port tracks at the point of the proposed crossing. Standards published in the *Manual for Railway Engineering* (American Railway Engineering and Maintenance-of-Way Association, 2001) specify that a crossing roadway should remain in the plane of the top of rails for a minimum of two feet outside each rail. (See Part 8, Highway-Railway Crossings, Profile and Alignment of Crossings and Approaches, 1993).

Figure 6 shows the plane of the tops of rail for the UP tracks, and the connecting grades between these crossing points at the location of the proposed Center Parkway crossing location. Figure 7 presents similar information for crossing of the Port tracks. The plane of rails ranges up to 2.8 percent for the Port tracks because they are superelevated in a curve at the crossing location. The connecting grades would exceed 9 percent on such a profile, exceeding the WSDOT standard for grade on urban arterial facilities. Moreover, the extreme shifts in grades over short distances would make this profile impractical for any public street.

Typically, grade changes of this magnitude would be connected with vertical curves with lengths of 150 to 600 feet, so that stopping sight distance could be provided for drivers operating on the proposed roadway. The applicable standards ensure that a driver can see a 6-inch object in the roadway in time to come to a stop. The choppiness of the grade changes in this profile would compromise the stopping sight distances at the crossing location. Without vertical curves, vehicle speeds would be reduced and driver comfort decreased.

