I-65 Bridges from I-264 to Kennedy Interchange Planning Study

Jefferson County, KY

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KENTUCKY TRANSPORTATION CABINET

In Partnership With

Palmer ENGINEERING

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Introduction

The Kentucky Transportation Cabinet (KYTC) initiated a study of the I-65 Bridges in Jefferson County in June 2018. This study's objective is to assess conditions and prioritize and develop conceptual strategies for repair or replacement of all bridges along Interstate 65 between the Watterson Expressway (I-264) and the rebuilt Kennedy Interchange in Louisville, KY, 28 bridges in all (**Figures ES1 and ES2**).

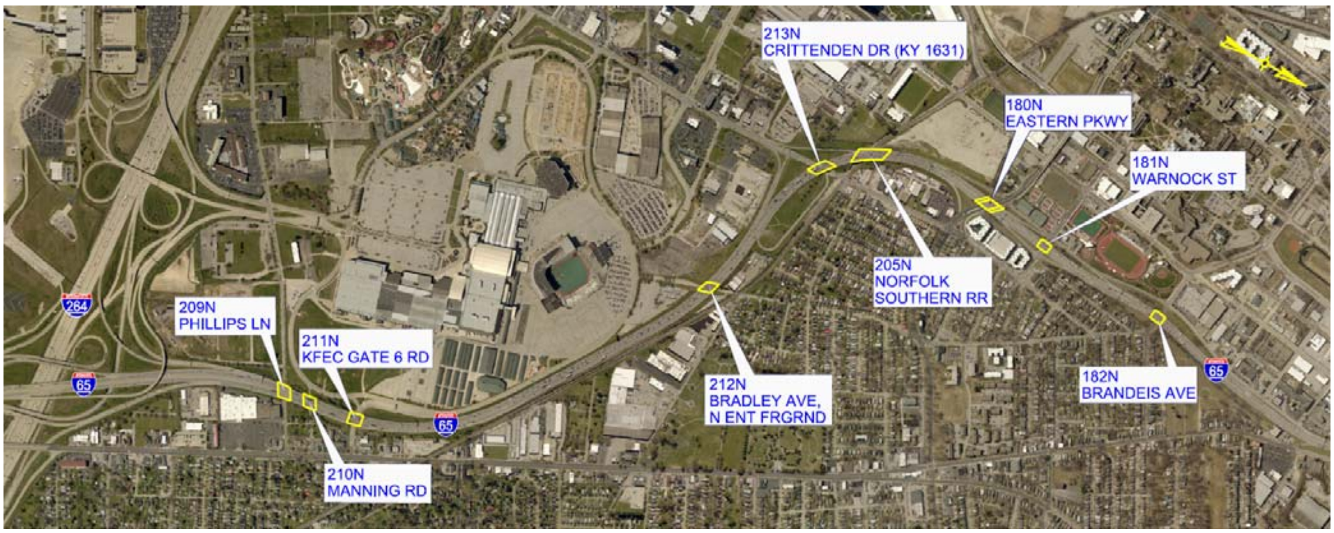

Figure ES1: Study Bridges – South

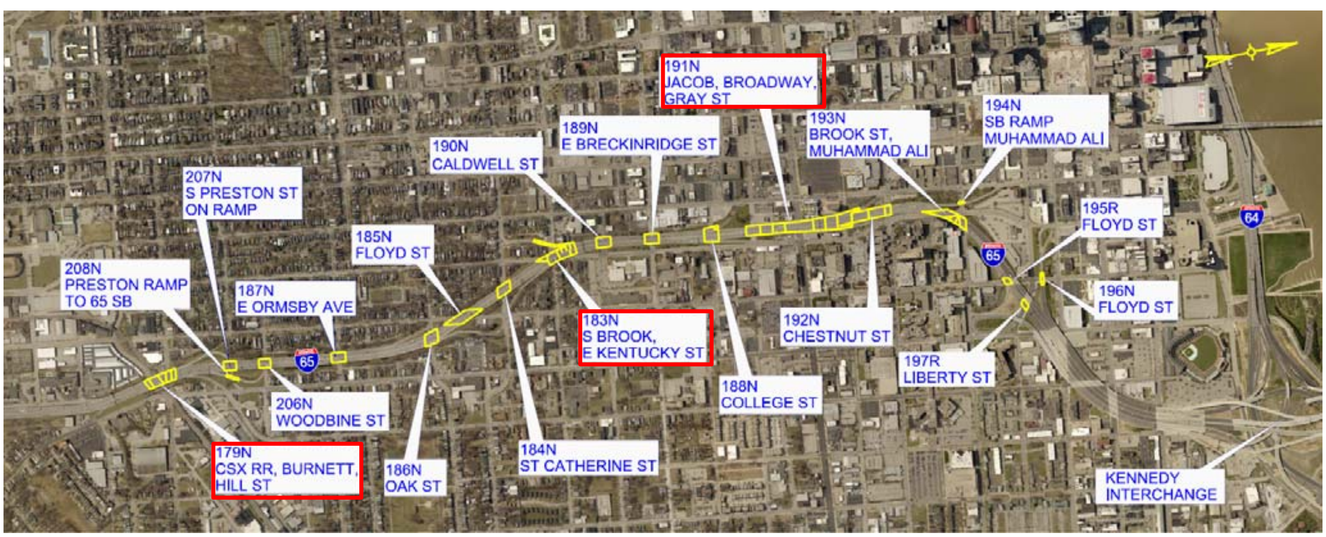

Figure ES2: Study Bridges – North

Three bridges were identified as priorities for KYTC: 179N over CSX RR, Burnett Avenue, and Hill Street; 183N over Brook Street and Kentucky Street; and 191N over Jacob Street, Broadway Street and Gray Street. Replacement scenarios have also been developed for bridges 183N and 179N due to their poor condition. In addition to the structural focus, this study includes an environmental overview with attention to socioeconomic impacts, review of adjacent projects for synergistic construction possibilities, preliminary traffic impact analyses, and a framework communication plan for construction activities.

Purpose and Need

The purpose of this study is to evaluate, identify and develop strategies to address deficiencies in 28 bridges on Interstate 65 between the Watterson Expressway (I-264) and the rebuilt Kennedy Interchange in Louisville.

As part of KYTC's asset management program, these strategies are needed to maintain safe and efficient travel through the I-65 corridor.

Structure Condition

Bridge inspections show declining conditions over time for most of the bridges in the study area. See (**Table ES1**) below for existing conditions.

Table ES1: Bridge Ratings

Bridge ID	Route Under	Sufficiency Rating	NBI Ratings			Bridge Condition
			Deck	Super-structure	Sub-structure	
209N	PHILLIPS LN	75.9	5	5	5	Fair
210N	MANNING RD	73	5	5	5	Fair
211N	E ENT TO FAIRGROUNDS	81.4	5	5	5	Fair
212N	BRADLEY AVE, N ENT FRGRND	82	5	5	5	Fair
213N	CRITTENDEN DR (KY 1631)	94	6	6	6	Fair
205N	NORFOLK SOUTHERN RR	72	5	5	5	Fair
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181N	WARNOCK ST	82	5	6	5	Fair
182N	BRANDEIS AVE	74.7	5	5	5	Fair
179N	CSX RR, BURNETT, HILL ST	49	5	4	3	Poor
208N	PRESTON RAMP TO 65 SB	66	5	5	6	Fair
207N	S PRESTON ST ON RAMP	80	5	6	6	Fair
206N	WOODBINE ST	70	6	6	5	Fair
187N	E ORMSBY AVE	80.2	5	6	6	Fair
186N	OAK ST	69	5	6	5	Fair
185N	FLOYD ST	81.6	5	6	6	Fair
184N	ST CATHERINE ST	82	5	7	5	Fair
183N	S BROOK, E KENTUCKY ST	46.7	5	4	4	Poor
190N	CALDWELL ST	86.8	6	6	6	Fair
189N	E BRECKINRIDGE ST	67.2	6	5	6	Fair

Table ES1: Bridge Ratings (continued)

Bridge ID	Route Under	Sufficiency Rating	NBI Ratings			Bridge Condition
			Deck	Super-structure	Sub-structure	
188N	COLLEGE ST	80.1	6	6	6	Fair
191N	JACOB, BROADWAY, GRAY ST	73.9	6	5	5	Fair
192N	CHESTNUT ST	77.1	6	5	5	Fair
193N	BROOK ST, MUHAMMAD ALI	76	5	5	5	Fair
194N	MUHAMMAD ALI	96	7	7	6	Fair
196N	FLOYD ST	75.7	5	6	5	Fair
195R	FLOYD ST	96.9	7	7	6	Fair
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Notes to Table 1:
Sufficiency rating is a numerical value (0 for the worst and 100 for the best) that gives an indication of a bridge's eligibility for rehabilitation or replacement and is based on structural adequacy, safety, serviceability, function obsolescence, and essentiality for public use.
National Bridge Inventory (NBI) condition rating (0 for worst and 9 for best) reports the condition of a bridge component as an evaluation of its current physical state compared to what it was on the day it was built.
Good = Bridge has all three NBI condition ratings for deck, super and sub of 7 or higher.
Poor = Bridge has at least one NBI condition rating for deck, super or sub of 4 or lower.
Fair = all other bridges.

Adjacent Projects

Louisville Metro Two-Way Streets
Louisville Metro has initiated a plan for the conversion of select one-way streets to two-way circulation. The only street under I-65 planned for conversion at this time is Jefferson Street, outside of our project limits. Louisville's Public Works Department should be contacted for possible coordination during construction if city streets have planned utility or paving work in the study area.

Brook Street Off-Ramp
Bridge 196N over Floyd Street is an off-ramp being studied for realignment. This project is in the design phase and could be ready for construction as early as 2021. Because alternates being considered would replace bridge 196N, it is recommended that any proposed repairs in this area be delayed until the disposition of a new bridge is known.

I-65 Ramp Modifications Scoping Study
This 2008 study included alternatives to improve traffic flow, safety, and access associated with the I-65 ramps from Crittenden Drive to St. Catherine Street. No recommendations have been implemented, and no particular advantage would be gained from concurrent I-65 bridge repairs if portions of the ramp improvements are implemented.

Environmental Overview

Any proposed bridge repair projects in the study area will have minimal environmental impacts because all construction will occur within existing right of way. No impacts to historic properties, archaeological sites, ecological resources, etc. are anticipated. Socioeconomic impacts may occur due to temporary disruptions during construction to commuters, local residences, businesses, and the homeless population who seek shelter beneath several of the area bridges.

With the availability of detour routes, the impacts to commuters and businesses are expected to be minimal. However, the homeless populations that reside under several of the bridges will be temporarily displaced by construction activities. After coordination with Louisville Metro and homeless advocacy groups, policies and procedures successfully implemented during similar projects will be utilized for this work.

User Impacts

Traffic Impacts Analyses

Traffic operational analyses were completed for both single-lane closures during the weekday and total closure by direction for weekend-only construction activities. These analyses indicated a reduction in Level of Service from LOS C/D to LOS E/F during weekday closures and weekend closures. Also, queueing analysis showed that during afternoon peak hours (4:00-6:00 pm), additional traffic backup of 7,000-8,600 feet could be anticipated for the single-lane weekday closure scenario. The queue analysis shows that the existing four-lane and three-lane sections have no queueing; however, the three-lane segments with a single-lane closure begin to generate a 7,000-8,600 feet queue during the peak hours (4:00-6:00 pm).

Under-Bridge Parking

Under-bridge parking exists at several locations within the study area via permits. Permit holders have been identified and when those areas are scheduled for repair, coordination should begin early so that alternate accommodations can be secured prior to construction.

Communication Plan

Successful Public Information Plans / Communication Plans for similar Louisville interstate projects were reviewed, and a conceptual plan for both weekday and weekend road or lane closures, as well as parking displacement, is included in **Appendix D**.

Recommendations

Abutment Joint Elimination

The vast majority of bridges in this study have active corrosion within the concrete at their abutments and concrete girder ends, if comprised of concrete girders. This is the location of expansion joints, and it is evident that many joints have failed and are leaking (**Figure ES3**). Abutment joint elimination via deck slab extension is recommended wherever possible (**Figure ES4**).


Figure ES3: Typical Abutment Joint Leakage and Concrete Damage

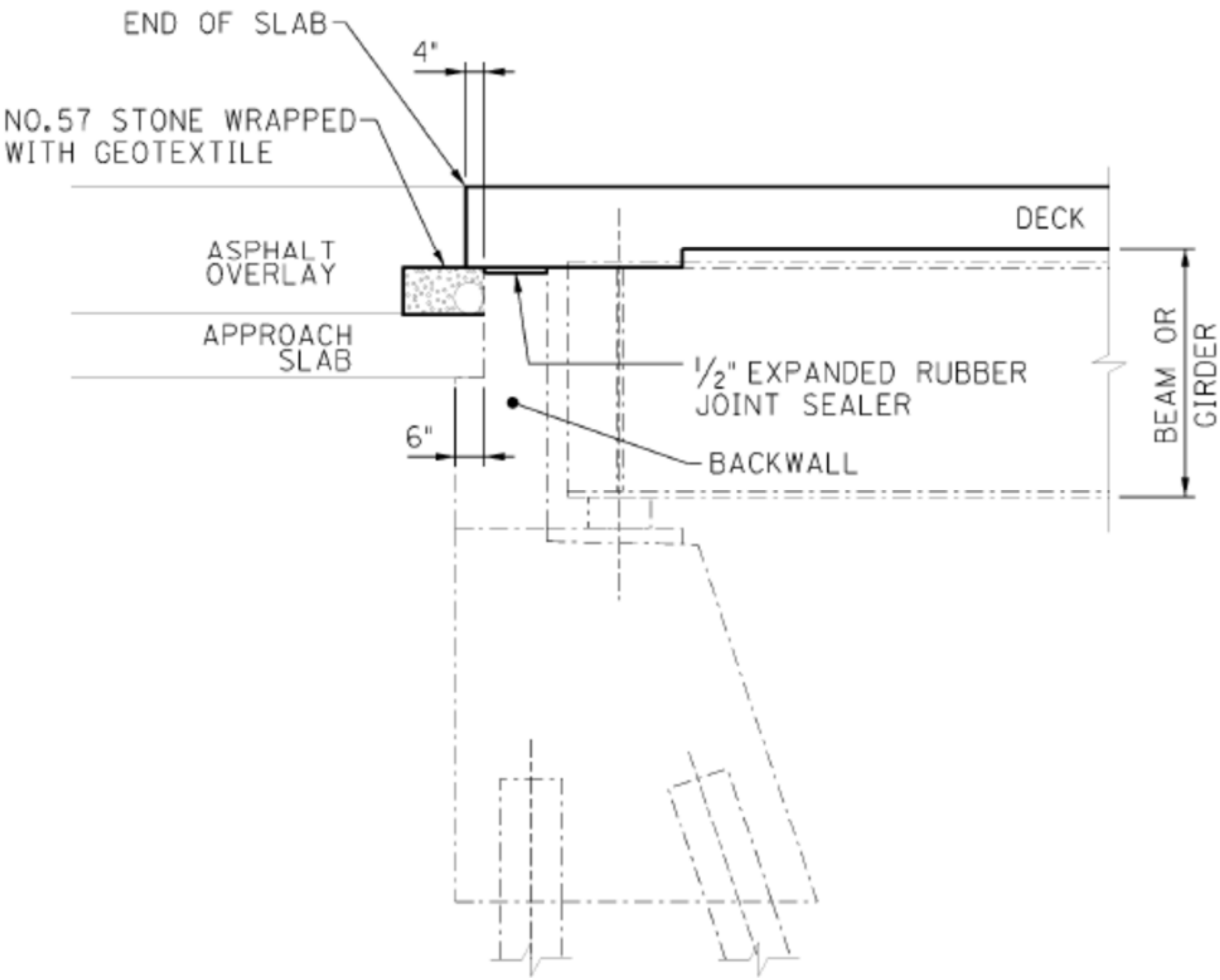


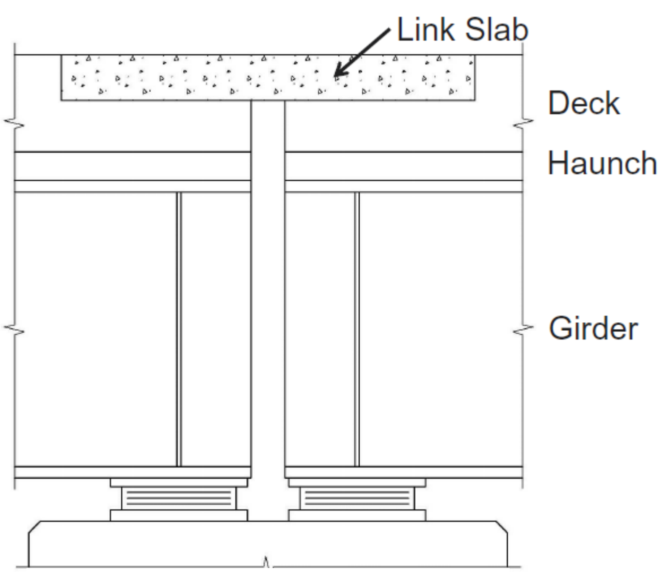
Figure ES 4: Abutment Joint Elimination by Slab Extension

Traffic operational analyses show that the effect/impact of the single-lane closure with traffic shift is comparable to complete direction closures with weekend-only work. The continuous single-lane closure to traffic is the recommended maintenance of traffic scheme to allow time for abutment joint elimination of half a bridge width, by direction, at a time.

