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1. Introduction

A benefit-cost analysis (BCA) was conducted for the East-West Passenger Rail Study, as part of an evaluation of proposed alternatives to expand rail service between Eastern and Western Massachusetts. The analysis was conducted in accordance with the benefit-cost methodology guidance described by the U.S. Department of Transportation (USDOT) in "BCA Guidance for Discretionary Grant Programs," released in January 2020.[1] This methodology is required for federal discretionary grant programs such as INFRA (Infrastructure for Rebuilding America), BUILD (Better Utilizing Investments to Leverage Development), and CRISI (Consolidated Rail Infrastructure and Safety Improvements).

1.1. BCA Framework

BCA is an evaluation framework to assess the economic advantages (benefits) and disadvantages (costs) of investment alternatives. Benefits and costs are broadly defined and are quantified in monetary terms to the extent possible. A BCA framework attempts to capture the net welfare change created by a project, including cost savings and increases in welfare (benefits), as well as disbenefits where costs can be identified (e.g., project capital costs), and welfare reductions where some groups are expected to be made worse off as a result of the proposed project.

The BCA framework involves defining a Base Case or "No Build" Case, which is compared to the "Build" Case, where the project is built as proposed. In the case of this project, three final alternative Build Cases are considered, described in Section 1.1.2.

The BCA assesses the incremental difference between the Base Case and each Build Alternative, which represents the net change in welfare. BCAs are forward-looking exercises which seek to assess the incremental change in welfare over a project lifecycle. The importance of future welfare changes is determined through discounting, which is meant to reflect both the opportunity cost of capital as well as the societal preference for the present.

1.2. Report Structure

Section 2 provides a description of the general assumptions used in the analysis, including more information on the Build and No-Build alternatives and the travel demand data underlying these scenarios. Section 3 describes the project alternatives' benefits and disbenefits and how these were monetized for the analysis. Section 4 presents the costs associated with the project alternatives. A summary of the results and key BCA indicators is presented in Section 5.

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[1] U.S. Department of Transportation, Benefit-Cost Analysis Guidance for Discretionary Grant Programs, January 2020, https://www.transportation.gov/sites/dot.gov/files/2020-01/benefit-cost-analysis-guidance-2020_0.pdf.

2. General Assumptions

Several common assumptions used throughout the BCA are described in this section.

2.1. Analysis Period

Though no project schedule is yet in place, the analysis period for this project assumes a 10-year design and construction period, from 2021 through 2030, during which capital expenditures are undertaken, plus 30 years of operations beyond project completion, from 2031-2060, during which benefits and operating and maintenance (O&M) costs accrue.

2.2. Dollar Values and Discounting

Dollar figures in this analysis are expressed in constant 2020 Dollars (2020$).

Values in this report are presented in undiscounted terms and in present value terms using a "discount rate." The discount rate is used in economic analysis to compare future benefits and costs to present values, and represents the fact that a dollar today is worth more than a dollar next year, and that public investments displace private investment. A real discount rate of 7 percent is used in this analysis. This represents the discount rate required for federal discretionary grant applications, per OMB Circular A-94, and reflects "the marginal pretax rate of return on an average investment in the private sector in recent years."[2]

2.3. Project Alternatives

1.1.1 Base Case

In the Base (No-Build) Case, current service along the corridor – consisting of 27 weekday roundtrips on MBTA's Worcester line, and 1 daily round-trip on Amtrak between Boston and Albany / Chicago – remains. Some pending projects are anticipated along the corridor and are included in the base case (and excluded from capital costs associated with any of the alternatives. These include Worcester Station improvements, South Station expansion, and Worcester triple tracking. No changes in East – West service are anticipated as part of the No-Build case.

1.1.2 Build Cases

The three final alternatives being considered enable expansion of passenger rail service between Eastern and Western Massachusetts. Each of these alternatives is described briefly below.