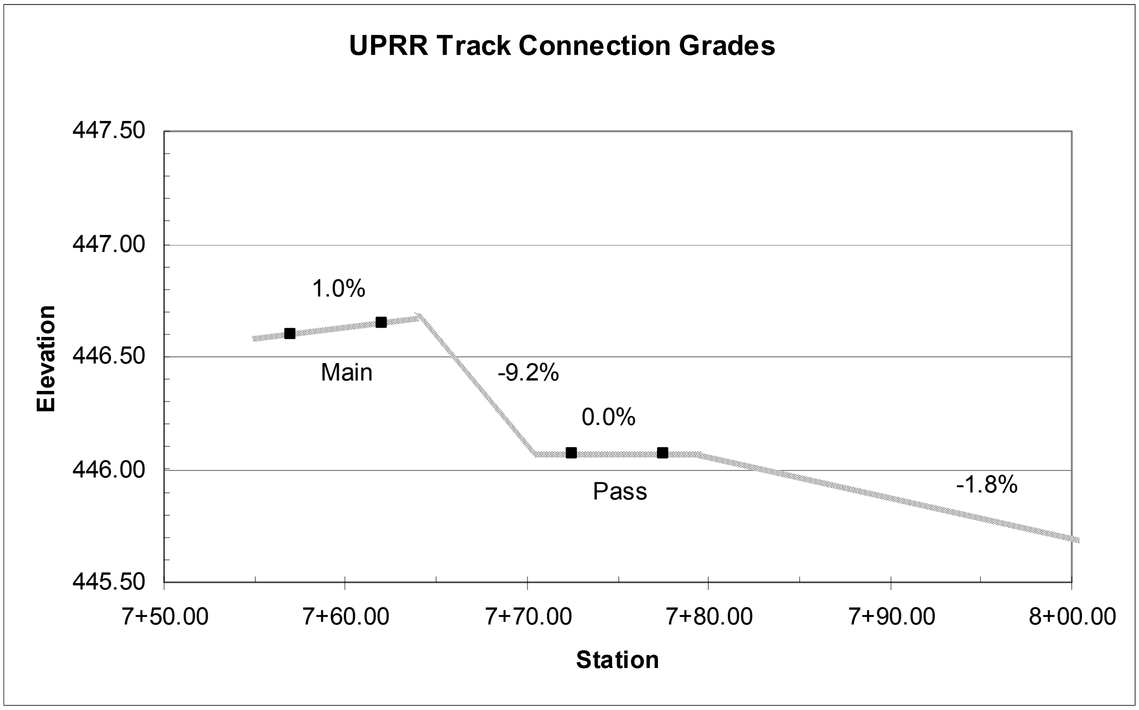


Figure 6 Existing Union Pacific Track Connection Grades

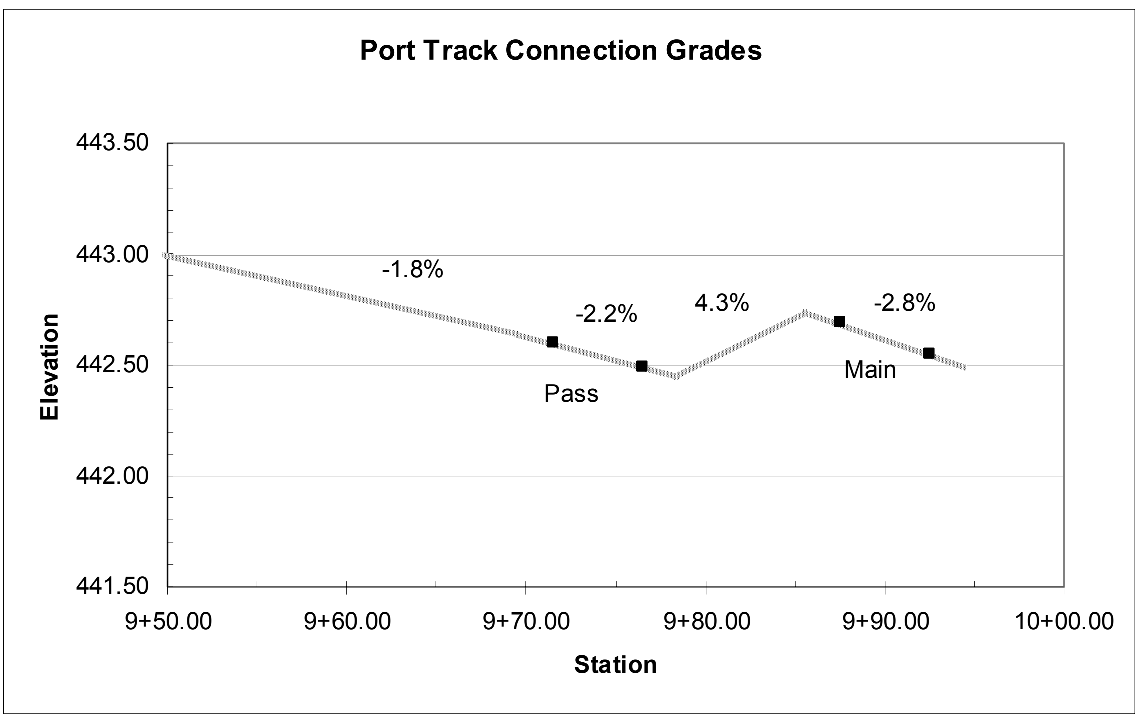


Figure 7 Existing Port Track Connection Grades

A second criteria for grading at railroad crossings is referenced in Figure 630-3 of the WSDOT *Design Manual* (Washington State Department of Transportation, May, 2004). It requires that the profile of the roadway remain within an envelope that is no higher than 3 inches above the plane of the rails or 6 inches below the plane of the rails, within a distance of 30 feet from the nearest rail. The connecting grades shown on Figures 6 and 7 do not meet these criteria. AREMA also quotes this identical standard.

Railroad Profile Adjustments

Considering that the roadway profile crossing the multiple railroad tracks discussed above is unacceptable, the possibility of grade adjustments of the railroad tracks also can be explored. The Cities' roadway profile would be in a sag vertical curve where it crosses the UP tracks at about elevation +442.5 feet, at a location where the existing tracks are near elevation +446.5. The existing UP Main and UP Pass tracks are constructed on a grade rising to the west at +0.5 percent, the maximum permissible under UP standards. The switch elevation at Richland Junction is estimated to be at elevation +441.

A concept showing potential profile adjustments of railroad tracks in the Richland Junction area is shown on Figure 8. The adjustment at the Center Parkway extension would require depressing the UP Main tracks by about 4.3 feet and the UP Pass tracks by about 3.6 feet. The profile extending east to the switch would be reduced from +0.5 percent to about +0.14 percent, reflecting a more moderate condition.

