Appendix: Benefit-Cost Analysis

Executive Overview

This Benefit-Cost Analysis was completed for the Connecting Toledo Neighborhoods to Opportunity (CTNO) project and follows methods established by the U.S. Department of Transportation's (USDOT's) Benefit-Cost Analysis Guidance for Discretionary Grant Programs (January 2023) and the National Cooperative Highway Research Program (NCHRP) in their Report 552: Guidelines for Analysis of Investments in Bicycle Facilities (2006). Benefits for this project were considered as improvements to 7 categories: recreation and amenities, decreased auto use, time savings and bus stops, environmental benefits, health benefits, mobility, and safety benefits. The results in this summary are based on the prescribed discount rate of 7% and a proposed lifetime of 20 years for the project beginning in 2032.

Table 1 below is a summary of the results of this analysis. Under the conservative assumptions made, the proposed project would provide an estimated Net Present Value Benefit of $183,940,955. As stated in the guidelines, the present value of maintenance costs is subtracted from the present value of benefits. Only the present value of capital costs is reported in costs. This is a benefit-to-cost ratio of 5.62:1. Sensitivity analysis conducted on these results proved them to be robust and reasonably conservative.

Table 1: Net Present Value Benefits with 7% Discount Rate

Present Value of Benefits	Present Value of Capital Costs	Net Present Benefits	Benefit to Cost Ratio
$183,940,955	$32,703,296	$151,237,659	5.62

Project Costs

Cost Estimates for the construction of the project were provided by the City of Toledo. Table 2 is a summary of project costs. The complete list and the Present Value (PV) calculations are available in the accompanying data files. All costs were calculated considering four different stages of construction between 2026 and 2031 on an average annual basis and discounted at a rate of 7% to obtain the Present Value (PV) of costs. Estimates given by the City of Toledo include only the construction costs. Literature suggests that the maintenance costs are typically between 1%-3% of the total cost of the project. Maintenance costs are estimated by calculating 1% of total project costs and converting this estimate on an annual basis. This estimate yields an annual maintenance cost of $26,457.01, which we feel is a reasonable estimate.

Table 2: Present Value of Costs with 7% Discount Rate

Category	Timeframe	Nominal Annual Average	Total Present Value
Construction	2026-2031	$8,819,004.17	$32,703,296.23
Maintenance	2032-2051	$26,457.01	$142,483.17

Project Benefits

To begin measuring benefits, we first forecasted the demand for this path using the Benefit-Cost Analysis of Bicycle Facilities tool developed by the NCHRP and the University of Minnesota[1]. Using data from the U.S. Census, NCHRP estimates demand for bicycle facilities in three possible scenarios. The "low" scenario represents the bare minimum expectation for demand, which we do not believe is appropriate for this analysis. Given the centrality of the city of Toledo in this project, we believe that the "medium" estimates are the best representation of anticipated demand. We did not use the "high" estimates because we wish to establish a conservative estimation of the expected benefits.

Using current GIS[2] and U.S. Census 2020 data,[3] we obtained estimates of 7,746 existing cyclists, with 125 of those being commuters. With the installation of a multi-use path along Dorr Street, we expect 2,510 new cyclists, with 33 of them being new commuters. With an estimated number of users for the new bike lanes, we followed the precedent of Report 552 in measuring benefits.

Below we discuss the methods used to quantify each category of benefits. A summary of the findings can be found in Table 5 at the end of this section. Note that the amounts listed in this section are annual benefits for the life of the project. The discounted total PV of benefits can be found in the executive summary, and intermediate calculations can be found in the accompanying data file.