Pier Joint Elimination

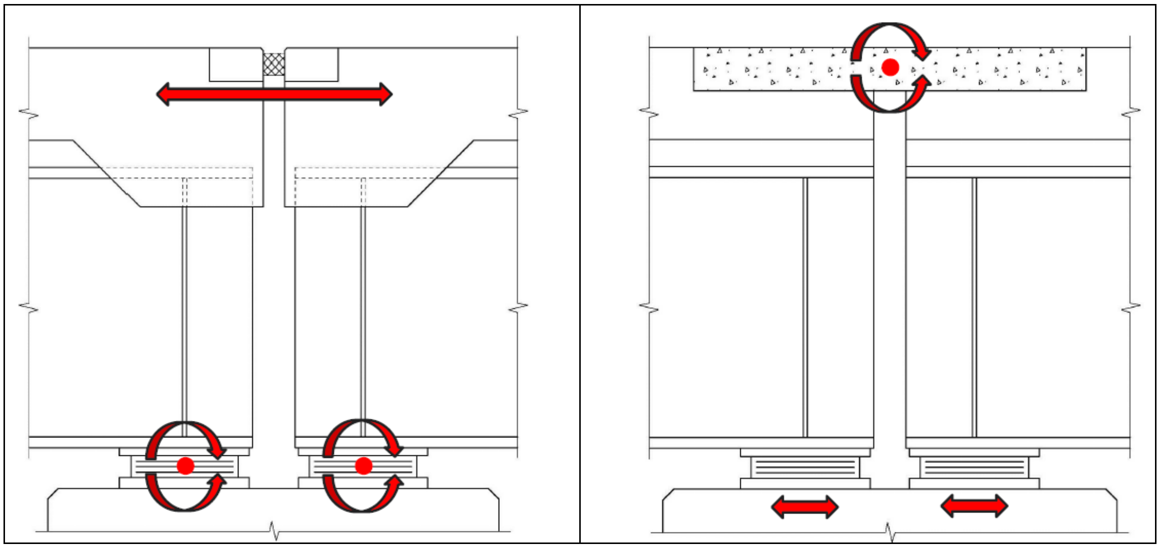
Similarly, expansion joints at piers have identical leakage and corrosion problems and can be eliminated in some instances (**Figure ES5**). Pier joint elimination by implementing link-slabs and reconfiguring bearings for longitudinal movement and load resistance is recommended wherever possible (**Figure ES6a and ES6b**).

Figure ES5: Typical Pier Joint Leakage and Concrete Damage



Pier with Link-Slab Labels

Figure ES6a: Changes to Bridge Using a Link Slab



Pier Configuration with Joint
Pier Configuration with Link-Slab

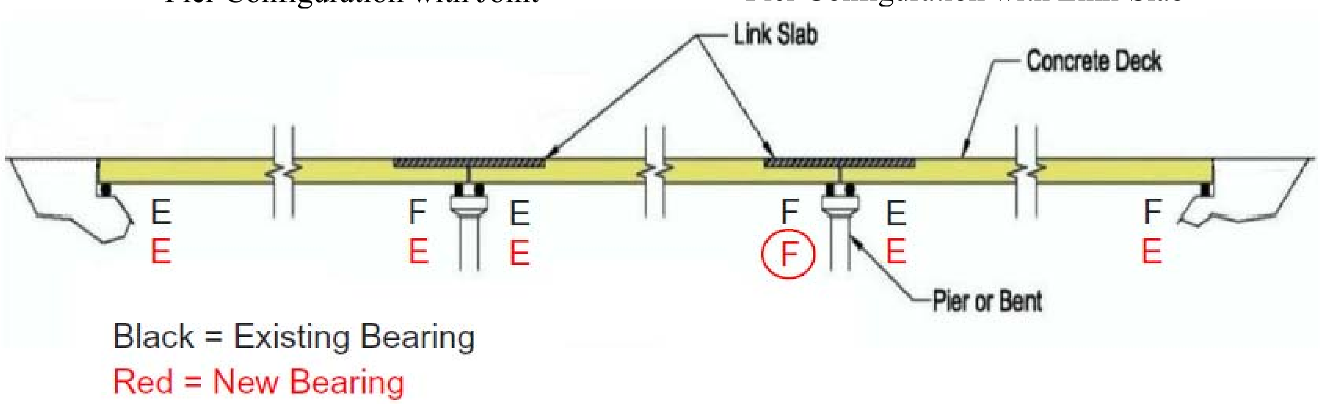


Figure ES6b: Changes to Bridge Using a Link Slab (New York Department of Transportation Presentation)

Additional Improvements

Several instances of slab debonding at bridge ends were observed. (**Figure ES7**) It is recommended to add shear studs to the top flange of the steel beams when abutment joints are eliminated. Likewise, corrosion was observed at several joints between bridge barriers at the median (**Figure ES8**). Elimination of this median joint is also recommended by replacing the two barriers with a single barrier, similar to the north end of the study area.

Figure ES7: Typical Slab Delamination at Bridge Ends

Figure ES8: Typical Median Joint Leakage and Corrosion

Baseline repair cost estimates include conventional repair techniques to known deficiencies, improvements listed above, and special repairs for isolated structural steel cracks and damage caused by vehicles. Special post-tensioned, integral straddle bents are repair options for Bridge 183N (Brook and Kentucky Streets); Bridge 191N (the Broadway Bridge) has options to use Fiber Reinforced Polymer (FRP) fabric for girder repairs or replacement with a new prestressed concrete girder line.

Extended Durability - Galvanic Cathodic Protection

It is recommended that traditional repairs be augmented with cathodic protection where leaky joints have infused concrete areas with chlorides. Basic cathodic systems distribute zinc rods or pucks uniformly throughout the repair zones, and at minimum, a 30-year corrosion-free repair can be achieved for only an additional 6% to the construction cost.

Priority Bridges

183N over Brook Street and Kentucky Street: Multiple options are provided to repair this bridge including repair of structural steel cracking by coverplating and by encasement into a post-tensioned (PT), integral straddle pier. Replacement options are also postulated with PT straddle bents where needed. Existing abutments are large counterfort vertical abutments; so replacement options identified recommend to leave most, or all of the existing abutments in place, and to span over them to establish new integral end bents.

179N over Burnett Avenue, Hill Street, and CSX RR: This bridge recently had emergency shoring due to disintegration of some of the south abutment's concrete-bearing areas. A concrete repair option is provided in the estimate as well as a superstructure-only replacement and a complete replacement.

191N over Jacob Street, Broadway Street, and Gray Street: This long bridge consists of seven different structural units, with a reinforced concrete unit over Broadway Street having a severely deteriorated girder. It can be repaired in place with a fiber reinforced polymer (FRP) fabric bonded to the repaired surface or by removing the damaged girder line and replacing the girder line with a new prestressed concrete girder and slab area.

Replacements

Bridge 183N over Brook and Kentucky Streets cost is $17.2 - $18.5 million to replace. Although approximately three times the cost of repairs, replacement would be a prudent investment for this 60 plus year-old bridge with fracture critical members and many undesirable fatigue prone details.

Bridge 179N over Burnett Avenue, Hill Street, and CSX railroad, cost is $5.7 million for superstructure replacement and $8.1 million for full bridge replacement. With the repair options approaching $3.8 million, replacement should be seriously considered.

Prioritization

All 28 bridges were ranked as High, Moderate, or Low priority based on condition. The three priority bridges, identified above, are the only ones ranked High, eight ranked as Moderate and 17 ranked Low priority. Bridge 196N was ranked moderate but it may be replaced as a part of an existing project; the project team recommends delaying action on it. The remaining seven moderately deteriorated bridges are clustered in two areas, namely at the north and south ends of the study area.

Schedule of Construction

Repair/replacement of 179N, 183N, and 191N should be first to be constructed, followed by all eight bridges rated moderate priority, then the 17 low-priority group would be completed. So construction crews are not hop-scotching around the corridor for years on end, it is recommended to geographically group the eight moderate-priority bridges with additional lower-priority bridges (**Figures ES9 and ES10**). Specific group size depends on available funding, exact scope of work, and tolerance for construction duration. Suggested contract packages with estimated construction costs are:

High Priority:
Repair Package No. 1: 179N, 183N and 191N Estimated Cost = $14,460,000

Moderate Priority: College Street to Liberty Street
Repair Package No. 2: 188N, 192N, 193N, 194N, 195R, 197R Estimated Cost = $7,650,000

Moderate Priority: Phillips Lane to Brandeis Avenue
Repair Package No. 3: 209N, 210N, 211N, 212N, 213N, 205N, 180N, 181N, 182N
Estimated Cost = $11,200,000

Low Priority: Preston Street Ramps to Breckinridge Street
Repair Package No. 4: 208N, 207N, 206N, 187N, 186N, 185N, 184N, 190N, 189N
Estimated Cost = $8,850,000

Figure ES9: Repair Package Grouping – South

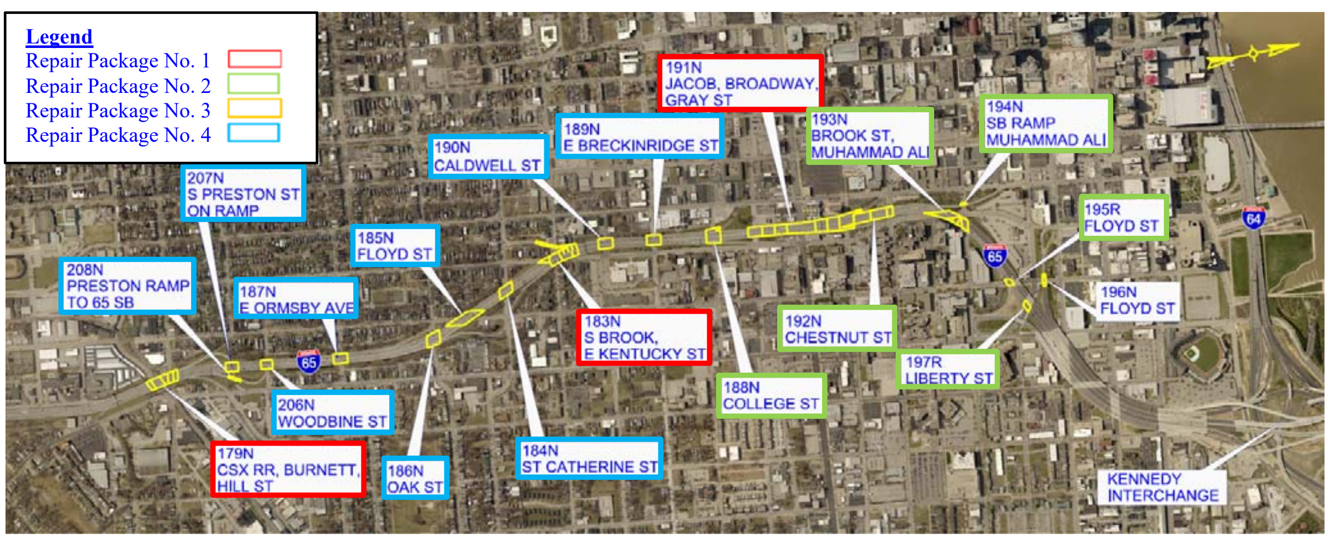


Figure ES10: Repair Package Grouping – North

Introduction

The Kentucky Transportation Cabinet (KYTC) initiated a study of the I-65 Bridges in Jefferson County in June 2018. This study examines the conditions, prioritizes, and develops conceptual strategies to address deficiencies of 28 Interstate 65 bridges between the Watterson Expressway (I-264) and the rebuilt Kennedy Interchange in Louisville, Kentucky (**Figures 1 and 2**). This corridor carries an annual average daily traffic (AADT) of nearly 120,000 vehicles. The area of bridge deck encompassed within these structures is over 717,000 square feet, or about 16.5 acres.

Figure 1: Study Bridges – I-264 to Brandeis Avenue

Figure 2: Study Bridges – Burnett/Hill Street to Kennedy Interchange

Three bridges were identified as priorities for KYTC: 179N over CSX RR, Burnett Avenue, and Hill Street; 183N over Brook Street and Kentucky Street; and 191N over Jacob Street, Broadway Street, and Gray Street. Replacement scenarios have also been developed for bridges 183N and 179N due to their poor condition. In addition to the structural focus, this study includes an environmental overview with attention to socioeconomic impacts, review of adjacent projects for synergistic construction possibilities, preliminary traffic impact analyses, and a framework communication plan for construction activities.

According to KYTC's 2018 Transportation Asset Management Plan (TAMP), most decisions regarding maintenance, repair, and rehabilitation are made by districts based on engineering judgment, knowledge of the inventory, and experience with recurring issues. KYTC's Central Office makes the decisions to replace bridges. This decision is based on district recommendations and the Sufficiency Rating (SR) of the bridge. To use federal funds for bridge replacements, the SR must be 50.0 or less (**See Table 1**)

The TAMP report recommends: maintenance of bridges in Fair and Good condition, rehabilitation of bridges in Fair condition, and major rehabilitation or replacements of bridges in Poor condition. Two study bridges are rated Poor, and 26 are rated Fair.

Purpose and Need

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Table 1: Bridge Ratings (continued)

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Fair = all other bridges.

Adjacent Projects

Louisville Metro Two-Way Streets

Louisville Metro has initiated a plan (**Figure 3**) for the conversion of select one-way streets to two-way circulation, where appropriate, to improve mobility and safety. Recent contact with Louisville Metro confirmed that the only street under I-65 planned for conversion at this time is Jefferson Street, scheduled for Fall 2019.

Additional streets are under consideration for conversion in the future. As bridge repairs are scheduled, Louisville's Public Works Department should be contacted for possible coordination during construction if utility or paving work is scheduled for any city streets in the study area.

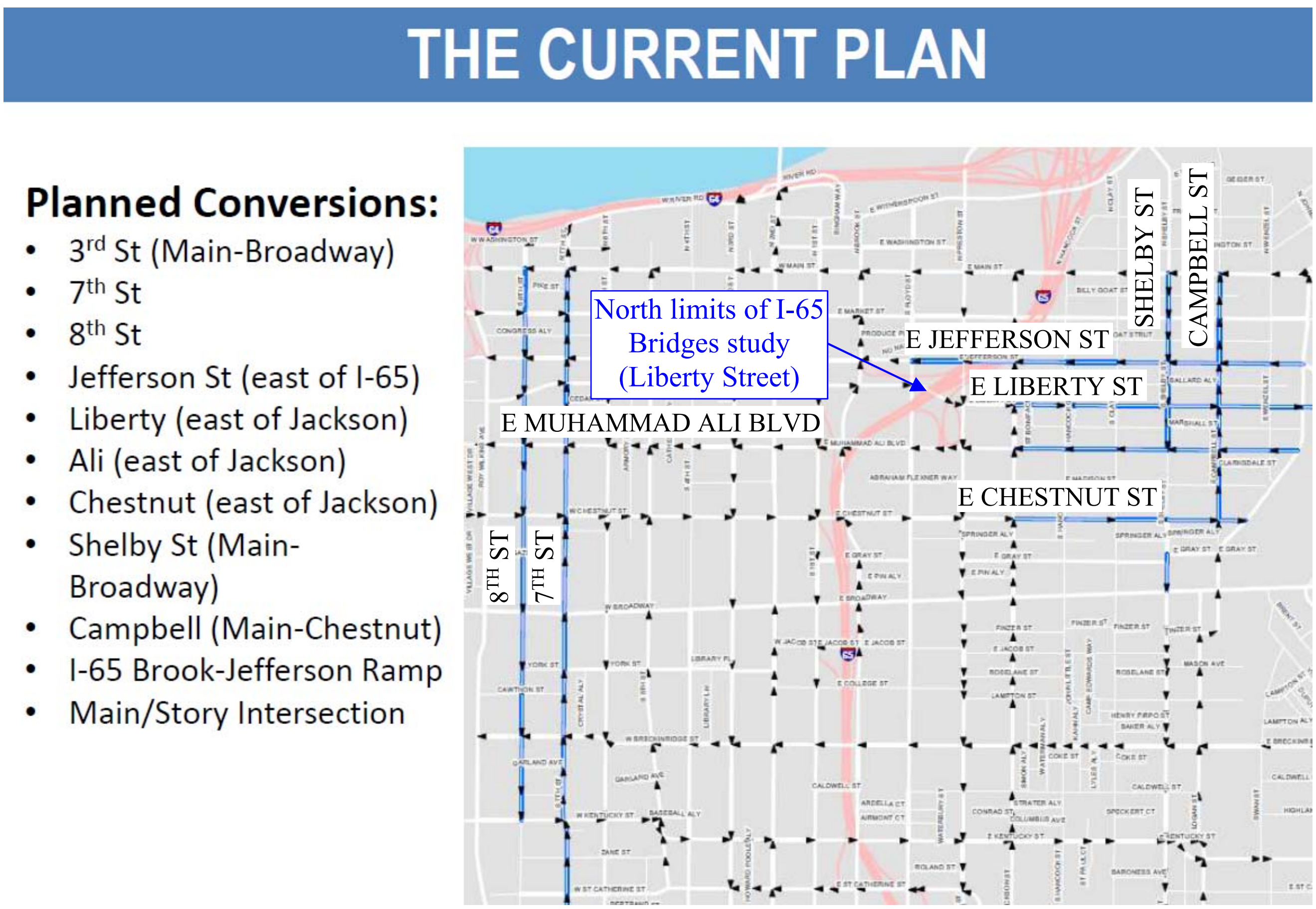


Figure 3: Louisville Metro's Planned Street Conversions (Louisville Metro)

Brook Street Off-Ramp (KYTC Item No. 5-378.10)

Bridge 196N over Floyd Street lies within the existing I-65 southbound off-ramp, under consideration for realignment (**Figure 4**). Louisville Metro's engineering consultant for the project was contacted for a status update. In both alternatives under evaluation, the Floyd Street Bridge would be replaced. A No-Build Alternative is also possible.

