Financial Framework that Maximizes Benefit of Water-Infrastructure Investment

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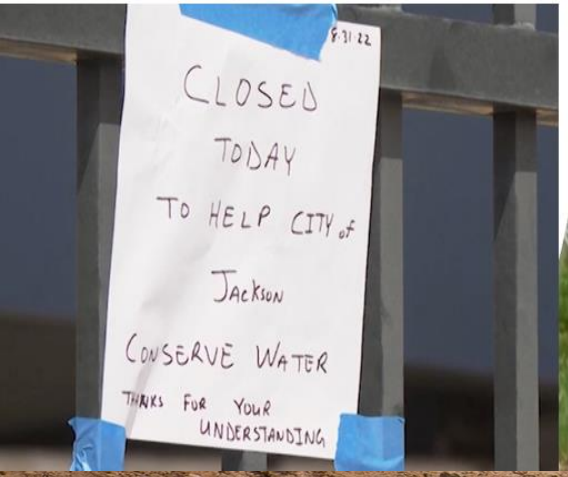
Background

How the Mississippi water crisis happened

- Since July 29, 2022 ~ Ongoing Issues
- 150,000 Jackson city's residents
- Main water treatment facility was damaged after a high level of flooding
- A result of years-long issues.

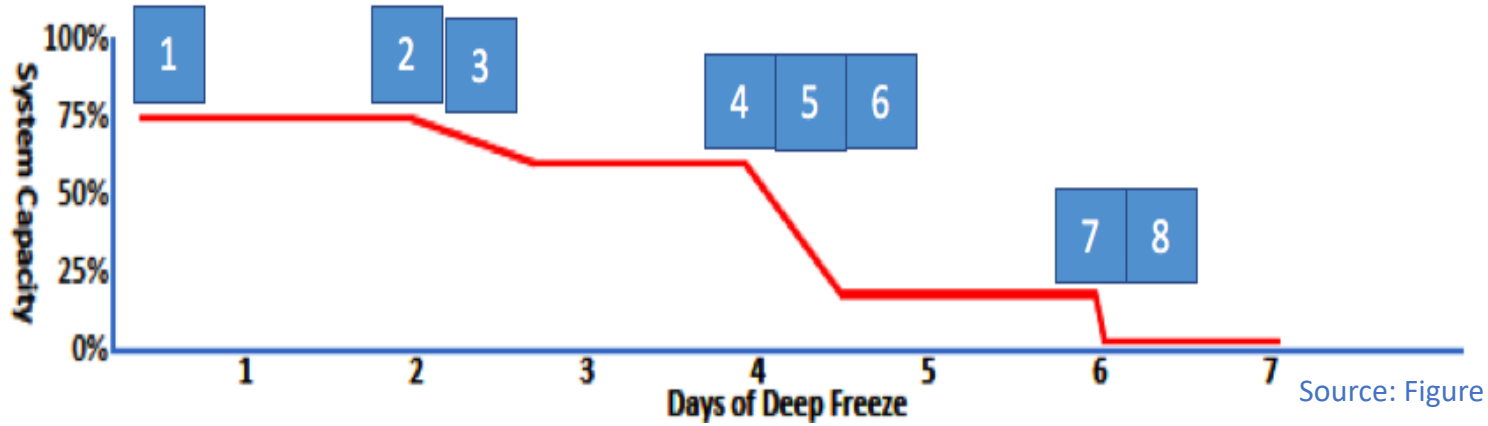


Recent Mississippi Water Crisis and Ongoing Issues 2022

Source: Figure created by the author (K. Im)

- Nearly 50 days of an ongoing boil water advisory has become common
- It is unknown when it will be resolved.
- Replacing the water treatment facility& solving this crisis could cost billions of dollars.
- More than a trillion dollars must be invested in water infrastructure by 2030.

Background: TX Water Crisis & Deep Freeze



Source: Figure created by the author

City Water Utilities

1 Systems offline

2 City Water pumps froze

3 Attempt to provide opening all water valves

8 Residential pipes burst

Wholesale Provider

4 Extended power outages

5 Refuel emergency generator fuel supplies, but Iced roads

6 Remaining Generator fuel wasted

7 Much water production offline

Operational failure of a water utility value stream in some of the US southern states during a deep-freeze event of a winter storm in February 2021 by Time Period

Photo: ABC News – Breaking News

Ongoing Water Crisis Cities

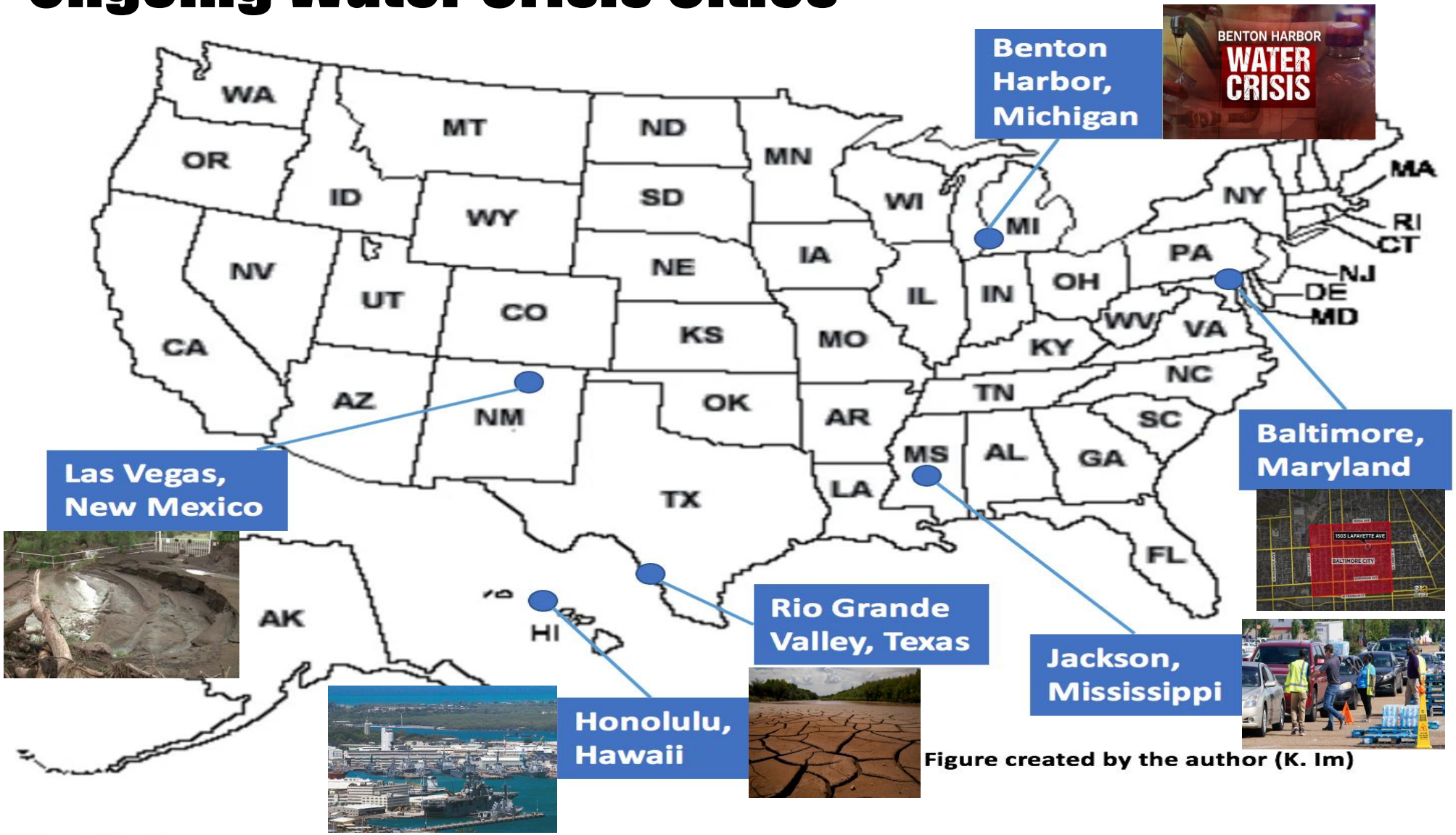
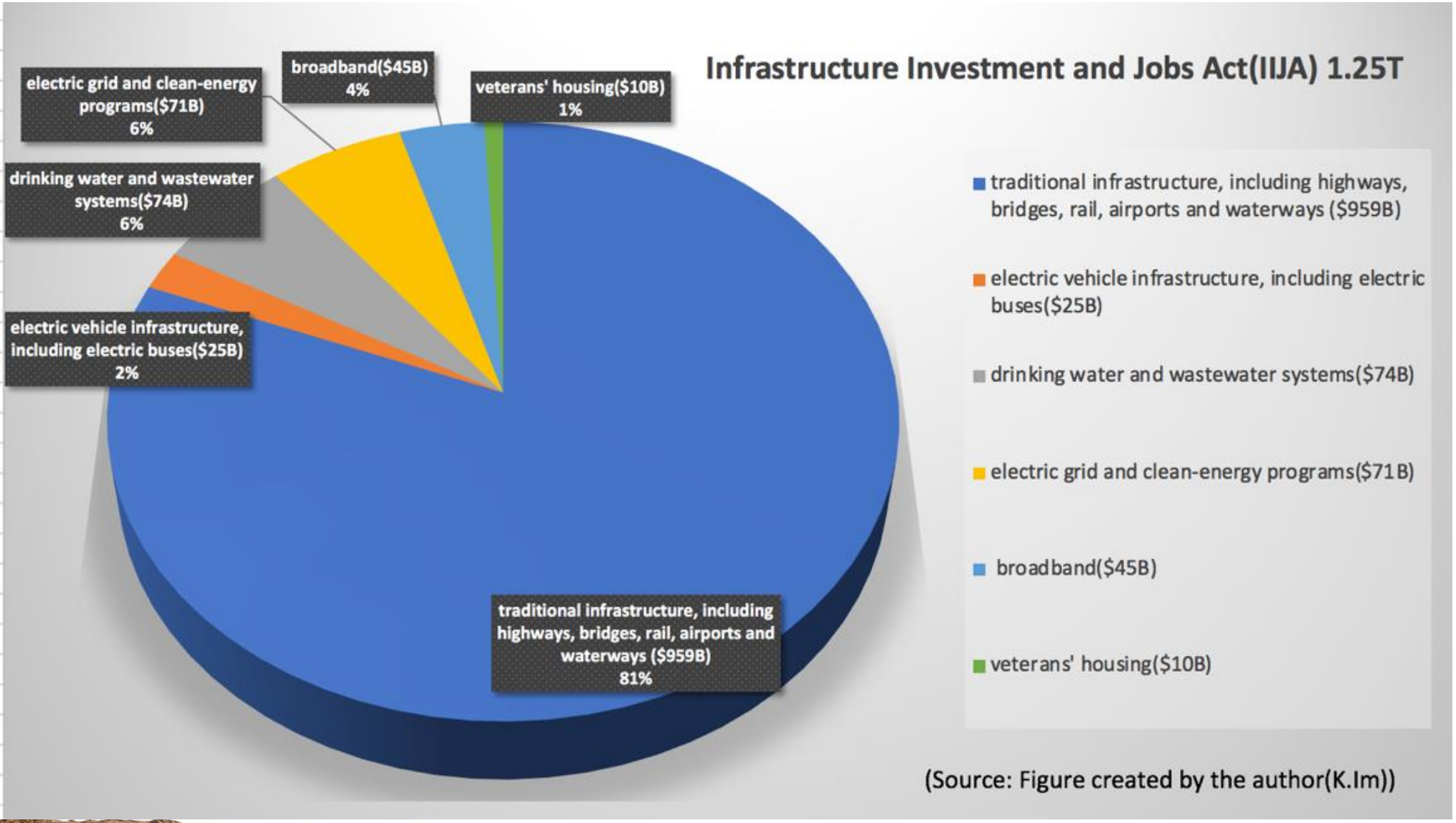