- ### Recreation and Amenities

  To obtain a figure for recreation benefits, the estimated number of total new cyclists, minus new commuters, was multiplied by the estimated value of outdoor recreation. NCHRP compiled a wide

[1] http://www.pedbikeinfo.org/bikecost_x/ Input parameters: Toledo OH, 2024, Off-Street Bicycle Trail, 0.7%, Residential Density 800 m: 895, 800 m – 1600 m: 3903, 1600 m- 2400 m: 4982, Facility Length: 2575 meters.
[2] Geographic Information System Mapping data provided by Toledo Metropolitan Area Council of Governments. ()
[3] 2020 United States Census for Metropolitan Area of Toledo, OH

variety of studies on valuing outdoor recreational activities and generated a typical value of $10/hour in 2004 dollars. NCHRP defines a "typical" day involves about one hour of bike riding. After adjusting to 2021 dollars, which is $14,00 per cyclist per day in benefits. The results of these calculations are presented in Table 3 below.

The above calculations are based solely on recreational benefits to cyclists and do not capture the benefits this shared-use path will have for pedestrians. There has been little research done in directly quantifying the value of recreation benefits this project would provide to pedestrians. However, there is abundant literature describing the immense benefits that have resulted from past projects. This project focuses on making walking within the neighborhood easier by updating sidewalks and pedestrian crosswalks and installing new streetlights. Pedestrian amenities upgrades include increased art, benches, seating, lighting, and street planters. There are pedestrian benefits brought by trees that can make an urban area more visually pleasing. A study looking at the U.S. top thirty metro areas concluded that walkability, economic activity, and educational attainment are all positively associated with each other[4]. It is our belief that the recreational benefits of this project go far beyond the scope of the bicycle facilities tool utilized here. According to Report 552, recreational walking is ten times as common as biking. Additionally, we believe that the unique characteristics of this project and its focus on walkability will attract far more pedestrian use than cyclists. A similar cost-benefit analysis done for the Toledo Metroparks estimated pedestrian benefits by doubling the benefits cyclist received[5]. This project creates a similar bike trail, and with an emphasis on walkability and other pedestrian benefits within the neighborhood, we believe the doubling of benefits is a fair assumption. For these reasons, we believe that a very conservative estimate for pedestrian benefits would be double the benefits to cyclists. See the results below in Table 3.

Table 3: Annual Recreations Benefits for Cyclists and Pedestrians

Cyclists	Pedestrians	Total
$10,547,040	$21,094,080	**$31,641,120**

- ## Decreased Auto Use

Decreased Auto Use benefits encompass benefits from reduced congestion and user cost savings. Pollution reduction is considered in an upcoming section and omitted from consideration here. Following the guidance of NCHRP Report 552, we assume that the 33 new bicycle commuters were previously driving to work and that they work five days a week, 50 weeks a year. According to the Brookings Institute, the average commute in Toledo is 6 miles[6]. Finally, NCHRP estimates a savings of

[4] Loh, Tracy Hadden, and Christopher Leinberger. *Foot Traffic Ahead: Ranking Walkable Urbanism in Americas Largest Metros*. George Washington University School of Business. Available at: https://cpb-us-e1.wpmucdn.com/blogs.gwu.edu/dist/a/326/files/2019/06/FTA19.pdf

[5] *Glass City Riverwalk*. Appendix B. Submitted May 18, 2020

[6] Kneebone, Elizabeth, and Natalie Holmes. The growing distance between people and jobs in Metropolitan America. Brookings Metropolitan Policy Program. March 2013. Available at: http://www.brookings.edu/~/media/research/files/reports/2015/03/24-job-proximity/srvy_jobsproximity.pdf

$0.13 per mile in urban areas for congestion and user costs. In the figure below, you can see that this, adjusted to $2021, produced an estimated savings of $8,494.20 annually.

