

TO: Florida Department of Transportation

FROM: EBP US

DATE: August 3, 2022

RE: Hatchet Creek Bridge Scour Revetment BCA Methodology and Findings

Project Description

This project involves a scour revetment of Hatchet Creek Bridge, a 200-foot reinforced concrete slab bridge in Northeast Alachua County, Florida that accommodates over 11,000 vehicles daily. Hatchet Creek Bridge is structurally deficient because of scour, including the impact of Hurricane Irma and other storm events. The project's repairs are expected to reclassify Hatchet Creek Bridge as no longer scour critical and structurally deficient, thereby reducing the risk of failure from a future storm event, the need for emergency repairs, and the need for load-posting and diversion of heavy trucks.

Summary of BCA Approach

The benefit-cost analysis (BCA) has as its basis two major project effects which yield benefit streams over the period of operation. These effects arise under the No Build and include **Avoided Storm Closure** and **Avoided Truck Restriction from Reclassification**. The Avoided Storm Closure benefit stream reflects the probability that under the No Build the bridge becomes unstable due to a 50-year storm event and is temporarily closed and then replaced with an emergency repair project. Closure of the bridge for an emergency repair project would result in detouring of all traffic for a significant length of time. The Avoided Truck Restriction from Reclassification benefit stream reflects the fact that without the project the bridge will remain classified as structurally deficient and will under FDOT engineering analysis be load posted to heavy trucks exceeding a given weight prior to 2026. This would result in detouring of heavy trucks above the posted load throughout the duration of the project's operation.

Probabilities are applied, as noted below, to reflect the uncertainty of major storm events and to avoid the potential for two mutually exclusive outcomes to occur at the same time. Specifically, probabilistic adjustments are used to reflect the uncertainty of a 50-year storm event in any given year and are also employed to ensure there is no double counting between the two sets of benefits. These are described more fully below and are incorporated in the BCA spreadsheet model which is submitted with the application.

The analysis is conducted over a three-year period of construction (engineering in 2023 and construction in 2025) and a twenty-year period of operation, commencing in 2026. The useful life

of the project, based on FDOT engineering judgment, is 50 years. A salvage value is included in the analysis, reflecting 30 years of additional useful life after the 20-year analysis period.

Project Cost

Construction costs were estimated by FDOT in today's 2022 prices and are shown below. For BCA purposes, the 2022 costs were adjusted to 2020 dollars based on the change in the GDP price deflator 2020-2022.

Year	Cost Item	2022 Dollars	2020 Dollars
2023	Preliminary Engineering	\$828,600	\$759,729
2025	Construction	\$4,204,853	\$3,855,546
2025	Construction Support	\$1,234,393	\$1,131,849
Total		\$5,852,664	\$5,366,469

Source: FDOT District II.

It should be noted that the proposed project is the required maintenance to keep the bridge in service. The scour and embedment concerns would not cause additional maintenance on the substructure, superstructure, or deck. Therefore, the differential in maintenance and rehabilitation costs between the no-build scenario and build scenario is zero. However, the probability of emergency repair costs is modeled in the analysis, in the Avoided Storm Closure effect.

Project Benefits

Avoided Storm Closure – FDOT has determined that a 50-year flood event would result in significant additional damage to the bridge's understructure and would require as a result an emergency repair of the bridge. This emergency repair would be equivalent in scope to the Build project itself. However, as it would entail an emergency, the structure would require immediate closure before project engineering and procurement would begin. This would result in complete bridge closure for an estimated 110 days and would increase the cost of construction by a factor of 3. This three-fold cost increase is an FDOT engineering rule of thumb for estimation purposes.

FDOT has also determined that under the Build scenario, the repairs would be made under non-emergency conditions, and can be conducted without closure to traffic, as construction can be done in phases and with maintenance of at least one lane of traffic during construction hours, and full traffic flow during peak hours.

Avoided Truck Restriction from Reclassification – FDOT engineers estimate that 10 percent of all trucks would be restricted under the posted load limit and would thus detour 8 miles. FDOT traffic counts indicate approximately 644 trucks daily across the bridge. VMT and VHT increases would result. These savings are reduced (i.e., weighted) based on the probability each year that a

storm would not occur (causing an emergency replacement) and that the load posting would remain in effect. If the storm closure were to occur, the bridge would be fixed, and load posting would cease.

BCA Results

The discounted cost of the project is approximately \$3.3 million in 2020 dollars (including the salvage value offset). The discounted benefits total approximately \$5.5 million. These costs and benefits result in a benefit-cost ratio of 2.04, as seen in Table 1. Costs and benefits are discounted at 7 percent, except for carbon emissions, which are discounted at 3 percent.