Alternative 3: Passenger Rail to Pittsfield with Upgrades to Existing Track would provide a new passenger service between Pittsfield, Chester, Springfield, Palmer, Worcester, and Boston along the existing rail corridor. Between Pittsfield and Springfield, this alternative would restore the missing

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[2] Office of Management and Budget, Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs, https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/circulars/A94/a094.pdf

double-track segment to increase maximum permitted speeds from 50 to 70 mph, with a maximum operating speed of 65 mph. This alternative would restore three missing double-track segments and install a new siding from between Springfield and Worcester. All trackage along this segment would be upgraded to a different classification/standard, thereby increasing maximum permitted speeds along most of the SPG-WOR segment from 60 to 80 mph, including some stretches where maximum permitted speeds would reach 90 mph. Maximum operating speeds between Springfield and Worcester would be 85 mph. Track and signal systems would be upgraded along the entire stretch of trackage from Pittsfield to Worcester. Between Worcester and Boston, this alternative assumes that strategic curve modifications would create two segments that transition from 80 to 90 mph maximum permitted speeds and that track class upgrades elsewhere along this segment would further increase average operating speeds, achieving a maximum operating speed of 85 mph.[3]

Alternative 4: Passenger Rail with New Track in Existing Alignment would offer a new passenger service between Pittsfield, Chester, Springfield, Palmer, Worcester, and Boston that relies on a new segment of exclusive track between Springfield and Worcester. The new track would provide reliability benefits and allow for higher maximum speeds by separating passenger trains from freight movements along a congested stretch of the CSX mainline. Instead of restoring three double-track segments and developing a new passing siding between Springfield and Worcester (Alternatives 1-3), Alternative 4 would implement a continuous stretch of new passenger track that would allow maximum permitted speeds to increase from a current limit of 60 to 110 mph between Springfield and Worcester, with a maximum operating speed of 100 mph along this segment. Infrastructure, maximum permitted and operating speeds, and travel times along the Pittsfield to Springfield and Worcester to Boston segments would be identical to Alternative 3.

Alternative 4/5 Hybrid: Passenger Rail with New Track in Existing Alignment and Priority Realignments would offer a new passenger service between Pittsfield, Chester, Springfield, Palmer, Worcester, and Boston that, like Alternative 4, relies on a new segment of exclusive track between Springfield and Worcester to separate passenger trains from freight movements along a congested stretch of the CSX mainline, thereby providing reliability benefits and increasing maximum permitted speeds relative to Alternative 3. This hybrid alternative would achieve the same maximum permitted speeds as Alternative 4; however, higher maximum operating speeds along portions of the SPG-WOR segment would increase to 105 mph due to Alternative 4/5's realignment of seven key segments, coupled with the consolidation of three existing at-grade crossings in Wilbraham into two overhead bridges. As with Alternative 4, infrastructure, anticipated speeds, and travel times along the Pittsfield to Springfield and Worcester to Boston segments would be identical to Alternative 3.

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[3] It is assumed that MBTA Commuter Rail would finance and undertake these improvements outside of the scope of this project.

For additional detail on the build alternatives, see Task 4 Preliminary Alternatives Draft Technical Memorandum, Section 4.

2.4. Demand Projections

Travel demand analysis was conducted for this study for the horizon year 2040. For more detail on this analysis, see Ridership Methodology Report. For each final alternative, there are two different ridership estimates – the Enhanced Hartford Line Proxy (HL) and the *Downeaster* Proxy (DE). The HL estimates are based on the NNEIRI model while also including New Haven as a larger market/station pair, and refinements to travel markets, market competition, trip distance, and market type. The DE estimates represent an approximation of the *Downeaster* service (Brunswick – Portland – Boston) with additional refinements related to market type and competition. Estimates for travel demand for years apart from the 2040 horizon year are interpolated based on forecast population and employment growth; the compound annual growth rate for ridership is assumed to be 0.32% across all alternatives.