Figure created by the author (K. Im)

*NM -The fire-related debris and ash due to wildfire contaminated the reservoir.
*HI - Jet fuel leaked by the Navy water system.
*TX - water crisis from an ongoing drought and record-breaking heat.
*MS - failing water treatment system from heavy rainfall and flooding
*MD - the bacteria was detected in the drinking water
*MI - lead pollution in the water system

Infrastructure Investment & Jobs Act



Bipartisan Infrastructure Law

↓

Water infrastructures - small percentage, 6%

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Constant and Major Water Crisis

↓

Effective Long-term Financial Framework

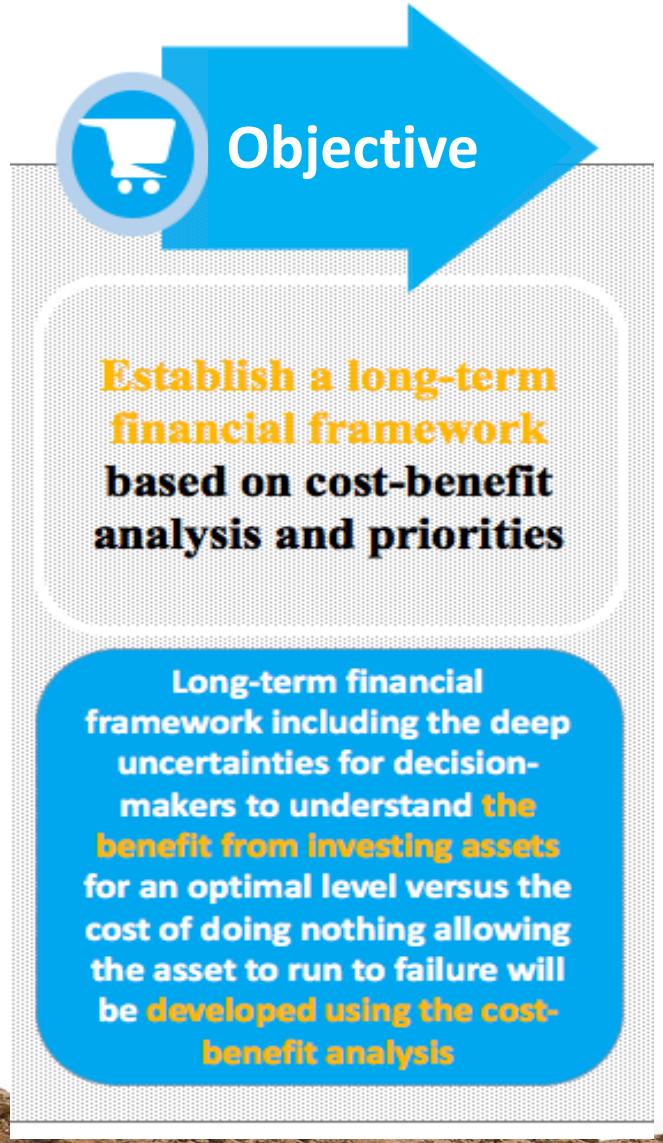
Detailed proportion for each infrastructure based on Infrastructure Investment and Jobs Act (IIJA) 1.25T

Problem Statement & Needs

- Therefore, there is a need to conduct a cost-benefit assessment related to the capital investment costs that will help government make the efficiency of limited budgets and resources for constructing, improving, and rehabilitating water infrastructures using historical financial and economic data.

- Minimizing risks of ineffectual and wasteful water sector investment through rehabilitating and improving water infrastructures in a rational manner will lead to improving grades of the infrastructure report card and the resiliency of interrelated infrastructures and sectors.

Objectives



Major Objective

- Establish a long-term financial framework based on cost-benefit assessment and priorities:
- Long-term financial framework including the deep uncertainties for decision-makers to understand the benefit from investing in assets for an optimal level versus the cost of doing nothing allowing the asset to run to failure will be developed using the benefit-cost assessment.

Major Purpose

- Major Purposes of this phase: are to conduct a benefit-cost assessment in terms of private, financial, economic, efficiency using nominal and real terms for maximizing the benefit from investing water sector and for reducing the vulnerability of water infrastructures.

Expected Outcomes

Long-term Financial Framework on water infrastructure

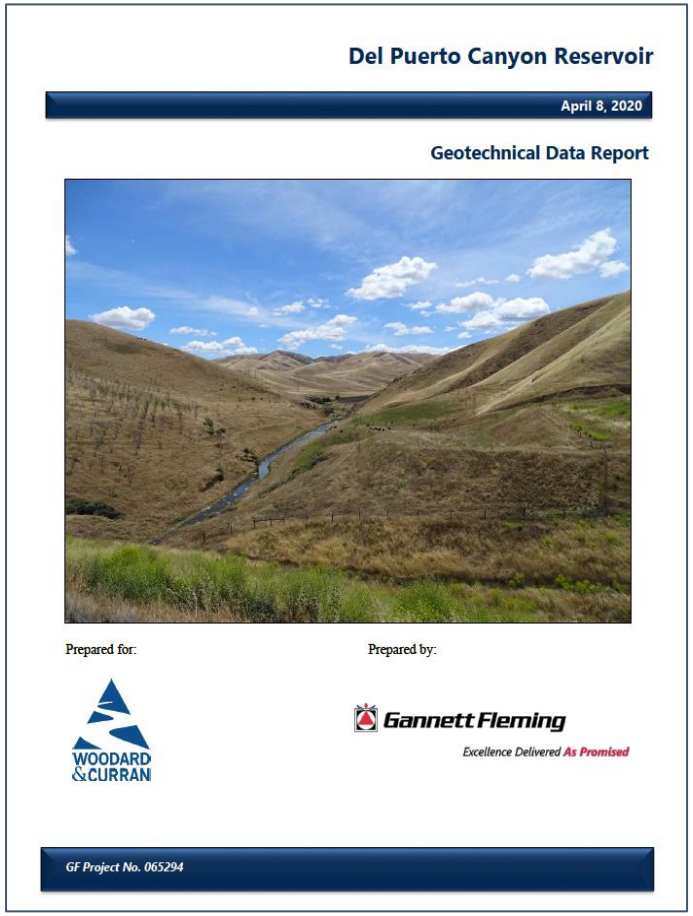
- The long-term financial framework including the deep uncertainties for decision-makers to understand the benefit from investing assets for an optimal level versus the cost of doing nothing allowing the asset to run to failure will be developed using the cost-benefit assessment.

Benefit-Cost Assessment for a strategy of maximizing the efficiency

- In order to measure the benefit and cost of a strategy of maximizing the efficiency of limited budgets and resources, the study will conduct a benefit-cost assessment due to the investment costs for rehabilitating and improving water infrastructures using historical economic and financial data.

❖ To minimize the increasing challenges associated with the aging water infrastructure and to maximize the efficiency of water infrastructures, this research conducts a benefit-cost assessment related to the investment costs and develops a long-term financial framework for water infrastructure.