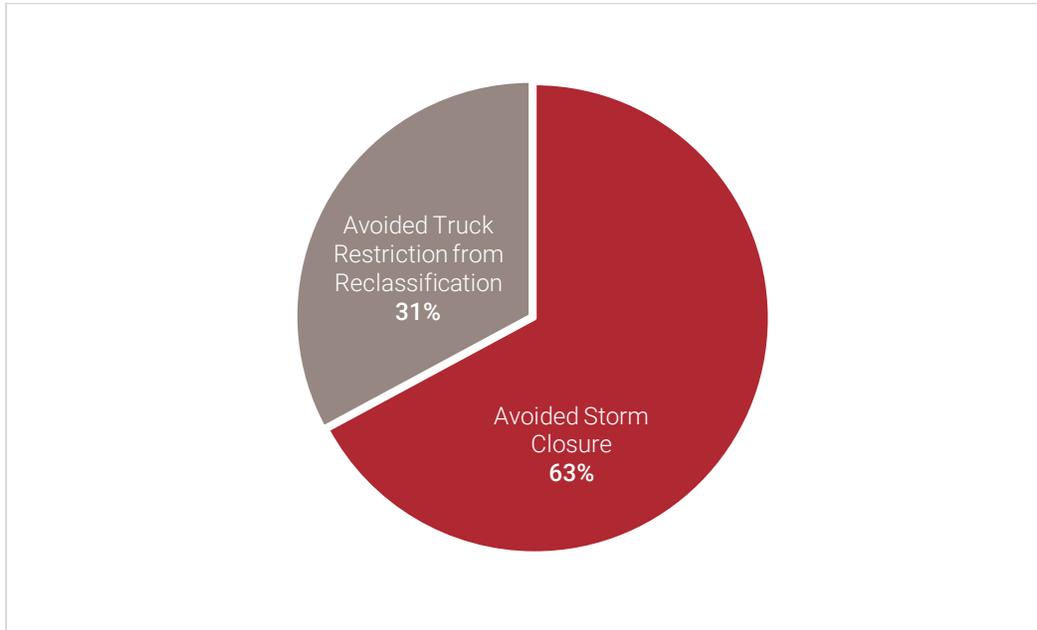
Table 1. Summary BCA Results (Discounted 2020 Dollars)

Cost and Benefit Categories	Present Value
Discounted Costs	
Build Capital Costs	\$3,904,707
Residual Value After 20 Years	-\$593,260
Total Discounted Costs	\$3,311,447
Discounted Benefits	
1. Annual Maintenance Cost Savings	\$0
2. Avoided Storm Related Emergency Closure	
2.1. Avoided Repair Cost	\$2,432,101
2.2. Travel Time Savings	\$1,034,098
2.3. Vehicle Operating Cost Savings	\$721,865
2.4. Emissions Reductions	\$80,277
3. Avoided Truck Restriction and Detour from Reclassification	
3.1. Travel Time Savings	\$966,450
3.2. Vehicle Operating Cost Savings	\$1,123,498
3.3. Emissions Reductions	\$393,640
Total Discounted Benefits	\$6,751,929
Summary	
Benefit Cost Ratio	2.04
Net Present Value	\$3,440,483

Source: EBP Analysis of Florida Department of Transportation Data.

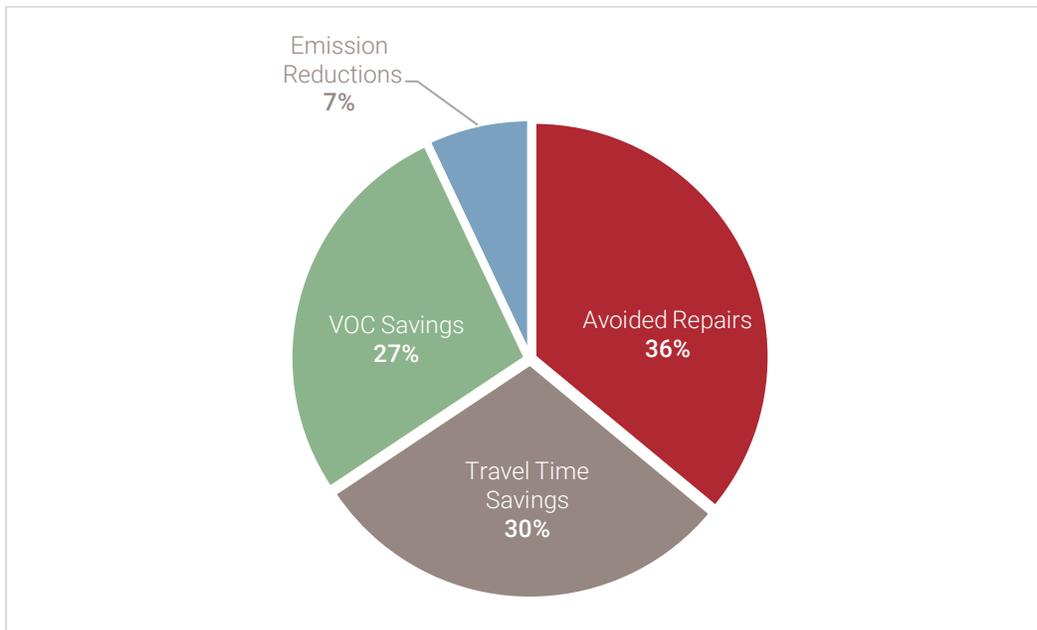
Approximately 63 percent of project benefits come from an **Avoided Storm Closure** and 31 percent of project benefits come from an **Avoided Truck Restriction from Reclassification** as seen in Figure 1.

Figure 1. Benefits by Source



Two-thirds of benefits come from **Travel Time Savings** and **Avoided Repairs**, as seen in Figure 2. The remaining benefits come from **Vehicle Operating Cost Savings** and **Emission Reductions**.

Figure 2. Benefits by Type



Methodology and Key Assumptions

As mentioned, this analysis considers two benefit elements in combination: the **Avoided Storm Closure** and the **Avoided Truck Restriction from Reclassification**. Below, we explain the key parameters and assumptions in each Excel workbook tab associated with the analysis. Screenshots of each workbook tab are provided at the end of this memorandum.

We used available FDOT data for the project and followed current USDOT benefit-cost analysis guidance for discretionary grant programs.

Summary Tabs:

- **Results:** Presents discounted costs, discounted benefits, benefit-cost ratio, and net present value of the project.
- **Costs:** Presents undiscounted costs and the residual value of improvements of the project. The residual value at the end of the 20th year of operation reflects the 50-year useful life of the bridge.