New trips on rail represent a reduction of automobile vehicle miles traveled (VMT), resulting in lower vehicle operating costs, reduced pollutant emissions, and fewer car crashes. Counteracting the benefits of reduced auto trips, the corresponding increase in rail service is associated with higher rail emissions and crashes (and O&M costs, captured separately in section 4.2). The increase in rail miles traveled is based on the assumed number of daily roundtrips and the train route distance.

Table 1 shows the estimated change in rail passenger trips, train miles traveled, and automobile VMT for each final alternative, compared to the No-Build alternative. Note that the estimated rail passenger trips reported here are thus 4,885 passengers lower than those reported elsewhere, which do not subtract out the No-Build values.

Table 1. Change in Annual Trips and Vehicle Miles Traveled by Type, 2040

SCENARIO	Rail Passenger Trips	Train Miles Traveled	Automobile VMT
ALT. 3 - HL	272,980	509,540	23,371,876
ALT. 3 – DE	353,655	509,540	31,234,674
ALT. 4 - HL	343,954	798,620	29,497,986
ALT. 4 – DE	411,575	798,620	36,318,653
ALT. 4/5 – HL	385,962	785,845	33,042,389
ALT. 4/5 – DE	464,235	785,845	40,831,308

The changes in automobile and train miles traveled are used in the next section to quantify the build alternatives' benefits and disbenefits.

3. Project Benefits

The East-West Passenger Rail alternatives could all generate several benefits, including:

- Travel time savings for passengers that would no longer be subject to severe automobile congestion, and for existing rail travelers that would experience faster speeds.
- Emissions reductions, vehicle operating cost savings, and reduced pavement damage, as travelers shift from driving to rail.
- Enhanced safety as vehicle miles traveled reductions lead to fewer car crashes.
- Residual capital value remaining at the end of the analysis period.

These benefits would be slightly offset by disbenefits associated with additional train mileage, including rail-based emissions and collisions.

The net benefits associated with each build alternative, and the assumptions used to calculate their monetary values, are described in the sub-sections that follow,

3.1. Travel Time Savings

Travel time is considered a cost to users, and its value depends on the disutility that travelers attribute to time spent traveling. A reduction in travel time translates into more time available for work, leisure, or other activities.

Travel time savings for each alternative, shown in Table 2, reflect the difference between transit and auto travel times across different origin-destination pairs for new riders, as well as the difference between No-Build and Build Alternative travel times for existing riders, as generated as part of the travel demand analysis.

Table 2: Travel Time Savings Estimates, 2040

SCENARIO	Average Travel Time Savings per Rider (Minutes)	Total Annual Travel Time Savings (Hours)
ALT. 3 - HL	27.7	128,178
ALT. 3 – DE	22.6	134,910
ALT. 4 - HL	35.8	208,195
ALT. 4 – DE	30.9	214,542
ALT. 4/5 – HL	42.8	278,752
ALT. 4/5 – DE	37.8	295,829

Depending on trip purpose, the benefits of travel time savings may accrue to the traveler (personal travel, including commuting) or their employer (business travel). For personal travel, which is assumed to account for approximately 78.6% of trips,[4] the travel time savings is considered a user benefit. For intercity travel, personal travel time is valued at 70 percent of the national hourly median household income; per USDOT guidance, this is assumed to be $21.30 in 2018 dollars, or $21.96 in 2020 dollars. Employers tend to value time more highly than individuals, such that the value for business travel time savings is based on the national median hourly wage rate plus fringe benefits of 46%, bringing the value to $27.10 in 2018 dollars, equivalent to $28.11 in 2020 dollars.[5] Business travelers are assumed to make up 21.4% of all future E-W Passenger Rail trips.

The hourly travel time values and trip purpose shares are used alongside the annual travel time savings estimates shown in Table 2 to calculate the monetary value of travel time savings, presented in Table 3 in undiscounted terms and using a 7 percent discount rate.