Scope of Research



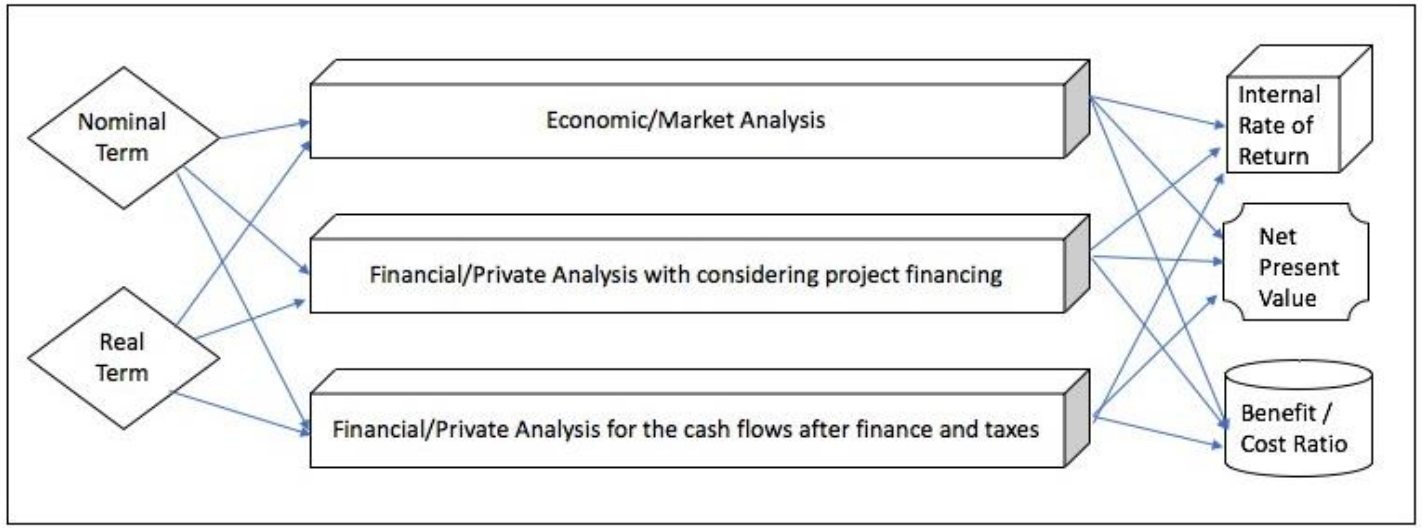
This research focuses on evaluating a proposed project (DPCR project) using a cost-benefit assessment to maximize the benefit of investing in water infrastructure for economic and financial feasibility and developing a long-term financial framework as a feasibility study.

Del Puerto Canyon Reservoir (DPCR)

This water infrastructure project proposes to construct a reservoir on Del Puerto Creek in the Del Puerto Canyon which is in the eastern foothills of the Coast Range Mountains.

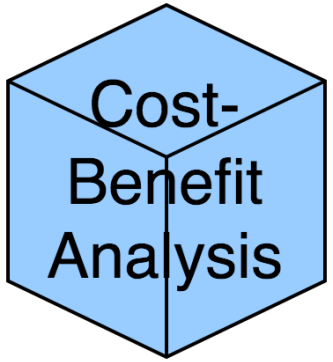
The purpose of the DPCR is to develop additional South of Delta water storage, utilizing the water after it is moved through the Delta, to maximize the management and efficient use of existing water supplies.

Several scenarios associated with cost-benefit analysis in the decision-making process & IRR, NPV, and B/C

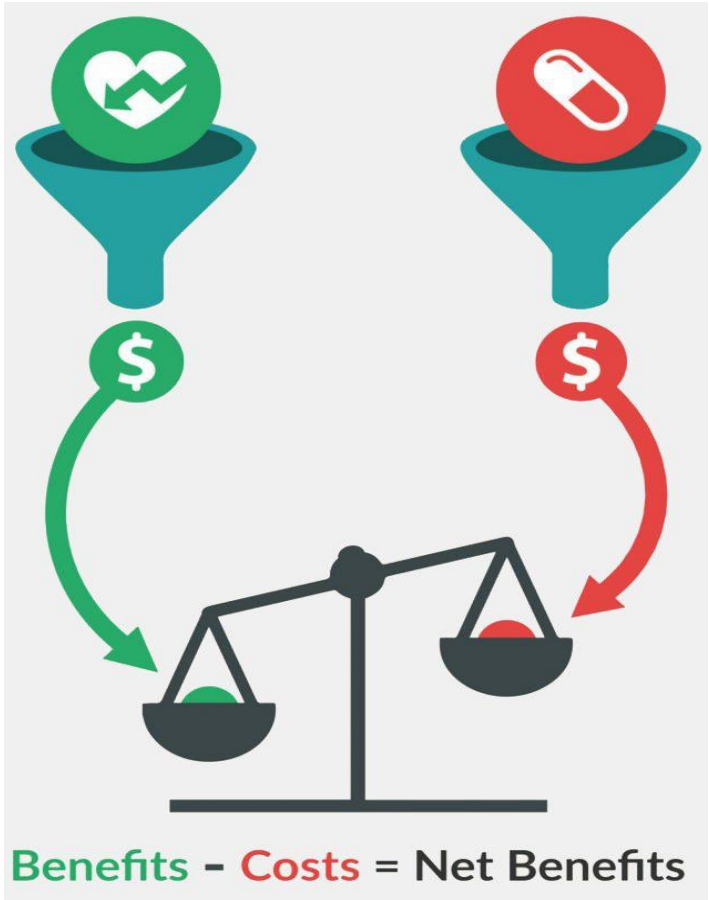


(I) It determines whether the project is efficient from a market perspective.
(II) Since it can be a large-scale infrastructure project that would be financed, built, and operated by the government, a build-operate-transfer contract point of view can be taken into consideration.
(III) It examines the proposed project from the financial perspective by netting the interests, taxes, and debt flows.

Method Used

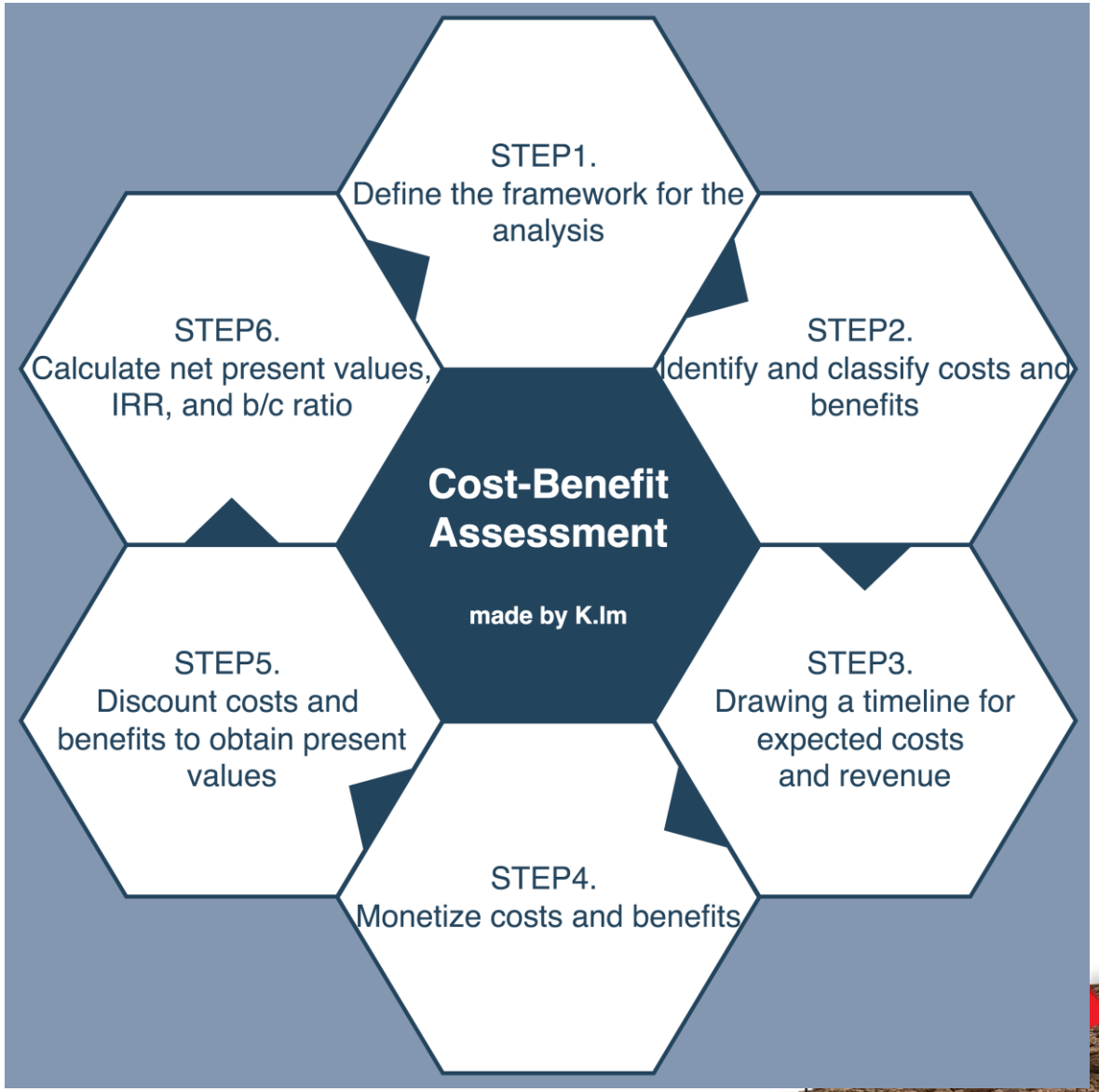


: A systematic process of evaluating the desirability of a decision by weighing its potential benefits and costs



: It evaluates the cost versus the benefit of a project to determine project feasibility as well as provide a decision-making metric when weighing up multiple options

A Process for Performing a Cost-benefit Assessment



Key Parameters

To conduct a benefit-cost assessment in terms of private, financial, economic, efficiency using nominal and real terms, if the key parameters are summarized in a table, those are as follows