Analysis Tabs:

- **Maintenance Cost Savings:** presents the life cycle cost savings associated with the project. In this case, the differential in maintenance and rehabilitation costs between the no-build scenario and build scenario is zero.
- **Structurally Deficient Impact:** presents the avoided cost of truck detouring when the bridge is structurally deficient. This tab calculates the annual heavy truck detour VMT and the annual heavy truck detour VHT based on the prediction that approximately 10 percent of trucks would be subject to an 8-mile detour starting in 2026. The tab includes estimates for travel time savings, operating cost savings, and emissions savings. Because the bridge would not remain structurally deficient and load posted if there were a major storm event and it was replaced (the second set of probabilistic benefits considered), this tab also incorporates an adjustment factor reflecting each year the probability the bridge has not yet failed and been replaced.
- **VMT-PHT Savings – Storm Close:** calculates the expected annual detour VMT and expected annual detour VHT and PHT in the event the bridge is closed due to a storm event. Local engineers expect such a closure to last 110 days while an emergency bridge replacement is planned and constructed. The tab considers the probability of storm event closure in calculations, based on an analysis that the bridge would be unstable during a 50-year storm event. Given the 50-year recurrence interval, the annual probability of closure is .02. The expected annual detour PHT is based on passenger vehicle occupancy parameters identified in the 2022 USDOT BCA guidance.
- **TT Benefits – Storm Close:** presents the value of travel time savings from avoided bridge closure, based on the hourly values of time identified in the 2022 USDOT BCA guidance.

- **Emissions Benefits – Storm Close:** presents estimated emissions savings associated with the avoided storm closure. This includes estimates for carbon dioxide (CO₂), nitrogen oxides (NO_x), particulate matter 2.5 (PM_{2.5}), and sulfur dioxide (SO₂). Emissions savings are based on rates per vehicle mile traveled from the United States Environmental Protection Agency’s (USEPA) Motor Vehicle Emission Simulator (MOVES3) model.
- **Repair Cost – Storm Close:** presents the expected emergency repair costs from storm event closure, under the assumption that an emergency repair would be three times the project costs. The calculations consider the probability of storm event closure.
- **VOC Benefits – Storm Close:** calculates the value of vehicle operating cost savings from avoided bridge closure based on the vehicle operating costs identified in the 2022 USDOT BCA guidance.

Data Tabs:

- **Look Up Data:** Provides the values used to calculate estimates in other tabs. Lists values and sources.

Discounted Summary Results (2020 \$s)

Year	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Years of Construction						1										
Years of Operation	-	-	-	-			1	2	3	4	5	6	7	8	9	10
Base Year Y for Discounting	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Discount Factor (7%)	1.000	1.070	1.145	1.225	1.311	1.403	1.501	1.606	1.718	1.838	1.967	2.105	2.252	2.410	2.579	2.759
Discount Factor(3%)	1.000	1.030	1.061	1.093	1.126	1.159	1.194	1.230	1.267	1.305	1.344	1.384	1.426	1.469	1.513	1.558

Discounted Costs	Present Value
Build Capital Costs	\$3,904,707
Residual Value after 20 years	-\$593,260
Net Capital Cost	\$3,311,447

Discounted Benefits																
1. Annual Maintenance Cost Savings	\$0					\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
2. Benefits from Avoided Storm Related Emergency Closure (probability weighted values)																
Avoided Repair Cost	\$2,432,101					\$214,554	\$200,518	\$187,400	\$175,140	\$163,682	\$152,974	\$142,967	\$133,614	\$124,873	\$116,703	
Value Travel Time Saving																
auto	\$977,894					\$0	\$88,424	\$82,640	\$77,233	\$72,181	\$67,459	\$63,045	\$58,921	\$55,066	\$51,464	
truck	\$56,204					\$0	\$5,082	\$4,750	\$4,439	\$4,149	\$3,877	\$3,623	\$3,386	\$3,165	\$2,958	
VOC Saving																
auto	\$649,436					\$57,292	\$53,544	\$50,041	\$46,767	\$43,708	\$40,848	\$38,176	\$35,678	\$33,344	\$31,163	
truck	\$72,429					\$6,389	\$5,971	\$5,581	\$5,216	\$4,875	\$4,556	\$4,258	\$3,979	\$3,719	\$3,475	
Emissions Reduction																
CO2	\$58,993					\$ 3,942	\$ 3,817	\$ 3,696	\$ 3,632	\$ 3,515	\$ 3,394	\$ 3,277	\$ 3,163	\$ 3,053	\$ 2,945	
Other Emissions	\$21,284					\$ 2,041	\$ 1,900	\$ 1,769	\$ 1,647	\$ 1,535	\$ 1,423	\$ 1,304	\$ 1,194	\$ 1,094	\$ 1,002	

3, Value of Avoided Loss of Recreational Access

4. Avoided Truck Restriction and Detour from Reclassification																
Travel Time Saving	\$966,450					\$98,239	\$89,976	\$82,407	\$75,476	\$69,128	\$63,313	\$57,988	\$53,110	\$48,643	\$44,552	
VOC Saving	\$1,123,498					\$114,202	\$104,597	\$95,799	\$87,741	\$80,361	\$73,601	\$67,411	\$61,741	\$56,548	\$51,791	
CO2	\$222,811					\$14,775	\$14,305	\$14,079	\$13,619	\$13,171	\$12,733	\$12,308	\$11,893	\$11,490	\$11,098	
Other Emissions	\$170,829					\$16,473	\$15,341	\$14,286	\$13,302	\$12,417	\$11,372	\$10,416	\$9,540	\$8,737	\$8,002	

Total Discounted Benefits	\$6,751,929
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Summary	
Benefit Cost Ratio	2.04
Net Present Value	\$ 3,440,483