Table 3: Cumulative Travel Time Savings Benefits, Millions of 2020 Dollars

SCENARIO	Undiscounted	Discounted, 7%
ALT. 3 - HL	$91.1	$18.9
ALT. 3 – DE	$95.9	$19.9
ALT. 4 - HL	$148.0	$30.6
ALT. 4 – DE	$152.5	$31.6
ALT. 4/5 – HL	$198.1	$41.0
ALT. 4/5 – DE	$210.3	$43.6

3.2. Vehicle Operating Cost Savings

The shift from automobile travel to rail travel reduces the costs associated with operating a vehicle, including fuel, maintenance, tire replacement, and vehicle depreciation. Estimates of automobile VMT reduction, described in Section 2.4, are multiplied by the USDOT recommended vehicle operating cost value of $0.42 per mile in 2020 dollars to arrive at the value of vehicle operating cost savings for each alternative. Corresponding increases in rail operating costs are included as a cost in Section 4.2, and are thus not calculated here. Table 4 shows the estimated vehicle operating cost savings for each build alternative in undiscounted terms and discounted using a 7 percent rate.

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[4] USDOT BCA Guidance, January 2020

[5] *Ibid.*

Table 4: Vehicle Operating Cost Savings Benefits, Millions of 2020 Dollars

SCENARIO	Undiscounted	Discounted, 7%
ALT. 3 - HL	$301.7	$62.5
ALT. 3 – DE	$403.1	$83.5
ALT. 4 - HL	$380.7	$78.9
ALT. 4 – DE	$468.8	$97.1
ALT. 4/5 – HL	$426.5	$88.3
ALT. 4/5 – DE	$527.0	$109.1

3.3. Pavement Damage Reduction

The reduction in vehicle miles traveled under the build alternatives also reduces the impact on the highway network in Massachusetts, resulting in less "wear and tear" on the system. This impact is quantified using an estimated cost of pavement damage per automobile VMT of $0.001.[6] The total benefits from reduced pavement damage, in undiscounted terms and discounted 7 percent, are contained in Table 5.

Table 5: Pavement Damage Reduction Benefits, Millions of 2020 Dollars

SCENARIO	Undiscounted	Discounted, 7%
ALT. 3 - HL	$0.6	$0.1
ALT. 3 – DE	$0.9	$0.2
ALT. 4 - HL	$0.9	$0.2
ALT. 4 – DE	$1.1	$0.2
ALT. 4/5 – HL	$1.1	$0.2
ALT. 4/5 – DE	$1.3	$0.3

[6] FHWA, Cost Allocation Study, 2000; reflects weighted average of rural and urban cost estimates, escalated to 2020 dollars.

3.4. Emissions

Passengers that shift from automobile to rail reduce the release of harmful emissions into the atmosphere. At the same time, the increase in diesel rail service results in an increase in emissions from rail. Across all final alternatives, the level of new rail emissions exceeds the level of displaced automobile emissions, resulting in a net increase in pollutant criteria emissions, which is considered a disbenefit. Higher ridership or more efficient trains than currently projected could reverse this pattern, such that the project would yield net emission reductions, rather than gains.

Emissions benefits/disbenefits are calculated based on the change in automobile and rail VMT between each build alternative and the baseline (see Section 2.4), estimated emissions per VMT, and costs per ton of emissions. Table 6 contains the default assumptions utilized in the calculations. The estimated changes in each type of emissions is shown by mode for each alternative in Table 7. The net change in emissions is presented in Table 8.