$$33\ commuters * \$0.13/mile * 6\ miles * 250\ days * 1.32 = \$8,494.20$$

- ## Time Saving and Bus Stops

Following the Guidelines from the United States Department of Transportations (USDOT) Benefit Cost Guidance, the value of time-saving is measured as a product of the value of time, change in trip time, and affected trips. This project focuses on improving mass transit infrastructure to connect residents to job opportunities, social services, and other opportunities within the community. To reduce time traveling, CTNO will update a bus stop and make it a "mobility hub" with an elevated floor to allow for more efficient boarding and deboarding, and provide bike shelters, so passengers can connect between the bike lanes and the bus lines. With these upgraded benefits, and the proximity to the transit center and downtown, we believe that it is reasonable to assume an estimated time saving of 5 minutes per bus user. If 17 commuters take advantage of the bike shelters in the mobility hub to connect with the one bus route serving that stop Monday through Friday (1 for each time the bus stops at the hub), we have 4250 trips affected annually, saving 21,250 minutes. Following USDOT's guidelines, we use a monetary value of $18.80 for an all-purpose trip, as seen in Table A-3 in the Appendix of their updated BCA guidelines[7]. It should be noted that there are other bus routes that pass through our area of study, and there are bus routes that take place Saturday and Sunday that are not considered. Not all trips will see time savings benefits, and because of uncertainty with our time-saving estimate, we believe that it is best to limit the affected trips to keep our estimates conservative. This process produces an annual benefit of $6,658.33 annually.

$$50\ weeks * 5\ days * 17\ commuters * 5\ minutes = 354,17\ hours * \$18.80\ /hour = \$6,658.33$$

- ## Environmental Benefits

To measure environmental impacts, we focus on two principal areas of benefits: reduction in air pollution and additional trees. To measure the effects of reduced air pollution, this part of the analysis relies on estimates from NCHRP Report 552, estimates of vehicle emission rate from the Bureau of Transportation Statistics, and average carbon dioxide emission per vehicle from the U.S. Environmental Protection Agency (EPA). Following the previous assumptions made with new bike commuters, the average vehicle releases 4.6 metric tons/year of carbon dioxide[8], .008g/mile of PM2.5, and .192g/mile of NOx[9]. Following the updated guidance on the monetization of these pollutants, as seen in Table A-6 of the Appendix of USDOT Benefit-Cost Analysis Guidance for

[7] Benefit Cost Analysis Guidance for Discretionary Grant Programs January 2020, U.S. Department of Transportation. Appendix A: Recommended Parameter Values

[8] U.S EPA. Greenhouse Gas Emissions from a Typical Passenger Vehicle. Available at: https://www.epa.gov/greenvehicles/greenhouse-gas-emissions-typical-passenger-vehicle

[9] U.S DOT. Bureau of Transportation Statistics. Available at: https://www.bts.gov/content/estimated-national-average-vehicle-emissions-rates-vehicle-vehicle-type-using-gasoline-and

Discretionary Grant Programs[10], the average annual benefit of reduced air pollution is $12,100.57. Discount rates follow as recommended by USDOT as 3% for carbon dioxide and 7% for the other pollutants. It should be noted that the monetization of each pollutant is not stationary every year, so the average annual benefit is taken by aggregating every year's estimated benefit and dividing it by the number of years of received benefits. Estimations are available in the accompanying data file.

In addition, 1068 new trees will be planted along the streets in this project. The city of Toledo uses a Combined Sewage Overflow (CSO) system to discharge heavy rains into the regional water networks. A CSO event is when combined raw sewage and stormwater collection is discharged into the surrounding rivers. There has been literature to estimate the benefits trees have in an urban setting by avoiding runoff from such episodes. More recently, The U.S. Forestry has devoted time to estimate these benefits more accurately. I-tree calculators have been developed to give more precise estimates, like the ones used in this report. Below are the estimated benefits from trees, as calculated with a formula developed by the U.S. Forest Service[11].

Table 4: Annual Environmental Benefits

Reduced Air Pollution	Trees	Total
$12,100.57	$44,821.86	**$56,922.43**

- ## Health Benefits

Health benefits are measured in reduced healthcare costs caused by the increase in physical activity associated with the new cyclists. NCHRP researched ten studies on the effects of physical activity on healthcare costs and determined a median value of $128 annually per capita. Multiplying the expected number of new cyclists (2,097) by the value of $128 and adjusting to 2021 dollars results in annual benefits of $354,309.12. It is worth noting pedestrians' health benefits would also increase and positively affect this category but are not considered.

$$\mathbf{2,097}\ \boldsymbol{new\ cyclist} * \mathbf{\$128} * \mathbf{1.32} = \mathbf{\$354,309.12}$$

