I-40 CLINTON
Mobility and Freight Improvement Project

Benefit-Cost Analysis Supplementary Documentation

OKLAHOMA Transportation

BRIDGE INVESTMENT PROGRAM:
FY 2025 Bridge Project Application

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1 EXECUTIVE SUMMARY

The I-40 Clinton Mobility and Freight Improvement Project (the Project) involves full reconstruction and replacement of four bridges on Interstate 40 (National Bridge Inventory structures 14477, 14478, 17581, and 17582) located in Clinton, Oklahoma. A Benefit-Cost Analysis (BCA) was conducted of this Project for the United States Department of Transportation (USDOT) Bridge Improvement Program (BIP) grant application by Oklahoma Department of Transportation (ODOT). USDOT's Microsoft Excel-based BIP BCA Tool was used to complete the analysis.

The Red Wheat Dr. bridges NBI #14478 and #14477 carry I-40 Eastbound (EB) and Westbound (WB), traffic, respectively, over the Farmrail Corporation Railroad right-of-way (FMRC RR) and Red Wheat Drive. The Neptune Dr. bridges NBI #17581 and #17582 carry I-40 EB and WB traffic, respectively, over the Grainbelt Corporation Railroad right-of-way (GNBC RR) and Neptune Drive.

The I-40 segments within the Project extents currently have an average annual daily traffic (AADT) volume of about 20,000 in both directions, or about 10,000 per direction at each bridge location. By 2040, traffic is forecasted to increase to a total of about 30,000 AADT, or 15,000 per direction for each bridge. Truck traffic accounts for 12 percent of the total; I-40 is a significant freight route and is located on the Primary Highway Freight System.

The replacement of the Red Wheat Dr. and Neptune Dr. bridges is a critical component of a larger ODOT project involving redesign and reconstruction of Exit 65 and Exit 65A on I-40 in Clinton, the I-40 at Exit 65 Interchange Project (I-40 at Exit 65 Project) intended to reduce the design complexity to improve interchange safety and reduce congestion. However, **this BCA focuses on the benefits and costs of the bridge replacements Project on its own**, independently of the larger interchange project.

The Project structures were built in 1959 (Red Wheat Dr. bridges) and 1969 (Neptune Dr. bridges), are rated as functionally obsolete and at-risk of becoming structurally deficient. Without a major rehabilitation program or replacement, all four bridges are forecasted to reach the NBI superstructure rating of 2 (critical condition) by 2053 and require closure by 2057. If the bridges are closed, drivers will be forced to take a detour to continue travel on I-40 leading to significant economic costs and disruptions in personal travel and across the goods supply chains.

The Project will construct new bridge structures with a design life of 75 years helping avoid future detours with their related economic costs as well as expensive maintenance and repair activities that would have to be conducted in the No Build scenario. In addition, it is expected that due to the modern design and lighting the Project will improve driving comfort and safety. Specifically, it is expected that the Project will reduce crashes on and around the bridges by 17 percent. Moreover, the increased vertical clearance over the roadway and rail tracks beneath the bridges will provide greater flexibility in the future as to the types of freight service that can use these facilities. **Table ES-1** summarizes the monetized benefits of this project.

Table ES-1: Summary of Project Improvements and Associated Benefits

Current Status or Baseline & Problems to Be Addressed	Changes to Baseline / Alternatives	Type of Impacts	Economic Benefit	Results (Discounted at 3.1%), Millions of $2022*
The Red Wheat Dr. bridges and Neptune Dr. bridges (two bridges for each set, one per direction, for a total of four structures) carry I-40 traffic with current AADT of about 20,000 which is forecasted to increase to 30,000 by 2040. 12% of AADT is truck traffic. The Project structures were built in 1959 (Red Wheat Dr. bridges) and 1969 (Neptune Dr. bridges), are rated as functionally obsolete and at-risk of becoming structurally deficient. Without a major rehabilitation program or replacement, all four bridges are forecasted to reach the NBI superstructure rating of 2 (critical condition) by 2053 and require closure by 2057. If the bridges are closed, drivers will be forced to take a detour to continue travel on I-40 which will cause significant economic costs and disruptions in personal travel and in freight movements along the nation's Primary Highway Freight System.	The Project will construct new bridge structures with a design life of 75 years helping avoid future detours with their related economic costs and expensive maintenance and repair activities that would have to be conducted in the No Build scenario. In addition, it is expected that due to the modern design and lighting, the Project will improve driving comfort and safety. Specifically, it is expected that the Project will reduce crashes on and around the bridges by 17%.	Avoided detours, reduced VMT in study area	Safety Benefits	**$19.0**
			Travel Time Savings	**$99.0**
			Vehicle Operating Cost Savings	**$36.5**
			CO2 Emissions Reduction Benefits	**$12.3**
			Non-CO2 Emissions Reduction Benefits	**$1.5**
			Other Environmental Benefits	**$0.1**
		State of good repair; infrastructure renewal	Maintenance Costs Impacts	**$5.1**
			Residual Value	**$6.4**

** Except for CO2 emissions reduction benefits which were discounted at the 2 percent discount rate.*

The period of analysis used in the estimation of benefits and costs is 33 years, including 3 years of project development and construction and 30 years of operations. Total project development and construction costs are estimated at $33.9 million in 2024 dollars, or $32.6 in 2022 dollars after adjustment with a GDP deflator. Including previously incurred costs in the amount of $5.9 million, increases the total cost of this project to $38.5 million in 2022 dollars ($33.9 million discounted at 3.1 percent).

All relevant data and calculations used to derive the benefits and costs of the project are shown in the BCA model that accompanies this grant application. Based on the analysis presented in the rest of this document, the Project is expected to generate $180.8 million in discounted benefits, and $33.9 million in discounted development and construction costs, using a 3.1 percent real discount rate. Therefore, the Project is expected to generate a Net Present Value of $146.9 million and a Benefit/Cost Ratio of 5.3 as shown below in **Table ES-2**.

Table ES-2: BCA Summary Results

Metric of Impact	Value, $Millions of 2022 Dollars*, 3.1% Discount Rate**
Total Benefits	$180.8
Total Capital Costs	$33.9
Benefit-Cost Ratio (BCR)	5.3
Net Present Value (NPV)	$146.9

** Except for BCR. ** Except for CO2 emissions reduction benefits which are discounted at the 2% discount rate.*

Source and Notes: BIP BCA Tool, Results. Resilience, Health and Amenity and Other Benefits categories were not evaluated.