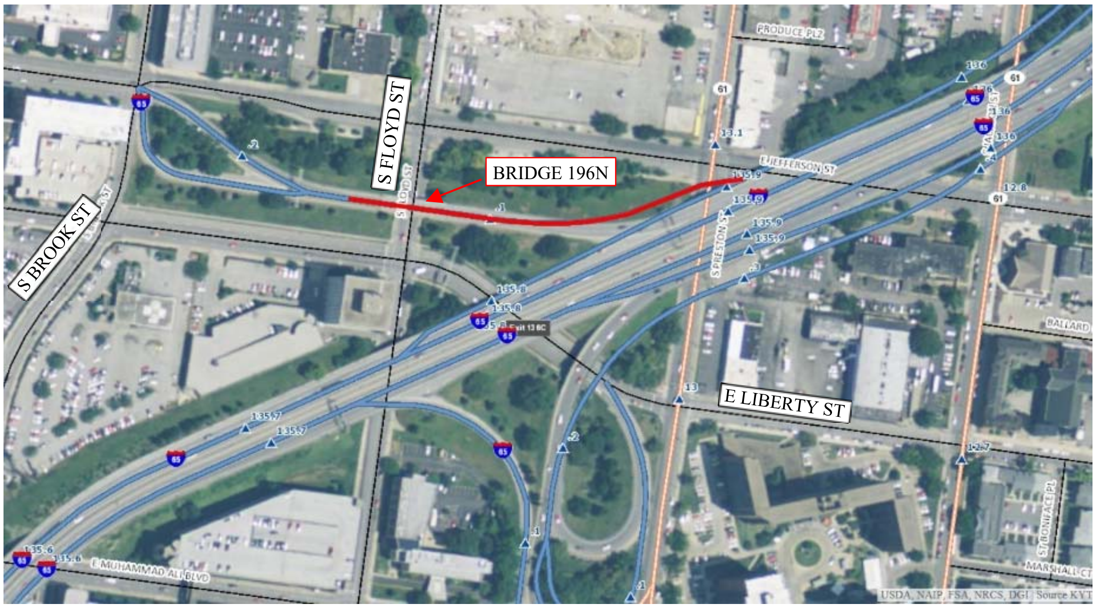
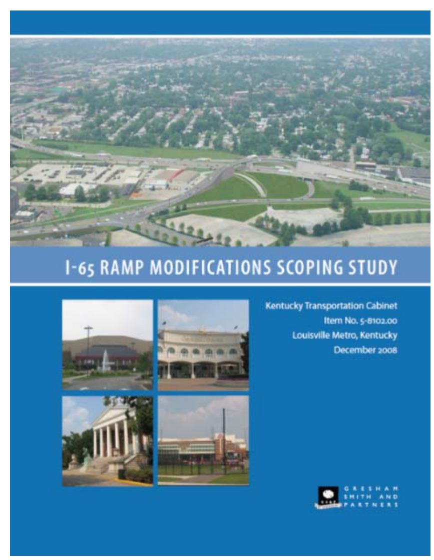


Figure 4: Brook Street Off-Ramp Project

The project is in preliminary engineering and environmental analysis and has not yet had public outreach. Final design may not begin until at least late 2019. With certain utility and possibly some right-of-way (relocations) impacts, it could be let for construction in 2021 or 2022.



I-65 Ramp Modifications Scoping Study

A 2008 study recommended to improve traffic flow, safety, and access associated with ramps along I-65 from Crittenden Drive to St. Catherine Street. The improvements were estimated to be $60-70 million in 2005 dollars (**Figure 5**) and none of these improvements have been implemented. In KYTC's Strategic Highway Investment For Tomorrow (SHIFT) rankings for 2017 North Region Projects[1], the recommendations from the 2008 study were ranked 123rd with a cost to complete of $100,400,000.

[1] In 2016, Gov. Matt Bevin directed the Kentucky Transportation Cabinet (KYTC) to develop a process to better allocate the Commonwealth's limited transportation funds. The Strategic Highway Investment Formula for Tomorrow (SHIFT) was the result -- a data-driven, objective approach to compare capital improvement projects and prioritize transportation spending. SHIFT helps reduce over programming and provides a clear road map for construction in the coming years. The formula applies to all transportation funding that isn't prioritized by other means, such as maintenance work, local government projects and dedicated federal projects. The North Region encompasses KYTC Districts 5, 6, and 7. (KYTC)

Some of the priority phases could be constructed concurrently with the repairs of nearby bridges, in this study, but no advantage is gained from combining them with the I-65 bridge work. Most of the ramp modification work would be adjacent to I-65 whereas the bridge work is on I-65.

I-65 Ramp Modifications (2008)						
Preliminary Estimates of Probable Costs						
Priority	Alternate No. 1	Item 1 Rdway	Item 2 R/W	Item 3 Utilities	Item 4 Engr.	Total
1	I-65 Connector to Crittenden Dr./Central Ave.	13,900,000	686,000	115,000	1,470,100	16,171,100
2	Arthur Street Southbound I-65	13,555,000	203,000	245,000	1,400,300	15,403,300
3	Crittenden Drive Ramp to Northbound I-65	1,270,000	155,000	65,000	149,000	1,639,000
4	I-65 Northbound Ramp to Warnock Street	4,800,000	1,740,000	165,000	670,500	7,375,500
5	Preston Street Ramp to Northbound I-65	9,850,000	3,000,000	980,000	1,383,000	15,213,000
6	Warnock Street Ramp to Northbound I-65	3,190,000	1,800,000	175,000	516,500	5,681,500
	Totals	46,565,000	7,584,000	1,745,000	5,589,400	61,483,400
	Alternate No. 4					
1	I-65 Connector to Crittenden Dr./Central Ave.	17,250,000	1,082,000	162,000	1,849,400	20,343,400
2	Arthur Street to Southbound I-65	13,555,000	204,000	215,000	1,397,400	15,371,400
3	I-65 Northbound Ramp to Warnock Street	4,800,000	1,740,000	165,000	670,500	7,375,500
4	Preston Street Ramp to Northbound I-65	13,225,000	3,650,000	1,200,000	1,807,500	19,882,500
5	Warnock Street Ramp to Northbound I-65	3,190,000	1,800,000	175,000	516,500	5,681,500
	Totals	52,020,000	8,476,000	1,917,000	6,241,300	68,654,300

Notes: (A) Priority 1 does not include cost for reconstruction of KFEC entrance or toll booths.
(B) Signing and lighting are included in Item 1.
(C) Item 4 (Engineering) is estimated as 10% of Item 1 through 3.
(D) Date of estimates is August 2005

Figure 5: Recommended I-65 Ramp Modifications from 2008 Planning Study (2005 Dollars) (KYTC)

Environmental Overview

The bridge repair projects will have minimal environmental impacts because all construction will occur within existing right of way. There will be no effects to historic properties, archaeological sites, ecological resources, etc. Socioeconomic impacts may occur due to temporary disruptions during construction to commuters, local residences, businesses, and the homeless population who seek shelter beneath several of the area bridges.

With the availability of detour routes (I-264 and I-265) around Louisville, the impacts to commuters and businesses is expected to be minimal. However, the homeless populations that reside under several of the bridges will be temporarily displaced by construction activities. Several site visits were made and homeless populations were observed at one or more of the priority bridges. In addition, individuals were observed at five other bridge locations scattered throughout the corridor (**Figure 6**). The number of homeless people under those structures varied. Visits were made during the morning daylight hours and it is expected that those numbers likely increase during the evening hours. The number of people observed at various locations ranged from several to more than 20 with most having set up encampments.

Figure 6: Debris from Homeless Encampments under Bridges

During assessment of this issue, local leaders and advocate groups such as the Coalition for the Homeless and Wayside Christian Mission were engaged to understand how to minimize adverse impacts to the homeless during construction activities. Louisville Metro expressed a strong preference and willingness to lead these efforts since they have procedures in-place to implement under similar circumstances. This involves providing a 21-day advance notice of construction activities, administered by Louisville Metro and networking with advocate groups to provide assistance to this population.

Outreach volunteers coordinated through Louisville Metro's Office of Resiliency was effective. Volunteers identify recent homeless persons and communicate options and services available. An effort was made to follow those in camps so that opportunities for available shelter or housing are conveyed. Louisville Metro strongly encouraged, from the outreach agencies, to utilize established communication channels to maximize effectiveness and for the safety of all involved. Experience on prior projects where homeless were displaced has yielded success stories and lessons learned.

It was noted that the homeless populations do not consistently use the same bridges as shelter from year-to-year and are more transient during the summer months. Typically, as winter approaches, the homeless become encamped at a particular location and remain there until spring. If displaced during cold weather months, materials gathered under bridges such as blankets, tents, or other forms of shelter could be left behind and quickly scavenged. Metro's experience has shown that timing construction to occur during warmer weather can minimize impacts to the homeless. The full Environmental Overview is found in **Appendix A**.

User Impacts

Traffic Impacts Analyses

Two different scenarios for maintaining traffic while constructing bridge repair / improvement scenarios were considered. The scenarios studied were:

- Full Closures during the weekend along I-65 between I-264 to the south and I-64 to the north
    - Closures begin on Friday evenings at about 9:00 pm and extend throughout the weekend with required opening of I-65 by 5:00 am on Monday morning.
    - Closures could involve either a single direction or both directions on I-65.

- Single-Lane Closures during weekdays
    - Scenario involves part-width construction of proposed repair / improvement concepts on a lane-by-lane basis.

Data Used for Analyses

Traffic count data for I-65 between I-264 and I-64 were obtained from the Kentucky Transportation Cabinet for August 2017 and August 2018. Hourly volume counts were analyzed for a two-week period between August 12-25, 2018. Short-term hourly counts were analyzed for the week of August 8 – 15, 2017. This helped to identify the AM and PM peak traffic volumes and the distribution of traffic for weekdays versus weekends. The greatest weekend peak hourly traffic volume for this segment of I-65 was 3,175 vehicles per hour. For weekday traffic, the greatest peak hourly traffic volume was 4,379 vehicles per hour. These weekend and weekday peak hourly volumes aided to evaluate worst-case analyses for each maintenance of traffic scenario. A worst-case analysis of traffic operations on I-65 determined significant advantages or disadvantages with either of the possible scenarios for maintaining traffic during construction.

Weekend Closures of I-65

Weekend closures of I-65 will require diversions of all traffic from I-65 to other routes. For example, closure of I-65 Northbound at the interchange with I-264 will require diverting all traffic from I-65 to either I-264 or the surface street network. An efficient or practical means of estimating the traffic diverted to surface streets was not within the scope of this study. Therefore, to approximate worst-case conditions, it was assumed when I-65 is closed at the I-264 Interchange, half of the traffic would use I-264 eastbound, and half of the traffic would use I-264 westbound. Thus, 1,587 vehicles per hour were added to the peak hour traffic on I-264 in each direction.

The augmented peak hour traffic volumes were then used for a Level of Service (LOS) analysis. Level of Service is a qualitative performance measure used to evaluate a roadway or intersection congestion. Levels of service are described according to a letter rating system ranging from LOS "A" (free flow, minimal or no delays – best condition) to LOS "F" (severe congestion, long delays – worst conditions) (**Figure 7**). LOS C or better is desirable in rural areas while LOS D or better is desirable in urban areas. Highway Capacity Software (HCS) was employed to determine the change in LOS for I-264 when traffic from I-65 is diverted onto it. From these analyses, the LOS on I-264 is worsened by at least a letter when I-65 is closed on weekends (**Table 2**). A similar analysis was completed for I-64 when southbound I-65 is closed during the weekend and diverted onto I-64. See **Appendix B** for HCS data.

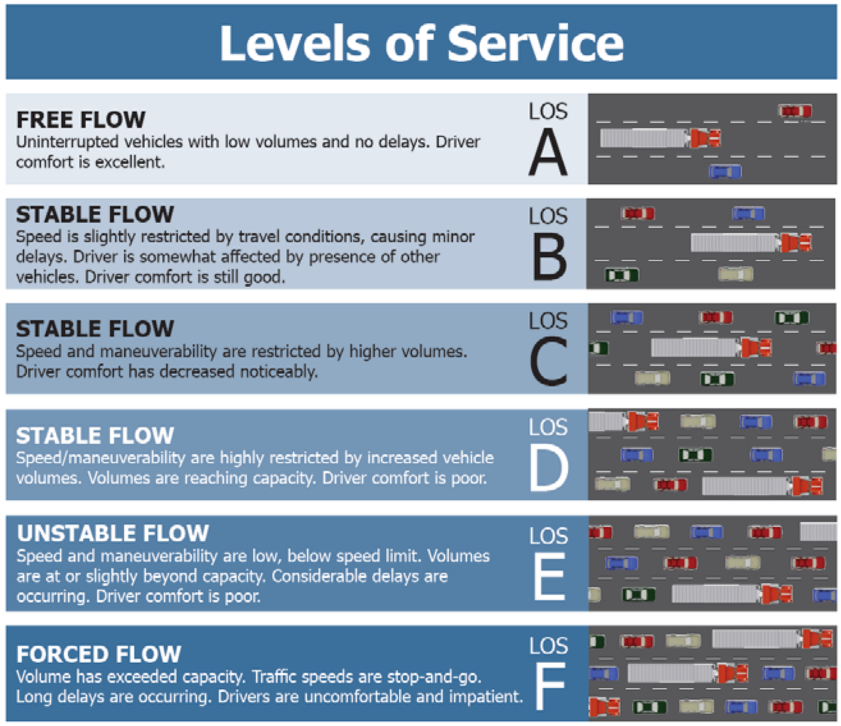


Figure 7: Level of Service Description

Table 2: Traffic Level of Service Analysis

Route	Time	Existing Conditions					Closure Conditions				
		Volume	Adjusted Capacity	Average Speed	Density	LOS	Volume	*Adjusted/ Workzone Capacity	Average Speed	Density	LOS
		veh / hr	pc / hr / ln	mph	pc / mi / ln		veh / hr	pc / hr / ln	mph	pc / mi / ln	
I-64 east of I-65	Weekend	2084	2141	51.2	23.7	C	3671	2141/-	47.7	44.7	E
I-64 west of I-65	Weekend	2368	2133	50.4	18.2	C	3955	2133/-	50.4	30.4	D
I-264 east of I-65	Weekend	4333	2132	50.2	25.1	C	5920	2132/-	50.2	34.3	D
I-264 west of I-65	Weekend	3048	2138	50.9	23.2	C	4635	2138/-	50.9	35.3	E
I-65 w/ three Lanes	Weekday	4379	2204	50.4	33.7	D	4379	2204/2294	-	-	F
I-65 w/ four Lanes	Weekday	4379	2204	50.4	25.3	C	4379	2204/2349	47.9	35.4	E

*Adjusted work zone capacity is calculated using the same equation as capacity with an additional work zone adjustment factor.

Weekday Single-Lane Closures

Segments of I-65 in this area involve both three and four lanes in each direction. Using the Work Zone configuration in HCS, it was determined that reducing the number of lanes from three to two lanes during construction for bridge work would worsen traffic flow from LOS D to LOS F. Similarly, reducing the number of available lanes from four to three lanes during construction, worsens traffic flow from LOS C to LOS E, as shown in **Table 2**.

A companion analysis using HCS was completed to estimate the queue length traffic backups associated with single-lane closures. It was determined from these analyses that backups would occur between 4:00 pm and 6:00 pm if the three lane portions of I-65 were reduced to two for construction (**Table 3**). Queue lengths are estimated to be 234 vehicles per hour (approximately 7,000 feet) between 4:00 pm and 5:00 pm. Queue lengths increase to 287 vehicles per hour (8,600 feet) between 5:00 pm and 6:00 pm. Based on the work zone queueing analysis, the queue lengths increase to 287 vehicles per hour (8,600 feet) between 5:00 pm and 6:00 pm during the single lane closure in the three-lane segment of I-65. The analysis revealed there to be no existing queue during the same peak hour time.

Table 3: I-65 Weekday Single-Lane Closure Queueing Analysis

Time Beginning	Estimated Volume	*Average Reduced Volume	Four to three lanes	Three to two lanes
			Queue (Veh)	Queue (Veh)
0:00	726	726	0	0
1:00	436	436	0	0
2:00	362	362	0	0
3:00	362	362	0	0
4:00	652	652	0	0
5:00	1668	1334	0	0
6:00	3772	3018	0	0
7:00	5440	4352	0	0
8:00	4642	3714	0	0
9:00	3626	2901	0	0
10:00	3408	2726	0	0
11:00	3554	2843	0	0
12:00	3772	3018	0	0
13:00	3916	3133	0	0
14:00	4424	3539	0	0
15:00	5222	4178	0	0
16:00	5802	4642	0	234
17:00	5802	4642	0	287
18:00	4280	3424	0	0
19:00	3046	2437	0	0
20:00	2466	1973	0	0
21:00	2248	1798	0	0
22:00	1668	1334	0	0
23:00	1160	928	0	0
Total Queue			0	521

*When the Estimated Volume exceeds 1,000 vehicles, it was assumed that 20% of vehicles would take alternate routes to avoid congestion in the construction zone. The vehicles that do not divert and enter construction is considered the Average Reduced Volume

Traffic Impact Summary

These analyses show that either scenario for maintaining traffic during construction will result in a reduced Level of Service (quality of traffic flow) during construction of up to two LOS letters, with several directions having an undesirable LOS E/F. It also was determined that single-lane weekday closures on I-65 could result in backups during afternoon peak hours (4:00 pm to 6:00 pm) up to 8,600 feet.