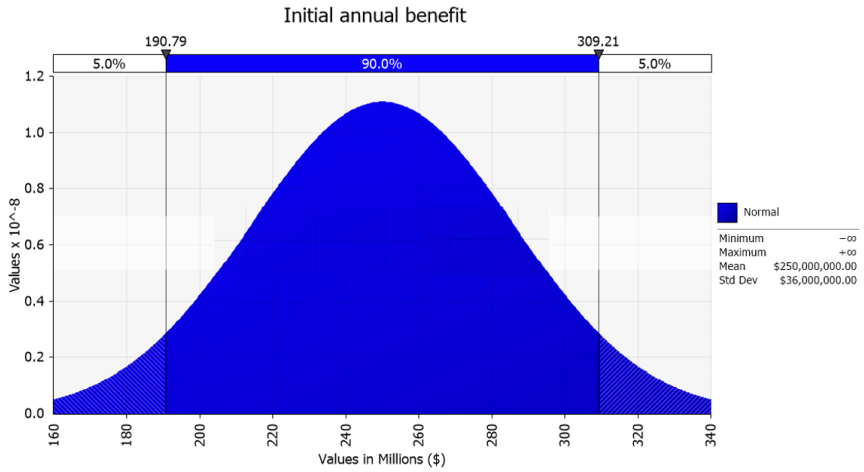
Parameters		
development period	5	years
benefit period	20	years
Benefit_ growing annual rate	2.0%	beginning in Y7
Income tax rate	9.3%	California state income tax
Real SPC discount rate	11%	
Initial annual benefit	$250,000,000	beginning at the end of year 6
Initial operation and maintenance cost	$80,000,000	from year 6 to end year
Nominal interest rate_ Debt (proposed project)	8%	
Loan financing	85%	(15% equity)
Loan repayment period	15	years
Inflation rate	3%	
Nominal SPC discount rate	14.33%	<=*(1+r)=(1+r~)(1+i)

* Real interest rate_ Debt (*r~=(1+r)/(1+i)-1): 4.85%
* Interest during the development period is capitalized
* r=(1+r~)*(1+i)-1
* Under US tax law, depreciation and loan interest, but not loan principal payment, are tax deductible.

Assumptions of Stochastic Analysis-1

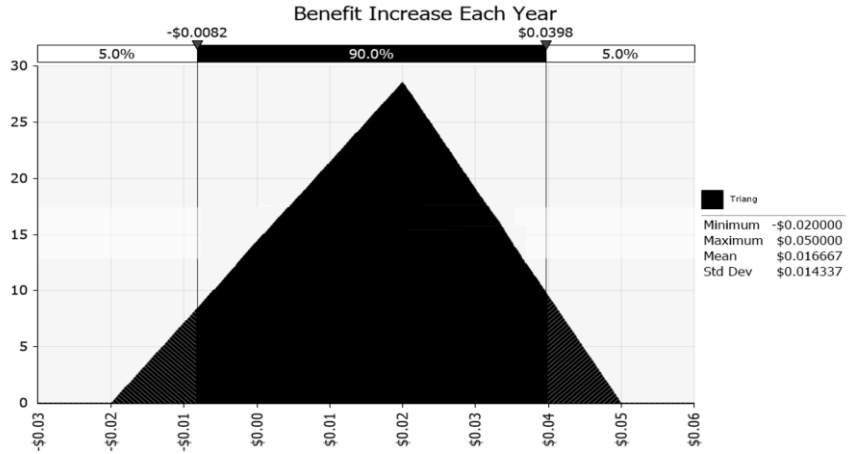
- The assumptions of stochastic analysis used in this research have additional main project parameters as follows.
- Stochastic analysis is used to model uncertainty in crucial project parameters in these analyses and to evaluate various risky projects.

The initial annual benefit level is normally distributed with a mean of $250,000,000 and a standard deviation of $36,000,000.



<The Initial Annual Benefit Level>

The benefits increase each year has an unknown distribution and hence is assumed triangular with a minimum of -2%, a most likely value of 2%, and a maximum of 5%.



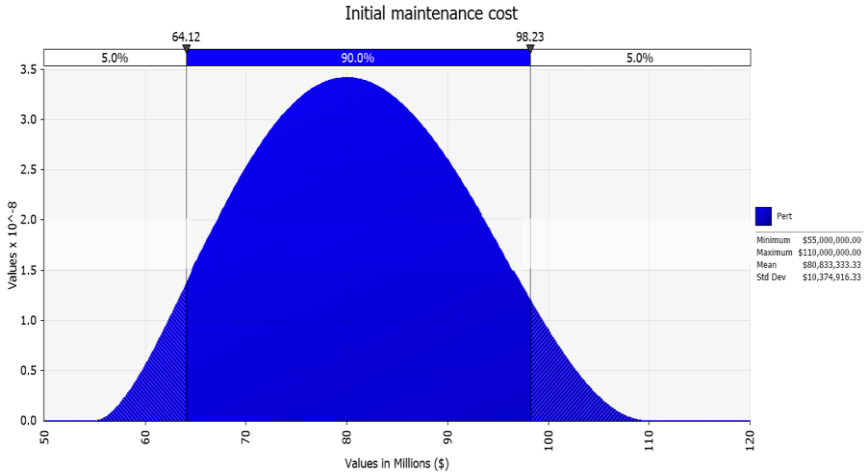
<Benefit Increase Each Year>

Assumptions of Stochastic Analysis-2

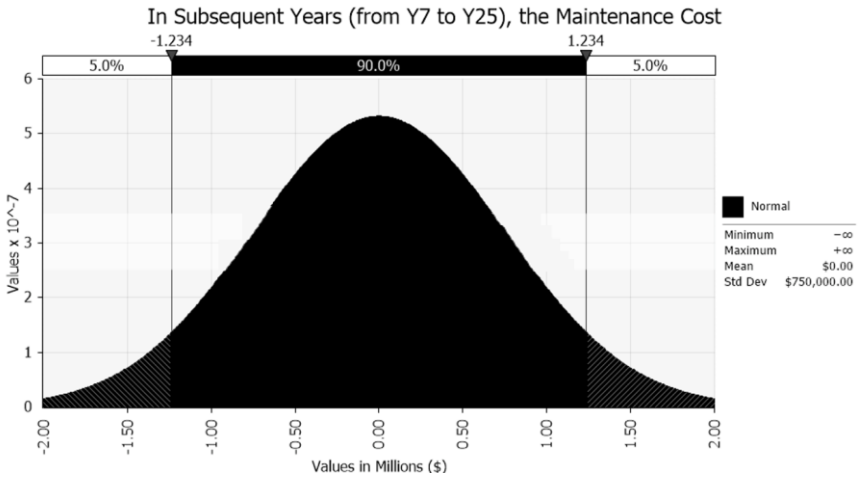
The initial year's operation and maintenance cost has a Pert distribution with a minimum of $55,000,000, a mode of $80,000,000, and a maximum of $110,000,000.

In subsequent years (from Y7 to Y25), the operation and maintenance cost is equal to the previous year's cost plus a normally distributed random component with a mean $0 and a standard deviation of $750,000.

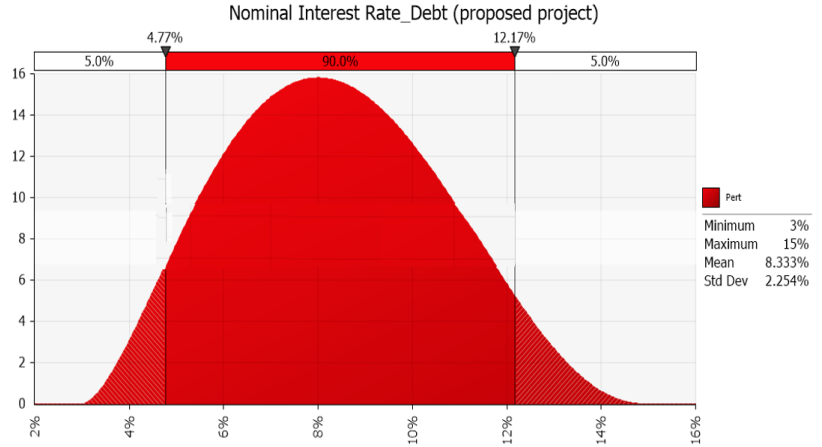
The nominal loan interest rate is not known with certainty, but one it has identified at the beginning of the project, it is fixed for the life of the project. It is assumed a Pert distribution with a minimum of 3%, a mode of 8%, and a maximum of 15%.