In addition to the monetized benefits, the Project is expected to generate benefits that are more difficult to quantify and monetize. These benefits are briefly outlined below.

- **Improved driver comfort**. In addition to reduced crash rates, the modernized geometric design of the bridges, new lighting, and new road surface itself can be expected to improve the overall driving experience and comfort.
- **Increased flexibility in freight transportation options.** Increased vertical clearance over the roadways and rail tracks beneath the bridges will provide greater flexibility in the future as to the types of freight service that can use these facilities.
- **Improved I-40 reliability/mobility for personal travel and freight transportation.** The Project will improve the state of good repair of Project bridges reducing the risk of unexpected closures for repairs and rehabilitation. Given that I-40 is a part of the Primary Highway Freight System, reliability of this corridor is of utmost importance for freight movements both nationally and locally for Clinton-area manufacturers and distributors.

2 INTRODUCTION

This document provides details on the data and methodology used to perform the BCA of the I-40 Clinton Mobility and Freight Improvement Project (the Project). After this introduction, Section 3 explains that the BIP BCA Tool was used for this analysis, apart from some supplementary off-model calculations. Section 4 provides an overview of the project, including a brief description of base case conditions versus the proposed changes with the Project, alternative routes that vehicles would have to take if the bridges were to be closed, and a summary of cost estimates and schedule. Section 5 provides a summary of traffic using Interstate 40 in the Project area. Section 6 describes each benefit expected from the project, input data used and any calculations performed in the off-model workbook sheets. Section 7 summarizes overall BCA results, and Section 8 describes the sensitivity analysis performed.

3 METHODOLOGY OVERVIEW

This BCA was performed using the USDOT Microsoft Excel-based Bridge Investment Program Benefit-Cost Analysis Tool (BIP BCA Tool). In most cases, default values generated by the BIP BCA Tool were used, including default passenger and truck vehicle traffic from the National Bridge Inventory (NBI) data. It is noted that estimates for bus traffic are zero for the Project location.

In some cases, the BIP BCA Tool default values were modified such as the net length of the detour if either of the bridges is closed. The NBI reference value of 0.0 km was deemed an error or missing value based on the actual road network in the study area.

The data and information required to populate the inputs to the BIP BCA Tool (in addition to NBI data and valuation parameters from USDOT BCA guidance pre-populated in the BIP BCA Tool) are shown on a separate “Project Input Data” sheet within the tool.

All monetary input values are expressed in 2022 dollars. The monetized benefits and costs are estimated in 2022 dollars with future dollars discounted in compliance with USDOT BCA guidance using a 3.1 percent real rate (except for CO_2 emissions, which are discounted using a 2 percent real rate) with discounting using 2022 as the base year.

The post-construction analysis period (Project operations) for the estimation of Project benefits is assumed at 30 years based on USDOT recommendations for projects that involve either initial construction or full reconstruction of highways and other similar facilities.

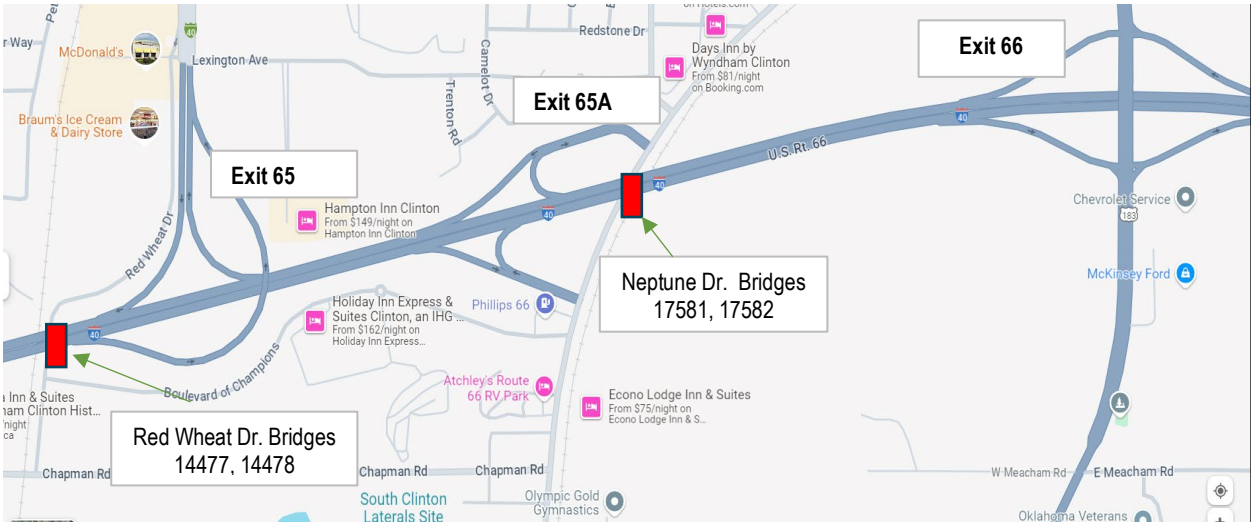
4 PROJECT OVERVIEW

4.1 Project Description, Current Conditions and Challenges

The Project involves full reconstruction of four bridges on Interstate 40 (I-40) located in Clinton, Oklahoma (population 8,521). The specific bridges include two bridges over Neptune Dr. (one per each direction of traffic) and two bridges over Red Wheat Dr. (also one per direction). The bridges are listed in the National Bridge Inventory (NBI) as structures 14477 and 14478 for the Red Wheat Dr. bridges, and 17581 and 17582 for the Neptune Dr. bridges.

Figure 1 illustrates the location of the bridges. As the figure shows, both sets of bridges are located just west of the I-40 Exit 66 interchange. The Neptune Dr. bridges are near the Exit 65A interchange, and the Red Wheat Dr. bridges are near the Exit 65 interchange.

Figure 1: Project Location on Interstate 40



The Red Wheat Dr. bridges NBI #14478 and #14477 carry I-40 Eastbound (EB) and Westbound (WB), traffic, respectively, over the Farmrail Corporation Railroad right-of-way (FMRC RR) and Red Wheat Drive. These structures were originally constructed in 1959 and rehabilitated in 1985.

The Neptune Dr. bridges NBI #17581 and #15782 carry I-40 EB and WB traffic, respectively, over the Grainbelt Corporation Railroad right-of-way (GNBC RR) and Neptune Drive. These structures were originally constructed in 1969 and have not been rehabilitated.