2036	2037	2038	2039	2040	2041	2042	2043	2044	2045
11	12	13	14	15	16	17	18	19	20
16	17	18	19	20	21	22	23	24	25
2.952	3.159	3.380	3.617	3.870	4.141	4.430	4.741	5.072	5.427
1.605	1.653	1.702	1.754	1.806	1.860	1.916	1.974	2.033	2.094

\$593,260

\$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0 \$0

\$109,069 \$101,933 \$95,265 \$89,032 \$83,208 \$77,764 \$72,677 \$67,922 \$63,479 \$59,326

\$48,097 \$44,951 \$42,010 \$39,262 \$36,693 \$34,293 \$32,049 \$29,952 \$27,993 \$26,162
 \$2,764 \$2,583 \$2,414 \$2,257 \$2,109 \$1,971 \$1,842 \$1,721 \$1,609 \$1,504

\$29,124 \$27,219 \$25,438 \$23,774 \$22,219 \$20,765 \$19,407 \$18,137 \$16,951 \$15,842
 \$3,248 \$3,036 \$2,837 \$2,651 \$2,478 \$2,316 \$2,164 \$2,023 \$1,890 \$1,767

\$ 2,841 \$ 2,777 \$ 2,678 \$ 2,581 \$ 2,488 \$ 2,398 \$ 2,310 \$ 2,225 \$ 2,170 \$ 2,089
 \$ 917 \$ 840 \$ 769 \$ 705 \$ 645 \$ 591 \$ 541 \$ 496 \$ 454 \$ 416

\$40,804 \$37,372 \$34,229 \$31,350 \$28,713 \$26,298 \$24,086 \$22,060 \$20,204 \$18,505
 \$47,435 \$43,445 \$39,791 \$36,444 \$33,379 \$30,571 \$28,000 \$25,644 \$23,487 \$21,512
 \$10,874 \$10,496 \$10,129 \$9,773 \$9,428 \$9,093 \$8,769 \$8,566 \$8,256 \$7,956
 \$7,329 \$6,713 \$6,148 \$5,631 \$5,157 \$4,724 \$4,326 \$3,962 \$3,629 \$3,324

Share of Benefits by Source

Avoided Storm Closure	63.2%
Avoided Truck Restriction from Reclassification	31.0%

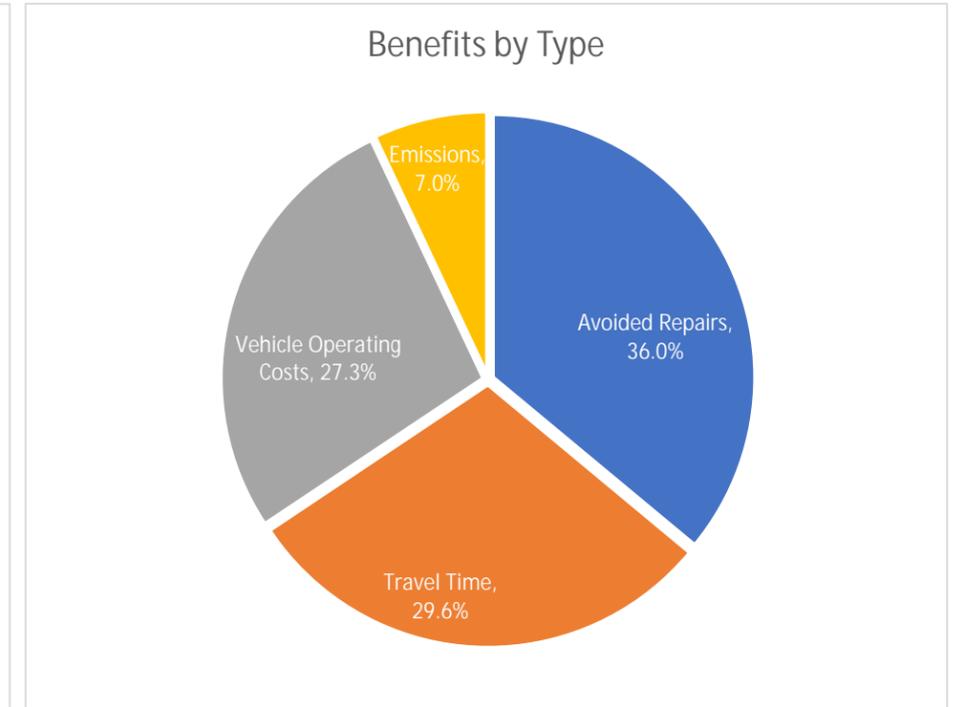
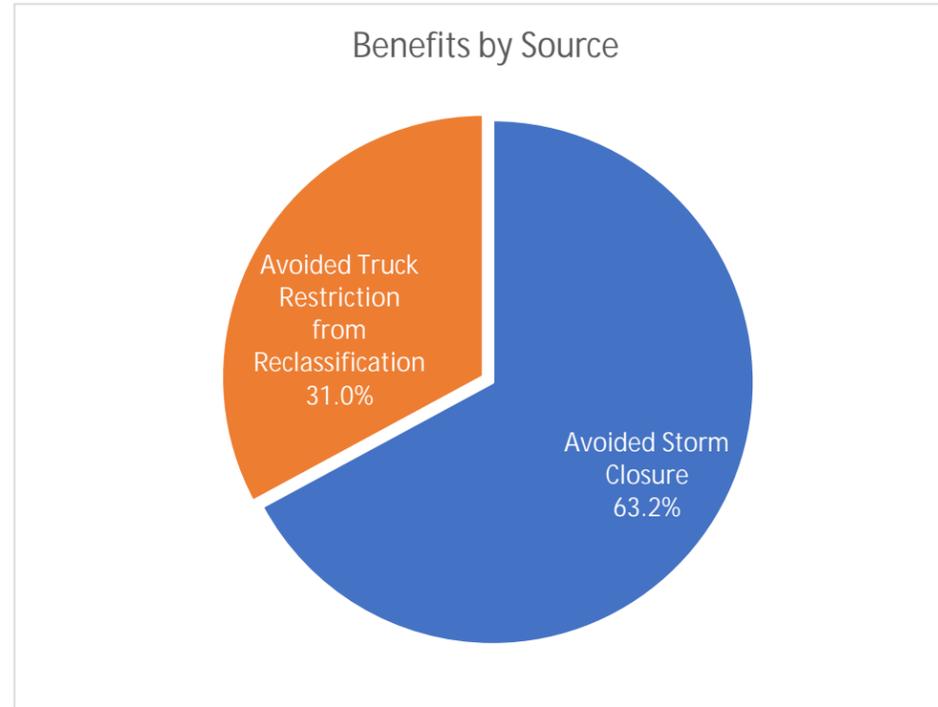
Share of Benefits by Type

