Paving the Way to a Sustainable Future: The City of Russell's Transportation Reconstruction Plan

Benefit Cost Analysis Project Technical Memo

USDOT 2022 RAISE Discretionary Transporation Grant Program

Benefit Cost Analysis Project Summary Matrix

Current Status/Baseline & Problem to be Addressed	Change to Baseline/ Alternatives	Type of Impacts	Population Affected by Impacts	Economic Benefit
Aging pavement Streets dangerous to travel for vehicles, and bicyclists slowing down traffic	Replace existing streets	Reduce wear and tear on vehicles, reduce travel time and make it safer for bicyclists	Number of drivers with reduced wait time & number of accidents & injuries per year	Monetized value of reduced travel times, emissions, and accident costs
Aging pavement or no pavement for Sidewalks, pedestrians walking in the streets, not all sidewalks are ADA Compliant	Replace existing sidewalks and add sidewalks where needed make sidewalks ADA Compliant	Improves accessibility to multimodal travel, jobs, and activity areas for all community members	Number of pedestrians able to walk in a safer environment	Pavement Repair Savings
Travel time delays due to timed cycle length of stop lights	Replace existing stop lights	Reduce Wait time for vehicles	Number of drivers with reduced wait time	Personal time saved
Pedestrian crossings inadequate on Main Street	Add curb extensions	Reduce crossing time for pedestrians and accessibility to multimodal travel, jobs, and activity areas for all community members	Number of pedestrians able to cross in a safer environment	Greater foot traffic into local businesses

Benefit Cost Analysis Summary of Benefits

	Option 1 <Build>	Option 2 <No Build>
Appraisal period (years)	20	20
Capital Costs	$22,421,112	$0
Whole of Life Costs	$22,650,522	$428,768,193
Cost-benefit analysis of monetary costs and benefits at the Public Sector Discount Rate		
Present Value of Benefits	$176,691,692	$17,462,510
Present Value of Costs	$17,945,228	$173,022,003
Benefit Cost Ratio	9.85	0.10
Net Present Value	$158,746,464	-$155,559,493

Assumptions and Methodology

A baseline of no build was compared to a build scenario. The baseline of no build assumed that repairs would be made each year using the average cost of repairs from 2017 to 2021 and dividing that by the total length of all streets to get a price per foot and multiplying that by the total length of the project. The benefits assumed in the baseline assumption, is the cost of not building the roadways and sidewalks. The cost of the baseline assumption was maintenance each year and travel time savings, accident savings and emission savings of the build scenario.

The build scenario assumed that repairs would take place in 2023 and 2024 until the project started in 2025. The cost of the project was split between seven years. The first two years, 2023 and 2024, the cost of the design engineering was calculated and then the cost of construction was split evenly between the next seven years. The build assumption included benefits of time savings and accident savings and emission savings.

Benefit-Cost Analysis Period

For this BCA, a 20-year period was used that starts in the year construction begins. This represents a period during which the long-term impacts can be confidently forecasted.

The initial costs of construction are applied over the years' that construction will take place. Construction is assumed to take up to seven years and start in 2025. Project benefits are assumed to take place in 2031 when the project has been completed.

It is expected that the service life of the major infrastructure elements will exceed the analysis period and as a conservative measure, a residual value has been calculated based on the service life of twenty-five years for the surface and forty years for the subbase and base.

All costs and benefits were estimated in year 2020 dollars and are based on the recommended values provided in the Benefit-Cost Analysis Guidance for Discretionary Grant Programs. A discount rate of 7 percent was applied to the calculated values to convert future year dollars into today's dollars without inflation and 3 percent for CO_2 emissions.

BCA Spreadsheet Format

Two different spread sheets were used in the Benefit Cost Analysis (BCA). The first BCA Spreadsheet is split into eight tabs: Summary, Residual Value, Yearly Cost of Repairs, Emissions, VTTS (Value of Travel Time Savings), Accidents, Accident break down and Accident Breakdown per year.