The project also includes the replacement of water and sanitary sewer lines under the roads that will be reconstructed. Such systems are currently around 150 years old, and replacing them with new ones prevents the risk of failure that could bring damage to people's health and the environment. According to a report from the WHO assessing the cost-benefit of water and sanitation interventions for the AMR-A subregion that includes Canada, Cuba, and the United States of America, an intervention that provides everyone with access to a regulated piped water supply & sewage connection in their houses would bring USD 235 million in economic benefits, given health

[10] Benefit Cost Analysis Guidance for Discretionary Grant Programs March 2022, U.S. Department of Transportation. Appendix A: Recommended Parameter Values. Table A-6

[11] https://planting.itreetools.org/. Input Parameters: Elm Tree, 20-year Project life, 10% mortality, 1068 trees, electricity emission factor, 807.8 kg, fuel emission factor, 92.61 kg, DBH 5 in, Distance to nearest building 20-39 feet.

and non-health benefits[12]. We did not add this estimation to our benefits because the project simply guarantees the continuity of a service already provided, but we find it worth noting the importance of investing in such renovations.

- ## Mobility

Mobility describes the benefits associated with bicycle mobility improvement. NCHRP Report 552 finds that bicycle commuters are willing to spend 20.38 extra minutes traveling on an off-street bicycle trail and 18.02 min for an on-street bicycle lane without parking, such as the ones in the project when the alternative is riding on a street with parked cars. Using an average value of $12/hour to value time, report 552 finds a benefit of $4.08 per trip on the off-street lane and $3.60 per trip on an on-street lane.[13] By getting a weighted average by the proportion of on-street/off-street lanes in the project, we get a $4.04 benefit per trip within the study area. Multiplying that for the assumed number of trips for all bicycle commuters and adjusting to $2021, the annual benefit is $421,291.20.

$$(125 + 33)\boldsymbol{commuters} * 4.04\ /\boldsymbol{trip} * 50\ \boldsymbol{weeks} * 5\ \boldsymbol{days} * 2\ \boldsymbol{trips} * 1.32 = \$421,291.20$$

- ## Safety Benefits

This category measures the benefits gained from a reduction in cyclist and pedestrian injuries and fatalities. This project calls for both an off-street bicycle lane as well as improvement in sidewalk conditions in the neighborhood streets and additional lighting. In addition to pedestrian and bicycle safety, several on-road and off-road improvements to make traffic safer. This project will add medians, on-street parking with bump outs, as well as upgraded road conditions to make intersections safer.

To measure these benefits, we utilized data from the Ohio Department of Transportation's (ODOT's) GCAT Crash Analysis Tool for the city of Toledo[14]. USDOT's guidance is to use a timeframe of 3 to 7 years for this data. We chose to use the five most recent years (2017-2021) with data available to capture the accident reduction the project expects to bring. For pedestrians, bicyclists, and vehicle safety, we measure the number of accidents occurring within the study area of this project to predict accident reduction or avoidance.

To measure the value of avoided injuries and fatalities, we followed USDOT's Benefit-Cost Analysis Guidance[15]. Per the guidelines, injuries were associated with severities on the KABCO scale and monetized with values from Table A-1 in Appendix A. To assume a 100% reduction in accidents does not seem reasonable, so we used a Crash Modification Factor (CMF) of 0.73, equating to a 27% reduction in crashes. We used a dominant CMF method to determine an appropriate measurement.

[12] https://apps.who.int/iris/bitstream/handle/10665/68568/WHO_SDE_WSH_04.04.pdf, page 63, Table A 2.18.
[13] https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_552.pdf, p. 39
[14] GCAT data provided by the Toledo Metropolitan Area Council of Governments
[15] Benefit Cost Analysis Guidance for Discretionary Grant Programs March 2022, U.S. Department of Transportation. Appendix A: Recommended Parameter Values

The CMF used measures an added bike lane[16]. The project does more, but a dominant method keeps CMF from compounding and keeps estimates conservative. We believe there are some overlaps between all our CMFs, so this seems to be the most appropriate CMF available to estimate the expected reduction.