<The Initial Year's operation and maintenance Cost - Pert Distribution>



<In Subsequent Years (from Y7 to Y25), the Operation and Maintenance Cost>

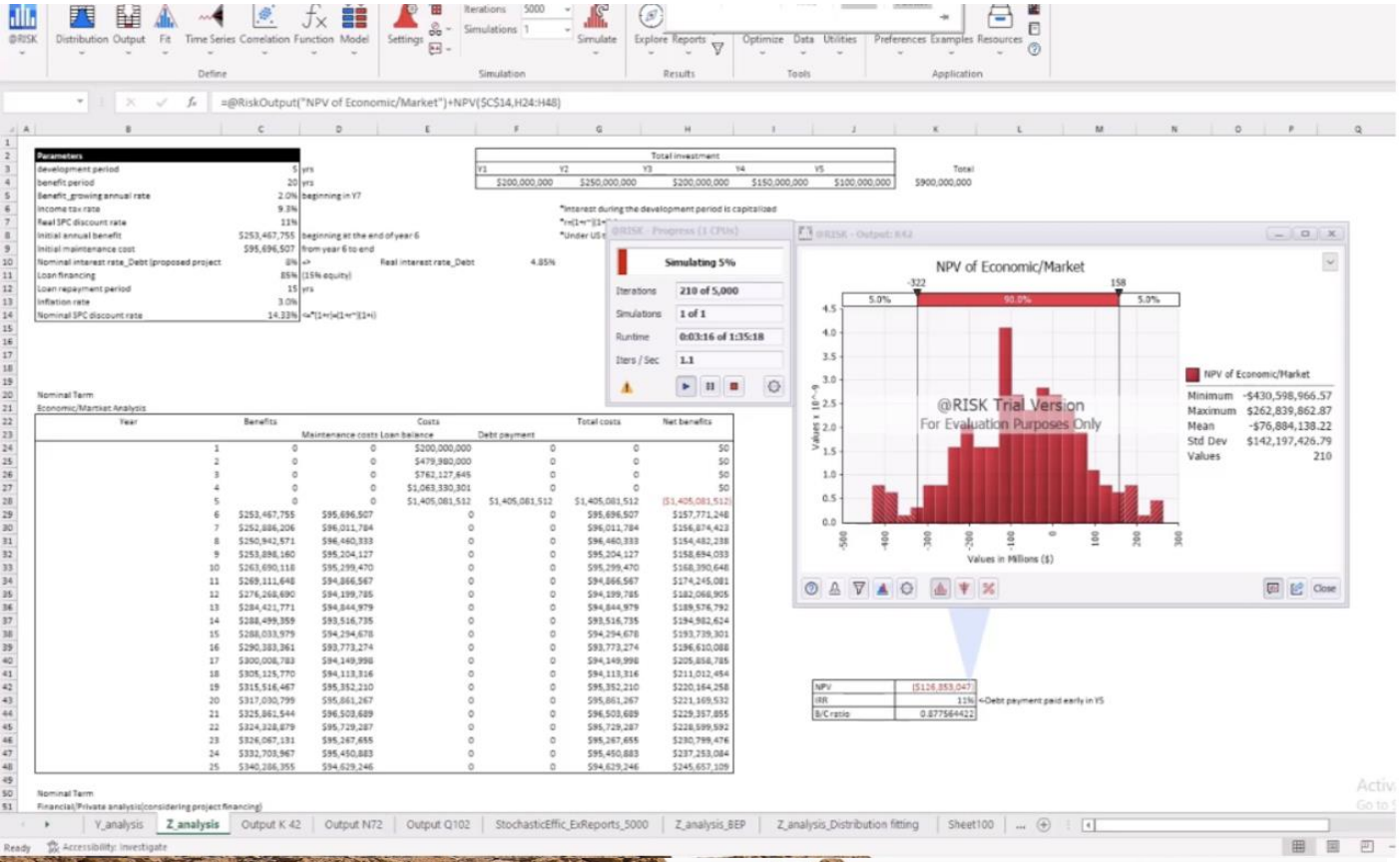


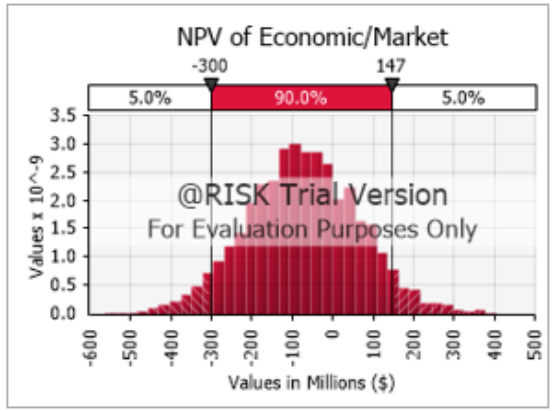
<The Nominal Loan Interest Rate>

- **Under United States tax law, depreciation and loan interest, but not loan principal payment, are tax-deductible, and the interest during the development period is capitalized.**

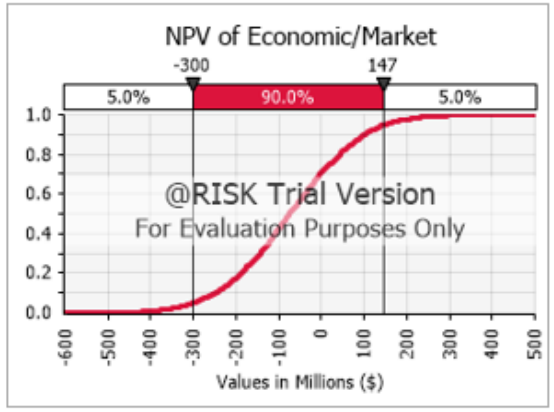
I) Economic/market analysis

I) Economic/market analysis - assessing the benefits and costs of the project at market prices without any consideration of financing or taxes except that the interest during construction will be included in the capital charge to be applied in year 5. It is calculated the NPV and IRR.

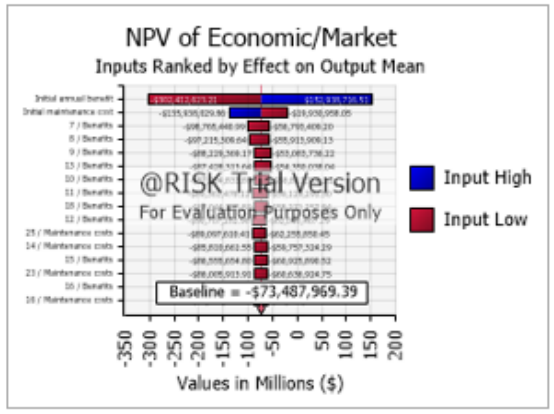




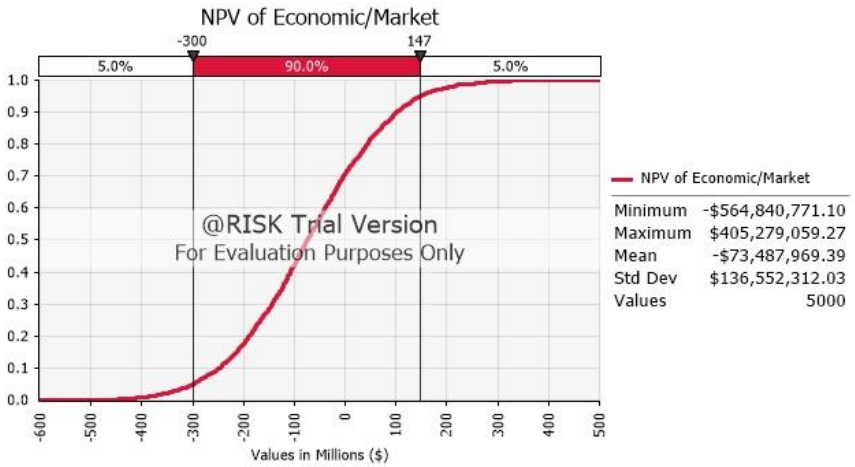
Summary Statistics	
Statistic	Value
Minimum	-$ 564,840,771.10
Maximum	$ 405,279,059.27
Mean	-$ 73,487,969.39
Std. Deviation	$ 136,552,312.03
Variance	1.865E+016
Skewness	0.0157
Kurtosis	2.9642
Median	-$ 74,887,569.80
Mode	-$ 54,623,445.30
Left X	-$ 299,767,884.55
Left P	5%
Right X	$ 146,837,267.70
Right P	95%



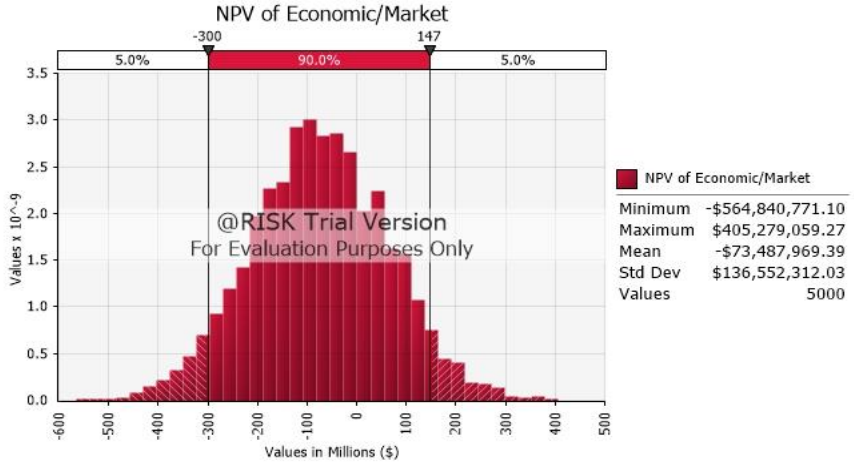
Percentiles	
Percentile	Value
1%	-$ 387,846,404.43
2.5%	-$ 344,133,047.03
5%	-$ 299,767,884.55
10%	-$ 246,914,698.34
20%	-$ 188,705,190.75
25%	-$ 166,517,658.44
50%	-$ 74,887,569.80
75%	$ 19,929,648.96
80%	$ 43,282,797.50
90%	$ 100,815,413.56
95%	$ 146,837,267.70
97.5%	$ 194,775,559.08
99%	$ 254,084,893.89



Change in Output			
Rank	Name	Lower	Upper
1	Initial annual benefit	-$ 302,412,623	$ 152,938,717
2	Initial maintenance co	-$ 135,938,030	-$ 19,930,958
3	7 / Benefits	-$ 98,765,441	-$ 56,793,409
4	8 / Benefits	-$ 97,215,310	-$ 55,913,909
5	9 / Benefits	-$ 88,229,369	-$ 53,083,736
6	13 / Benefits	-$ 87,428,314	-$ 54,350,038
7	10 / Benefits	-$ 87,904,834	-$ 56,811,709
8	11 / Benefits	-$ 89,363,476	-$ 59,129,291
9	18 / Benefits	-$ 87,044,756	-$ 58,271,258
10	12 / Benefits	-$ 90,707,283	-$ 62,096,467
11	25 / Maintenance cost	-$ 89,097,610	-$ 62,255,850
12	14 / Maintenance cost	-$ 85,810,662	-$ 59,757,324
13	15 / Benefits	-$ 86,555,655	-$ 60,925,891