Table 6: Emissions Reduction Assumptions and Sources

Variable	*Unit*	*Value*	*Source*
Emissions per Automobile VMT	grams / VMT	Varies by year; for 2040: NOx - 0.0253 $PM_{2.5}$ - 0.0016 PM_{10} - 0.0018 SOX - 0.0012 VOC - 0.0031 CO_2 - 172.1970	MOVES 2014b
Emissions per Diesel Rail VMT	10^{-6}xUS Tons / VMT	NOX – 303.5 VOC - 14.63 SOX – 0.22 PM – 9.58 CO_2 – 0.025	Surface Transportation Board (STB), Draft Environmental Impact Statement regarding CN Acquisition of EJ&E, Appendix K "Air Quality and Climate Analysis" EPA Emissions Factors for Locomotives calculation
Cost of NOx	2020$ per short ton	$8,865	USDOT, BCA Guidance 2020
Cost of $PM_{2.5}$	2020$ per short ton	$399,234	USDOT, BCA Guidance 2020
Cost of SO_2	2020$ per short ton	$51,644	USDOT, BCA Guidance 2020
Cost of VOC	2020$ per short ton	$2,165	USDOT, BCA Guidance 2020
Cost of CO_2	2020$ per metric ton	$51 - $85 (2020-2050)	USDOT, FASTLANE Guidance 2016

Table 7: Change in Emissions by Mode

MODE	Auto	Auto	Auto	Auto	Auto	Rail	Rail	Rail	Rail	Rail
METRIC	NOX	PM	SOX	VOC	CO2	NOX	PM	SOX	VOC	CO2
ALT. 3 - HL	0.40	0.08	0.03	0.06	4,192	(154.65)	(4.88)	(0.11)	(7.45)	(12,625)
ALT. 3 – DE	0.54	0.11	0.04	0.09	5,602	(154.65)	(4.88)	(0.11)	(7.45)	(12,625)
ALT. 4 - HL	0.51	0.10	0.04	0.08	5,290	(242.38)	(7.65)	(0.18)	(11.68)	(19,787)
ALT. 4 – DE	0.63	0.13	0.05	0.10	6,514	(242.38)	(7.65)	(0.18)	(11.68)	(19,787)
ALT. 4/5 – HL	0.57	0.12	0.04	0.09	5,926	(238.50)	(7.53)	(0.17)	(11.50)	(19,471)
ALT. 4/5 – DE	0.70	0.14	0.05	0.11	7,323	(238.50)	(7.53)	(0.17)	(11.50)	(19,471)

Table 8: Net Change in Emissions

METRIC	NOX	PM	SOX	VOC	CO2
ALT. 3 - HL	(154.24)	(4.80)	(0.08)	(7.39)	(8,433)
ALT. 3 – DE	(154.11)	(4.77)	(0.07)	(7.37)	(7,023)
ALT. 4 - HL	(241.87)	(7.54)	(0.14)	(11.60)	(14,497)
ALT. 4 – DE	(241.76)	(7.52)	(0.13)	(11.58)	(13,274)
ALT. 4/5 – HL	(237.93)	(7.41)	(0.13)	(11.41)	(13,545)
ALT. 4/5 – DE	(237.80)	(7.38)	(0.12)	(11.38)	(12,148)

Table 9 shows the estimated value of net emissions reductions for build alternative in undiscounted terms and discounted using a 7 percent rate. Because in this case there is a net gain in emissions, the values are negative.

Table 9: Emissions Reduction Benefits, Millions of 2020 Dollars

	Undiscounted	Discounted, 7%
ALT. 3 - HL	($118.3)	($24.6)
ALT. 3 – DE	($114.5)	($23.9)
ALT. 4 - HL	($188.8)	($39.3)
ALT. 4 – DE	($185.5)	($38.7)
ALT. 4/5 – HL	($183.8)	($38.3)
ALT. 4/5 – DE	($180.1)	($37.5)

3.5. Safety

The reduction in automobile VMT described in Section 2.4 is expected to be accompanied by a corresponding reduction in vehicle collisions, based on average crash rates per 100 million VMT (shown in Table 10). At the same time, rail-involved collisions are expected to increase in proportion to the greater level of rail mileage. The net reduction in fatalities, injuries, and property damage only (PDO) crashes are multiplied by USDOT recommended values, escalated to 2020 dollars (see Table 10).