The summary tab ties five tabs together presenting the conclusion of the BCA. The residual value tab calculates the value the project will retain in twenty years. The yearly cost of repairs tab calculates the cost of repairs related to the baseline scenario. The emissions tab calculates the savings in carbon dioxide emissions. The value of travel time savings calculates the value of time saved by drivers. The accident tab calculates the value of accident savings, the accident breakdown tab breaks down the accidents by type and the breakdown per year tab breaks the accidents down by year.

The second spreadsheet compares a build scenario to a no build scenario, the baseline. The build scenario takes the cost of construction and compares it with the benefits of the value of travel time savings, the savings from accidents and savings of carbon dioxide emissions. The no build scenario uses the costs of repairs, the value of travel time savings, the savings from accidents and savings of carbon dioxide emissions as the cost and the cost of the construction of the build scenario as a benefit.

Residual Value

The calculation for the residual value to reconstruct the streets and sidewalks assumed that the preliminary engineering, removal of current pavement, engineering and the traffic signals would have no value after twenty years. The surface is projected to have a twenty-five-year life. The subbase and base are projected to have a forty-year life. The residual value of the reconstruction project at the end of twenty years is projected to be $3,295,394.

Yearly Cost of Repairs

The BCA compares the baseline scenario to the reconstruction of the streets. The baseline scenario is simply the repair costs annually. The baseline scenario assumes no maintenance of sidewalks from the city, except for a possible cost sharing of replacement of existing sidewalks. The owner of each parcel is ultimately responsible to replace or construct a new sidewalk at their expense in the City’s right of way.

The cost of repairs every year is an average of the repairs to the streets done in 2017 through 2021 based on a price per foot and total length of the project.

The alternate construction scenario is the total reconstruction of streets and sidewalks including replacement of twelve stoplights, one pedestrian cross light and adding curb extensions to the downtown district.

The total repairs and maintenance done assuming the baseline scenario is $1,215,189, which is discounted to 7 percent.

The analysis shown in the table below shows the maintenance cost each year starting in 2025 if the construction scenario is not done. The cost of maintenance each year was discounted by 7% to convert future year dollars into what it costs today without inflation. The pavement maintenance savings is an average of what the city would approximately spend each year in the area proposed to be replaced.

Calendar Year	Project Year	Pavement Maintenance Savings	Discounted to 7%
2025	1	$ 114,705	$ 107,200.76
2026	2	$ 114,705	$ 100,187.62
2027	3	$ 114,705	$ 93,633.29
2028	4	$ 114,705	$ 87,507.75
2029	5	$ 114,705	$ 81,782.95
2030	6	$ 114,705	$ 76,432.66
2031	7	$ 114,705	$ 71,432.39
2032	8	$ 114,705	$ 66,759.24
2033	9	$ 114,705	$ 62,391.82
2034	10	$ 114,705	$ 58,310.11
2035	11	$ 114,705	$ 54,495.43
2036	12	$ 114,705	$ 50,930.31
2037	13	$ 114,705	$ 47,598.42
2038	14	$ 114,705	$ 44,484.50
2039	15	$ 114,705	$ 41,574.30
2040	16	$ 114,705	$ 38,854.49
2041	17	$ 114,705	$ 36,312.61
2042	18	$ 114,705	$ 33,937.01
2043	19	$ 114,705	$ 31,716.84
2044	20	$ 114,705	$ 29,641.90
Total		$ 2,294,096	$ 1,215,184