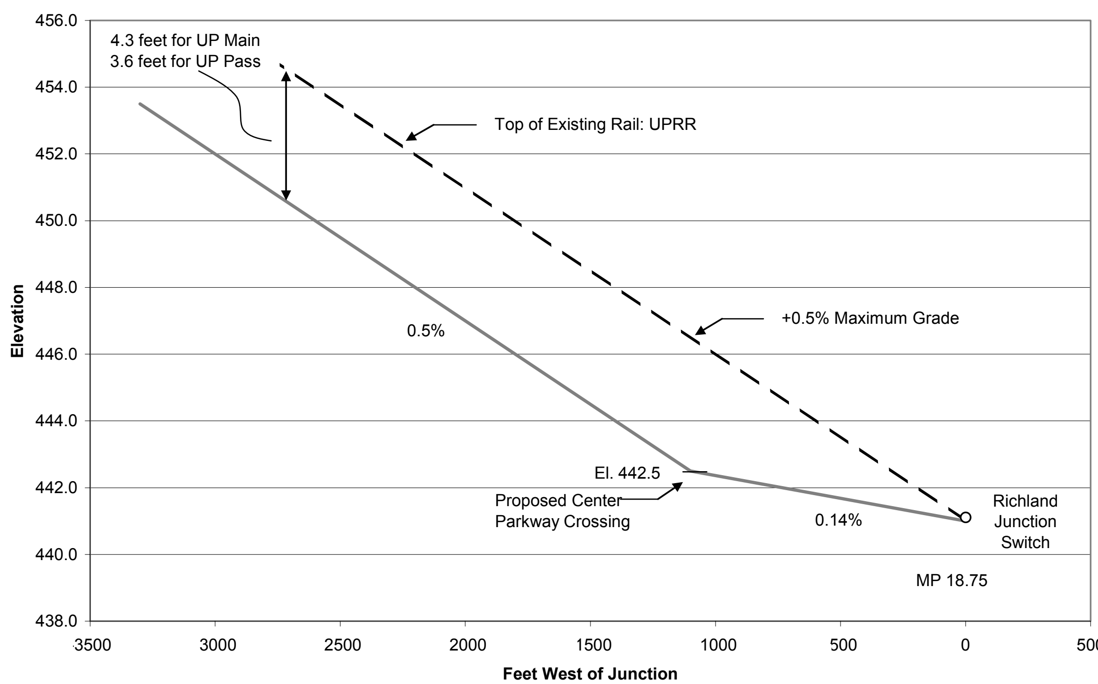


Figure 8 UPRR Track Reconstruction

Considering the maximum allowable grade criteria of +0.5 percent, the vertical adjustments would extend westward from the new roadway to the western terminus of the UP trackage. Reconstruction on this lower profile line would require complete reconstruction of the tracks, because, at four feet of depth, it extends below the existing sub-grade on which the railroad was built. New sub-grade foundations and drainage facilities would be required to support the adjusted ballast, ties and rail.

Vertical adjustment also would be required for the Port tracks at the crossing of the Center Parkway extension. The Center Parkway extension would be in a crest vertical curve at about elevation +443. Total adjustment shown on Figure 8 would involve raising the Port Main tracks about three inches and Port Pass tracks about seven inches.

The costs of adjustments to the railroad facilities would be substantial, although it was not fully considered in the Cities' 2002 *Design Report*. The Cities' 2002 *Design Report* acknowledged (p 23) that adjustment of the Port Main tracks would be required to conform to the roadway profile, yet no line item is included in the project cost estimate for this reconstruction. The assumption that the UP Main, UP Pass, and Port Pass tracks would be eliminated fails to consider their ongoing active status.

Alternative Roadway Profiles

The 2002 *Design Report* considered a series of three alternative alignments for the Center Parkway extension, all crossing the railroad corridors at-grade. The differences among the three alignment alternatives were primarily related to issues of right-of-way acquisition, property remainders, and access to adjacent properties, all affecting horizontal alignment. The vertical (profile) elements of the three alternatives were very similar.

The *Design Report* discusses the possibilities of grade separated crossings (p 20), but only for an alignment passing above the railroad corridor. It discussed qualitatively the difficulties associated with an alignment on an overcrossing profile, including steep grades and extensive retaining walls. The construction cost was estimated to exceed $10 million, but it was not documented in the same format as the three at-grade alternatives.

The *Design Report* did not consider an undercrossing alignment of the railroad corridor, yet the existing topography presents an excellent opportunity for the Center Parkway extension to assume such a profile. In addition, the opportunity exists to cross under all the active railroad tracks, without requiring abandonment, removal or elimination of any part of the switching facilities at Richland Junction. A planning level cost estimate suggests this alternative could be constructed for under $10 million.