Depending on the exact bundle of bridges to repair, an additional maintenance of traffic scenario might be appropriate to consider. If the geographic location is favorable, a traffic crossover could be beneficial. This scenario would entail splitting a direction of travel so that one lane is left of the median barrier and one lane is right of the median barrier. This option should be explored further once bridge groupings are finalized.

Project Area Parking Impacts

Under-Bridge Parking

Site visits to the various bridges in the study area indicated parking lots with a number of spaces exist under the following bridges:

- Bridge 183N – South Brook, and East Kentucky Streets
- Bridge 191N – Jacob, Broadway, and Gray Streets
- Bridge 192N – Chestnut Street
- Bridge 193N – Brook Street and Muhammad Ali

Additionally, metered street parking is present under the following bridges:

- Bridge 191N – Jacob, Broadway, and Gray Streets
- Bridge 192N – Chestnut Street
- Bridge 193N – Brook Street and Muhammad Ali
- Bridge 196N – Floyd Street
- Bridge 195R – Floyd Street

Permitting for parking under interstate bridges such as those noted above typically is handled through Encroachment--Air Space Use Agreements or Permits. Parking at these locations has been in place for several decades. Thus, no electronic copies of the permit documents were located. Transportation Cabinet records were researched with the assistance of Permitting Staff in both District 5 and Central Office. A manual search of permit files indicated the following files may be applicable to parking under bridges:

- Brook and Gray Street – August 28, 1978 Encroachment Agreement (Updated November 4, 2005) – James Graham Brown Foundation with Commonwealth of Kentucky
    - Adjacent to I-65 – Purposes of maintaining an elevator shaft, air conditioner, parking lot, and retaining wall and waterline – parking lot encroaches 5.3 feet by 2.1 feet.
- Jacob Street to Broadway, Broadway to Gray Street, Gray Street to Chestnut Street – Air Space Agreement – May 6, 1965 – Jewish Hospital Association and Commonwealth of Kentucky -- Parking for an indefinite term until revoked
    - Broadway to Chestnut Street – November 29, 1961 – Air Space Agreement for Parking – City of Louisville and Commonwealth of Kentucky
        - City of Louisville allocated the parking areas from Broadway to Gray Street to University of Louisville

- City of Louisville allocated parking areas from Gray Street to Chestnut Street to Jewish Hospital

- Preston and Jefferson Street – Air Space Agreement – September 17, 1984 – University of Louisville and Commonwealth of Kentucky – Parking beneath I-65
- Broadway and Jacob Street – Air Space Agreement – University of Kentucky, Jefferson Community College, and Commonwealth of Kentucky – December 7, 1989 – Expanded existing parking areas under I-65 between Broadway and Jacob Streets.

Scanned copies of the above documents can be found in **Appendix C**. This information is provided for reference only and describes all information pertaining to airspace agreements under I-65 for this area that could be easily found within KYTC files. Both District 5 and Central Office Permits Branch staff have undergone changes since these airspace agreements were executed, and both offices have moved to new facilities. Therefore, it is possible that not all existing documents were found during research.

As repair and improvements to bridges are initiated, the information described above may be a useful starting point in developing a plan for managing any affected parking areas. Most parking areas also have signage indicating the administrator for that specific parking area (**Figure 8**).

Figure 8: Parking Lots under I-65 Bridges

Thus, administrators of parking areas affected by construction should be contacted early to coordinate necessary parking limitations during construction. Many of these air space agreements include the phrase “for an indefinite time until revoked without charge or rental.” Early agreements also may have permitted the air space lease holder to make improvements such as paving, lighting, and fencing that, if damaged, may need to be repaired / replaced during construction. Specifics of liability and responsibility should be determined and enumerated for the lease holders and contractors prior to beginning construction. Also, early coordination with parking permit holders will allow alternate parking to be found for users of the facilities.

Communication Plan/Public Information Plan

The primary goal of the Communication Plan or Public Information Plan (PIP) is to inform the motoring public and area stakeholders of project information including planned Maintenance of Traffic (MOT) activities including significant lane and ramp closures. The KYTC District 5 Public Information Officer (PIO) will coordinate and disseminate to stakeholders and the media appropriate information regarding the construction plans.

A conceptual Communication Plan / PIP is intended to serve as a framework for developing a specific plan for each bridge repair / improvement project tailored to the specific schedule, scope of work, and maintenance of traffic plan for addressing that bridge or group of bridges.
The PIP includes the following:

- Local Stakeholders
- Local Agencies potentially affected by the project (Emergency responders: Police; Fire; EMS)
- Utility Companies
- A method of outreach to trucking firms and out-of-state stakeholders
- Special events and venues that could affect or be affected by the project
- Project Schedule and Description of Work
- Proposed Media Relations
- Coordination with out-of-state Departments of Transportation and Traffic Centers

Appendix D is a conceptual Communication Plan / Public Information Plan intended as a starting point to develop individual plans once bridge groupings and MOT plans are known.

Engineering Investigation

For this study, each bridge was visited with the most current bridge inspection report and plans in hand. Site visits allowed for confirmation of major bridge deficiencies as well as information gathering that could affect a contractor’s means and methods of bridge repair. All bridge site visits occurred prior to the first project team meeting held December 13, 2018.

KYTC’s Bridge Management program (BrM) was accessed to obtained original bridge plans, bridge widening plans, repair histories, bridge inspection reports, and photo logs of previous bridge inspections. Additionally, the bridge element-level condition state data[2] was downloaded for all bridges

[2] Element-level bridge inspection consists of defining the elements (individual part of the bridge) and total quantities of each element on the bridge. The total quantity of defects for each element is recorded based on their severity (1 for the best and 4 for the worst) to show the condition of each element.

for use in repair cost estimating (**Appendices E and F**). The wealth of data contained in BrM was extremely useful to assess declining bridge conditions over time and the success / failure of previous bridge repairs.

In particular, it was determined that bridge expansion joints are a major weakness of these high-traffic bridges. Records show that expansion joints have been repaired several times over roughly the past decade, on all study bridges, but they continue to deteriorate rapidly once these repairs are in service. Not only are the expansion joints themselves failing rapidly, but leakage of brackish water from deicing salts through the joints during winter months wreak havoc on reinforced concrete structures below. Chlorides penetrate the saturated concrete and migrate toward reinforcing steel. Over time, the steel corrodes and causes cracking and spalling of the surrounding concrete. One major recommendation of this report is to investigate innovative ways to eliminate this widespread problem and preserve the significant infrastructure value these bridges represent.

Findings

Most bridges within this study area were constructed as part of Louisville's North-South Expressway in the late 1950's. Since then, most have been widened and, on / off ramps have been added. Some superstructure replacements have occurred. A significant portion of the study bridges are original and, being 60 years old, have specific areas of distress. One of the most detrimental deficiencies to the longevity of the bridges is joint leakage, as mentioned in the previous section (Engineering Investigation). Several bridges have obvious joint leakage at abutments and resulting damage to the reinforced concrete abutments (**Figures 9a and 9b**).

Figure 9a: Typical Abutment Joint Leakage and Concrete Damage

Figure 9b: Typical Abutment Joint Leakage and Concrete Damage

Bridge expansion joints show distress or failure at many locations. Even joints recently replaced in 2017 showed signs of premature failure and leakage onto the substructures below (**Figure 10**).

Figure 10: Expansion Joints Replaced in 2017 showing signs of distress in 2018 Inspections

Similar Projects

In July 2008, KYTC repaired four bridges on I-265 (two over Westport Road and two over a ramp to Westport Road). This project entailed several repair methods recommended for the bridges in this study. **Appendix G** contains the plans showing similar repairs: pier joint eliminations with link-slabs; bearing replacements; end-of-bridge uplift mitigation; structural steel repairs; pier cap restoration, etc. Also included are the bids for that project with average bids calculated and unit costs escalated to 2019 dollars. This prior project is analogous to the study area bridges as both are within Jefferson County; include bridges on an interstate highway; include similar bridge repairs with a similar maintenance of traffic plan to one of the options presented for this study: to work on half a bridge-width at a time.

A second, more recent project was also analyzed for similarities. The project involved bridge deck restoration and waterproofing of five bridges on and/or intersecting I-65 and I-264 and was let to construction in March 2019. This project is just south of the limits of this study and also entails repairs to interstate bridges. Some of the types of repairs are similar, but not as extensive as recommended for the 28 bridges in this study. One significant item that was found to be useful was that the maintenance of traffic costs were more current and should better reflect current requirements than the other similar project. Data from this project is also included in **Appendix G**.

Estimates

Traditional KYTC project estimates are broken into four distinct phases: design (D), right of way (R), utilities (U), and construction (C). Although mostly focused on the construction phase, all phases are included to indicate which bridges will require added design, right of way and / or utility time, and cost. It is recommended that all other phases be completed prior to construction if at all possible. If advantageous and acceptable to all parties, utility relocations could become a portion of the construction contract as long as impediments to the contractor's control of construction are eliminated.

Design

Many repair details can be developed using the KYTC Standard Specifications for Road and Bridge Construction, standardized details, and special notes (see **Appendix H** for sample special notes) in a Contract Ready Proposal (CRP) format. Other repairs will require structural analysis, design, and unique details. In either case, it will be necessary to prepare a maintenance of traffic plan and associated PIP, general notes, repair location schematics, etc. Design estimates herein are based on historical projects covering both CRP preparation and bridge-specific repair designs. Duration estimates assume negotiation time for a consultant to be engaged to prepare the required repair plans. If KYTC utilizes in-house forces for this effort, the duration could be shorter.

Right of Way

All of the work to repair the 28 study bridges can be accomplished within existing KYTC right of way. However, a few bridges host under-bridge parking. In these situations, time and cost estimates are included for coordination with leaseholders. Additionally, time and cost estimates are included in the right-of-way phase for coordination with Norfolk and Southern Railroad, CSX Railroad, Kentucky Fair and Exposition Center, University of Louisville, and Louisville Metro for impacts and restrictions to city streets and rail crossings.

Utilities

Many of the bridges have one or more utilities attached, under, or near the structure. If a utility is directly attached at or near a repair site, it would have to be (temporarily or permanently) relocated. For utilities adjacent to a bridge, contractor access could be limited or restricted. Therefore, advance planning and coordination with utility owners will be required. This portion of estimates typically has more variability and risk due to utility companies' policies regarding prequalification for design, relocation services, and scheduling. Bridges eligible for abutment joint elimination with conduit attached to the abutment are assumed to require temporary utility relocations and have the highest utility estimates (**Table 4 and Appendix I**).

Table 4: Utility and Constraint Matrix

Bridge ID	Route Under	Billboard adjacent	Bridge over a railroad	Buildings adjacent	Conduit attached to the abutment face	Conduit attached to the pier face	Conduit running along or in the barrier rail	Fire hydrant adjacent to or under	Lights hang from superstructure	Light pole on bridge barrier rail	Overhead signs on bridge barrier rail	Overhead utilities adjacent - west face	Overhead utilities adjacent - east face	Overhead utilities crossing over	Overhead utilities crossing under	Pedestrian bridge parallel to	Permit parking under bridge	TRIMARC line, camera, or control box adjacent to abutment
209N	PHILLIPS LN					X	X		X			X	X					
210N	MANNING RD					X			X	X								
211N	E ENT TO FAIRGROUNDS				X	X			X	X								X
212N	BRADLEY AVE, N ENT FRGRND				X													X
213N	CRITTENDEN DR (KY 1631)				X	X	X		X				X	X	X			X
205N	NORFOLK SOUTHERN RR		X							X								
180N	EASTERN PKWY				X	X		X	X									X
181N	WARNOCK ST				X				X				X	X	X			
182N	BRANDEIS AVE				X	X			X				X					X
179N	CSX RR, BURNETT, HILL ST	X	X			X			X	X				X	X	X		
208N	PRESTON RAMP TO 65 SB					X												
207N	S PRESTON ST ON RAMP					X			X									
206N	WOODBINE ST				X	X			X			X		X				X
187N	E ORMSBY AVE					X		X	X	X		X		X	X			
186N	OAK ST				X	X			X	X		X		X	X			X
185N	FLOYD ST					X		X	X	X		X		X				
184N	ST CATHERINE ST					X			X	X		X			X			X
183N	S BROOK, E KENTUCKY ST			X		X		X	X	X		X	X	X	X		X	
190N	CALDWELL ST				X	X			X									X
189N	E BRECKINRIDGE ST					X			X			X		X	X			
188N	COLLEGE ST					X			X	X		X						
191N	JACOB, BROADWAY, GRAY ST			X		X			X	X	X	X	X	X	X		X	X
192N	CHESTNUT ST				X	X	X		X	X							X	
193N	BROOK ST, MUHAMMAD ALI			X	X	X			X	X							X	X
194N	MUHAMMAD ALI				X				X									X
196N	FLOYD ST				X				X	X					X			
195R	FLOYD ST				X				X	X								X
197R	LIBERTY ST				X				X									

Construction

For repairs, the construction phase should be straightforward since conventional means and methods can be used. Bundling similar repairs of multiple bridges into a single contract should result in efficiencies from repetition by the contractor's work crews. Similarly, bundling multiple bridges within a geographic area should result in cost efficiencies for maintenance of traffic setup and limit the number of takedowns and resets.

Typical repairs were estimated using KYTC average unit bid prices where practical. Special repairs were estimated by comparison to nearby similar projects, when possible. For example, some recommended repairs are very similar to those done on the I-265 over Westport Road project in 2008 described earlier. Jack and Support Bridge Span, Bearing Conversion, and Pier Joint Elimination are from Westport Road average bids of three contractors, escalated to 2019 dollars (**Appendix J**).

For the Abutment Joint Elimination, there is not a strictly similar comparison, but Westport Road had "Uplift Mitigation," which required bridge deck removal, forming and pouring concrete diaphragms between steel girders, and then replacing the bridge deck that was removed. The steps for Abutment Joint Elimination are similar, but more complex. Average bid costs for Westport Road's Uplift Mitigation were escalated to 2019 dollars, then divided by the length of abutment repaired, to obtain a unit cost per linear foot abutment. This baseline abutment repair unit cost was increased to account for partial backwall removal and more complex concrete forming. Details are shown in **Appendix J**.

Table 5 lists traditional phased cost estimates and durations. Construction cost estimates include baseline structural repairs, maintenance of traffic, mobilization and demobilization, cleaning and repairing bridge drainage, and a 10% contingency. Additional details are shown in **Appendix J**.

Table 5: Estimates

Bridge ID	Route Under	D	Duration (months)	R	Duration (months)	U	Duration (months)	C	Duration (months)	Totals
209N	PHILLIPS LN	$25,000	2	$1,000	1	$2,000	2	$1,670,000	3	$1,698,000
210N	MANNING RD	$15,000	1	$1,000	1	$2,000	2	$1,240,000	3	$1,258,000
211N	E ENT TO FAIRGROUNDS	$15,000	1	$2,000	1	$10,000	4	$1,180,000	3	$1,207,000
212N	BRADLEY AVE, N ENT FRGRND	$15,000	1	$2,000	1	$10,000	4	$1,340,000	3	$1,367,000
213N	CRITTENDEN DR (KY 1631)	$15,000	1	$1,000	1	$10,000	4	$540,000	2	$566,000
205N	NORFOLK SOUTHERN RR	$15,000	1	$5,000	2	$2,000	2	$760,000	2	$782,000
180N	EASTERN PKWY	$70,000	6	$2,000	1	$10,000	4	$2,620,000	4	$2,702,000
181N	WARNOCK ST	$15,000	1	$2,000	1	$10,000	4	$910,000	3	$937,000
182N	BRANDEIS AVE	$15,000	1	$2,000	1	$10,000	4	$940,000	3	$967,000
179N (1)	CSX RR, BURNETT, HILL ST	$120,000	8	$5,000	2	$10,000	4	$3,680,000	8	$3,815,000
208N	PRESTON RAMP TO 65 SB	$15,000	1	$1,000	1	$2,000	2	$480,000	1	$498,000

Table 5: Estimates (continued)

Bridge ID	Route Under	D	Duration (months)	R	Duration (months)	U	Duration (months)	C	Duration (months)	Totals
207N	S PRESTON ST ON RAMP	$15,000	1	$1,000	1	$2,000	2	$930,000	3	$948,000
206N	WOODBINE ST	$15,000	1	$1,000	1	$10,000	4	$970,000	3	$996,000
187N	E ORMSBY AVE	$15,000	1	$1,000	1	$2,000	2	$1,090,000	3	$1,108,000
186N	OAK ST	$15,000	1	$1,000	1	$10,000	4	$1,240,000	3	$1,266,000
185N	FLOYD ST	$15,000	1	$1,000	1	$2,000	2	$830,000	2	$848,000
184N	ST CATHERINE ST	$15,000	1	$1,000	1	$2,000	2	$1,130,000	3	$1,148,000
183N (2)	S BROOK, E KENTUCKY ST	$200,000	10	$10,000	3	$10,000	4	$4,430,000	8	$4,650,000
183N (3)	S BROOK, E KENTUCKY ST	$250,000	12	$10,000	3	$10,000	4	$4,770,000	8	$5,040,000
190N	CALDWELL ST	$15,000	1	$1,000	1	$10,000	4	$1,090,000	3	$1,116,000
189N	E BRECKINRIDGE ST	$15,000	1	$1,000	1	$2,000	2	$1,090,000	3	$1,108,000
188N	COLLEGE ST	$25,000	2	$1,000	1	$2,000	2	$1,550,000	3	$1,578,000
191N (4)	JACOB, BROADWAY, GRAY ST	$60,000	5	$10,000	3	$10,000	4	$5,970,000	7	$6,050,000
191N (5)	JACOB, BROADWAY, GRAY ST	$70,000	6	$10,000	3	$10,000	4	$6,010,000	7	$6,100,000
192N	CHESTNUT ST	$50,000	4	$10,000	3	$10,000	4	$1,920,000	4	$1,990,000
193N	BROOK ST, MUHAMMAD ALI	$120,000	8	$10,000	3	$10,000	4	$2,270,000	4	$2,410,000
194N	MUHAMMAD ALI	$15,000	1	$1,000	1	$10,000	4	$400,000	1	$426,000
196N	FLOYD ST	$15,000	1	$1,000	1	$10,000	4	$670,000	1	$696,000
195R	FLOYD ST	$15,000	1	$1,000	1	$10,000	4	$760,000	1	$786,000
197R	LIBERTY ST	$15,000	1	$1,000	1	$10,000	4	$750,000	1	$776,000
	TOTALS (6) =	$1,030,000		$77,000		$200,000		$42,830,000		$44,137,000

(1) Repairs for Abutment 1 bearings, Girders 8-10, have already been ordered by KYTC
(2) Includes Crack Repairs using Structural Cover plating.
(3) Includes Crack Repairs via encasement into a PT Integral Straddle Bent.
(4) Estimate uses FRP on Span 114 Girder 8 repair.
(5) Estimate replaces Span 114 Girder 8 with a prestressed beam.
(6) Totals use 183N (3) and 191N (5).