Table 10: Safety Benefits Assumptions and Sources

Variable	*Unit*	*Value*	*Source*
Passenger Car Crash Rate	crashes per 100 million VMT	439	BTS National Transportation Statistics, Table 2-21
Passenger Car Injury Rate	injuries per 100 million VMT	119.6	BTS National Transportation Statistics, Table 2-21
Passenger Car Fatality Rate	fatalities per 100 million VMT	1.1	BTS National Transportation Statistics, Table 2-21
Passenger Rail Crash Rate	crashes per 100 million VMT	32.8	BTS, National Transportation Statistics, Table 2-33

Variable	Unit	Value	Source
Passenger Rail Injury Rate	injuries per 100 million VMT	16.4	BTS, National Transportation Statistics, Table 2-33
Passenger Rail Fatality Rate	fatalities per 100 million VMT	5.5	BTS, National Transportation Statistics, Table 2-33
Cost of Property Damage	$2020 / vehicle	$4,536	USDOT BCA Guidance, January 2020
Cost of Injury	$2020 / injury	$258,322	USDOT BCA Guidance, January 2020
Cost of Fatality	$2020 / fatality	$10,964,356	USDOT BCA Guidance, January 2020

For each final build alternative, Table 11 shows the net value of the reduction in safety incidents in undiscounted term and in discounted terms using a 7 percent rate.

Table 11: Safety Benefits

SCENARIO	Undiscounted	Discounted, 7%
ALT. 3 - HL	$310.9	$64.4
ALT. 3 – DE	$418.8	$86.7
ALT. 4 - HL	$389.3	$80.6
ALT. 4 – DE	$482.9	$100.0
ALT. 4/5 – HL	$438.2	$90.7
ALT. 4/5 – DE	$545.1	$112.9

3.6. Residual Value

The new infrastructure developed as part of the build alternatives would be expected to last for approximately 40 years before major rehabilitation/replacement is required. As this asset life exceeds the 30-year operations period, a “residual value” is calculated to represent the remaining value of the project at the end of the analysis period. The residual value is calculated by assuming that the asset depreciates linearly over its life, such that at the end of 30 years, the project would still have 25 percent of its value remaining. This value is then discounted and included as a benefit. Table 12 shows the residual value for each alternative, undiscounted and using a 7 percent discount rate.

Table 12: Residual Value, Millions of 2020 Dollars

SCENARIO	Undiscounted	Discounted, 7%
ALT. 3	$603.5	$40.3
ALT. 4	$965.0	$64.4
ALT. 4/5	$1,156.3	$77.2

4. Project Costs

4.1. Capital Costs

Capital costs for the build alternatives include hard costs for construction of new tracks, stations, yards, road crossings, bridges, signaling and other required infrastructure, purchase of new vehicles, and soft costs such as planning and engineering, construction management, contingency, etc. For more detail on cost estimates, see Cost Estimates Methodology Report.

As no project schedule has yet been developed, the project team made assumptions about when costs would occur. Across all alternatives, spending is assumed to take place over 10 years, with property acquisition and design/engineering primarily taking place in earlier years, construction distributed somewhat evenly throughout, and vehicle purchases occurring near the end of the period (see Table 13).

Table 13: Assumed Distribution of Spending Across by Category over Time

YEAR	*Property Acquisition*	*Engineering*	*Construction*	*Vehicles*
2021	10.00%	10.00%	10%	0%
2022	40.00%	30.00%	15%	0%
2023	50.00%	24.00%	15%	0%
2024	0.00%	24.00%	15%	0%
2025	0.00%	2.00%	15%	0%
2026	0.00%	2.00%	15%	0%
2027	0.00%	2.00%	10%	0%
2028	0.00%	2.00%	5%	50%
2029	0.00%	2.00%	10%	50%
2030	0.00%	2.00%	15%	0%

Total project cost estimates for each final build alternative are shown in undiscounted 2020 dollars in Table 14, alongside discounted costs using a 7 percent rate.