Figure 9 presents an illustrative profile of the vertical alignment for an Alternative Undercrossing Alignment. This alternative would place the railroad tracks on a series of four bridges crossing above the Center Parkway extension. The roadway would be placed on a profile that would provide 16½ feet of vertical clearance for vehicles operating below in conformance with the current WSDOT standard. A structure depth of 5½ feet was assumed. Retaining walls would be required to support the excavated cut for the roadway.

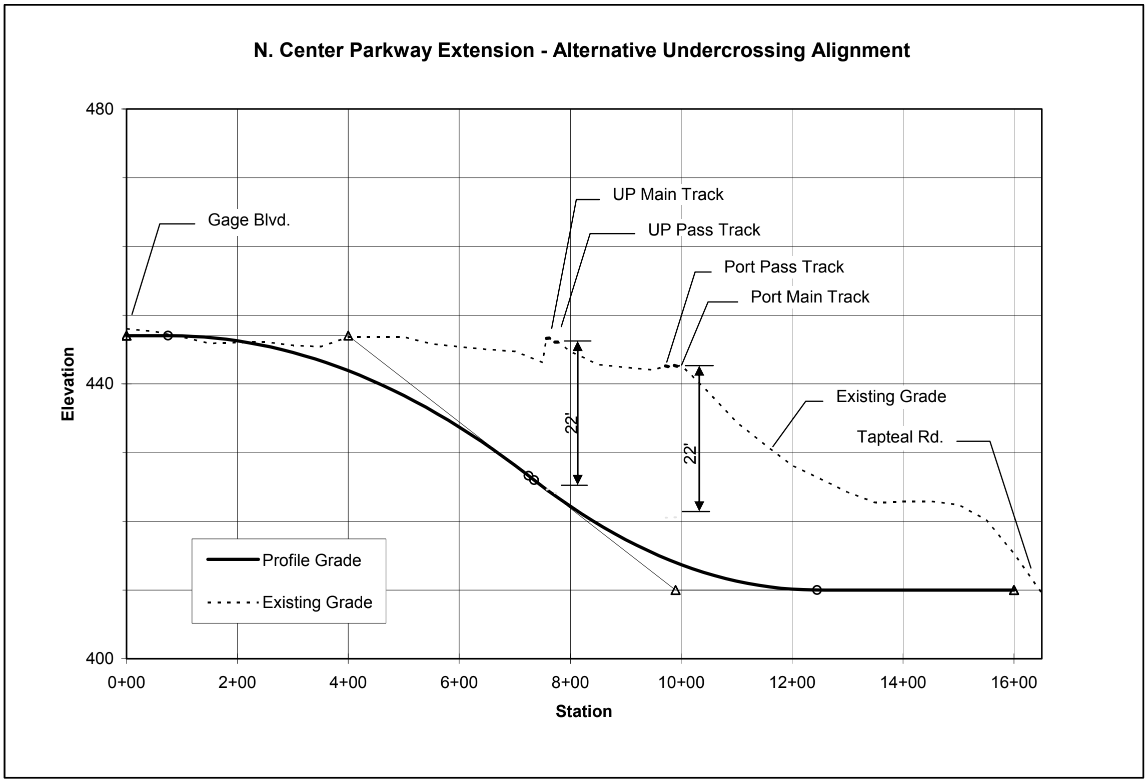


Figure 9 Alternative Profile

The illustrative profile indicates that existing connection of the side streets south of the railroad corridor could be maintained, although driveway access to the existing substation would need to be revised. Driveway access also would require adjustment at the Holiday Inn Express north of the railroad corridor.

The undercrossing profile would eliminate the delays and hazards associated with at-grade highway-railroad crossings. It would leave the railroad infrastructure intact and the railroad switching operations unchanged, and no adjustments of railroad grades would be needed. The benefits associated with grade separation were not adequately analyzed or addressed in the 2002 *Design Report*.