Recommendations

One major recommendation of this report is to geometrically change bridge configurations to eliminate expansion joints wherever possible. This effort is endorsed by KYTC Division of Structural Design as a method to prevent leakage of chloride-contaminated water through expansion joints and onto the reinforced concrete substructures below the joints. A second major recommendation is to preserve the reinforced concrete substructures embedded with chlorides by installing passive galvanic cathodic protection. These two innovative repair techniques cost more than traditional repair methods, but result in a far longer expected remaining service life.

Repair Items/Techniques

Abutment Joint Elimination

The vast majority of bridges in this study have active corrosion within the concrete at their ends (the location of expansion joints), and it is evident many joints have failed and are leaking. When deicing salts are used in winter, the brine leaks through joints and penetrates into the concrete. Over time, the chlorides migrate to reinforcing steel, causing corrosion. The corroded rebar expands, causing cracks and spalls of the concrete cover.

Various types of expansion joints have been used over the years, but most fail and require replacement at regular intervals. Because expansion joint leakage is the cause of significant damage to the bridges, it is recommended to eliminate them whenever possible.

For many years, Kentucky, as well as many other states, has promoted “Jointless Bridges” for new construction, when possible. Most have Integral or Semi-Integral End Bents instead of expansion joints at their ends. A variation on this idea for existing bridges is to eliminate the expansion joint between the abutment backwall and end of slab by extending the bridge deck over top of the backwall (**Figure 11**).

For this study, the criteria used by the Virginia Department of Transportation (VDOT) for determining if a bridge qualifies for abutment joint elimination was adopted. A bridge was compared to chart values to determine qualification based on girder type, bridge length, substructure skew, and curvature (**Table 6).**

Table 6: VDOT Criteria for Abutment Joint Elimination

	FULL INTEGRAL STRAIGHT	SEMI-INTEGRAL STRAIGHT	CONVENTIONAL CANTILEVER ABUTMENT WITH DECK SLAB EXT.	
			STRAIGHT	CURVED
Steel bridges	300 feet for 0° skew 150 feet for 30° skew	450 feet 30° max. skew	450 feet 45° max. skew	300 feet 30° max. skew
Concrete bridges	500 feet for 0° skew 250 feet for 30° skew	750 feet 30° max. skew	750 feet 45° max. skew	n/a
Total movement at abutment	$1\frac{1}{2}$"	$2\frac{1}{4}$"	$2\frac{1}{4}$"	$1\frac{1}{2}$"

*Adapted from VDOT

For this study, 23 of the 28 bridges meet the criteria above for abutment joint elimination by deck slab extension, and five exceed the limit criteria. If a similar policy is adopted by KYTC, the five outlying bridges will require traditional joint replacements.

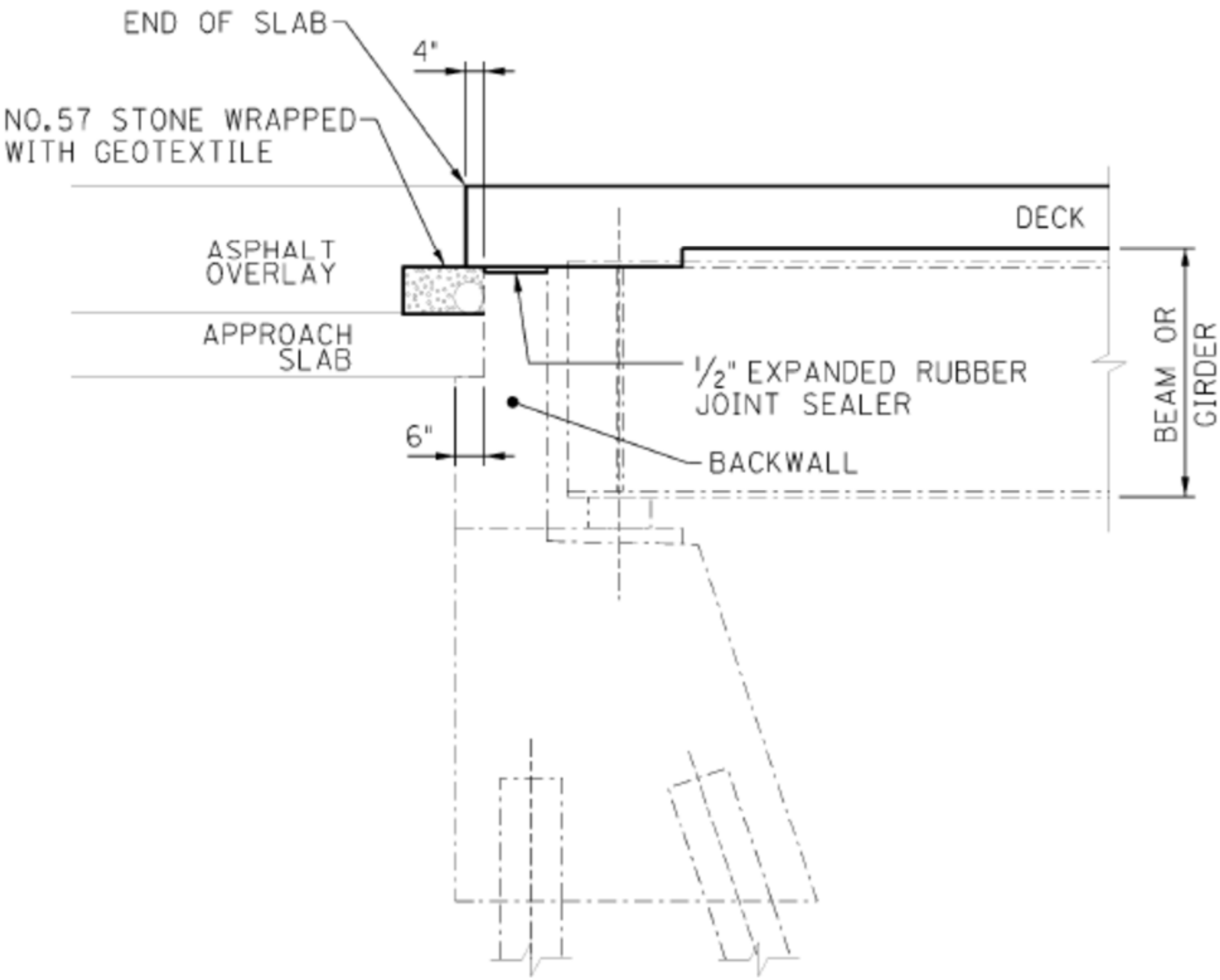


Figure 11: Abutment Joint Elimination by Slab Extension

Slab Debonding Mitigation

During our field reviews, the slab at several bridges had become debonded from the steel girders several feet out from the ends of bridge (**Figure 12**). It is recommended to add shear studs to the top flange of the steel girders to ensure the slab and girders remain in intimate contact.

Figure 12: Typical Slab Delamination at Bridge Ends

Pier Joint Elimination

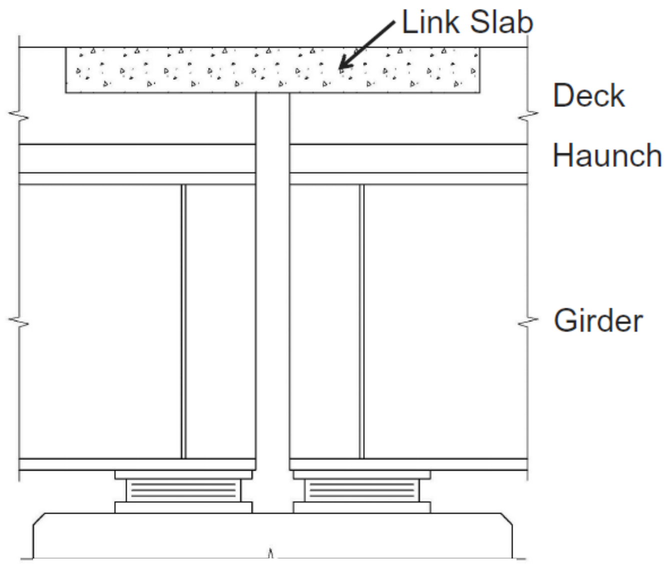
Similarly, expansion joints at piers have identical leakage and corrosion problems as those at abutments and can sometimes be eliminated. As discussed previously, a recent successful example of their removal can be found in Louisville on the I-265 bridges over Westport Road. Pier joints were eliminated by designing link-slabs across the joint area. This solution was accompanied by revised bearings to accommodate thermal movements at the piers and abutments.

Figure 13: Typical Pier Joint Leakage and Concrete Damage

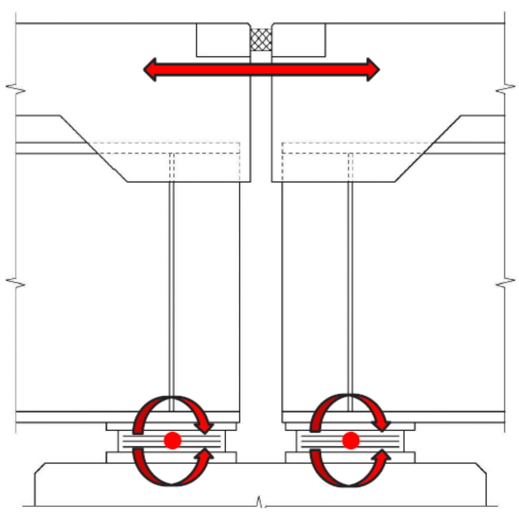
This study includes six bridges with expansion joints at piers (**Figure 13**). Some have much more complex geometry and length than the Westport Road Bridges, so all are not candidates for pier joint elimination. Changing the system behavior of the bridge regarding lateral loads from thermal, wind, and braking forces should be studied in further detail. However, study estimates assume some pier joints can be eliminated.

When pier joints are eliminated, link-slabs are recommended over the former joint area. Link-slabs are designed to be debonded from girders for approximately 5% of the span on each side of the joint. Slab rotation from span flexure and thermal forces are accounted for when proportioning reinforcing steel in the link-slab.

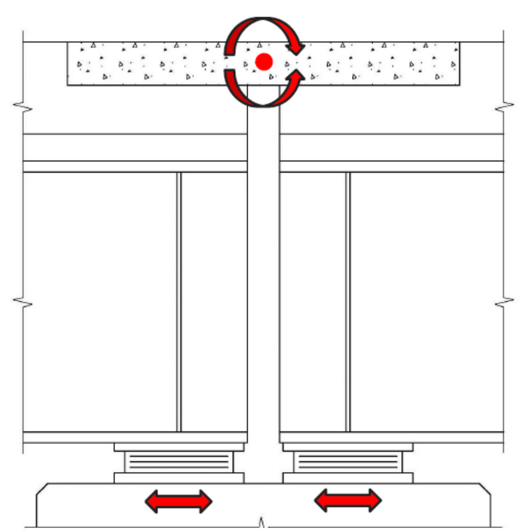
In addition to link-slabs spanning across the joint between girders, bearing conversions could be necessary. **Figures 14** shows how the link-slab joins formerly separate slabs and could require expansion bearings to replace fixed ones. Also, the location of fixed bearings should be studied to assure that the anchors, piers, and foundations at the new points of fixity can accommodate all lateral forces that could act on the bridge.



Pier with Link-Slab Labels



Pier Configuration with Joint



Pier Configuration with Link-Slab

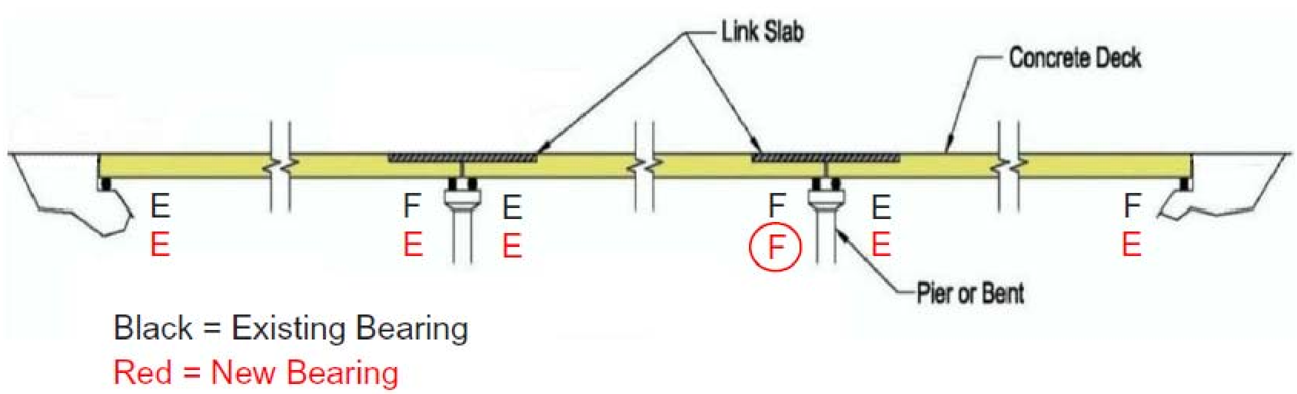


Figure 14: Changes to Bridge Using a Link-Slab (New York Department of Transportation Presentation)

Median Joint Elimination

Although not an expansion joint, the gap between the median bridge barriers is small, allows saltwater spray down onto the adjacent girders, and is in an interior location that gets no sunshine and very little air circulation to dry. These conditions are present at many of the joints with corrosion of the slab overhangs and girder deterioration (**Figure 15**). Elimination of this median joint is recommended by replacing the two barriers with a single barrier, similar to the north end of the study area.

Figure 15: Typical Median Joint Leakage and Corrosion

Other Repairs

Baseline repair cost estimates include conventional repair techniques for concrete restoration and other typical bridge repairs, such as resetting, cleaning, and greasing steel rocker bearings, spot painting, and embankment repairs. The Phillips Lane (209N) and College Street Bridges (188N) have structural steel girder and crossframe damage from overheight vehicle strikes. Costs were included for heat straightening and steel repair for those specific bridges. Likewise, the Brook and Kentucky Streets Bridge (183N) has unique cost options to repair many cracked girders via structural coverplating or through encasement into a post-tensioned, integral straddle bent; the Broadway Bridge (191N) has options to use fiber reinforced polymer (FRP) fabric for girder repairs or replacement with a new prestressed concrete girder line. Details of recommended repairs for each bridge are in **Appendices F and J.**

Advanced Repair Techniques

Structural Steel Crack Repairs

Basic crack repair consists of drilling crack arrest holes at the tip of existing cracks. An enhanced crack repair option developed and used in the aviation industry is Cold Expansion / Enhanced Drill Stop – whereby a bushing is inserted in the crack arrest hole, and a mandrel is pulled through it expanding it through cold work plastification. This technology mechanically introduces a zone of residual compressive stress, which “shields” the crack from reforming due to cyclic loading.

Galvanic Cathodic Protection

When existing corroded concrete highway structures are repaired, a high likelihood exists for embedded chlorides within the concrete, from deicing salts, to continue to attack embedded reinforcing steel. Installing galvanic anodes can prevent this corrosion from expanding. Specially designed galvanic anodes were first installed in the late 1990's to provide cathodic prevention (corrosion prevention) in concrete patch repairs (**Figure 16**). Historically, cathodic protection systems required an impressed current power supply to provide sufficient current to the reinforcing steel. This is no longer the case as properly designed galvanic encasements using high output, long life distributed galvanic anodes, provide sufficient current density to polarize the reinforcing steel and meet all National Association of Corrosion Engineers (NACE) Cathodic Protection criteria.