Avoided Repairs	36.0%
Travel Time	29.6%
Vehicle Operating Costs	27.3%
Emissions	7.0%

Key Parameters

20 years of operation
Discount all benefits and costs at 7% real discount rate except carbon
Carbon emissions savings discounted at 3%

0.264765578



Costs (Undiscounted, \$2020M)

	Years of Construction Year of Operation	Total	2020	2021	2022	pre	constructio	1	2	3	4	5	6	7
						construcon	n							
						2023	2024	2026	2027	2028	2029	2030	2031	2032
<u>2020 \$s</u>														
<u>Build</u>														
Construction		\$4,606,739				\$759,729	\$4,606,739							
Pre-Construction		\$759,729												
Maintenance and Rehab		\$0.00												
Residual Value (50-year useful life for bridge)		\$3,219,881												
<u>No Build</u>														
Maintenance and Rehab		\$0.00												

Source: FDOT District II

Key Parameters & Assumptions

- Pre construction costs incurred in 2023
- Operations commence in 2026
- 20-year period of operation analysis (carries through to all subsequent sheets)
- Salvage value assumes new substructure will have a 50 year useful life

US BEA GDP price deflator index, % change Q12020-Q12022 1.090599
<https://fred.stlouisfed.org/series/GDPDEF/>

Note: FDOT estimtaed costs in current (mid year 2022) prices initially. These were deflated to 2020 dollars using the GDP price deflator

8	9	10	11	12	13	14	15	16	17	18	19	20
2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045

\$3,219,881

Life Cycle Cost Savings (Maintenance and Rehab Cost Savings, 2020 \$s)

	Year of Operation															
	2020	2021	2022	2023	2024	2025	1 2026	2 2027	3 2028	4 2029	5 2030	6 2031	7 2032	8 2033	9 2034	10 2035
No Build							\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
Build							\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0
No Build - Build							\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0	\$0

Source: FDOT District II

The proposed project is the required maintenance to keep the structure in service

The scour and embedment concerns would not cause additional maintenance on the substructure, superstructure, or deck.

Therefore, the differential in maintenance and rehab costs between no build and build is zero but we separately model the probability of emergency repair costs

Avoided Cost of Truck Detouring when Bridge is Structurally Deficient

Year of Operation	1	2	3	4	5	6	7	8	9	10	11	12	13
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Truck AADT	644	644	644	644	644	644	644	644	644	644	644	644	644
Truck Detour Percentage	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%	10%
Truck Trips Detoured	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4	64.4
Detour Miles Per Trip	8	8	8	8	8	8	8	8	8	8	8	8	8
Annual Heavy Truck Detour VMT	188048	188048	188048	188048	188048	188048	188048	188048	188048	188048	188048	188048	188048
Annual Heavy Truck Detour VHT	4701	4701	4701	4701	4701	4701	4701	4701	4701	4701	4701	4701	4701
Average Detour Route Speed	40	40	40	40	40	40	40	40	40	40	40	40	40
Travel Time Savings	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438
Operating Cost Savings	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885
Heavy Truck Emissions (Based on VMT)													
NOx	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73	0.73
SO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	315.83	315.83	315.83	315.83	315.83	315.83	315.83	315.83	315.83	315.83	315.83	315.83	315.83
PM 2.5	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Heavy Truck Emissions Savings													
NOx	\$ 12,328	\$ 12,549	\$ 12,769	\$ 12,989	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282
SO2	\$ 47	\$ 48	\$ 49	\$ 50	\$ 51	\$ 51	\$ 51	\$ 51	\$ 51	\$ 51	\$ 51	\$ 51	\$ 51
CO2	\$ 18,002	\$ 18,318	\$ 18,950	\$ 19,266	\$ 19,582	\$ 19,897	\$ 20,213	\$ 20,529	\$ 20,845	\$ 21,161	\$ 21,792	\$ 22,108	\$ 22,424
PM 2.5	\$ 12,851	\$ 13,054	\$ 13,262	\$ 13,474	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688
Carbon Emissions Benefits	\$ 18,002	\$ 18,318	\$ 18,950	\$ 19,266	\$ 19,582	\$ 19,897	\$ 20,213	\$ 20,529	\$ 20,845	\$ 21,161	\$ 21,792	\$ 22,108	\$ 22,424
Non-Carbon Emissions Benefits	\$ 25,226	\$ 25,651	\$ 26,080	\$ 26,513	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022
Adjustment Factor for Storm Replacement	0.98	0.96	0.94	0.92	0.90	0.89	0.87	0.85	0.83	0.82	0.80	0.78	0.77
Probability-Adjusted Heavy Truck Emissions (Based on VMT)													
NOx	0.72	0.70	0.69	0.68	0.66	0.65	0.64	0.62	0.61	0.60	0.59	0.58	0.56
SO2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CO2	309.51	303.32	297.26	291.31	285.49	279.78	274.18	268.70	263.32	258.06	252.90	247.84	242.88
PM 2.5	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Probability-Adjusted Heavy Truck Emissions Savings													
NOx	\$ 12,082	\$ 12,052	\$ 12,018	\$ 11,981	\$ 12,006	\$ 11,766	\$ 11,531	\$ 11,300	\$ 11,074	\$ 10,853	\$ 10,636	\$ 10,423	\$ 10,215
SO2	\$ 46	\$ 46	\$ 46	\$ 46	\$ 46	\$ 45	\$ 44	\$ 43	\$ 42	\$ 41	\$ 41	\$ 40	\$ 39
CO2	\$ 17,642	\$ 17,593	\$ 17,835	\$ 17,770	\$ 17,700	\$ 17,626	\$ 17,548	\$ 17,465	\$ 17,379	\$ 17,290	\$ 17,450	\$ 17,349	\$ 17,245
PM 2.5	\$ 12,594	\$ 12,537	\$ 12,482	\$ 12,428	\$ 12,373	\$ 12,126	\$ 11,883	\$ 11,646	\$ 11,413	\$ 11,184	\$ 10,961	\$ 10,741	\$ 10,527
Probability-Adjusted Carbon Emissions Benefits	\$ 17,642	\$ 17,593	\$ 17,835	\$ 17,770	\$ 17,700	\$ 17,626	\$ 17,548	\$ 17,465	\$ 17,379	\$ 17,290	\$ 17,450	\$ 17,349	\$ 17,245
Probability-Adjusted Non-Carbon Emissions Benefits	\$ 24,722	\$ 24,635	\$ 24,546	\$ 24,454	\$ 24,425	\$ 23,937	\$ 23,458	\$ 22,989	\$ 22,529	\$ 22,079	\$ 21,637	\$ 21,204	\$ 20,780