Cumulative Distribution Function of Net Present Value of Economic/Market Analysis



Histogram of Net Present Value of Economic/Market Analysis

Nominal Term
Economic/Martket Analysis

Year	Benefits	Costs			Total costs	Net benefits
		Maintenance costs	Loan balance	Debt payment		
1	0	0	$200,000,000	0	0	$0
2	0	0	$479,980,000	0	0	$0
3	0	0	$762,127,645	0	0	$0
4	0	0	$1,063,330,301	0	0	$0
5	0	0	$1,405,081,512	$1,405,081,512	$1,405,081,512	($1,405,081,512)
6	$250,000,000	$80,000,000	0	0	$80,000,000	$170,000,000
7	$254,166,667	$80,000,000	0	0	$80,000,000	$174,166,667
8	$258,402,778	$80,000,000	0	0	$80,000,000	$178,402,778
9	$262,709,491	$80,000,000	0	0	$80,000,000	$182,709,491
10	$267,087,982	$80,000,000	0	0	$80,000,000	$187,087,982
11	$271,539,449	$80,000,000	0	0	$80,000,000	$191,539,449
12	$276,065,106	$80,000,000	0	0	$80,000,000	$196,065,106
13	$280,666,191	$80,000,000	0	0	$80,000,000	$200,666,191
14	$285,343,961	$80,000,000	0	0	$80,000,000	$205,343,961
15	$290,099,694	$80,000,000	0	0	$80,000,000	$210,099,694
16	$294,934,689	$80,000,000	0	0	$80,000,000	$214,934,689
17	$299,850,267	$80,000,000	0	0	$80,000,000	$219,850,267
18	$304,847,771	$80,000,000	0	0	$80,000,000	$224,847,771
19	$309,928,567	$80,000,000	0	0	$80,000,000	$229,928,567
20	$315,094,044	$80,000,000	0	0	$80,000,000	$235,094,044
21	$320,345,611	$80,000,000	0	0	$80,000,000	$240,345,611
22	$325,684,704	$80,000,000	0	0	$80,000,000	$245,684,704
23	$331,112,783	$80,000,000	0	0	$80,000,000	$251,112,783
24	$336,631,329	$80,000,000	0	0	$80,000,000	$256,631,329
25	$342,241,851	$80,000,000	0	0	$80,000,000	$262,241,851

NPV	($71,413,805)
IRR	13% <-Debt payment paid early in Y5
B/C ratio	0.927531419

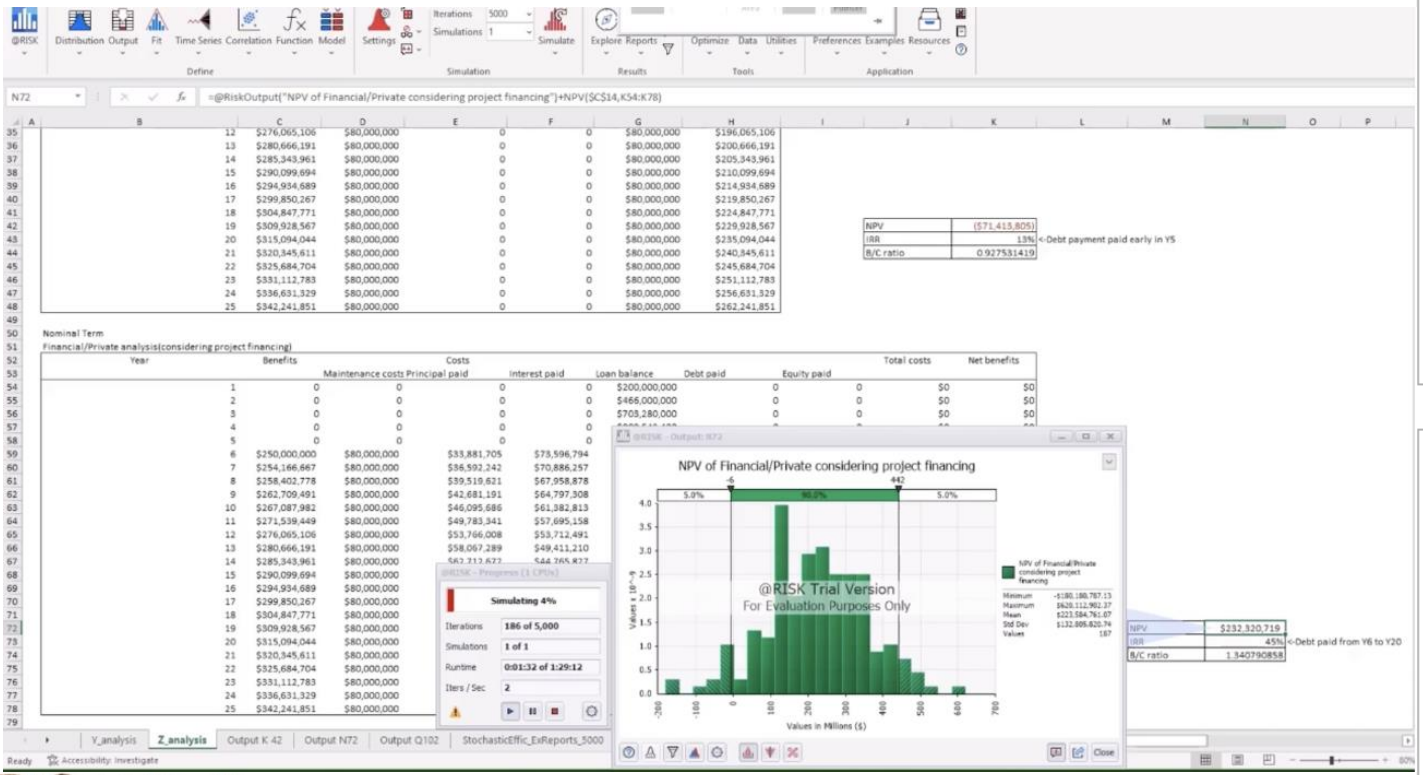
Real Term
Economic/Martket Analysis

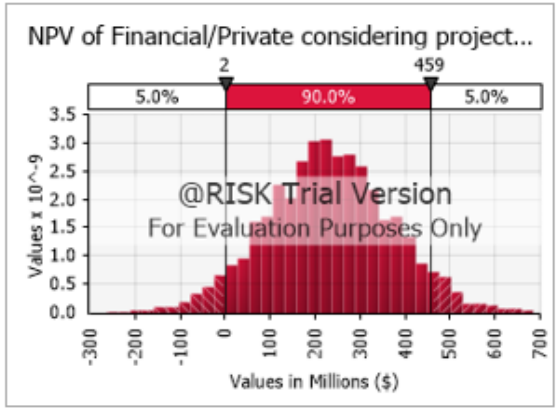
Year	Benefits	Costs			Total costs	Net benefits
		Maintenance costs	Loan balance	Debt payment		
1	0	0	$194,174,757	0	0	$0
2	0	0	$452,427,184	0	0	$0
3	0	0	$697,454,757	0	0	$0
4	0	0	$944,755,200	0	0	$0
5	0	0	$1,212,035,655	$1,212,035,655	$1,212,035,655	($1,212,035,655)
6	$209,371,064	$66,998,741	0	0	$66,998,741	$142,372,324
7	$206,660,759	$65,047,321	0	0	$65,047,321	$141,613,438
8	$203,985,539	$63,152,739	0	0	$63,152,739	$140,832,800
9	$201,344,949	$61,313,339	0	0	$61,313,339	$140,031,611
10	$198,738,542	$59,527,513	0	0	$59,527,513	$139,211,029
11	$196,165,875	$57,793,702	0	0	$57,793,702	$138,372,173
12	$193,626,511	$56,110,390	0	0	$56,110,390	$137,516,121
13	$191,120,019	$54,476,107	0	0	$54,476,107	$136,643,912
14	$188,645,973	$52,889,424	0	0	$52,889,424	$135,756,549
15	$186,203,954	$51,348,956	0	0	$51,348,956	$134,854,999
16	$183,793,547	$49,853,355	0	0	$49,853,355	$133,940,192
17	$181,414,343	$48,401,316	0	0	$48,401,316	$133,013,027
18	$179,065,937	$46,991,569	0	0	$46,991,569	$132,074,368
19	$176,747,931	$45,622,882	0	0	$45,622,882	$131,125,049
20	$174,459,932	$44,294,060	0	0	$44,294,060	$130,165,872
21	$172,201,551	$43,003,942	0	0	$43,003,942	$129,197,609
22	$169,972,405	$41,751,400	0	0	$41,751,400	$128,221,005
23	$167,772,115	$40,535,340	0	0	$40,535,340	$127,236,775
24	$165,600,308	$39,354,699	0	0	$39,354,699	$126,245,609
25	$163,456,614	$38,208,446	0	0	$38,208,446	$125,248,169

NPV	($71,413,805)
IRR	9% <-Debt payment paid early in Y5
B/C ratio	0.927531419

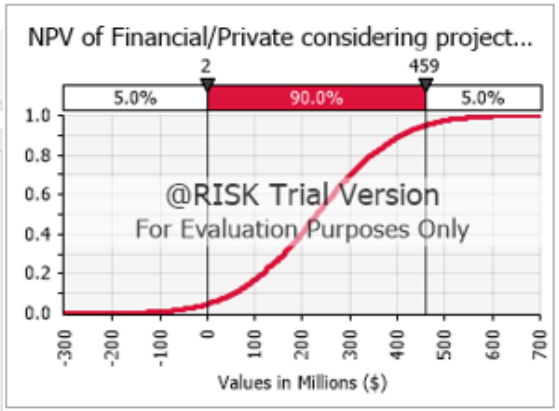
II) Financial/private analysis - (considering project financing)

II) Financial/private analysis - (considering project financing) assessing the benefits and costs to the Special Purpose Corporation (SPC). It is assumed the SPC makes a loan for 85% of the total investment with the 15% equity paid at the end of year 5, repayable at an 8% interest rate. It is assumed that the loan balance at the end of year five, which includes capitalized interest, less equity paid is serviced through equal installments over a fifteen-year repayment period.