Reduction in Emissions

The reduction of carbon dioxide was considered by the length of time a vehicle was on the road. The speed limits for the project are no more than 30 mph and emissions do not increase until a vehicle reaches a speed above 50 mph. Therefore, the assumption was the less time a vehicle spends on the city's roads the fewer the carbon dioxides are emitted into the air. Using the recommended values from the BCA guidance for discretionary grant programs, the social cost of carbon for a metric ton of carbon dioxide is $63 in 2031 and increases up to $78 in 2044. The savings was based on a per gallon of gasoline idling rate for the savings by traveling time by10 mph and spending less time on the roads. A second calculation was done based on replacing the stop lights from an old light that cycled 37 seconds through yellow and red to a stop light with a sensor to sense vehicles approaching and turning green or staying green to let them pass which creates less idling time. Calculating on the conservative side, the new estimated wait time, when traffic is at high volume, was determined to be 15 seconds, therefore the decrease of 22 seconds was calculated in the formula. The future costs of economic damages that can be avoided by reducing emissions is computed to be $2,268,810.

The analysis shown in the table below shows the cost savings of carbon dioxide emissions each year when a vehicle can spend 10 mph less on the road by speeding up the safe drivable speed limit and saving 22 seconds at a stoplight.

Calendar Year	Project Year	Value of CO2 Savings	Discounted Value of CO2 Savings at 3%
2031	7	$ 215,420.09	$ 175,156.25
2032	8	$ 219,040.07	$ 172,912.26
2033	9	$ 222,667.30	$ 170,655.94
2034	10	$ 226,301.77	$ 168,389.77
2035	11	$ 229,943.48	$ 166,116.06
2036	12	$ 236,997.69	$ 166,225.41
2037	13	$ 240,657.52	$ 163,876.06
2038	14	$ 244,324.59	$ 161,527.34
2039	15	$ 247,998.91	$ 159,181.06
2040	16	$ 251,680.48	$ 156,838.95
2041	17	$ 255,369.29	$ 154,502.62
2042	18	$ 259,065.34	$ 152,173.59
2043	19	$ 266,199.24	$ 151,809.71
2044	20	$ 269,913.41	$ 149,444.51
Total		$ 3,385,579.18	$ 2,268,809.52

To compute the cost savings, an estimation of the traffic on each of the nine streets was calculated. The assumption of the traffic for each street varied depending on if there were industry, businesses, schools, and housing on the streets. The calculation of streets with schools on them included the number of staff and students per building with each arriving and leaving school two times a day. Any blocks with housing had a calculation of 1.3 vehicles per household leaving two times a day from their home. The figures per household and vehicle came from the BCA guidance for discretionary grant programs. The major collectors and major business streets were calculated based on the population of the city. The idling savings of fuel was based on research from http://www.transportation.anl.gov. All streets in the project see all vehicle types, and because of that an average gallon per hour idling for all types was calculated. This average equaled .59 gallons per hour of idling. The miles per street was divided by a 10-mph savings and multiplied by the average gallon of idling fuel used per hour and then multiplied by the metric tons of carbon dioxide that a gallon of gas produces. That figure is the amount of carbon dioxide produced by idling. To figure the carbon dioxide produced per idling at each stop light, the average idling fuel use per gallon per second was figured and then multiplied by an average 15 seconds times three stoplights. Then these figures were multiplied by the calculation of each vehicle per year multiplied by the dollar figure for the year.

Value of Travel Time Savings Calculation

The value of travel time savings calculation was calculated using the recommended hourly value of travel time savings provided in the BCA guidance for discretionary grant programs. The amount used was $17.80 per person per hour for business and private vehicle travel combined.

The city streets are so deteriorated that vehicles cannot safely travel at the posted speed limit of 30 mph. Being conservative, the assumption used was a safe travel speed of 20-mph which is a higher speed limit than can be safely traveled on a few of the streets included in the project. The 10-mph savings in dollars is $3.04, which is calculated by dividing 10 minutes by 60 minutes and multiplying that figure by $17.80.

The assumption of traffic for each street varied depending on if there were industry, businesses, schools, and housing on the streets. The calculation of streets with schools on them included the number of staff and students per building with each arriving and leaving school two times a day. Any blocks with housing had a calculation of 1.3 vehicles per household and 1.67 persons per vehicle leaving two times a day from their home. The figures per household and vehicle came from the BCA guidance for discretionary grant programs. The major collectors and major business streets were calculated on the population of the city.