This process yielded an estimate of $1,485,526.50 in annual benefits from prevented crashes in the study area. It is reasonable to assume that bicycle commuters can also come from areas outside the area of study, for which accidents are not included in the benefits in this section. Those accidents in the immediate area are not considered. These estimates are conservative compared to the actual impact of accident reduction.

Additional lighting in the streets also brings benefits in terms of reduced crimes. According to a report from the University of Chicago Urban Lab, a study conducted in New York City showed evidence for a reduction in "index crimes" due to improved lighting in the streets and neighborhoods.[17] The study estimates a reduction of 4% in serious offenses per year, considering a constant benefit from the improvements over the years. The City of Toledo provided the number of index crimes in the study area for 2022. Using these numbers of such index crimes in the study area for 2022 and the values associated with each offense provided by the Urban Lab study, we found a total of $177,612.06 (in 2021 real dollars) in benefits for avoided crime in the region. We add that total to the safety benefits in the summary below:

Table 5: Summary of Annual Benefits

Recreation	$31,641,120.00
Decreased Auto Use	$8,494.20
Time Saving	$6,658.33
Environmental	$56,922.43
Health	$354,309.12
Mobility	$421,291.20
Safety	$1,663,138.56
Total	**$34,151,933.84**

- ## Qualitative Benefits

The overarching goal of this project is the creation of equitable economic and social opportunities in disadvantaged communities that have been historically marginalized and located in the proximity of the study area. According to the U.S. Census Bureau, in 2021, the Median Household Income of the study area, mainly covered by census tract 27, was $21,982, and 49.3% of the population was in a

[16] http://www.cmfclearinghouse.org using the Countermeasure: Install Bicycle Lane (CMF ID: 7839)
[17] Uchicago urban Labs, 2019
https://urbanlabs.uchicago.edu/attachments/e95d751f7d91d0bcfeb209ddf6adcb4296868c12/store/cca92342e666b1ffb1c15be63b484e9b9687b57249dce44ad55ea92b1ec0/lights_04242016.pdf

poverty situation.[18] This project will provide improved access to facilities and job opportunities for these neighborhoods as well as social and recreational benefits. This project hopes to make an impact with the flow of overall benefits on a community that has been marginalized, underserved and overburdened by economic and social issues. When we investigate the spatial distribution of demographic indicators, the highest percentiles of the population living two times below the poverty level are mostly near the study area. Consequently, we expect that this project will help alleviate some past and present issues that have negatively affected the community.

Other qualitative benefits that come from this project include new parking kiosks to make street parking more efficient, new art, and economic benefits to the community. In the project area, new economic development is springing. This includes the Windsor project, which is expected to bring 120 mixed-income workforce housing to the area. Bitwise anticipates this project will bring 378 new jobs to the area with an estimated payroll of around twenty million dollars. Bitwise predicts this will bring an additional 4.3 jobs to every created one. These benefits are not appropriate to report in our BCA but should be noted as these jobs typically go to historically disenfranchised individuals in the community.

These benefits are not easily quantifiable but have an important impact on our analysis. These qualitative benefits should be considered in addition to the quantitative benefits estimated above. This project focuses on the connectivity and accessibility of communities and the arts; therefore, the quantitative benefits underestimate the true benefits of this project.

Sensitivity Analysis

Several major assumptions were made in this analysis to reach these conclusions. It is our belief that our assumptions were all very conservative and represents a reasonable assessment of the expected Net Benefits. This section will briefly discuss some of the major assumptions made and how realistic changes in these parameters would affect calculations. Then, we will present the effects of these proposed changes in Table 5. Our focus in this section will be these areas of benefits: Recreation, Time Saving, and Safety, as well as construction costs in our Costs sections.