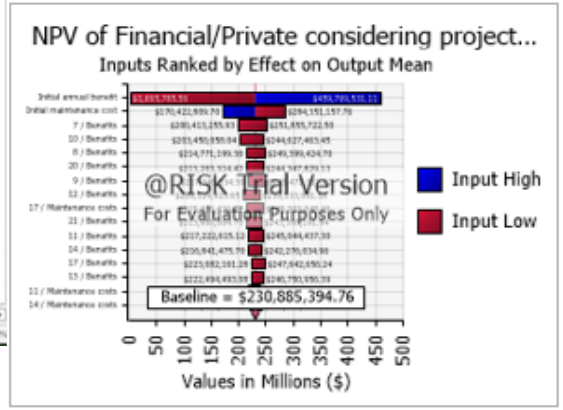




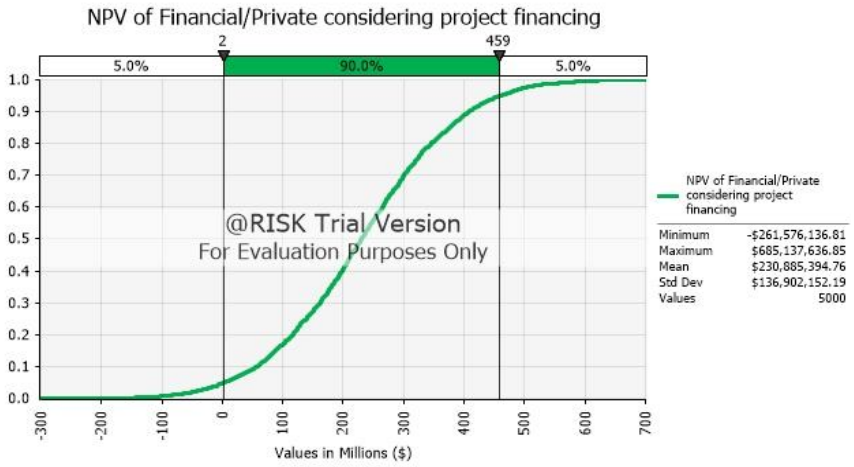
Summary Statistics	
Statistic	Value
Minimum	-$ 261,576,136.81
Maximum	$ 685,137,636.85
Mean	$ 230,885,394.76
Std. Deviation	$ 136,902,152.19
Variance	1.874E+016
Skewness	0.0222
Kurtosis	2.9546
Median	$ 229,968,058.35
Mode	$ 211,700,806.66
Left X	$ 1,717,919.30
Left P	5%
Right X	$ 458,560,856.47
Right P	95%



Percentiles	
Percentile	Value
1%	-$ 83,852,458.08
2.5%	-$ 41,623,876.88
5%	$ 1,717,919.30
10%	$ 56,790,408.11
20%	$ 116,217,521.79
25%	$ 139,433,252.32
50%	$ 229,968,058.35
75%	$ 321,267,062.54
80%	$ 345,079,402.61
90%	$ 408,293,435.27
95%	$ 458,560,856.47
97.5%	$ 497,764,227.68
99%	$ 554,537,296.78



Change in Output			
Rank	Name	Lower	Upper
1	Initial annual benefit	$ 1,665,786	$ 459,769,531
2	Initial maintenance co	$ 170,422,810	$ 284,351,158
3	7 / Benefits	$ 200,413,256	$ 251,855,723
4	10 / Benefits	$ 203,450,058	$ 244,627,463
5	8 / Benefits	$ 214,771,199	$ 249,399,425
6	20 / Benefits	$ 213,203,314	$ 244,347,829
7	9 / Benefits	$ 217,346,334	$ 248,471,368
8	12 / Benefits	$ 209,524,926	$ 239,533,002
9	17 / Maintenance cost	$ 215,466,427	$ 245,203,048
10	21 / Benefits	$ 213,988,865	$ 243,388,192
11	11 / Benefits	$ 217,222,615	$ 245,044,437
12	14 / Benefits	$ 216,841,476	$ 242,276,035
13	17 / Benefits	$ 223,082,161	$ 247,642,656



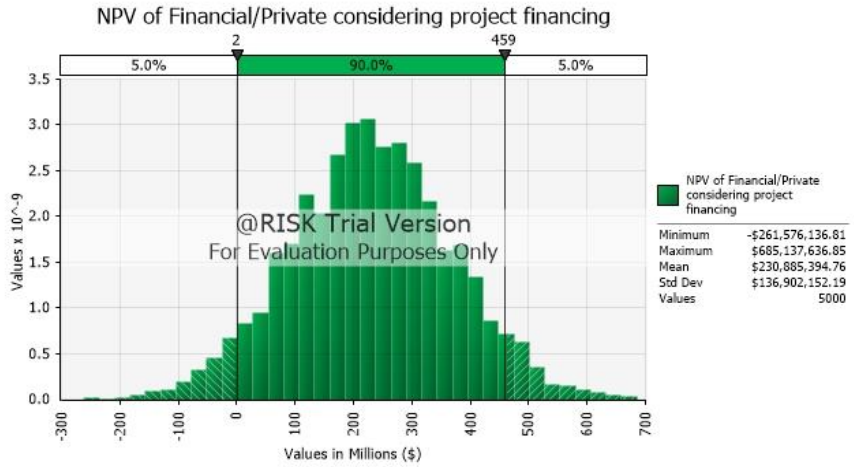
Cumulative Distribution Function of Net Present Value of Financial/Private Analysis considering project financing

Nominal Term

Financial/Private analysis(considering project financing)

Year	Benefits	Costs						Total costs	Net benefits
		Maintenance costs	Principal paid	Interest paid	Loan balance	Debt paid	Equity paid		
1	0	0	0	0	$200,000,000	0	0	$0	$0
2	0	0	0	0	$466,000,000	0	0	$0	$0
3	0	0	0	0	$703,280,000	0	0	$0	$0
4	0	0	0	0	$909,542,400	0	0	$0	$0
5	0	0	0	0	$919,959,923	0	$162,345,869	$162,345,869	($162,345,869)
6	$250,000,000	$80,000,000	$33,881,705	$73,596,794	$886,078,218	$107,478,499	0	$187,478,499	$62,521,501
7	$254,166,667	$80,000,000	$36,592,242	$70,886,257	$849,485,976	$107,478,499	0	$187,478,499	$66,688,167
8	$258,402,778	$80,000,000	$39,519,621	$67,958,878	$809,966,355	$107,478,499	0	$187,478,499	$70,924,279
9	$262,709,491	$80,000,000	$42,681,191	$64,797,308	$767,285,164	$107,478,499	0	$187,478,499	$75,230,992
10	$267,087,982	$80,000,000	$46,095,686	$61,382,813	$721,189,478	$107,478,499	0	$187,478,499	$79,609,483
11	$271,539,449	$80,000,000	$49,783,341	$57,695,158	$671,406,137	$107,478,499	0	$187,478,499	$84,060,949
12	$276,065,106	$80,000,000	$53,766,008	$53,712,491	$617,640,129	$107,478,499	0	$187,478,499	$88,586,607
13	$280,666,191	$80,000,000	$58,067,289	$49,411,210	$559,572,840	$107,478,499	0	$187,478,499	$93,187,692
14	$285,343,961	$80,000,000	$62,712,672	$44,765,827	$496,860,168	$107,478,499	0	$187,478,499	$97,865,462
15	$290,099,694	$80,000,000	$67,729,686	$39,748,813	$429,130,482	$107,478,499	0	$187,478,499	$102,621,195
16	$294,934,689	$80,000,000	$73,148,061	$34,330,439	$355,982,422	$107,478,499	0	$187,478,499	$107,456,189
17	$299,850,267	$80,000,000	$78,999,905	$28,478,594	$276,982,516	$107,478,499	0	$187,478,499	$112,371,768
18	$304,847,771	$80,000,000	$85,319,898	$22,158,601	$191,662,619	$107,478,499	0	$187,478,499	$117,369,272
19	$309,928,567	$80,000,000	$92,145,490	$15,333,009	$99,517,129	$107,478,499	0	$187,478,499	$122,450,068
20	$315,094,044	$80,000,000	$99,517,129	$7,961,370	$0	$107,478,499	0	$187,478,499	$127,615,544
21	$320,345,611	$80,000,000	0	0	$0	$0	0	$80,000,000	$240,345,611
22	$325,684,704	$80,000,000	0	0	$0	$0	0	$80,000,000	$245,684,704
23	$331,112,783	$80,000,000	0	0	$0	$0	0	$80,000,000	$251,112,783
24	$336,631,329	$80,000,000	0	0	$0	$0	0	$80,000,000	$256,631,329
25	$342,241,851	$80,000,000	0	0	$0	$0	0	$80,000,000	$262,241,851

NPV	$232,320,719
IRR	45% <-Debt paid from Y6 to Y20
B/C ratio	1.340790858



Histogram Net Present Value of Financial/Private Analysis considering project financing