14 2039	15 2040	16 2041	17 2042	18 2043	19 2044	20 2045
644	644	644	644	644	644	644
10%	10%	10%	10%	10%	10%	10%
64.4	64.4	64.4	64.4	64.4	64.4	64.4
8	8	8	8	8	8	8
188048	188048	188048	188048	188048	188048	188048
4701	4701	4701	4701	4701	4701	4701
40	40	40	40	40	40	40
\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438	\$150,438
\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885	\$174,885
0.73	0.73	0.73	0.73	0.73	0.73	0.73
0.00	0.00	0.00	0.00	0.00	0.00	0.00
315.83	315.83	315.83	315.83	315.83	315.83	315.83
0.02	0.02	0.02	0.02	0.02	0.02	0.02
\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282	\$ 13,282
\$ 51	\$ 51	\$ 51	\$ 51	\$ 51	\$ 51	\$ 51
\$ 22,740	\$ 23,056	\$ 23,372	\$ 23,687	\$ 24,319	\$ 24,635	\$ 24,951
\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688	\$ 13,688
\$ 22,740	\$ 23,056	\$ 23,372	\$ 23,687	\$ 24,319	\$ 24,635	\$ 24,951
\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022	\$ 27,022
0.75	0.74	0.72	0.71	0.70	0.68	0.67
0.55	0.54	0.53	0.52	0.51	0.50	0.49
0.00	0.00	0.00	0.00	0.00	0.00	0.00
238.02	233.26	228.60	224.03	219.55	215.15	210.85
0.01	0.01	0.01	0.01	0.01	0.01	0.01
\$ 10,010	\$ 9,810	\$ 9,614	\$ 9,422	\$ 9,233	\$ 9,048	\$ 8,867
\$ 38	\$ 38	\$ 37	\$ 36	\$ 35	\$ 35	\$ 34
\$ 17,138	\$ 17,028	\$ 16,916	\$ 16,802	\$ 16,905	\$ 16,782	\$ 16,657
\$ 10,316	\$ 10,110	\$ 9,908	\$ 9,709	\$ 9,515	\$ 9,325	\$ 9,138
\$ 17,138	\$ 17,028	\$ 16,916	\$ 16,802	\$ 16,905	\$ 16,782	\$ 16,657
\$ 20,365	\$ 19,957	\$ 19,558	\$ 19,167	\$ 18,784	\$ 18,408	\$ 18,040

VMT and VHT Savings from Avoided Bridge Closure - 50 Year Storm Event

Year of Operation		2020	2021	2022	2023	2024	2025	1	2	3	4	5	6	7	8	9	10
								2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Probability of Storm Event Closure								0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
AADT								11500	11500	11500	11500	11500	11500	11500	11500	11500	11500
	truck share							0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056	0.056
	auto							10856	10856	10856	10856	10856	10856	10856	10856	10856	10856
	truck							644	644	644	644	644	644	644	644	644	644
	truck adjustment to net out already diverted truck traffic							90%	90%	90%	90%	90%	90%	90%	90%	90%	90%
Detour Length (miles)								8	8	8	8	8	8	8	8	8	8
Average detour route speed								40	40	40	40	40	40	40	40	40	40
Duration of detour (days)								110	110	110	110	110	110	110	110	110	110
Expected annual detour VMT								191,066	191,066	191,066	191,066	191,066	191,066	191,066	191,066	191,066	191,066
	auto							191,066	191,066	191,066	191,066	191,066	191,066	191,066	191,066	191,066	191,066
	truck							10,201	10,201	10,201	10,201	10,201	10,201	10,201	10,201	10,201	10,201
Expected annual detour VHT								4777	4777	4777	4777	4777	4777	4777	4777	4777	4777
	auto							4777	4777	4777	4777	4777	4777	4777	4777	4777	4777
	truck							255	255	255	255	255	255	255	255	255	255
Expected annual detour PHT								7977	7977	7977	7977	7977	7977	7977	7977	7977	7977
	auto							7977	7977	7977	7977	7977	7977	7977	7977	7977	7977
	truck							255	255	255	255	255	255	255	255	255	255

Assumptions

bridge would be closed for 110 days

detour is 8 miles

50 year storm has occurrence probability of 2 percent each year, independent of other years.