Calendar Year	Project Year	Value of Travel Time Savings	Discounted Travel Time Savings at 7%
2031	7	$ 29,903,378.36	$ 18,622,321.16
2032	8	$ 29,934,042.60	$ 17,421,885.33
2033	9	$ 29,964,706.84	$ 16,298,815.14
2034	10	$ 29,995,371.09	$ 15,248,125.66
2035	11	$ 30,026,035.33	$ 14,265,153.09
2036	12	$ 30,056,699.57	$ 13,345,534.06
2037	13	$ 30,087,363.81	$ 12,485,186.31
2038	14	$ 30,118,028.05	$ 11,680,290.54
2039	15	$ 30,148,692.29	$ 10,927,273.52
2040	16	$ 30,179,356.53	$ 10,222,792.20
2041	17	$ 30,210,020.77	$ 9,563,718.91
2042	18	$ 30,240,685.02	$ 8,947,127.50
2043	19	$ 30,271,349.26	$ 8,370,280.32
2044	20	$ 30,298,427.15	$ 7,829,689.33
Total		$ 391,135,729.52	$ 167,398,503.74

It is concluded that $167,383,504 will be saved in travel time if the city proceeds with the construction scenario instead of the baseline scenario. The value of time was discounted at 7 percent. The year of savings started at 2031 when the complete project will be finished.

The table to the left shows the value of travel time savings each year based on driving 10 mph faster after construction is completed. The savings is discounted to 7 percent to show the cost at today's value without inflation.

Motor Vehicle Accidents

Motor vehicle accident data was calculated for the period of January 1, 2013, through March 31, 2022, and then averaged to come up with an accident rate per year. The value of accidents was calculated using the recommended value from the BCA guidance for discretionary grant programs. The only type of accidents that occurred on the streets of the project was property damage only accidents and minor injury accidents.

Data was computed by the police department for a ten-year time span. The number of accidents that occurred in each category was averaged over the ten-year time span. The average amount of accidents then was multiplied by the value recommended in the BCA guidance for discretionary grant programs. The accident savings was then discounted at 7 percent. The total number of savings of accidents if the project is completed will be $593,131.

The table below shows the savings of the cost of the average accidents per year when construction is completed. The cost is discounted by 7 percent to show the value in today's dollars without inflation.

Calendar Year	Project Year	Accident Savings	Discounted at 7%
2031	7	$ 101,782	$ 63,384.60
2032	8	$ 101,782	$ 59,237.94
2033	9	$ 101,782	$ 55,362.57
2034	10	$ 101,782	$ 51,740.72
2035	11	$ 101,782	$ 48,355.81
2036	12	$ 101,782	$ 45,192.34
2037	13	$ 101,782	$ 42,235.84
2038	14	$ 101,782	$ 39,472.74
2039	15	$ 101,782	$ 36,890.41
2040	16	$ 101,782	$ 34,477.02
2041	17	$ 101,782	$ 32,221.52
2042	18	$ 101,782	$ 30,113.57
2043	19	$ 101,782	$ 28,143.52
2044	20	$ 101,782	$ 26,302.36
Total		$ 1,424,945	$ 593,130.96

Qualitative Benefits

The benefits that are not able to be shown as a quantitative figure include: safer travel of pedestrians, alternative modes of transportation for citizens with no vehicles, safer travel for bicycles, and the cost of maintenance on vehicles due to the road condition.

Constructing new sidewalks will provide safer travel for pedestrians. The baseline scenario provides no maintenance of sidewalks. It is up to the parcel owners to provide sidewalks in the city right of way. The City of Russell has a cost sharing program for sidewalk replacement program for existing sidewalks only. The proposed project area is in a low-income area where many of the residents cannot afford the cost sharing program, therefore sidewalks either are not getting replaced nor are new sidewalks being built. The new sidewalks will provide a means of transportation for the low-income individuals and handicap people who cannot afford other means of transportation. It will connect them to local businesses, schools, and health care.