I-40 segments within the Project extents currently have an average annual daily traffic (AADT) volume of about 20,000 in both directions, or about 10,000 per direction for each bridge. By 2040, traffic is forecasted to increase to a total of about 30,000 AADT, or 15,000 per direction for each bridge. Truck traffic accounts for 12% of total; I-40 is a significant freight route and is located on the Primary Highway Freight System.

Detailed information on the origin and destination of the vehicle traffic on the I-40 Project bridges was not available at the time of this analysis. However, traffic data compiled for the engineering study conducted for the Exit 65 redesign project, shows that on- and off- traffic on the interchange ramps at Exit 66, Exit 65A, and Exit 65 account for about 5 percent to 15 percent of total traffic approaching these exits. This is indicative that the vast majority of I-40 traffic in the Project area is long-distance/through traffic coming from/going to outside of Clinton.

Three of the Project structures are at-risk of becoming structurally deficient due to current substructure conditions and one structure is at-risk of becoming structurally deficient due to current deck, superstructure, and substructure condition. Additionally, all four structures are rated as functionally obsolete.

The replacement of the Red Wheat Dr. and Neptune Dr. bridges is a critical component of a larger project currently planned by Oklahoma Department of Transportation (ODOT) involving redesign and reconstruction of Exit 65 and Exit 65A, the I-40 at Exit 65 Interchange Project (I-40 at Exit 65 Project).

The current interchange configuration provides full access at Neptune Dr. but lacks direct access from southbound Gary Boulevard to eastbound I-40. The spacing of the interchanges results in approximately 1,000 feet of weaving distance in the WB direction. In addition to the ramp access and spacing issues, a six-legged intersection at the intersection of Gary Boulevard/I-40 ramps at Red Wheat Dr/Oliver Avenue/Lexington Avenue forces drivers to make complex decisions/judgments from multiple legs, including nearby driveway access. The unconventional geometrics create congestion, safety, and connectivity issues throughout the study area.

The I-40 at Exit 65 Project will consolidate ramp access at the interchanges, eliminate weaving, improve roadway geometry to meet modern design standards, provide connectivity via a one-way frontage roads/protected turnaround system, connect Gary Boulevard to Chapman Road and I-40 EB, and simplify the complex and congested 6-legged intersection referenced above.

Consistent with the BIP Program's goals, the objectives of Project are to improve the safety, efficiency, and reliability of the movement of people and freight over bridges and to reduce the number of bridges that do not meet current geometric design standards of the regional transportation network. The original geometry for all four structures does not provide adequate shoulder width, sufficient lighting, or modern safety barrier designs. To address these transportation challenges, the Project's scope of work includes the following:

- The existing structures will be removed and replaced with two conventional three-span prestressed beam bridges. The existing cross section of three 12-foot travel lanes, and 5-foot inside and outside shoulders will be replaced with three 12-foot-wide travel lanes with a 4-foot inside shoulder and a 12-foot outside shoulder.
- Vertically, the I-40 profile will be raised to meet both the current geometric highway standards for a design speed of 70 mph.
- Additional safety investments include the introduction of LED lighting and enhancements to the safety barriers to meet current design standards.
- The new bridges have been designed to accommodate the 16'-9" vertical clearance over roadways per current ODOT Bridge Directives (an increase from current clearance by about 8 feet), and the 23'-6" clearance over the railroad right-of-way per the Union Pacific Railroad and BNSF Railway Guidelines for Railroad Grade Separation Projects.

It is noted that **this BCA focuses on the benefits and costs of the bridge replacements Project on its own**, independently of the larger interchange project.

As mentioned earlier, both sets of bridges were constructed more than 50 years ago, are functionally obsolete, and at risk of becoming structurally deficient.[1]

Without a major rehabilitation program or replacement, all four bridges are forecasted to reach the NBI superstructure rating of 2 (critical condition) by 2053 and require closure by 2057. If the bridges are closed, drivers will be forced to take a detour to continue travel on I-40. The detour route for the Neptune Dr. bridges is shown in **Figure 2** while the detour route for the Red Wheat Dr. bridges is shown in **Figure 3**.

The detour route for the Neptune Dr. bridges would be a loop along W Gary Blvd. and S 4th Street which connects to Exit 65 and Exit 66. The incremental distance would be about 2 miles and the incremental travel time would be about 7 minutes.

The detour route for the Red Wheat Dr. bridges would be much longer due to the configuration of the road network and presence of roads suitable to carry interstate traffic. Specifically, vehicles would have to travel a loop along State Highway (SH) 44, SH-73, and S 4th Street which connects to Exit 53 just south of the Town of Foss (about 13 miles south-west of Clinton) and Exit 66 in Clinton. The incremental distance would be almost 5 miles and the incremental travel time would be about 10 minutes.[2]