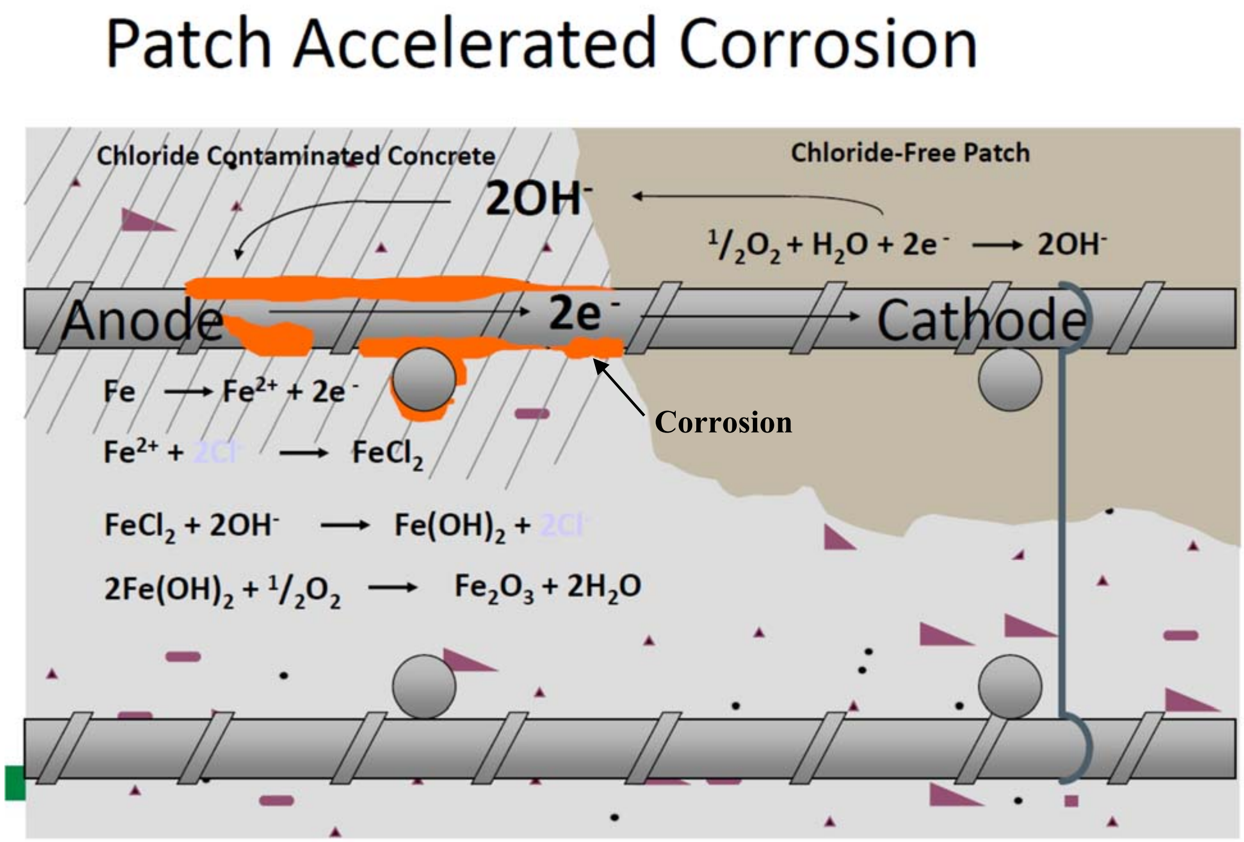


Figure 16: Conventional Patch Allows Corrosion to Continue (Vector Corrosion Technologies presentation)

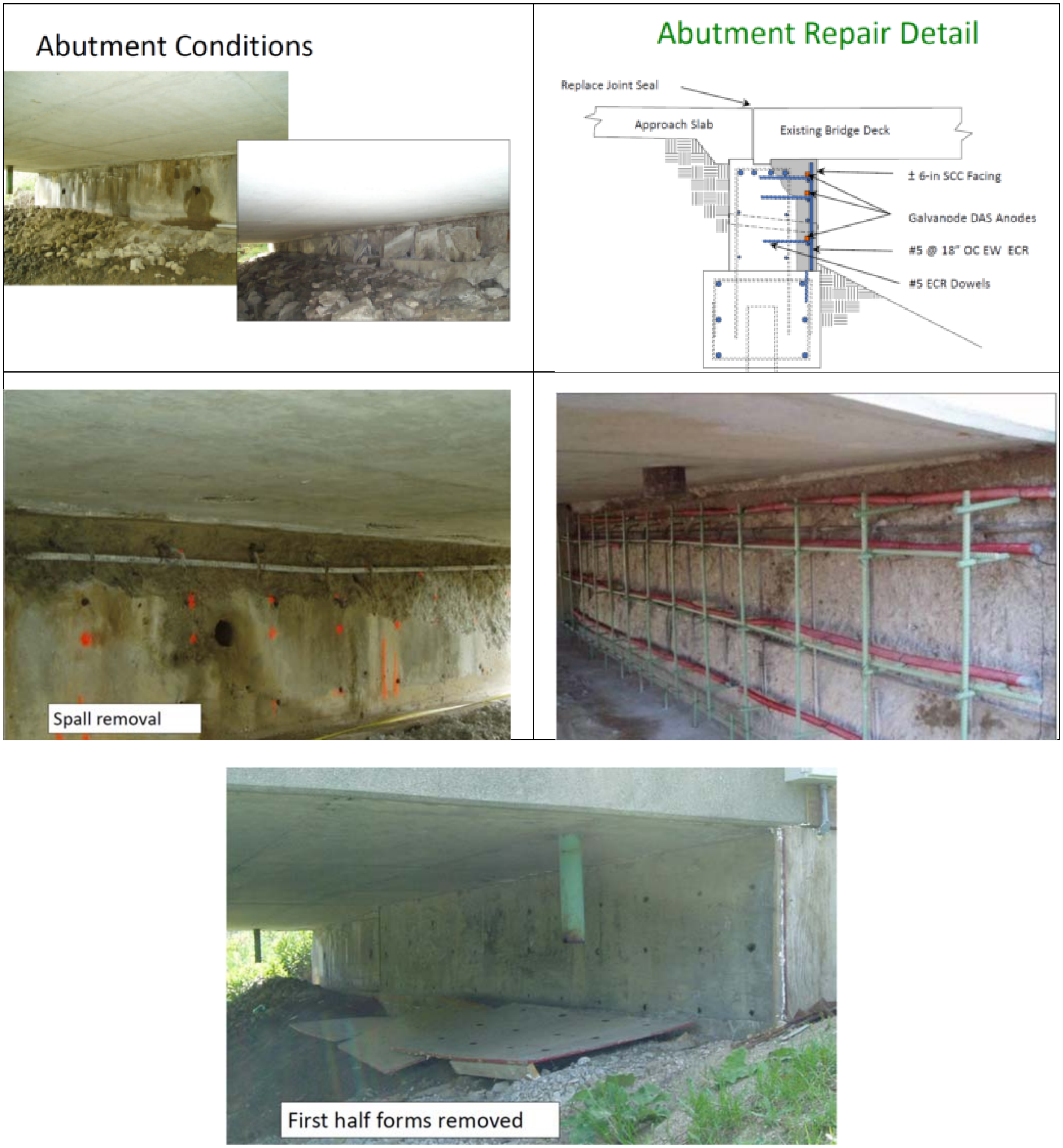


Figure 17: Abutment Repairs with Cathodic Protection (Vector Corrosion Technologies presentation)

Traditional repairs augmented with cathodic protection is recommended where leaky joints have infused concrete areas with chlorides (**Figure 17**). Basic systems distribute zinc rods or pucks uniformly throughout the repair zones, to connect to existing or added rebar, and provide a minimum of 20 years of corrosion-free service (**Figure 18**). A minimum 30-year corrosion-free service can be achieved with marginal additional cost by using larger anodes.

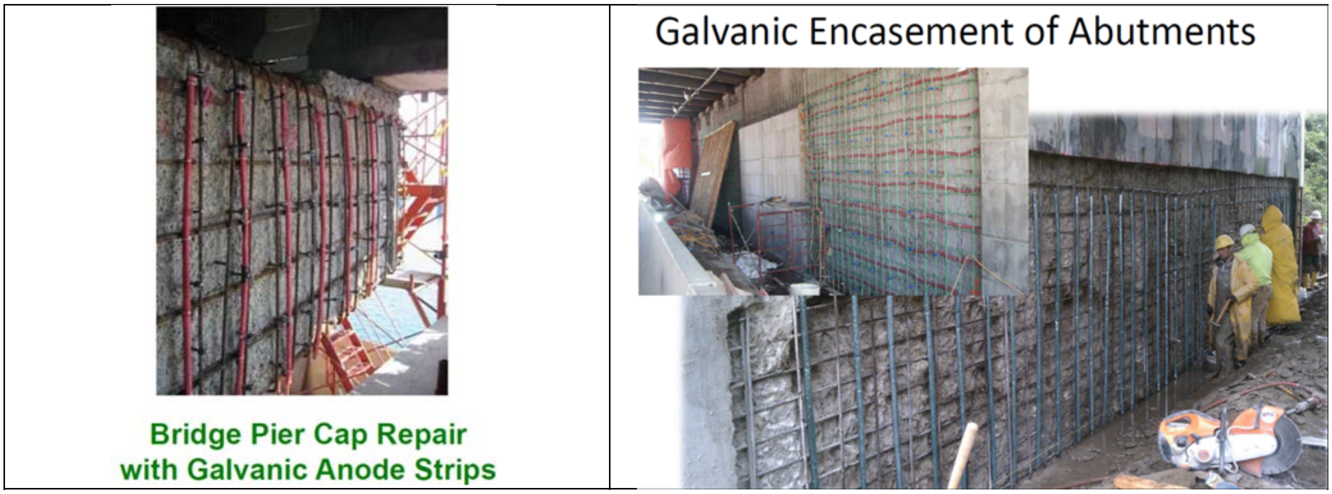


Figure 18: Substructure Repairs with Galvanic Anodes (Vector Corrosion Technologies presentation)

Although this preventive technology is somewhat new, research and demonstrated projects have provided validation. Consequently, it is routinely included in some states (**Appendix K**). With the importance of the I-65 corridor bridges and to disrupt to the traveling public as little as possible with continued construction, it is further recommended to implement a 30-year system of protection for only an additional 6% to the construction cost.

Coordination

Prior to beginning this study, a Scope of Work Meeting was held to define tasks, list priorities, and specify deliverables. During the study, two Project Team Meetings were held with KYTC District 5 and Central Office personnel, a representative of the Kentuckiana Regional Planning & Development Agency (KIPDA) and the consultant. At these meetings, progress updates were provided along with discussion, guidance, and suggestions for the remainder of the study (**Appendix L**).

Priority Bridges

183N over Brook Street and Kentucky Street

This bridge crosses over an intersection (**Figure 19**) in the Old Louisville Historic District, the third largest district of its kind in the country. The bridge has fracture critical steel straddle bents, as shown in red on **Figure 20**, and numerous undesirable geometries and structural details. The crack locations can be found in red on **Figures 21a and 21b** along with the crack sizes and growth history in **Figure 22**. The cracks highlight in red, on **Figure 22**, have grown since the last inspection and the ones highlight in green are new. Because of its location, the city streets are unlikely to be realigned, so straddle pier supports are likely necessary for new construction.

Figure 19: Bridge 183N, I-65 over Brook Street and Kentucky Street

Options to repair the cracking include coverplating and by encasement into a post-tensioned (PT), integral straddle pier (**Figures 23 and 24**). Replacement options are also postulated with PT straddle bents where needed. Abutments are large counterfort breastwall abutments on numerous piles. Replacement options leave most, or all of, the existing abutments in place, and to span over them to establish new integral end bents (**Appendix M**).

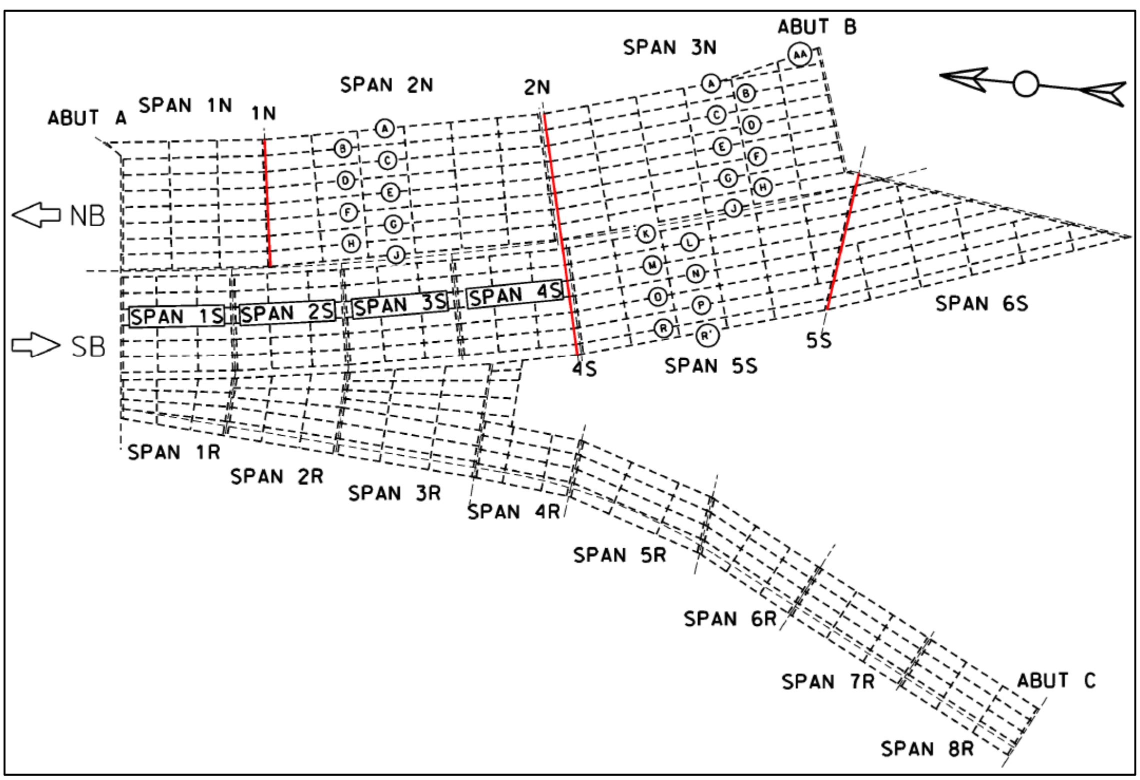


Figure 20: Bridge 183N over Brook Street and Kentucky Street Framing Plan (2018 AECOM Bridge Inspection Report)

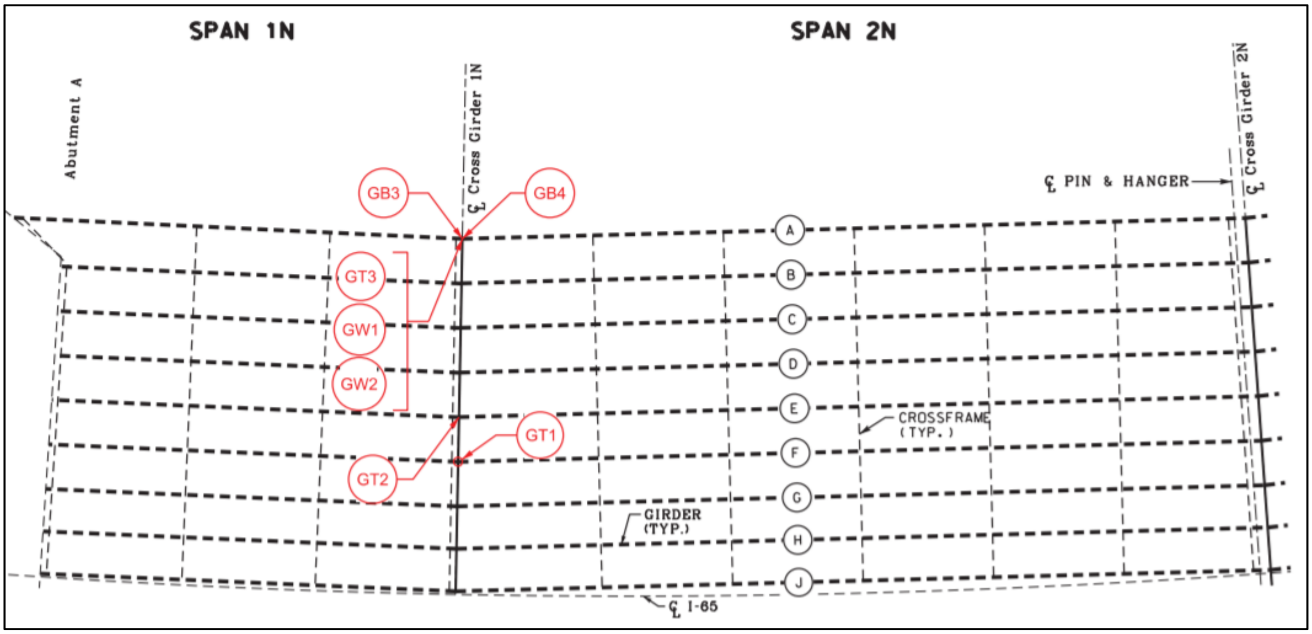


Figure 21a: Framing Plan (continued) Showing Crack Locations (2018 AECOM Bridge Inspection Report)