APPENDIX A – ACCIDENT PREDICTION MODEL

Track: Union Pacific Railroad
Location: West of Richland Junction
Analysis Year: 2003

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	2,200	Vehicles per day	
t =	6	Train crossings per day	
EI =	25.76	Source: Table 3-4; based on (c x t) =	13,200
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1.35	Source: Table 3-4; based on 2 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.023	Accidents per year	
	43.5	Years between accidents	

Track: Port of Benton Railroad
Location: West of Richland Junction
Analysis Year: 2003

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	2,200	Vehicles per day	
t =	10	Train crossings per day	
EI =	30.67	Source: Table 3-4; based on (c x t) =	22,000
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1	Source: Table 3-4; based on 0 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.020	Accidents per year	
	49.4	Years between accidents	

Track: Union Pacific Railroad
Location: West of Richland Junction
Analysis Year: 2023

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	4,250	Vehicles per day	
t =	6	Train crossings per day	
EI =	32.49	Source: Table 3-4; based on (c x t) =	25,500
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1.35	Source: Table 3-4; based on 2 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.029	Accidents per year	
	34.5	Years between accidents	

Track:	Port of Benton Railroad
Location:	West of Richland Junction
Analysis Year:	2023

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	4,250	Vehicles per day	
t =	10	Train crossings per day	
EI =	37.55	Source: Table 3-4; based on (c x t) =	42,500
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1	Source: Table 3-4; based on 0 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.025	Accidents per year	
	40.3	Years between accidents	

Track: Union Pacific Railroad with Reduced Siding Area
Location: West of Richland Junction
Analysis Year: 2003

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	2,200	Vehicles per day	
t =	8	Train crossings per day	
EI =	28.44	Source: Table 3-4; based on (c x t) =	17,600
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1.35	Source: Table 3-4; based on 2 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.025	Accidents per year	
	39.4	Years between accidents	

Track: Port of Benton Railroad with Reduced Siding Area
Location: West of Richland Junction
Analysis Year: 2003

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	2,200	Vehicles per day	
t =	12	Train crossings per day	
EI =	32.49	Source: Table 3-4; based on (c x t) =	26,400
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1	Source: Table 3-4; based on 0 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.021	Accidents per year	
	46.6	Years between accidents	

Track:	Union Pacific Railroad with Reduced Siding Area
Location:	West of Richland Junction
Analysis Year:	2023

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	4,250	Vehicles per day	
t =	8	Train crossings per day	
EI =	34.87	Source: Table 3-4; based on (c x t) =	34,000
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1.35	Source: Table 3-4; based on 2 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.031	Accidents per year	
	32.2	Years between accidents	

Track:	Port of Benton Railroad with Reduced Siding Area
Location:	West of Richland Junction
Analysis Year:	2023

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	4,250	Vehicles per day	
t =	12	Train crossings per day	
EI =	39.83	Source: Table 3-4; based on (c x t) =	51,000
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1	Source: Table 3-4; based on 0 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.026	Accidents per year	
	38.0	Years between accidents	

Track: Union Pacific Railroad with Increased Activity
Location: West of Richland Junction
Analysis Year: 2023

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	5,500	Vehicles per day	
t =	10	Train crossings per day	
EI =	39.83	Source: Table 3-4; based on (c x t) =	55,000
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1.35	Source: Table 3-4; based on 2 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.036	Accidents per year	
	28.1	Years between accidents	

Track: Port of Benton Railroad with Increased Activity
Location: West of Richland Junction
Analysis Year: 2023

USDOT Accident Prediction Equations

Source: Railroad-Highway Grade Crossing Handbook, Federal Highway Administration, Sept. 1986.

General Form of Basic Formula: a = K x EI x DT x MS x MT x HP x HL

Where:

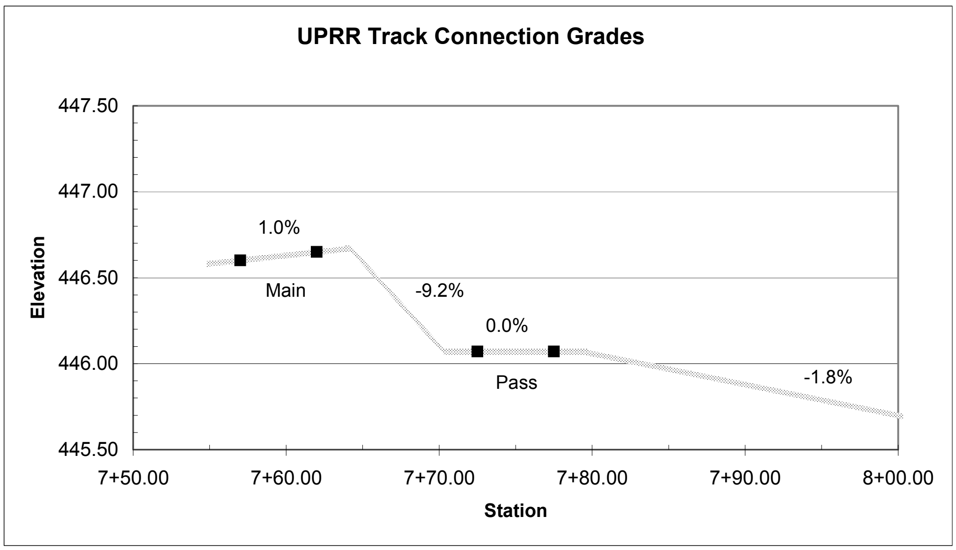
K	Formula Constant
c	Number of Highway Vehicles per Day
t	Number of Trains per Day
EI	Exposure Index Factor
MT	Main Tracks Factor
DT	Day Through Trains Factor
HP	Highway Paved Factor
MS	Maximum Timetable Speed Factor
HL	Highway Lanes Factor

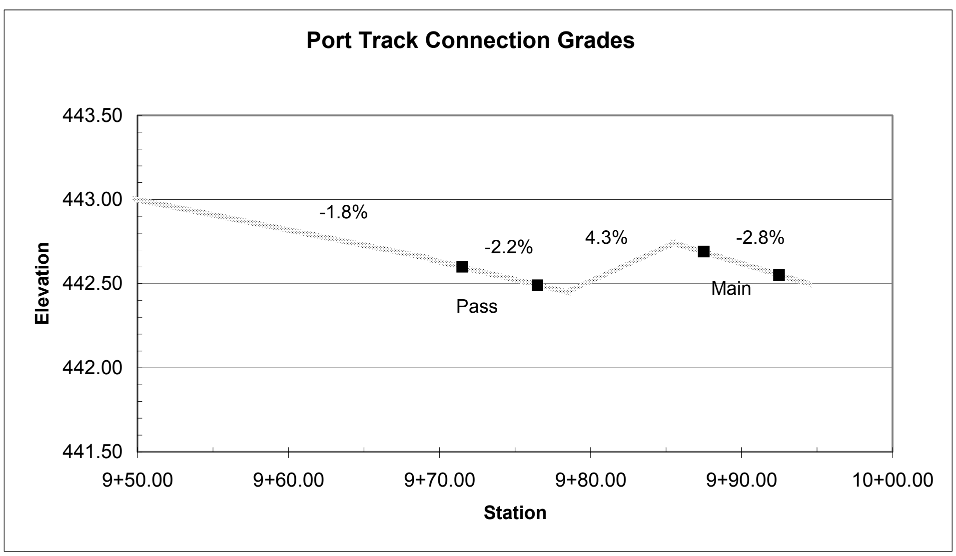
K =	0.000575	Source: Table 3-4; factor for crossing with gate warning device	
c =	5,500	Vehicles per day	
t =	14	Train crossings per day	
EI =	44.48	Source: Table 3-4; based on (c x t) =	77,000
DT =	1	Source: Table 3-4; factor does not affect crossings with gates	
MS =	1	Source: Table 3-4; based on 15 MPH	
MT =	1	Source: Table 3-4; based on 0 main tracks	
HP =	1	Source: Table 3-4; based on paved crossing roadway	
HL =	1.15	Source: Table 3-4; based on 2 highway lanes	
a =	0.029	Accidents per year	
	34.0	Years between accidents	

APPENDIX B – CONNECTING GRADE CALCULATIONS

Assumptions:
AREMA-recommended lateral clearance for railroad tracks, each side (ft): 2