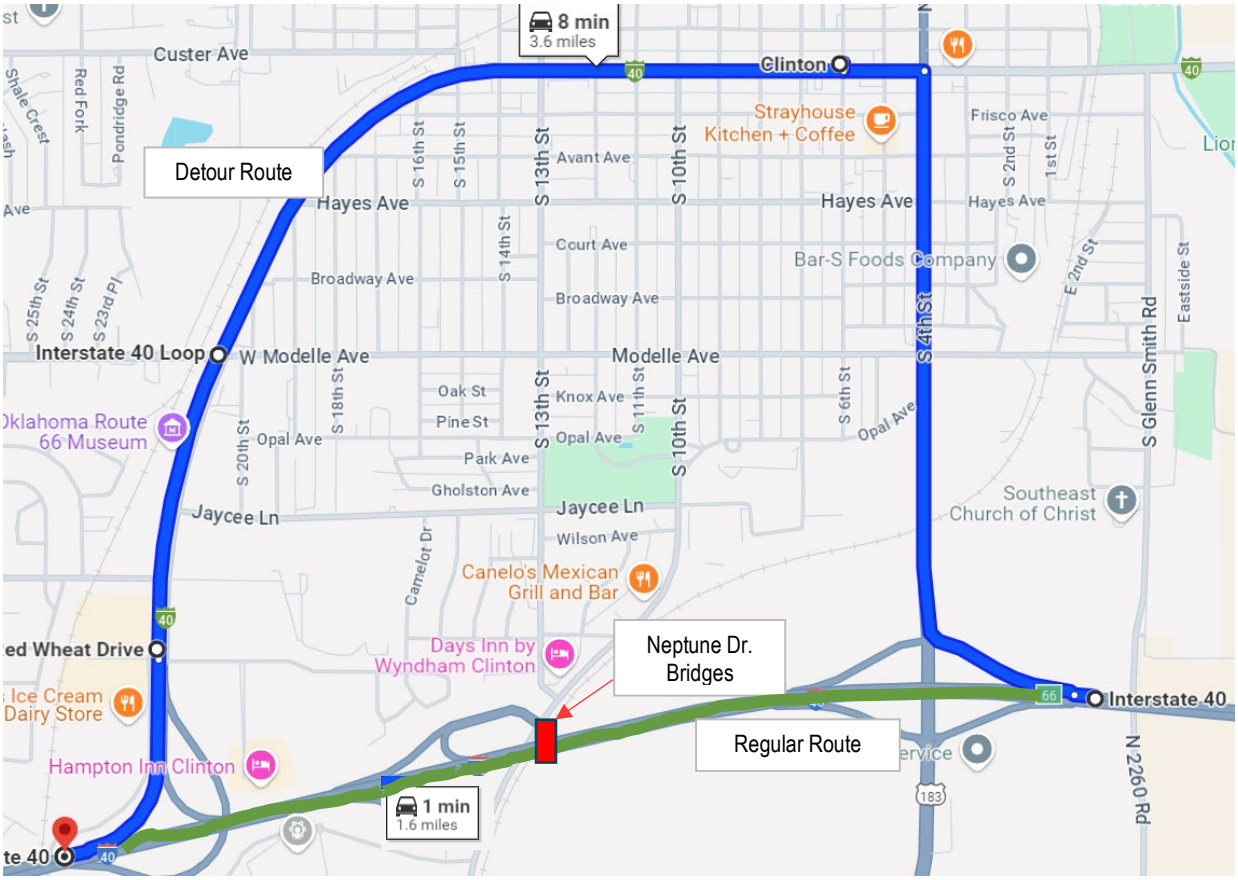
The Project will construct new bridge structures with a design life of 75 years helping avoid future detours with their related economic costs as well as expensive maintenance and repair activities that would have to be conducted in the No Build scenario. In addition, it is expected that due to the modern design and lighting the Project will improve driving comfort and safety. Specifically, it is expected that the Project will reduce crashes on and around the bridges by 17 percent according to the engineering analysis conducted using Highway Safety Manual (HSM) predictive modeling and the ISATe tools.[3] Moreover, the increased vertical clearance over the roadway and rail tracks beneath the bridges will provide greater flexibility in the future as to the types of freight service that can use these facilities.

[1] Oklahoma Transportation, Documented Categorical Exclusion (DCE) for I-40: At Exit 65, I-40B West Jct. in Clinton Custer County, J3-1842(004), JP 31842(04), June 20, 2022.

[2] The detour route illustrated in Figure 3 is specifically for eastbound traffic. For westbound traffic, a somewhat shorter route between Exit 53 and Exit 65 may be feasible with an incremental travel time of 9 minutes. The BIP BCA Tool uses the distances and travel times specific for the travel direction.

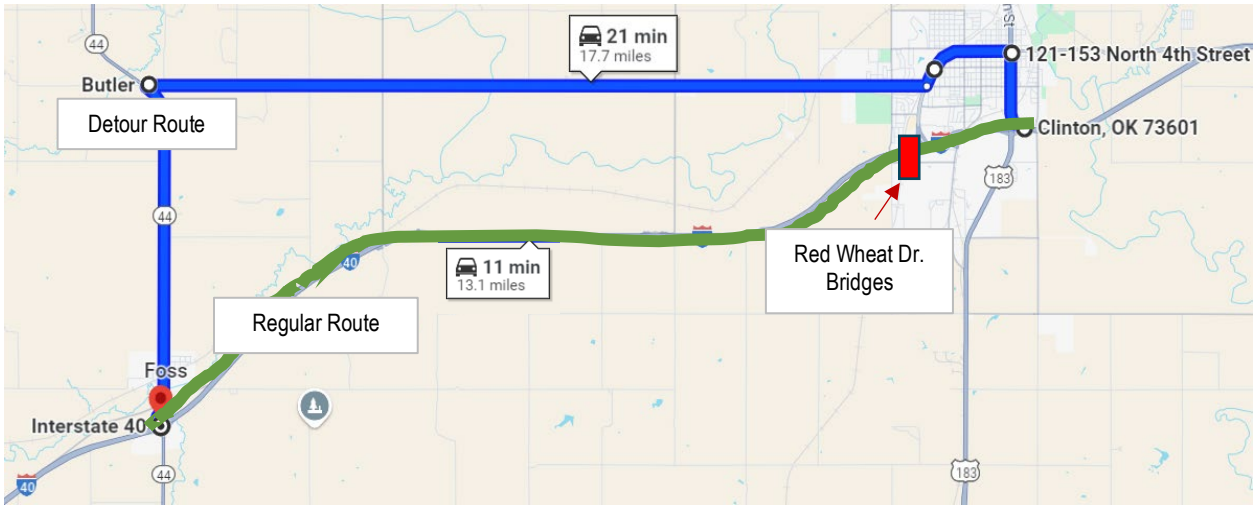
[3] Oklahoma Department of Transportation, Interstate 40 at Exit 65 Access Justuification Report, Custer County (Division V), ODOT JP 31842(04), November 2022, prepared by Garver for Oklahoma Department of Transportation.

Figure 2: Neptune Dr. Bridges Travel Routes



Source: Google Maps.

Figure 3: Red Wheat Dr. Bridges Travel Routes



Source: Google Maps.

4.2 Base Case and Alternatives

Base Case/No Build: The Neptune Dr. and Red Wheat Dr. bridges are in fair condition and functionally obsolete. Without replacement, the bridges would have to be closed to all traffic by 2057. Traffic using these bridges would be forced to take a detour route on local Clinton and rural arterial roads instead of I-40.

This will result in additional VMT in Clinton and the broader region, and create several economic costs including additional travel time, vehicle operating costs, emissions, and increased crashes.

The aging bridges will also require intensive maintenance, monitoring and costly repairs.

Build Case: In the "Build Case" or "Project case", all I-40 bridges will be replaced thus bringing them to a state of good repair and avoiding future closures with long-term traffic detours, travel time delays and related costs. Because of modernized bridge design and roadside lighting, the Project will also help achieve a reduction in the number of crashes. Maintenance costs for the new structures are expected to be significantly lower than for the old ones.