In the area of recreation benefits, there are two major assumptions we will assess. The first is the use of the medium scenario of projected demand and not the low or high scenarios. The high scenario of demand estimates 3,109 new cyclists adding to 11,545 existing. Obviously, this is a significant difference and, thus, a highly influential factor in the analysis. We believe that the high-demand scenario is reasonable. The bicycle path reaches close enough to the University of Toledo, with the neighborhood of study close to downtown Toledo, high demand is very realistic. To keep our estimates conservative, we deferred the high-demand scenario to the sensitivity analysis. We hold that the low scenario is not a reasonable parameter for this analysis for the reasons listed previously.

Another area of uncertainty in the recreation category is the measurement of pedestrian benefits. We believe the proposed doubling of cyclist benefits is very conservative, but for this sensitivity analysis, we will consider the scenario that the benefits are equal (an absolute minimum, in our opinion).

In Time Savings, we assumed that the total value of time saved was 5 minutes per bus stop. In this part of the sensitivity analysis, we will assume the time saved value is 1.5 minutes. We believe that 5 minutes

[18] https://data.census.gov/profile/Census_Tract_27,_Lucas_County,_Ohio?g=1400000US39095002700

in time saved for the aggregated bus stops could be unrealistic, but because of the uncertainty of this estimate, we have decided to present it to further display the benefits of this project.

Next is Safety. The assumption we made about CMF of .73 was very conservative, which was the goal of this analysis. We used a dominant CMF, where the lowest CMF is chosen. The other appropriate method is the dominant common residuals, where all countermeasures are multiplied together and raised to the lowest CMF. This produces an exceptionally low CMF, and more research needs to be done on combining more than two countermeasures. Because of this, we will assume a crash reduction of 50% to show an appropriate balance.

We also considered changes to costs. A 2002 paper entitled "Cost Underestimation in Public Work Projects: Error or Lie?" found that 9 out of 10 transportation infrastructure projects underestimate costs[19]. More specifically, this paper estimates that the median road project actual costs are 20% higher than projected. The costs that are estimated for CTNO already have a contingency buffer of 10%, so we consider an additional 10% increase in construction costs. It should be noted that even considering a full 20%, this project still brings projected Net Benefits of 4:1.

The last point of consideration in this section is the real discount rate. Given that costs for this project are incurred sooner than benefits, the effects of the discount rate are disproportionate. To illustrate how a change in the real discount rate might affect this analysis, we consider a 2% change in either direction from the prescribed 7% in the analysis. It should be noted that the literature supports a 5% discount rate and that 9% is considered outside of the reasonable range. We consider it here only to illustrate the effects of changes in the discount rate. In addition, the carbon dioxide recommended discount rate of 3% is honored in these sensitivity cases and does not change. The results of this sensitivity analysis are reported on the following page.

Table 6: Results of Sensitivity Analysis

Proposed Change	New NPV of Benefits	Change
Baseline, no change	$183,940,955	$0
High Scenario of Demand	$268,411,606.96	$84,470,651.86
Low Pedestrian Rec. Benefits	$127,140,297	-$56,800,658
Low Time Saved Benefits	$183,915,854.37	-$25,100.73
50% Reduction in Crashes	$190,755,976.92	$6,815,021.83
Construction Costs 10% Greater	$183,926,706.78	-$14,248.32

[19] Flyvbjerg, Bent, Mette Holme, Soren Buhl. *Costs Underestimation in Public Work Projects: Error or Lie?* Available at: https://www.waterboards.ca.gov/waterrights/water_issues/programs/bay_delta/california_waterfix/exhibits/docs/STCDA%20et%20al/part2/scda_212.pdf

5% Real Discount Rate	$261,184,858.77	$77,243,903.67
9% Real Discount Rate	$131,786,733.43	-$52,154,221.67

The results of this sensitivity analysis determined that our initial findings are robust and conservative. Nearly all the reasonable changes resulted in significantly higher NPVs, and even under the most stringent parameter change, the expected NPV of benefits is still $131 million. That is a benefit-to-cost ratio of **4:1**. Taking into account that this project will renovate important sanitary infrastructure, increase safety, and benefit historically disadvantaged members of the community while showing great quantitative benefits, it is clearly beneficial to the city of Toledo and deserves public investments.