17 2042	18 2043	19 2044	20 2045
\$141,990	\$141,990	\$141,990	\$141,990
\$8,161	\$8,161	\$8,161	\$8,161

Expected Emergency Repair Cost from Storm Event Closure

Year of Operation	1	2	3	4	5	6	7	8	9	10	11	12	13
	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
No Build	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407	\$16,099,407
probability of closure	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
expected value of repair cost from storm event	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988	\$321,988

assumption
 Emergency repair = three times the build project cost

17	18	19	20
2042	2043	2044	2045

\$ 85,980	\$ 85,980	\$ 85,980	\$ 85,980
\$ 9,589	\$ 9,589	\$ 9,589	\$ 9,589

Value of VOC Savings from Avoided Bridge Closure - 50 Year Storm Event

Year of Operation													1	2	3	4	5	6	7	8	9	10	11	12
	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037						
Reduced Tons																								
Auto																								
Oxides of Nitrogen (NOx)							0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.03	0.03	0.03						
Sulfur Dioxide (SO2)							0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
CO2 Equivalent							76.44	74.91	73.41	71.94	70.51	69.10	67.71	66.36	65.03	63.73	62.46	61.21						
PM2.5							0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
Truck (Blended Light and Heavy Truck)																								
Oxides of Nitrogen (NOx)							0.03	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02						
Sulfur Dioxide (SO2)							0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
CO2 Equivalent							15.48	15.18	14.87	14.57	14.28	14.00	13.72	13.44	13.17	12.91	12.65	12.40						
PM2.5							0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00						
Reduced \$ Per Ton																								
Auto																								
Oxides of Nitrogen (NOx)							\$ 686	\$ 684	\$ 682	\$ 681	\$ 678	\$ 680	\$ 666	\$ 653	\$ 640	\$ 627	\$ 615	\$ 602						
Sulfur Dioxide (SO2)							\$ 19	\$ 19	\$ 19	\$ 19	\$ 19	\$ 19	\$ 18	\$ 18	\$ 18	\$ 17	\$ 17	\$ 17						
CO2 Equivalent							\$ 4,281	\$ 4,270	\$ 4,258	\$ 4,317	\$ 4,301	\$ 4,284	\$ 4,266	\$ 4,247	\$ 4,227	\$ 4,206	\$ 4,185	\$ 4,223						
PM2.5							\$ 1,440	\$ 1,434	\$ 1,427	\$ 1,421	\$ 1,415	\$ 1,409	\$ 1,380	\$ 1,353	\$ 1,326	\$ 1,299	\$ 1,273	\$ 1,248						
Truck (Blended Light and Heavy Truck)																								
Oxides of Nitrogen (NOx)							\$ 426	\$ 425	\$ 424	\$ 422	\$ 423	\$ 415	\$ 406	\$ 398	\$ 390	\$ 383	\$ 375	\$ 367						
Sulfur Dioxide (SO2)							\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2						
CO2 Equivalent							\$ 883	\$ 880	\$ 892	\$ 889	\$ 886	\$ 882	\$ 878	\$ 874	\$ 869	\$ 865	\$ 873	\$ 868						
PM2.5							\$ 490	\$ 488	\$ 486	\$ 484	\$ 482	\$ 472	\$ 463	\$ 453	\$ 444	\$ 435	\$ 427	\$ 418						

13 2038	14 2039	15 2040	16 2041	17 2042	18 2043	19 2044	20 2045
0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
59.98	58.78	57.61	56.46	55.33	54.22	53.14	52.07
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12.15	11.91	11.67	11.44	11.21	10.98	10.76	10.55
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
\$ 590	\$ 578	\$ 567	\$ 556	\$ 544	\$ 534	\$ 523	\$ 512
\$ 16	\$ 16	\$ 16	\$ 15	\$ 15	\$ 15	\$ 14	\$ 14
\$ 4,199	\$ 4,174	\$ 4,148	\$ 4,121	\$ 4,094	\$ 4,067	\$ 4,091	\$ 4,062
\$ 1,223	\$ 1,198	\$ 1,174	\$ 1,151	\$ 1,128	\$ 1,105	\$ 1,083	\$ 1,062
\$ 360	\$ 353	\$ 346	\$ 339	\$ 332	\$ 325	\$ 319	\$ 313
\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2	\$ 2
\$ 863	\$ 857	\$ 852	\$ 846	\$ 841	\$ 846	\$ 840	\$ 833
\$ 410	\$ 402	\$ 394	\$ 386	\$ 378	\$ 370	\$ 363	\$ 356

Comprehensive BCA Look Up Table

	Source
Discount Rate	0.07 USDOT 2022 BCA Guidance (revised)
Discount Rate (Carbon Emissions)	0.03 USDOT 2022 BCA Guidance (revised)
Occupancy - Passenger vehicles all travel	1.67 USDOT 2022 BCA Guidance (revised)
Annualization factor	365 365
Annual probability of 50 year storm event	0.02
Vehicle operating cost per mile - light duty vehicles \$	0.45 USDOT 2022 BCA Guidance (revised)
Vehicle operating cost per mile - trucks \$	0.94 USDOT 2022 BCA Guidance (revised)
average cost of gasoline (2019\$, net of fuel taxes) \$	2.11 https://www.eia.gov/todayinenergy/detail.php?id=42435
average cost of diesel fuel (2019\$, net of fuel taxes) \$	2.00
Reduced Pavement Damage Cost	
Roadway maintenance cost/truck VMT \$	0.05 FHWA Comprehensive Truck Size and Weight Study, updated; Bai, et al, Estimating Highway Pavement Costs Attributed to Truck Traffic, 2009.