The construction approach entails replacing one bridge at a time and using temporary crossover to direct one traffic lane to the parallel bridge that remains open which effectively reduces the number of lanes to one but keeps this segment of I-40 open to traffic

4.3 Project Cost and Schedule

Total future project construction costs for all four bridges are estimated at $33.9 million in 2024 dollars. For this BCA, all costs were de-escalated to 2022 dollars using the implicit price deflator for GDP provided within the BIP BCA Tool.[4] The adjusted costs amount to $32.6 million in 2022 undiscounted dollars and $28 million discounted at 3.1 percent. Costs include construction of the new bridges, roadway approaches, temporary cross-overs, traffic management during construction, and construction inspection. Estimates also include a 20 percent contingency.

In addition to these costs, there are some previously incurred costs in relation to this Project estimated at about $5.9 million that include design, environmental assessment, utilities and right of way (estimate for all four bridges, 2022 dollars). The total Project development and construction cost amounts then to $38.5 million undiscounted and $33.9 million discounted at 3.1 percent.

Construction is expected to start in 2026 and be completed by end of 2028 (duration of 3 years).

The new bridges are not expected to require major maintenance or rehabilitation for the first 30 years. The routine annual maintenance is expected to be lower than for the old bridges generating a net savings. This savings is treated as a benefit in this BCA.

Table 1 below provides a summary of project costs.

[4] The adjustment amounted to multiplying the 2024 costs by the deflator index of 0.961 based on Table A-6 Inflation Adjustment Values from the BIP BCA tool.

Table 1: Project Cost Summary, Millions of 2022 Dollars

Cost Category	In Constant Dollars	Discounted at 3.1 Percent
▸ Red Wheat Dr. Bridges Construction		
▸ Bridge 14477 (I-40 WB)	$5.1	$4.3
▸ Bridge 14478 (I-40 EB)	$5.6	$4.8
▸ Neptune Dr. Bridges Construction		
▸ Bridge 17581 (I-40 EB)	$9.7	$8.4
▸ Bridge 17582 (I-40 WB)	$9.8	$8.4
Total Project Construction Costs	**$30.2**	**$25.9**
Previously Incurred Costs	$5.9	$5.9
Total Costs	**$38.5**	**$33.9**

5 BRIDGE TRAFFIC AND DETOURS

Table 2 presents current and forecasted traffic on the Project I-40 bridges. In 2020, total vehicle traffic amounted to an annual average daily traffic (AADT) of about 9,200 to 9,500 on each bridge with trucks accounting for 12 percent of total traffic. This implies total bi-directional traffic on this stretch of I-40 of almost 20,000 AADT. Traffic is expected to grow at an average annual rate of 2.38 percent across all bridges implying that by 2040 traffic would increase to about 15,000 AADT per bridge for the bi-directional total of about 30,000 AADT. These traffic estimates were the default values in the BIP Tool which the Tool used to calculate the average annual rate of growth in traffic. This rate of growth was then used to interpolate traffic volume in Project opening year, last year of the analysis period, and between those years, as shown in Table 2.

Table 2: I-40 Bridge Traffic, AADT, and Rate of Growth

Traffic Category, By Bridge	2020	2040 Forecast	Rate of Growth 2020-2040	2029 Forecast (Project Opening)	2058 Forecast (Project Last Year)
Red Wheat Dr. Bridges	**18,800**	**30,080**		**23,228**	**45,918**
Bridge 14477 (I-40 WB) - Total	9,250	14,800	2.38%	11,429	22,593
▸ Autos	8,140	13,024	2.38%	10,057	19,882
▸ Trucks	1,110	1,776	2.38%	1,371	2,711
Bridge 14478 (I-40 EB) - Total	9,550	15,280	2.38%	11,799	23,326
▸ Autos	8,404	13,446	2.38%	10,383	20,526
▸ Trucks	1,146	1,834	2.38%	1,416	2,799
Neptune Dr. Bridges	**18,700**	**29,920**		**23,104**	**45,674**
Bridge 17581 (I-40 EB) - Total	9,450	15,120	2.38%	11,676	23,081
▸ Autos	8,316	13,306	2.38%	10,275	20,312
▸ Trucks	1,134	1,814	2.38%	1,401	2,770
Bridge 17582 (I-40 WB) - Total	9,250	14,800	2.38%	11,429	22,593
▸ Autos	8,140	13,024	2.38%	10,057	19,882
▸ Trucks	1,110	1,776	2.38%	1,371	2,711

Source: BIP Tool/NBI database.

Detailed information on the origin and destination of the vehicle traffic on the I-40 bridges was not available at the time of this analysis. However, traffic data compiled for the engineering study conducted for the Exit 65/65A redesign project, shows that on- and off-traffic on the ramps at Exit 65, Exit 65A, and Exit 66 account for about 5 percent to 15 percent of total traffic. This is indicative that the majority of traffic is long-distance through traffic coming from/going to outside of the Project extents. This traffic would have to take a detour to continue travel when either of the bridge sets is closed as illustrated in **Figure 2** and **Figure 3**. Traffic with local destinations/origins may be able to find other routes using the local road network with shorter incremental travel distances and time. The impacts to this traffic are more difficult to quantify. For simplicity, this BCA focuses on the quantification of the impacts to through traffic.

6 BENEFITS AND IMPACTS CATEGORIES

This section describes each of the project benefits and disbenefits in more detail and provides information on the data used for the BIP BCA Tool.

6.1 Travel Time Savings

In the No Build scenario, all I-40 bridges will deteriorate over time and require closure by 2057. As a result, vehicles would have to take a detour route. In the case of the Neptune Dr. bridges closure, the detour route would lead through the Town of Clinton arterial roads with total incremental driving distance of 2 miles and incremental travel time of 7 minutes (as shown in **Figure 2**). In the case of Red Wheat Dr. bridges closure, the detour route would lead through the town arterial roads to rural arterial roads (SH 73 and SH 44) to the Town of Foss with total incremental driving distance of 5 miles and incremental travel time of 9 to 10 minutes, depending on the direction of travel (as shown in **Figure 3**).

The Project Build scenario will replace the existing bridge infrastructure to ensure that all bridges remain in state of good repair to extend their operations beyond 2057. By avoiding the detours, vehicles will reduce total VMT and thus avoid the additional travel time.