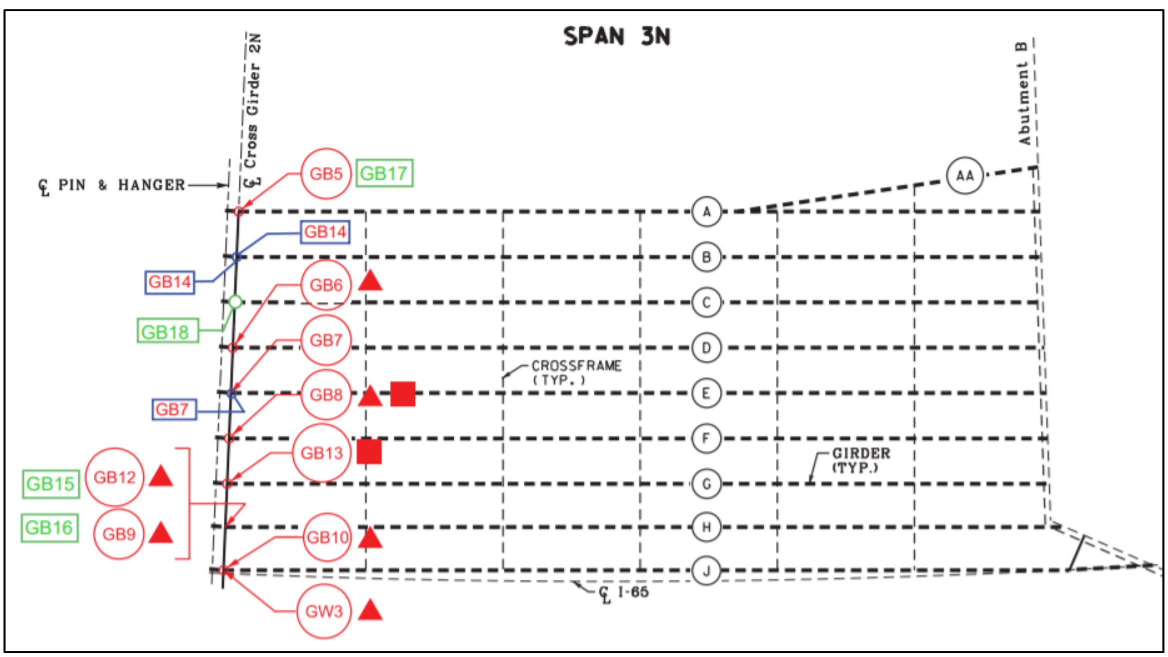


Figure 21b: Framing Plan (continued) Showing Crack Locations (2018 AECOM Bridge Inspection Report)

Crack Location	Face	Span #	Adjacent Member	Side	X-Section Location	Crack #	2014 Inspection	2016 Inspection	2017 Inspection	2018 Inspection	Comments
Girder A	East	1N	Pier 1N	North	Bottom Flange Cope	GB3	3/4	3/4	3/4	3/4	Arrestor Hole in Place - Crack propagates past hole
Girder A	West	1N	Pier 1N	North	Girder Connection	GW1	7 1/2	7 1/2	7 3/4	7 3/4	At Bolt Bottom Connection to Pier Cap
Girder A	West	1N	Pier 1N	North	Girder Connection	GW2	2 3/4	1 3/8	1 1/2	1 1/2	At 2nd-to-Bottom Bolt Connection to Pier Cap; Partially Ground Out
Girder A	West	1N	Pier 1N	North	Top Flange Cope	GT3	1/2	-	1/2	1/2	At Bottom of Top Flange Fillet Weld
Girder E	West	1N	Pier 1N	North	Bottom Flange Cope	GT2	1/4	1/4	1/2	1/2	
Girder A	East	2N	Pier 1N	South	Top Flange Cope	GB4	5/8	5/8	1/2	5/8	
Girder F	East	2N	Pier 1N	South	Top Flange Cope	GT1	2 1/2	2 1/2	2 1/2	2 1/2	
Girder F	West	2N	Pier 1N	South	Top Flange Cope	GT1	2 1/2	2 1/2	2 1/2	2 1/2	
Girder A	East	3N	Pier 2N	South	Bottom Flange Cope	GB5	2 CA	2 CA	2 CA	3/4	Crack Propagates 3/4" Past Second Arrest Hole, Web Buckling (5/16" offset) and Bottom Flange Distortion. 2" Web Distortion
Girder A	West	3N	Pier 2N	South	Bottom Flange Cope	GB5	2 CA	2 CA	2 CA	2 CA	No Crack Propagation Past Second Arrest Hole
Girder A	East	3N	Pier 2N	South	Bottom Flange Cope	GB17				3/4	2 Cracks Extending from Arrest Hole (GB5 & GB17)
Girder B	East	3N	Pier 2N	South	Bottom Flange Cope	GB14			6 3/4	6 3/4	
Girder B	West	3N	Pier 2N	South	Bottom Flange Cope	GB14			2 3/8	3 1/2	0.050" Web Offset
Girder C	East	3N	Pier 2N	South	Bottom Flange Cope	GB18				3/8	
Gider D	East	3N	Pier 2N	South	Bottom Flange Cope	GB6	3 7/8	4 1/4	4 5/8	4 7/8	3/16" Web offset
Girder D	West	3N	Pier 2N	South	Bottom Flange Cope	GB6	3	3 5/8	3 7/8	4 1/16	3/16" Web offset
Girder E	East	3N	Pier 2N	South	Bottom Flange Cope	GB7	1 1/2	1 1/2	1 3/4	2 1/8	Minor Web Buckling
Girder E	West	3N	Pier 2N	South	Bottom Flange Cope	GB7			1/4	3/8	
Girder F	East	3N	Pier 2N	South	Bottom Flange Cope	GB8	1 1/8	2 1/16	2 1/4	3 1/4	
Girder F	West	3N	Pier 2N	South	Bottom Flange Cope	GB8		3/4	3/4	2 1/4	
Girder G	East	3N	Pier 2N	South	Bottom Flange Cope	GB13		6 5/16	6 3/4	7	0.150" Web Distortion
Girder G	West	3N	Pier 2N	South	Bottom Flange Cope	GB13		4 3/16	4 1/2	5 3/8	
Girder H	East	3N	Pier 2N	South	Bottom Flange Cope	GB9	1/4	1/4	5/8	5/8	
Girder H	East	3N	Pier 2N	South	Bottom Flange Cope	GB12	3/8	3/8	3/4	1/2	
Girder H	East	3N	Pier 2N	South	Bottom Flange Cope	GB15				1/8	
Girder H	East	3N	Pier 2N	South	Bottom Flange Cope	GB16				1/8	
Girder J	East	3N	Pier 2N	South	Bottom Flange Cope	GB10	1	1 1/8	1 3/4	1 3/8	
Girder J	West	3N	Pier 2N	South	Bottom Flange Cope	GB10	1/2	1/2	1/2	3/4	
Girder J	West	3N	Pier 2N	South	Girder Connection	GW3	3 7/8	3 7/8	3 7/8	3 7/8	At Bottom Bolt Connection to pier cap
Girder R	East	4S	Pier 3S	South	Diaphragm Weld	GD1	5/8	5/8	5/8	5/8	At Toe of Weld Termination
Girder R'	West	5S	Pier 5S	North	Top Flange Cope	GT4				2	
Girder R	West	6S	Pier 5S	South	Bottom Flange Cope	GB11	9/16	9/16	9/16	9/16	
Girder R	East	6S	Pier 5S	South	Bottom Flange Cope	GB11				9/16	

Figure 22: Bridge 183N over Brook Street and Kentucky Street Crack History (2018 AECOM Bridge Inspection Report)

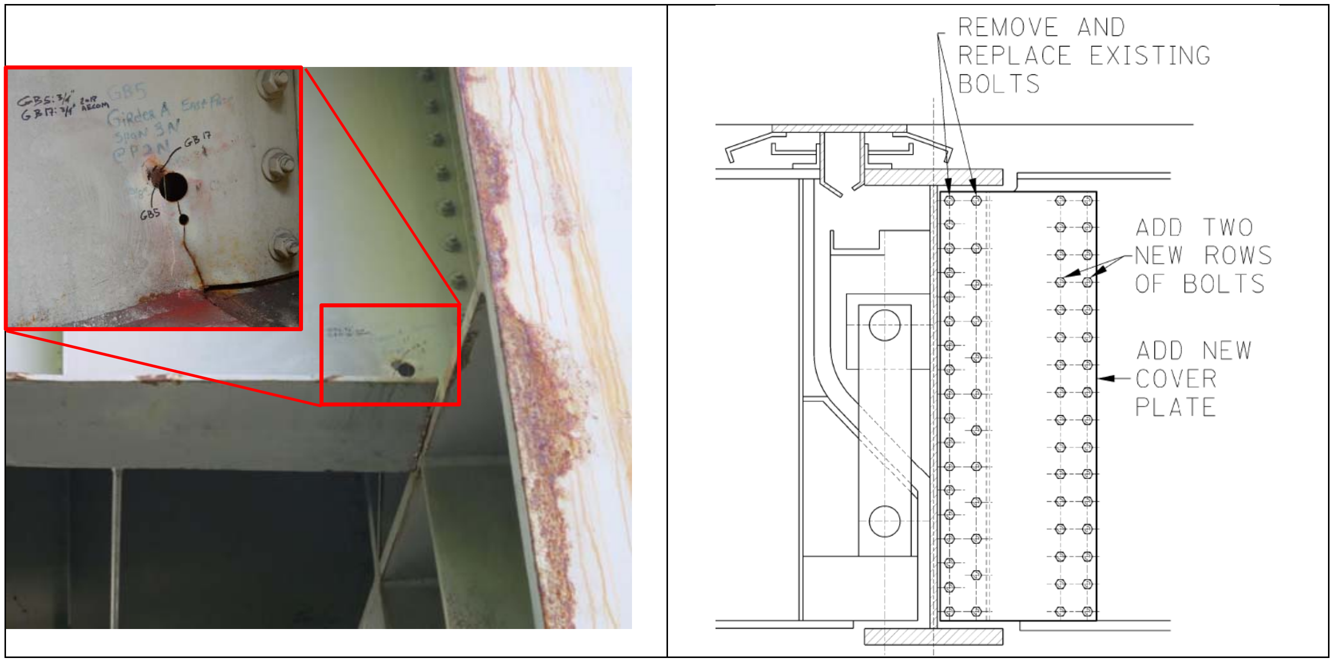


Figure 23: Steel Girder Crack and Cover Plate Repair Option

Figure 24: Post-Tensioned Integral Straddle Bent Option and Example from Kennedy Interchange

179N over Burnett Avenue, Hill Street, and CSX RR

This bridge (**Figure 25**) recently had emergency shoring due to disintegration of some of the south abutment's concrete-bearing areas (**Figure 26**). Repair and replacement options are provided (**Appendices F and M**). Repair options include abutment and pier joint elimination. Replacement options include superstructure replacement with re-use of some of the existing substructures. The south abutments would not be used in this case, but would be spanned over to new integral end bents. A complete bridge replacement estimate is also included.

Figure 25: Bridge 179N over Burnett Avenue, Hill Street, and CSX Railroad

Abutment 1-Girder 9
(End Bent B-Girder 20)

Girders 7 through 10 at Abutment 1

Figure 26: Emergency Shoring to Bridge 179N (KYTC)

191N over Jacob Street, Broadway Street, and Gray Street

This bridge is 1,208 ft long with seven continuous structural units of steel, prestressed concrete girders, and one Reinforced Concrete Deck Girder (RCDG) unit. The greatest repair need is the northbound, median-side girder of the RCDG unit over Broadway Street (**Figure 27**). The severe deterioration can be fixed in place with Fiber Reinforced Polymer (FRP) fabric bonded to the repaired surface, or by removing the damaged girder line and replacing it with a new prestressed concrete girder and slab area. Both options are provided, with additional repairs and a few joint eliminations (**Appendix F**).

Figure 27: Bridge 191N over Broadway Street showing Corroded Concrete Girder

Replacements

Two options to replace bridge 183N, over Brook Street and Kentucky Street, were evaluated and found to cost $17.2 - $18.5 million (**Table 7**). One option reuses the existing abutments, but with some modifications (**Figure 28**). The other replacement option is recommended, and spans over the existing south abutment with a new integral end bent and eliminates the triangular shaped span (**Figure 29**). Although, approximately three times the cost of repairs, replacement would be a prudent investment. A repaired bridge would still contain many undesirable elements and many components over 60 years old. An aged structure, such as this one, will continue to require maintenance whereas a modern design could eliminate fracture critical elements, eliminate expansion joints, and include fatigue and corrosion resistant details.

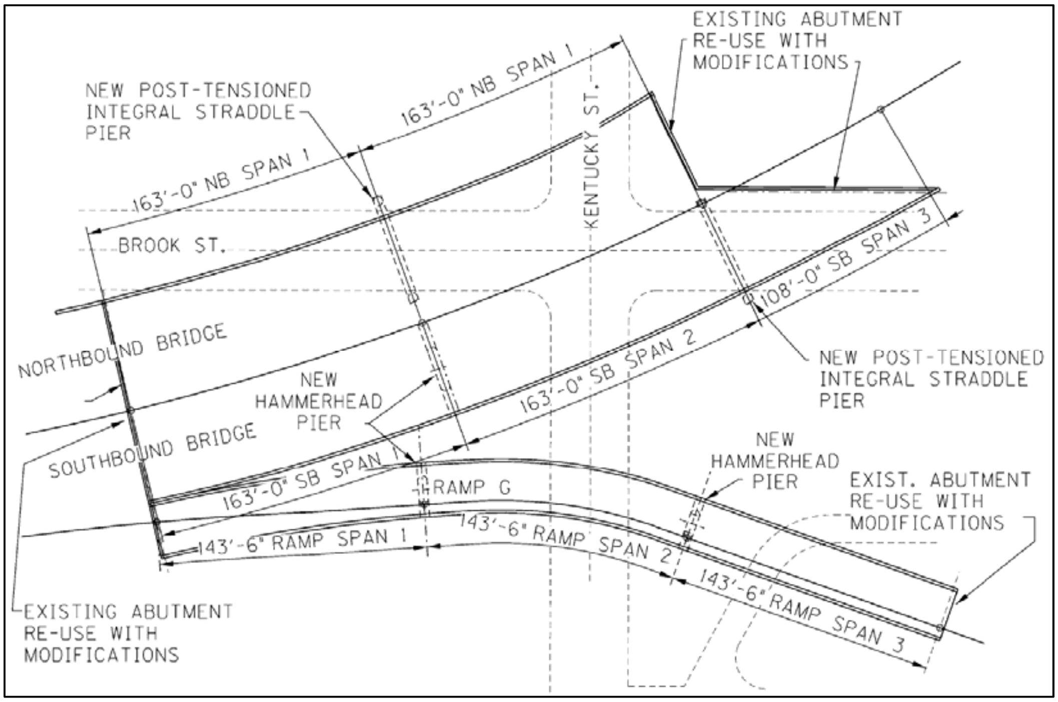


Figure 28: Bridge 183N Replacement – Reuse of Existing Abutments Option

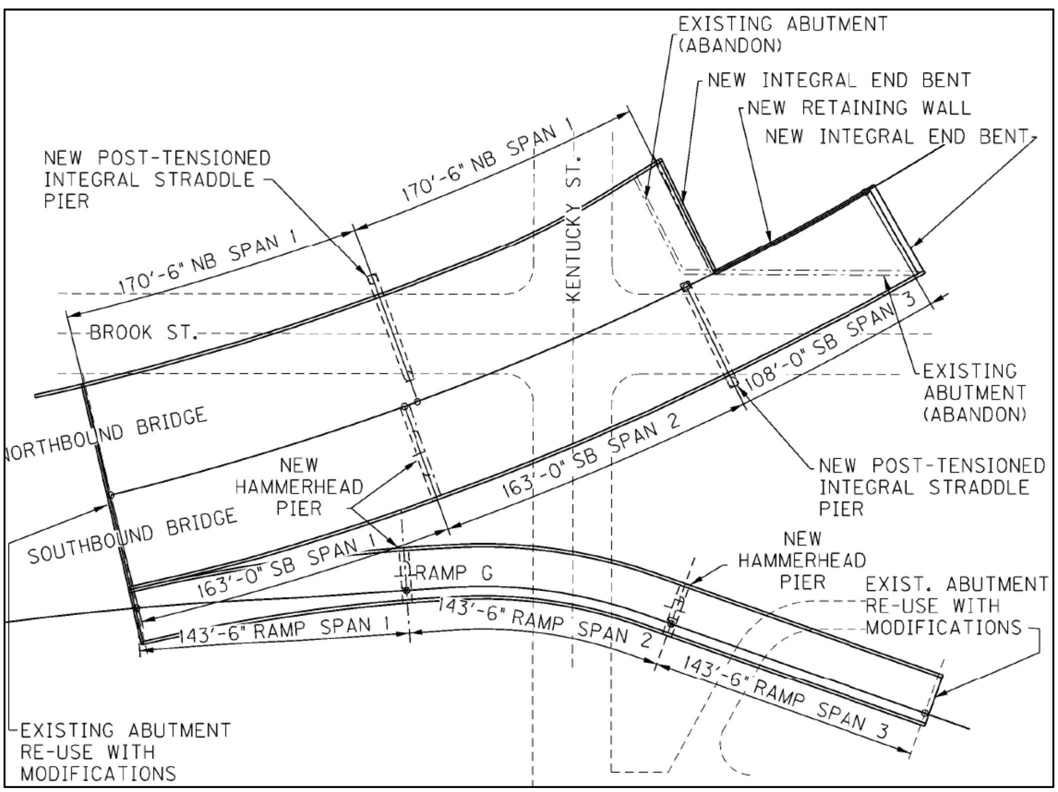


Figure 29: Bridge 183N Replacement – New Integral End Bents at South End

Two options to replace bridge 179N over Burnett Avenue, Hill Street, and CSX Railroad were evaluated with cost of $5.7 million for a superstructure replacement with the re-use of some of the existing substructures (**Figure 30**), but spanning over the south abutment with a new integral end bent (**Figure 31**). A full bridge replacement is $8.1 million (**Table 7**). Repair options approach $3.8 million, so replacement should be seriously considered. Similar to the 183N replacement, a new superstructure or complete bridge could be "jointless" and contain enhanced durability compared to a repaired structure.