Emissions Tons per VMT				2025
Passenger Car				
Oxides of Nitrogen (NOx)	MOVES3	tons/VMT	Car (Gasoline)	2.18E-07
Sulfur Dioxide (SO2)	MOVES3	tons/VMT	Car (Gasoline)	2.20E-09
CO2 Equivalent	MOVES3	tons/VMT	Car (Gasoline)	4.00E-04
PM2.5	MOVES3	tons/VMT	Car (Gasoline)	9.40E-09
Light/Medium Truck				
Oxides of Nitrogen (NOx)	MOVES3	tons/VMT	Medium Duty Truck	1.07E-06
Sulfur Dioxide (SO2)	MOVES3	tons/VMT	Medium Duty Truck	3.50E-09
CO2 Equivalent	MOVES3	tons/VMT	Medium Duty Truck	1.36E-03
PM2.5	MOVES3	tons/VMT	Medium Duty Truck	3.41E-08
Heavy Truck				
Oxides of Nitrogen (NOx)	MOVES3	tons/VMT	Tractor Trailers	3.90E-06
Sulfur Dioxide (SO2)	MOVES3	tons/VMT	Tractor Trailers	5.50E-09
CO2 Equivalent	MOVES3	tons/VMT	Tractor Trailers	1.68E-03
PM2.5	MOVES3	tons/VMT	Tractor Trailers	8.39E-08

Emissions Costs Per Ton	Source	Unit	2021	2022	2023	2024	2025	2026
Nox	USDOT 2022 BCA Guidance	\$/Metric Ton	\$15,600	\$15,800	\$16,000	\$16,200	\$16,500	\$16,800
Sox	USDOT 2022 BCA Guidance	\$/Metric Ton	\$41,500	\$42,300	\$43,100	\$44,000	\$44,900	\$45,700
CO ₂	USDOT 2022 BCA Guidance	\$/Metric Ton	\$52	\$53	\$54	\$55	\$56	\$57
PM2.5	USDOT 2022 BCA Guidance	\$/Metric Ton	\$748,600	\$761,600	\$774,700	\$788,100	\$801,700	\$814,500

Value of Accidents KABCO Values (\$2019)	Source	Unit	2021	2022	2023	2024	2025	2026
No injury (PDO equivalent)	USDOT 2022 BCA Guidance	\$/Crash	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900
Possible Injury (=OK Severity 2)	USDOT 2022 BCA Guidance	\$/Crash	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200
Non-incapacitating Injury (=OK Severity 3)	USDOT 2022 BCA Guidance	\$/Crash	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100
Incapacitating Injury (=OK Severity 4)	USDOT 2022 BCA Guidance	\$/Crash	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800
Fatal	USDOT 2022 BCA Guidance	\$/Crash	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000

Hourly Value of Time (\$2019)	2021	2022	2023	2024	2025	2026

	Passengers (All Purposes)	USDOT 2022 BCA Guidance	\$	17.80	\$	17.80	\$	17.80	\$	17.80	\$	17.80
	Truck Drivers	USDOT 2022 BCA Guidance	\$	32.00	\$	32.00	\$	32.00	\$	32.00	\$	32.00
	Truck VOC per truck mile	USDOT 2022 BCA Guidance	\$	0.94	\$	0.93	\$	0.93	\$	0.93	\$	0.93
GDP Price Deflators												
		1.00745										

Emissions (Metric Tons) per VMT:

Mode	PM 2.5	SO2	VOCs	NOx	CO2
Passenger Car	9.40E-09	2.20E-09	2.23E-07	2.18E-07	4.00E-04
Light/Medium Truck	3.41E-08	3.50E-09	2.60E-07	1.07E-06	1.36E-03
Heavy Truck	8.39E-08	5.50E-09	1.83E-07	3.90E-06	1.68E-03

2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
\$17,100	\$17,400	\$17,700	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100
\$46,500	\$47,300	\$48,200	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100
\$58	\$60	\$61	\$62	\$63	\$64	\$65	\$66	\$67	\$69	\$70	\$71	\$72	\$73	\$74	\$75
\$827,400	\$840,600	\$854,000	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600

2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900
\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200
\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100
\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800
\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000

2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
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2043	2044	2045	2046	2047	2048	2049	2050
\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100	\$18,100
\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100	\$49,100
\$77	\$78	\$79	\$80	\$81	\$82	\$84	\$85
\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600	\$867,600

2043	2044	2045	2046	2047	2048	2049	2050	2051	2052
\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900	\$3,900
\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200	\$77,200
\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100	\$151,100
\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800	\$554,800
\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000	\$11,600,000

2043	2044	2045	2046	2047	2048	2049	2050	2051	2052
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₹ -

Metric tons of avoided pollutants - cumulative (2026-2045)

Pollutant	Structurally Deficient Impact	Storm Closure	Total
Oxides of Nitrogen (NOx)	11.95	1.11	13.06
Sulfur Dioxide (SO2)	0.02	0.01	0.02
CO2 Equivalent	5144.01	1527.74	6671.75
PM2.5	0.26	0.04	0.30