The BIP BCA Tool was used to estimate the total monetary value of travel time savings from avoided detours. Total travel time savings are based on the incremental travel distance and time and monetized using value of time for personal auto trips, business auto trips, and truck value of travel time for truck trips.[5] The share of long-distance personal travel was assumed at 80 percent based on the share of through traffic on I-40 on Clinton's interchanges. Also, it was assumed that only the through traffic would take the detours discussed above. Local traffic and out-of-town traffic with trip origins or destinations in Clinton will likely be affected to a smaller extent assuming that this traffic may be able to modify the travel route without using I-40 in the Project area. The impacts to this traffic are more challenging to quantify and are acknowledged here qualitatively.

Table 3 shows assumptions regarding detour length, average speed, and travel time for each bridge, while **Table 4** shows assumptions regarding value of time and percentage of traffic that would be taking detours when the Project bridges are closed.

[5] In the BIP tool, average speed on detour route was modified to obtain the average detour travel time that matches the incremental detour travel time estimated by Google Maps. The average speed on I-40 is much higher than on detour route. As a result, default BIP BCA Tool calculating detour travel time based on incremental detour length and detour average speed will understate the incremental travel time due to detours. Average speeds on detour routes were reduced as a correction to this default approach.

Table 3: Net Detour Length, Average Speed, and Detour Travel Time Assumptions

Bridge	Net Detour Length, Miles	Incremental Travel Time, Minutes/Vehicle	Detour Average Speed, Mph
Red Wheat Dr. Bridges			
Bridge 14477 (I-40 WB)	4.6	9.0	32.0
Bridge 14478 (I-40 EB)	4.8	9.9	28.0
Neptune Dr. Bridges			
Bridge 17581 (I-40 EB)	2.0	7.0	17.2
Bridge 17582 (I-40 WB)	2.0	7.0	17.2

Source: Net detour length and travel time determined by comparing detour routes with regular routes using mapping tools (Google Maps). Detour average speed simulated to obtain the indicated incremental travel time.

Table 4: Detour Travel Time Valuation Assumptions

Variable	Unit	Value	Source
Average Car Occupancy	persons/vehicle	1.67	BIP BCA Tool Default
Share of Long-Distance Personal Travel	Percent	80.0%	Assumption based on share of through traffic on I-40
Value of Time - Long-Distance Personal Travel	$/h	$25.10	BIP BCA Tool Default
Share of Business Travel	Percent	11.8%	BIP BCA Tool Default
Value of Travel Time - Business	$/h	$32.30	BIP BCA Tool Default
Value of Travel Time - Personal	$/h	$17.90	BIP BCA Tool Default
Value of Travel Time - All Purposes	$/h	$25.40	Calculated value from inputs above
Value of Time - Truck Driver	$/h	$33.50	BIP BCA Tool Default
I-40 Traffic Taking Detours When Bridges Closed	Percent	80%	Assumption based on share of through traffic on I-40

6.2 Vehicle Operating Cost Savings

As discussed in the context of travel time savings, the Project will help avoid the use of the detour routes when the Neptune Dr. bridges or the Red Wheat Dr. bridges are closed and thus the need to travel incremental distances.

The BIP BCA Tool was used to estimate the vehicle operating cost savings from avoided detours. Total value of vehicle operating costs savings was based on the total VMT avoided by autos and trucks and unit vehicle operating costs for auto and truck, respectively.

Detour VMT were estimated based on assumptions outlined in **Table 3** and **Table 4** while unit operating costs were based on default values in the BIP BCA Tool.

6.3 Safety Benefits

As discussed above, the project will help reduce traffic and VMTs by avoiding permanent detours in the future. Assuming a constant average crash rate (expressed in terms of number of crashes per mile), this will result in a reduction in total number of crashes.

Separate calculations were performed in an off-model Excel sheet to calculate the average crash rate per 100 million VMT on the detour routes for the Neptune Dr. bridges and Red Wheat Dr. bridges based on the historical crash data and traffic data. Historical accident data over the years 2017-2021 was used to derive the average annual number of crashes on the detour routes. Vehicle counts, by link, together with the link length were then used to estimate link VMT and summed across to obtain total VMT on the detour routes. Average annual number of crashes, by type, was then divided by total VMT to derive the crash rates (by type of accident, in terms of the number of crashes per 100 million VMT). These were used as the crash rate inputs in the BIP BCA Tool.

The crash statistics on the detour routes and the resulting crash rate calculated using the approach described above are shown in **Table 5** below.

Table 5: Number of Crashes and Crash Rates on Detour Routes

Crash Severity	Number of Crashes (2017-2021)		Crash Rate (Per 100 M VMT)	
	Neptune Dr. Bridges Detour	Red Wheat Dr. Bridges Detour	Neptune Dr. Bridges Detour	Red Wheat Dr. Bridges Detour
Property Damage Only	92	102	233.6	165.0
Possible Injury	32	32	81.3	51.8
Non-Incapacitating Injury	12	15	30.5	24.3
Incapacitating Injury	2	5	5.1	8.1
Injury (Total)	46	52	116.8	84.1
Fatal	0	0	0.0	0.0
Total	**138**	**154**	**350.4**	**249.1**

Source: calculated based on crash statistics and vehicle traffic data (by link) from ODOT

Crash rates (by type of crash) on the detour routes combined with estimated detour VMTs and unit costs of crashes produced the value of the safety benefits due to avoidance of detours (avoided crashes).

In addition, it is expected that this bridge replacement Project will improve safety on the bridges and bridge approaches due to its modern geometry, wider shoulders, enhanced barriers, and improved lighting. An engineering safety analysis was conducted for the broader interchange project that incorporates the bridges and uses similar design features throughout. This analysis used methodologies described in the Highway Safety Manual (HSM) based on safety performance functions along with crash modification factors. This analysis estimated the overall

reduction in crashes of about 17 percent, including 20-30 percent reduction in injury crashes and a 14 percent reduction in no injury/property damage only (PDO) crashes.

Table 6 shows the number of crashes on the bridges and approaches over the years 2017-2021. The table shows that over the 5-year period 2017-2021, there were 12 crashes on Project bridges, almost all of them PDO crashes. The Project is expected to reduce the number of these crashes by 17 percent.

Table 6: Number of Crashes on Project Bridges and Approaches, 2017-2021

Bridge	PDO Crashes	Injury Crashes	Total Crashes
Red Wheat Dr. Bridges			
Bridge 14477 (I-40 WB)	2	0	2
Bridge 14478 (I-40 EB)	1	0	1
Neptune Dr. Bridges			
Bridge 17582 (I-40 WB)	3	2	5
Bridge 17581 (I-40 EB)	4	0	4
Total	**10**	**2**	**12**

Source: extracted from ODOT crash statistics databases.