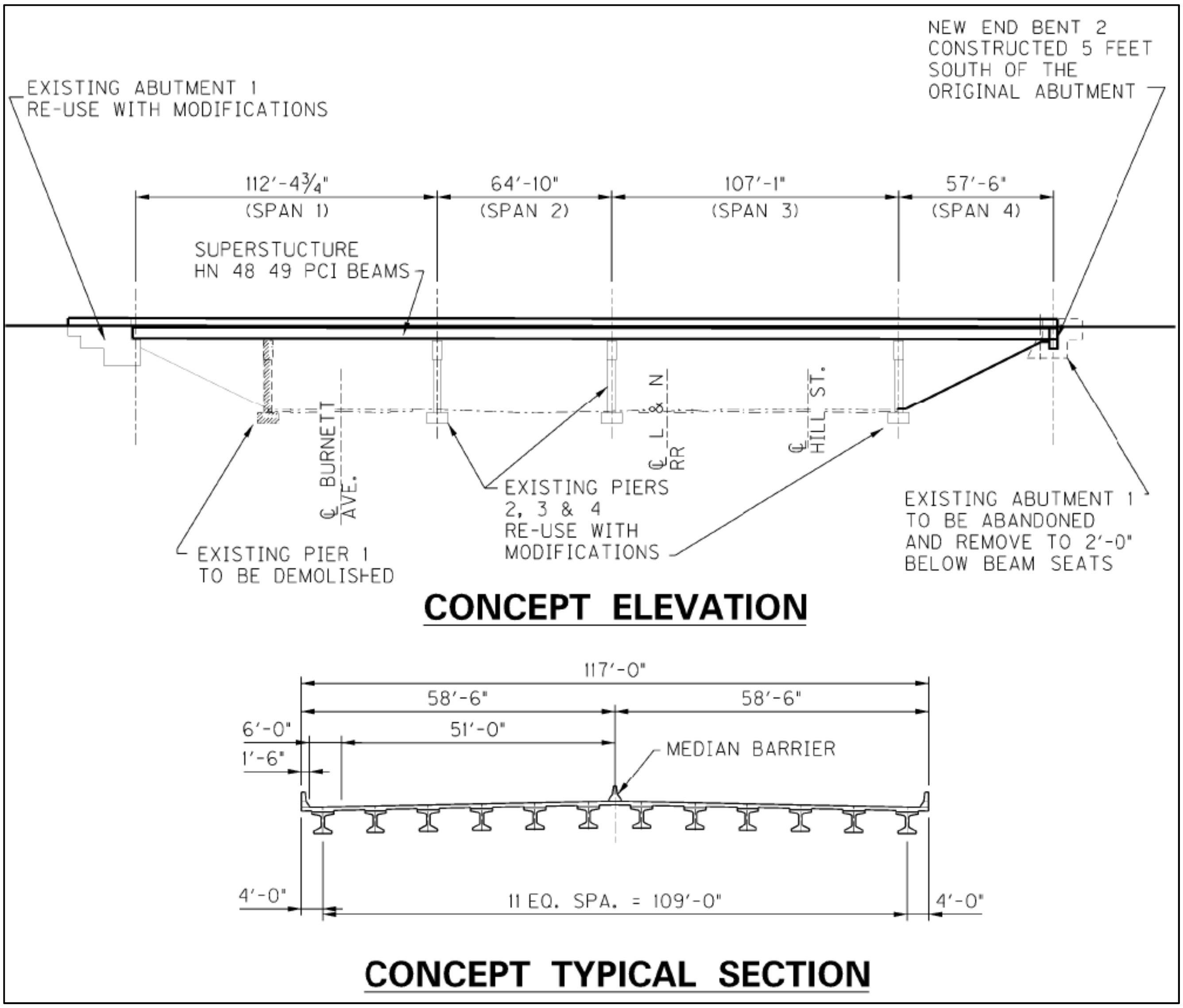


Figure 30: Bridge 179N Prestressed Concrete Girder Superstructure Replacement Option

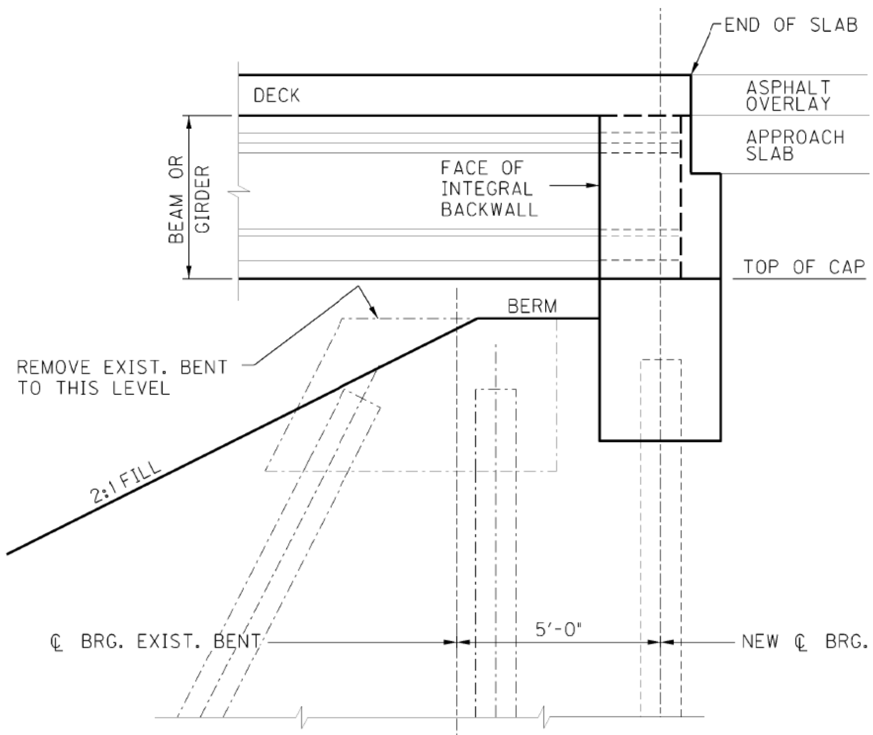


Figure 31: Bridge 179N - New Integral End Bents at South End

Table 7: Replacement Estimates for Bridges 179N and 183N

Bridge ID	Route Under	D	Duration (months)	R	Duration (months)	U	Duration (months)	C	Duration (months)	Totals
179N (1)	CSX RR, BURNETT, HILL ST	$265,000	6	$5,000	2	$100,000	12	$5,300,000	12	$5,670,000
179N (2)	CSX RR, BURNETT, HILL ST	$380,000	9	$5,000	2	$100,000	12	$7,600,000	12	$8,085,000
183N (3)	S BROOK, E KENTUCKY ST	$810,000	15	$10,000	3	$200,000	12	$16,200,000	18	$17,220,000
183N (4)	S BROOK, E KENTUCKY ST	$870,000	15	$10,000	3	$200,000	12	$17,400,000	18	$18,480,000

(1) Superstructure Replacement and Substructure Repair
(2) Full Replacement
(3) Replacement with Reuse of All Existing Breastwall Abutments
(4) Replacement with New Integral End Bents at South Bridge End
Notes: Design cost estimated at 5% of Construction Cost.
See **Appendix M** for further replacement cost details.

Prioritization of Work

All 28 bridges were ranked as High, Moderate, or Low priority based on condition. The three priority bridges, identified in the above section, are the only ones ranked High, eight ranked as Moderate and 17 ranked Low priority. Ideally, repair/replacement of the high priority bridges (179N, 183N, and 191N) would be first. Then, all eight bridges rated in the moderate-priority group would be fixed next, followed by the 17 in the low-priority group. So construction crews are not hopscotching around the corridor for years on end, it is recommend to geographically group the eight moderate-priority bridges with lower priority bridges (**Figures 32 and 33**). The bridge prioritization ranking and grouping for construction can be found in **Table 8**, **Table 9**, **Table 10**, and **Table 11**.

Also, since bridge 196N is being actively studied for replacement by another project it is recommended to delay action on it until decisions are made on the adjacent project. The remaining seven moderately deteriorated bridges are 209N, 212N, 205N, 180N, 188N, 192N, and 193N, clustered in two areas, at the north and south ends of the study area.

Work requiring traffic control on I-65 can be completed in two phases, half a bridge width at a time. This strategy requires one lane closure and shifting the remaining two travel lanes to the shoulder and adjacent lane. Traffic operational analyses show the single-lane closure with traffic shift is comparable to complete direction closures with weekend-only work. However, for the recommended joint eliminations, it could be very challenging to accomplish half a bridge width during weekend-only work resulting in additional weekends to complete the project and a higher cost. The continuous closure of half the bridge to traffic appears to be advantageous and it is the recommended maintenance of traffic scheme.

Specific contract size depends on available funding, exact scope of work, and tolerance for construction duration. The suggested contract packages, including 30-year galvanic protection, are highlighted in phased cost estimate repair packages in **Table 8**, **Table 9**, **Table 10**, and **Table 11**.

Table 8: Repair Package 1

Bridge ID	Route Under	Priority of Repairs	D	Duration (months)	R	Duration (months)	U	Duration (months)	C	Duration (months)	Totals
179N (1)	CSX RR, BURNETT, HILL ST	1	$120,000	8	$5,000	2	$10,000	4	$3,680,000	8	$3,815,000
183N (2)	S BROOK, E KENTUCKY ST	1	$200,000	10	$10,000	3	$10,000	2	$4,430,000	8	$4,650,000
183N (3)	S BROOK, E KENTUCKY ST	1	$250,000	12	$10,000	3	$10,000	2	$4,770,000	8	$5,040,000
191N (4)	JACOB, BROADWAY, GRAY ST	1	$60,000	5	$10,000	3	$10,000	2	$5,970,000	7	$6,050,000
191N (5)	JACOB, BROADWAY, GRAY ST	1	$70,000	6	$10,000	3	$10,000	2	$6,010,000	7	$6,100,000
	TOTAL (6) =		$440,000		$25,000		$30,000		$14,460,000		$14,955,000

(1) Repairs for Abutment 1 bearings, Girders 8-10, have already been ordered by KYTC
(2) Includes Crack Repairs using Structural Cover plating.
(3) Includes Crack Repairs via encasement into a PT Integral Straddle Bent.
(4) Estimate uses FRP on Span 114 Girder 8 repair.
(5) Estimate replaces Span 114 Girder 8 with a prestressed beam.
(6) Totals use 183N (3) and 191N (5).

Table 9: Repair Package 2

Bridge ID	Route Under	Priority of Repairs	D	Duration (months)	R	Duration (months)	U	Duration (months)	C	Duration (months)	Totals
188N	COLLEGE ST	2	$25,000	1	$1,000	1	$2,000	2	$1,550,000	3	$1,578,000
192N	CHESTNUT ST	2	$50,000	4	$10,000	3	$10,000	4	$1,920,000	4	$1,990,000
193N	BROOK ST, MUHAMMAD ALI	2	$120,000	8	$10,000	3	$10,000	2	$2,270,000	4	$2,410,000
194N	MUHAMMAD ALI	3	$15,000	1	$1,000	1	$10,000	4	$400,000	1	$426,000
*~~196N~~	~~FLOYD ST~~	~~2~~	~~$15,000~~	~~1~~	~~$1,000~~	~~1~~	~~$10,000~~	~~4~~	~~$670,000~~	~~1~~	~~$696,000~~
195R	FLOYD ST	3	$15,000	1	$1,000	1	$10,000	4	$760,000	1	$786,000
197R	LIBERTY ST	3	$15,000	1	$1,000	1	$10,000	4	$750,000	1	$776,000
	TOTAL =		$240,000		$24,000		$52,000		$7,650,000		$7,966,000

*Note: Bridge 196N should be re-inserted if not replaced as part of the Brook St. Ramp Project.

Table 10: Repair Package 3

Bridge ID	Route Under	Priority of Repairs	D	Duration (months)	R	Duration (months)	U	Duration (months)	C	Duration (months)	Totals
209N	PHILLIPS LN	2	$25,000	1	$1,000	1	$2,000	2	$1,670,000	3	$1,698,000
210N	MANNING RD	3	$15,000	1	$1,000	1	$2,000	2	$1,240,000	3	$1,258,000
211N	E ENT TO FAIRGROUNDS	3	$15,000	1	$2,000	1	$10,000	4	$1,180,000	3	$1,207,000
212N	BRADLEY AVE, N ENT FRGRND	2	$15,000	1	$2,000	1	$10,000	4	$1,340,000	3	$1,367,000
213N	CRITTENDEN DR (KY 1631)	3	$15,000	1	$1,000	1	$10,000	2	$540,000	2	$566,000
205N	NORFOLK SOUTHERN RR	2	$15,000	1	$5,000	2	$2,000	2	$760,000	2	$782,000
180N	EASTERN PKWY	2	$70,000	6	$2,000	1	$10,000	4	$2,620,000	4	$2,702,000
181N	WARNOCK ST	3	$15,000	1	$2,000	1	$10,000	4	$910,000	3	$937,000
182N	BRANDEIS AVE	3	$15,000	1	$2,000	1	$10,000	4	$940,000	3	$967,000
	TOTAL =		$200,000		$18,000		$66,000		$11,200,000		$11,484,000

Table 11: Repair Package 4

Bridge ID	Route Under	Priority of Repairs	D	Duration (months)	R	Duration (months)	U	Duration (months)	C	Duration (months)	Totals
208N	PRESTON RAMP TO 65 SB	3	$15,000	1	$1,000	1	$2,000	2	$480,000	1	$498,000
207N	S PRESTON ST ON RAMP	3	$15,000	1	$1,000	1	$2,000	2	$930,000	3	$948,000
206N	WOODBINE ST	3	$15,000	1	$1,000	1	$10,000	4	$970,000	3	$996,000
187N	E ORMSBY AVE	3	$15,000	1	$1,000	1	$2,000	2	$1,090,000	3	$1,108,000
186N	OAK ST	3	$15,000	1	$1,000	1	$10,000	4	$1,240,000	3	$1,266,000
185N	FLOYD ST	3	$15,000	1	$1,000	1	$2,000	2	$830,000	2	$848,000
184N	ST CATHERINE ST	3	$15,000	1	$1,000	1	$2,000	2	$1,130,000	3	$1,148,000
190N	CALDWELL ST	3	$15,000	1	$1,000	1	$10,000	4	$1,090,000	3	$1,116,000
189N	E BRECKINRIDGE ST	3	$15,000	1	$1,000	1	$2,000	2	$1,090,000	3	$1,108,000
	TOTAL =		$135,000		$9,000		$42,000		$8,850,000		$9,036,000

Figure 32: Repair Package Grouping – South

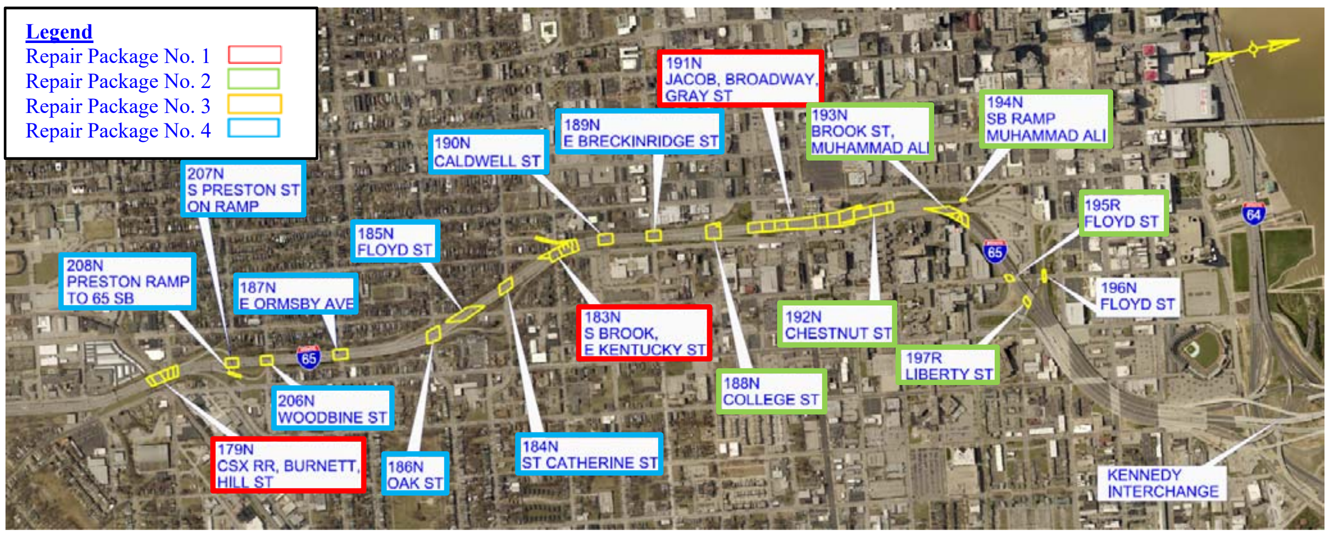


Figure 33: Repair Package Grouping – North