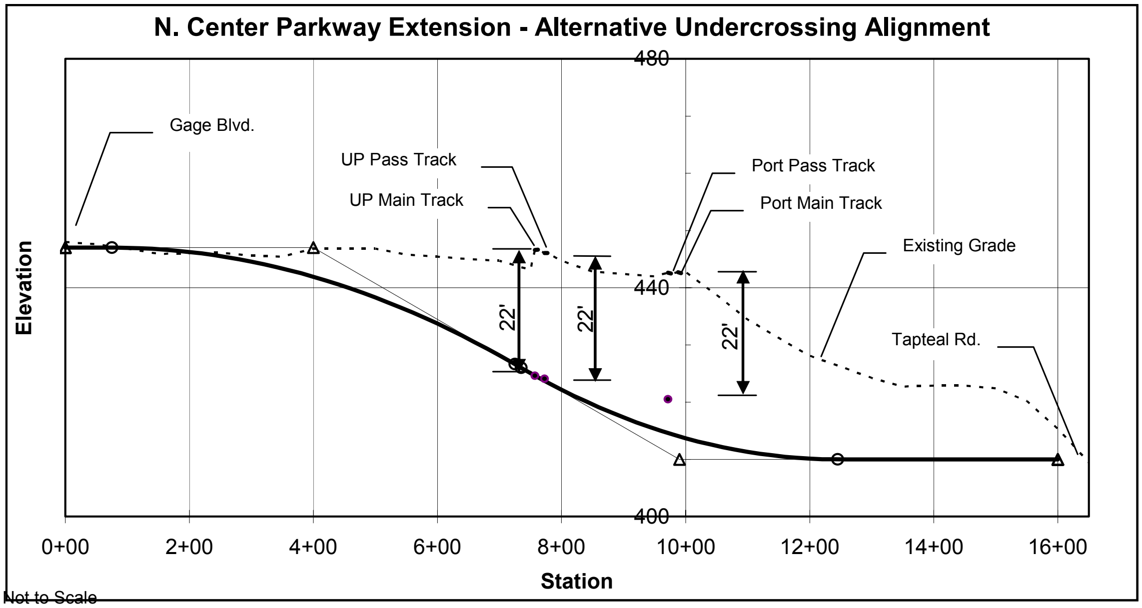
	Top of Existing Rail						Resulting Roadway Profile				
	Rail	Sta.	Elev.	Rise	Run	Grade	Sta.	Elev.	Rise	Run	Grade
South	1	7+57.00	446.60				7+55.00	446.58			
↓	2	7+62.00	446.65	0.05	5.00	1.0%	7+64.00	446.67	0.09	9.00	1.0%
	3	7+72.50	446.07	-0.58	10.50	-5.5%	7+70.50	446.07	-0.60	6.50	-9.2%
	4	7+77.50	446.07	0.00	5.00	0.0%	7+79.50	446.07	0.00	9.00	0.0%
	5	9+71.50	442.60	-3.47	194.00	-1.8%	9+69.50	442.64	-3.43	190.00	-1.8%
	6	9+76.50	442.49	-0.11	5.00	-2.2%	9+78.50	442.45	-0.20	9.00	-2.2%
	7	9+87.50	442.69	0.20	11.00	1.8%	9+85.50	442.75	0.30	7.00	4.3%
North	8	9+92.50	442.55	-0.14	5.00	-2.8%	9+94.50	442.49	-0.25	9.00	-2.8%





APPENDIX C – UNDERCROSSING PROFILE

	Job Number 42956-DS-001-001	Sheet
	Made by DMR	Date 10/25/05
	Checked by	Date



Station	Elev.	Vertical Curve Length	Forward Grade	K	Stopping Sight Distance	Design Speed Calculated (Design)	Design Speed Calculated (Existing)	Design Speed Req'd	Ahead Tangent Length
			-0.75%						
0+00.00	447.00	0 ft	0.00%	N/A	N/A	N/A	N/A	40 mph	75 ft
4+00.00	447.00	650 ft	-6.27%	-104	371 ft	40.6 mph	47.6 mph	40 mph	10 ft
9+90.00	410.00	510 ft	0.00%	81	372 ft	40.7 mph	47.7 mph	40 mph	355 ft
16+00.00	410.00	0 ft	-1.20%	N/A	554 ft	54.8 mph	62.9 mph	40 mph	

←→ Direction of Travel

Notes
1) The Stopping Sight Distance and Design Speed calculations are based on WSDOT Figures 650-2, 650-3, and 650-4, June 1999.

Rail to Road Clearance:

Structure Depth (ft):	5.5
Clearance, Road Surface to Bridge Soffit (ft):	16.5
Total (ft):	22