The historical crash statistics shown in **Table 6** together with the estimated reduction in crashes of 17 percent were used as inputs in the BIP BCA Tool in the estimation of Project safety benefits due to improved and modernized bridge design.

6.4 Emission Cost Savings

In the No Build scenario, vehicles will be forced on detour routes which are longer than the regular route. The Build scenario will help avoid the detours and therefore reduce total VMT in the broader region. This will translate to a reduction in vehicle emission, including CO2 and non-CO2 emissions. The BIP BCA Tool calculates these avoided emissions, separately for passenger vehicles and trucks and separately for CO2 and other air pollutants, based on the incremental detour VMT and emission rates per mile corresponding to the prevailing average speed. Detour VMT were estimated based on assumptions outlined in **Table 3** and **Table 4** while emission rates and unit values of emissions reduced were based on the BIP BCA Tool defaults.

6.5 Operating and Maintenance Costs Impacts

In the No Build scenario, all four bridges will require extensive maintenance and repairs to ensure continued safe operations of the bridges. New bridge structures have a much lower regular operations and maintenance (O&M) needs in the first 30 years of operations.

Table 7 provides estimates of O&M costs in the No Build and Build Scenarios, by year of operations (after construction is completed). The No Build scenario includes periodic O&M costs determined from maintenance records and rehabilitation and repair costs in year 5. No Build O&M costs are set to $0 since in year 29 and 30 since the bridges are assumed to close to traffic. The Build scenario includes silane application in year 2.

Over 30 years, total No Build O&M costs amount to more than $1.7 million for each of the Red Wheat Dr. bridges and $2.2 million for each of the Neptune Dr. bridges for a grand total cost of $7.9 million. By comparison, the 30-year Build costs for any of the bridges are less than $50,000 for a grand total of $146,000 over 30 years for all bridges. The above annual O&M costs were entered manually into the BIP BCA Tool.

Table 7: No Build and Build O&M Costs

Year of Operations	NO BUILD COSTS				BUILD COSTS			
	Red Wheat Dr. Bridges		Neptune Dr. Bridges		Red Wheat Dr. Bridges		Neptune Dr. Bridges	
	I-40 Bridge 14478	I-40 Bridge 14477	I-40 Bridge 17582	I-40 Bridge 17581	I-40 Bridge 14478	I-40 Bridge 14477	I-40 Bridge 17582	I-40 Bridge 17581
Year 1	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 2	$4,500	$4,500	$9,000	$9,000	$11,000	$11,000	$34,000	$34,000
Year 3	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 4	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 5	$1,603,500	$1,603,500	$2,008,000	$2,008,000	$0	$0	$0	$0
Year 6	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 7	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 8	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 9	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 10	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 11	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 12	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 13	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 14	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 15	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 16	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000

Year of Operations	NO BUILD COSTS				BUILD COSTS			
	Red Wheat Dr. Bridges		Neptune Dr. Bridges		Red Wheat Dr. Bridges		Neptune Dr. Bridges	
	I-40 Bridge 14478	I-40 Bridge 14477	I-40 Bridge 17582	I-40 Bridge 17581	I-40 Bridge 14478	I-40 Bridge 14477	I-40 Bridge 17582	I-40 Bridge 17581
Year 17	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 18	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 19	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 20	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 21	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 22	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 23	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 24	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 25	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 26	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 27	$3,500	$3,500	$8,000	$8,000	$0	$0	$0	$0
Year 28	$4,500	$4,500	$9,000	$9,000	$1,000	$1,000	$1,000	$1,000
Year 29	$0	$0	$0	$0	$0	$0	$0	$0
Year 30	$0	$0	$0	$0	$1,000	$1,000	$1,000	$1,000
Total	**$1,712,000**	**$1,712,000**	**$2,238,000**	**$2,238,000**	**$25,000**	**$25,000**	**$48,000**	**$48,000**

6.6 Other Benefits

In addition to the benefits discussed above, the Project will have other benefits which are more difficult to quantify and monetize. These benefits are briefly outlined below.

- Improved driver comfort. In addition to reduced crash rates, the modernized geometric design of the bridges, new lighting, and new road surface itself can be expected to improve the overall driving experience and comfort.
- Increased flexibility in freight transportation options. Increased vertical clearance over the roadway and rail tracks beneath the bridges will provide greater flexibility in the future as to the types of freight service that can use these facilities.
- Improved I-40 reliability/mobility for personal travel and freight transportation. The Project will improve the state of good repair of Project bridges reducing the risk of unexpected closures for repairs and rehabilitation. Given that I-40 is a part of the Primary Highway Freight System, reliability of this corridor is of utmost importance for freight movements both nationally and locally for Clinton-area manufacturers and distributors.

6.7 Residual Value

The Project will replace the existing bridges with new structures, thus improving the state of good repair. The new structures were assumed to have a useful life of 75 years based on design industry standards for similar bridges. The residual value of the new bridge structures is based only the total construction costs spending components, which account for about 83 percent of total project costs. Other project cost components, including mobilization and traffic control during construction were excluded as they are not expected to have a significant residual value at the end of the analysis period. The BIP BCA Tool estimated the residual value benefit based on Project capital costs and these assumptions.

6.8 Disbenefits During Construction

Project construction will take place over three years from 2026 to 2028. It is anticipated that construction will be conducted on one of the directional bridges from the two sets of bridges at a time. Crossovers will be used to direct traffic onto the other directional bridge. This will reduce the capacity of that bridge to one lane but will ensure that traffic can move in both directions and help avoid the need to take a detour by all vehicles.

The travel delays due to lane reduction during construction were simulated for year 2028 using traffic volumes estimated based on data assumptions shown in Table 2 and using the Missouri Department of Transportation's (MoDOT's) *Work Zone Impact Analysis Spreadsheet*.

In addition to volumes, this tool allows users to enter the percentage of truck traffic, roadway grade, the typical number of lanes available to traffic, the number of lanes closed, times when the closure is in place, and work location. The tool uses this information to project the buildup and dissipation of traffic on the facility due to the work zone during the specified times of operation and produces estimates of delay throughout the day (in minutes). The estimated minutes of delay was then multiplied by the number of vehicles on the road during the time when the delay occurs to obtain the delay in vehicle-minutes. The results for total daily delays and implied average minutes of delay per vehicle (based on AADT shown in **Table 2)** are presented in **Table 8** below. The table shows that delays are expected only in the eastbound direction. They are relatively small at less than one minute per vehicle on average.