Table 14: Capital Costs, Millions of 2020 Dollars

SCENARIO	Undiscounted	Discounted, 7%
ALT. 3	$2,413.9	$1,669.0
ALT. 4	$3,859.9	$2,677.7
ALT. 4/5	$4,625.3	$3,208.2

4.2. Operating and Maintenance Costs

Estimates of annual operating and maintenance (O&M) costs associated with running new service are presented in Table 15. These costs are assumed to take place in each year of the operations period, beginning in 2031 and lasting for 30 years. Baseline O&M costs are subtracted from the costs of each alternative to arrive at the net new O&M costs.

Table 15: Average Annual Operating and Maintenance Costs, Millions of 2020 Dollars

SCENARIO	Operating and Maintenance Costs
Baseline	$8.5
ALT. 3	$27.9
ALT. 4	$34.1
ALT. 4/5	$33.9

Table 16 shows the cumulative change in O&M costs over the analysis period for each build alternative in undiscounted terms and using a 7 percent discount rate.

Table 16: Cumulative Operating and Maintenance Costs, Millions of 2020 Dollars

SCENARIO	Undiscounted	Discounted, 7%
ALT. 3	$531.0	$111.7
ALT. 4	$768.0	$161.5
ALT. 4/5	$762.0	$160.2

5. Summary of Results

This analysis compares the benefits and costs of the East-West Passenger Rail, under three different build alternatives with two ridership scenarios each, to a baseline alternative in which no major infrastructure improvements or service enhancements are made. The following common benefit-cost evaluation measures are used to summarize the results:

- **Benefit Cost Ratio (BCR)**: The BCR is calculated by dividing the present value (meaning the value after discounting) of incremental benefits by the present value of incremental costs. A BCR greater than 1.0 indicates that project's benefits exceed its costs, while a BCR less than 1.0 signifies that the project's monetizable benefits fall short of its costs.

- **Net Present Value (NPV)**: NPV compares the net benefits (benefits minus costs) after being discounted to present values using the real discount rate assumption. The NPV provides a perspective on the overall dollar magnitude of cash flows over time in today's dollar terms.

A detailed summary of benefits, costs, and summary metrics can be found in Table 17 using a 7 percent discount factor, with the undiscounted values presented in Table 18. All the alternatives fall short of achieving a BCR above 1 or a positive NPV, suggesting the project's benefits may not merit the costs. Nevertheless, Alternative 3 performs most favorably across both ridership scenarios. Alternatives 4 and 4/5 perform similarly, suggesting that the higher costs associated with Alternative 4/5 may not be worthwhile relative to the incremental additional benefits.

Table 17: Summary of Benefit Cost Analysis (Discounted at 7%), Millions of 2020 Dollars

SCENARIO	Total Benefits	Total Costs	Benefit-Cost Ratio	Net Present Value
ALT. 3 - HL	$161.5	$1,780.6	0.09	($1,619.2)
ALT. 3 – DE	$206.6	$1,780.6	0.12	($1,574.0)
ALT. 4 - HL	$215.4	$2,839.2	0.08	($2,623.8)
ALT. 4 – DE	$254.6	$2,839.2	0.09	($2,584.5)
ALT. 4/5 – HL	$259.2	$3,368.4	0.08	($3,109.2)
ALT. 4/5 – DE	$305.5	$3,368.4	0.09	($3,062.9)

Table 18: Summary of Benefit Cost Analysis (Undiscounted) , Millions of 2020 Dollars

SCENARIO	Total Benefits	Total Costs	Benefit-Cost Ratio	Net Present Value
ALT. 3 - HL	$1,189.4	$2,944.9	0.40	($1,755.6)
ALT. 3 – DE	$1,407.6	$2,944.9	0.48	($1,537.4)
ALT. 4 - HL	$1,694.9	$4,627.9	0.37	($2,933.0)
ALT. 4 – DE	$1,884.6	$4,627.9	0.41	($2,743.3)
ALT. 4/5 – HL	$2,036.2	$5,387.3	0.38	($3,351.1)
ALT. 4/5 – DE	$2,259.8	$5,387.3	0.42	($3,127.5)