The baseline scenario in its current state does not allow for safe travel for all modes of transportation. The sidewalks are uneven, disconnected or do not exist leaving pedestrians to walk in the streets. The streets are cracked or uneven which does not allow for safe travel by bicycle.

Connecting the sidewalks in the main corridor will allow citizens with no vehicles a safe way to travel to school, employment, recreation, and health care. With the baseline scenario, there is no easy way to travel throughout the main corridor of the city without walking in the streets or through yards. Children who walk to school have no connecting sidewalks and therefore find themselves walking in the streets.

Walking has health benefits, however the number of people who will take advantage of these new modes of travel is not quantifiable. By connecting the sidewalks throughout the corridor, it will give citizens an alternative to driving to and from work, school and other activities. By walking, citizens will gain a healthier lifestyle that will increase their life expectancy.

The condition of the streets causes many alignment and maintenance problems for vehicles. This costs consumers more money for repairs. By doing nothing in the baseline scenario causes vehicle owners a lot of money.

It is rough travel for bicyclists within the main corridor. The City is not bicycle friendly due to the condition of the streets. Bicycling is an alternative mode of transportation that focuses on a healthier lifestyle increasing a longer life. Without safe travel for bicyclists throughout the streets, many citizens do not travel by bicycle.

Benefit Cost Ratio and Net Present Value

As shown in the summary table below, the Build option has a positive net present value of $158,796,464 and the no build option has a negative net present value of $155,559,493. The benefit cost ratio for the build option is 9.85 and the no build option is .10. This makes the build option a much stronger option.

	Option 1 <Build>	Option 2 <No Build>
Appraisal period (years)	20	20
Capital Costs	$22,421,112	$0
Whole of Life Costs	$22,650,522	$428,768,193
Cost-benefit analysis of monetary costs and benefits at the Public Sector Discount Rate		
Present Value of Benefits	$176,691,692	$17,462,510
Present Value of Costs	$17,945,228	$173,022,003
Benefit Cost Ratio	9.85	0.10
Net Present Value	$158,746,464	-$155,559,493

The assumptions used in the build option were, capital costs of $22,421,112 split between six years and repairs for the roads in 2023 and 2024 in the amount of $229,410 before construction is ready to start. These costs were then converted to present value using a 7 percent discount rate.

The benefits of the build scenario included the value of travel time savings that totaled $167,398,504 over a 14-year period starting after construction is complete. This figure was converted to net present value using a 7 percent discount rate. Also, another benefit used was savings of accident costs. The total savings for 14 years assuming no savings until after the project is complete total $593,031 which was converted to net present value using a 7 percent discount rate. The cost of carbon dioxide emissions was included and totaled $2,268,810 and then converted to net present value using a 3 percent discount rate.

The no build assumptions used a cost of repairs. The total cost of repairs amounted to $1,215,189 which was converted to net present value using a 7 percent discount rate. Benefits in this scenario included the cost savings of the construction cost of $22,421,112, which was also discounted at 7 percent.

The benefit cost ratio in both scenarios was calculated by taking the present value of benefits and dividing it by the present value of costs.

Conclusion

After evaluating the different costs through the benefit analysis and the existing condition of the pavement, the build option is the best option. There will be minimal maintenance for the next 5-10 years, allowing for the city to redirect the money for repairs to future reconstruction of streets and sidewalks and being able to self-pay for these projects. The local economy will benefit by improved roadways and better access to services. The appearance of the community will greatly improve. During winter, snow removal will be easier with a smother surface; especially since most of the roadways in this project are primary snow routes.

With the no build option, the current street conditions will continue to worsen at an increasing rate and the future cost of replacement will be more than the current cost of reconstruction now. Construction costs will continue to increase, plus the longer that roadway improvements are delayed the worse shape that the subgrade and roadway base will be and will require additional subgrade reconstruction under the roadway.