Table 8: Delays due to Construction Disruptions, 2028 Traffic Conditions

Bridge	Total Daily Delay, Vehicle-minutes	Average Minutes of Delay per Vehicle
Neptune Dr. Bridges		
Bridge 17581 (I-40 EB)	3,681	0.32
Bridge 17582 (I-40 WB)	0	0.0
Red Wheat Dr. Bridges		
Bridge 14478 (I-40 EB)	7,740	0.69
Bridge 14477 (I-40 WB)	0	0.0

Source: Estimated by Garver using MoDOT's Work Zone Impact Analysis Spreadsheet.

The average minutes of delay per vehicle shown in **Table 8** were used as inputs in the BIP BCA Tool in the estimation of construction disbenefits. These travel delays were assumed to take place 365 days per year over the construction period of three years.

7 SUMMARY OF FINDINGS AND BCA OUTCOMES

Using a real discount rate of 3.1 percent (apart from CO2 emissions), the $33.9 million investment would result in $180.8 million in total benefits. This produces a net present value of $146.9 million and a BCR of 5.3. These results are shown in **Table 9** below.

Table 9 shows that over 50 percent of Project benefits are accounted for by travel time savings followed by vehicle operating costs savings (at 20.5 percent), safety benefits (at 10.6 percent) and reduction in CO2 emissions (at 6.9 percent)

The Red Wheat bridges account for 59 percent of total benefits and the Neptune Dr. bridges for 41 percent. When looking individually, BCRs range from 3.5 for the EB Neptune Dr. bridge to 8.5 for the EB Red Wheat Dr. bridge.

Table 9: BCA Results, Millions of 2022 Dollars, 3.1% Discount Rate*

Category of Impact	Red Wheat Dr. Bridges		Neptune Dr. Bridges		Total	Percent of Total Benefits
	Bridge 14478 (I-40 EB)	Bridge 14477 (I-40 WB)	Bridge 17581 (I-40 EB)	Bridge 17582 (I-40 WB)		
Safety	$5.9	$5.9	$3.5	$3.9	**$19.2**	10.6%
Travel Time	$31.8	$23.4	$21.0	$22.7	**$98.9**	54.7%
VOC	$12.9	$13.1	$5.6	$5.5	**$37.1**	20.5%
CO2 Emissions	$4.1	$4.1	$2.1	$2.1	**$12.5**	6.9%
Non-CO2 Emissions	$0.5	$0.5	$0.3	$0.3	**$1.5**	0.8%
Other Environmental	$0.0	$0.0	$0.1	$0.1	**$0.1**	0.1%
Maintenance	$1.1	$1.1	$1.4	$1.4	**$5.1**	2.8%
Residual Value	$1.3	$1.2	$2.0	$2.0	**$6.4**	3.6%
Total Benefits	**$57.5**	**$49.4**	**$35.9**	**$37.9**	**$180.8**	100.0%
Total Discounted Costs	$6.8	$6.3	$10.3	$10.4	**$33.9**	
BCR	**8.5**	**7.8**	**3.5**	**3.6**	**5.3**	
Net Present Value (NPV)	$50.7	$43.1	$25.6	$27.5	**$146.9**	

** Except for BCR. ** Except for CO2 emissions reduction benefits which are discounted at the 2% discount rate.*

Source and Notes: BIP BCA Tool, Results. Resilience, Health and Amenity and Other Benefits categories were not evaluated.

8 SENSITIVITY ANALYSIS

A sensitivity analysis was conducted using the BIP BCA Tool. The sensitivity analysis was used to examine input value changes from the main BCA scenario analysis. Only one change was implemented at a time to examine the impact of each change. The scenarios are described below:

- **Incremental Length of Detour Routes**: the main BCA scenario calculates total Project benefits as a sum of benefits across all four Project bridges. However, in the actual event of closures of all four bridges at the same time, drivers taking detour around the Red Wheat Dr. bridges would at the same time detour the Neptune Dr. bridges. Therefore, it can be argued that the benefits stemming from detour avoidance are equal to the sum of benefits for the Red Wheat Dr. bridges only (and include benefits of avoiding detours related to the Neptune Dr. bridges). The sensitivity analysis involved then an adjustment to Project benefits such that benefits related to detour avoidance were calculated based on the detour distance for Red Wheat Dr. bridges only.
- **Reduction in Bridge Traffic**: the main BCA scenario forecasts future traffic based on 2020 traffic volume and a rate of growth in traffic implied by NBI data 2040 forecasts. These forecasts imply a fairly strong traffic growth at 2.38 percent annually. The sensitivity analysis involved a reduction of this rate after 2029 leading to lower annual traffic volumes: the growth rate was reduced to an average annual of 1.59 percent which resulted in lower traffic volumes every year of Project operations – up to 20 percent lower in the last year in 2058 than in the scenario with main parameter values.
- **Excluding residual value of capital**: the main BCA scenario accounts for the residual value of capital at the end of the evaluation period. The sensitivity test recalculates Project performance metrics without the residual value of capital.
- **Increase in capital costs**: for the sensitivity analysis an increase in costs of 20 percent was assumed. The sensitivity test recalculates Project performance metrics with these higher capital costs.

Table 10 below summarizes the sensitivity analysis results from the BIP BCA Tool. As shown in the table, Project performance remains very strong in both scenarios which tend to decrease benefits with Project BCR of 3.3 or higher.

Table 10: Results of Sensitivity Analysis

Parameter	Change in Parameter Value	NPV, $ millions	% change in NPV	BCR
Main Analysis Results	**No change**	$146.9	**n/a**	**5.3**
Sensitivity Test: Detour Route	Assuming Red Wheat Dr. detour for all four bridges	$78.2	-46.8%	3.3
Sensitivity Test: Reduction in Traffic	Assuming reduction in traffic rate of growth after 2029 from 2.38% to 1.59%, or a 20% reduction in traffic in 2058.	$112.0	-23.8%	4.3
Sensitivity Test: Excluding Residual Value	Residual Value not included in Project Benefits	$140.5	-4.4%	5.1
Sensitivity Test: Higher Costs	Capital costs increase of 20%	$142.4	-3.1%	4.6