Real Term

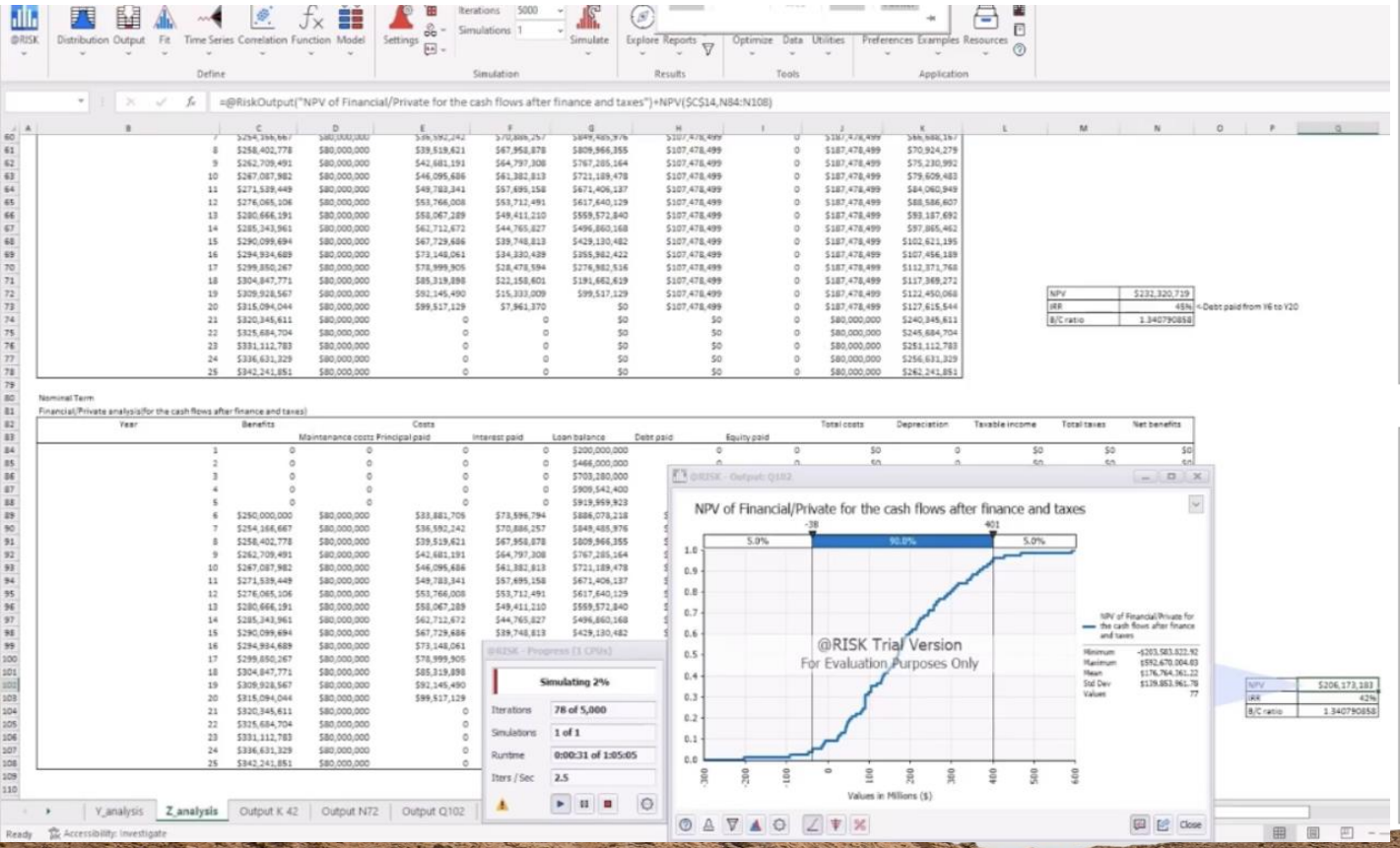
Financial/Private analysis(considering project financing)

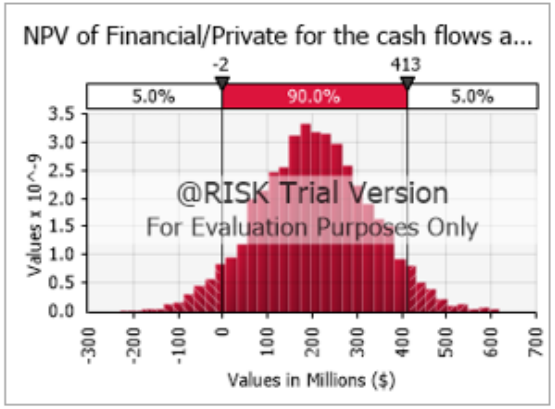
Year	Benefits	Costs						Total costs	Net benefits
		Maintenance costs	Principal paid	Interest paid	Loan balance	Debt paid	Equity paid		
1	0	0	0	0	$194,174,757	0	0	$0	$0
2	0	0	0	0	$439,249,694	0	0	$0	$0
3	0	0	0	0	$643,600,826	0	0	$0	$0
4	0	0	0	0	$808,116,642	0	0	$0	$0
5	0	0	0	0	$793,565,511	0	$140,040,973	$140,040,973	($140,040,973)
6	$209,371,064	$66,998,741	$28,375,395	$61,636,156	$742,076,558	$90,011,551	0	$157,010,292	$52,360,773
7	$206,660,759	$65,047,321	$29,752,841	$57,637,014	$690,709,836	$87,389,855	0	$152,437,176	$54,223,583
8	$203,985,539	$63,152,739	$31,197,154	$53,647,366	$639,394,920	$84,844,520	0	$147,997,258	$55,988,280
9	$201,344,949	$61,313,339	$32,711,579	$49,661,741	$588,060,188	$82,373,320	0	$143,686,659	$57,658,291
10	$198,738,542	$59,527,513	$34,299,519	$45,674,578	$536,632,702	$79,974,097	0	$139,501,610	$59,236,932
11	$196,165,875	$57,793,702	$35,964,545	$41,680,210	$485,038,079	$77,644,755	0	$135,438,457	$60,727,418
12	$193,626,511	$56,110,390	$37,710,396	$37,672,860	$433,200,360	$75,383,257	0	$131,493,647	$62,132,864
13	$191,120,019	$54,476,107	$39,540,998	$33,646,630	$381,041,875	$73,187,628	0	$127,663,735	$63,456,284
14	$188,645,973	$52,889,424	$41,460,464	$29,595,485	$328,483,104	$71,055,950	0	$123,945,374	$64,700,599
15	$186,203,954	$51,348,956	$43,473,108	$25,513,251	$275,442,527	$68,986,359	0	$120,335,315	$65,868,640
16	$183,793,547	$49,853,355	$45,583,453	$21,393,594	$221,836,476	$66,977,047	0	$116,830,403	$66,963,145
17	$181,414,343	$48,401,316	$47,796,242	$17,230,018	$167,578,978	$65,026,260	0	$113,427,575	$67,986,767
18	$179,065,937	$46,991,569	$50,116,448	$13,015,843	$112,581,589	$63,132,291	0	$110,123,859	$68,942,077
19	$176,747,931	$45,622,882	$52,549,285	$8,744,201	$56,753,228	$61,293,486	0	$106,916,368	$69,831,563
20	$174,459,932	$44,294,060	$55,100,221	$4,408,018	$0	$59,508,239	0	$103,802,299	$70,657,633
21	$172,201,551	$43,003,942	0	0	$0	$0	0	$43,003,942	$129,197,609
22	$169,972,405	$41,751,400	0	0	$0	$0	0	$41,751,400	$128,221,005
23	$167,772,115	$40,535,340	0	0	$0	$0	0	$40,535,340	$127,236,775
24	$165,600,308	$39,354,699	0	0	$0	$0	0	$39,354,699	$126,245,609
25	$163,456,614	$38,208,446	0	0	$0	$0	0	$38,208,446	$125,248,169

NPV	$232,320,719
IRR	40% <-Debt paid from Y6 to Y20
B/C ratio	1.340790858

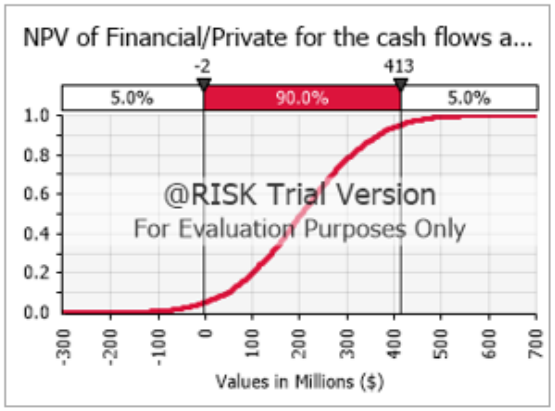
III) Financial/private analysis - (for the cash flows after finance and taxes)

III) Financial/private analysis - (for the cash flows after finance and taxes) calculating the NPV and IRR for the cash flows after finance and taxes. The total capital investment can be depreciated under US tax law over a period of 15 years, starting in year 6 using the straight-line method. Salvage value is zero. Under US tax law, depreciation and loan interest (but not loan principal payment) are tax-deductible. It is assumed the interest capitalized in capital investment is not tax-deductible.

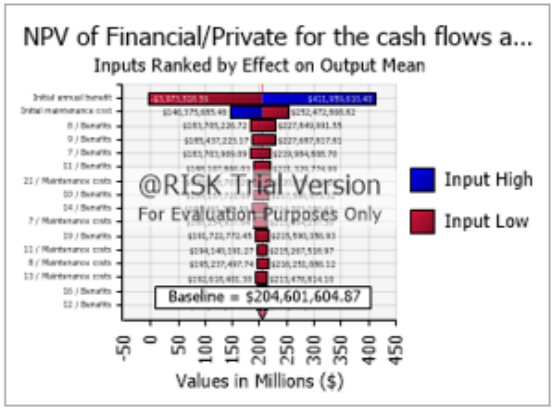




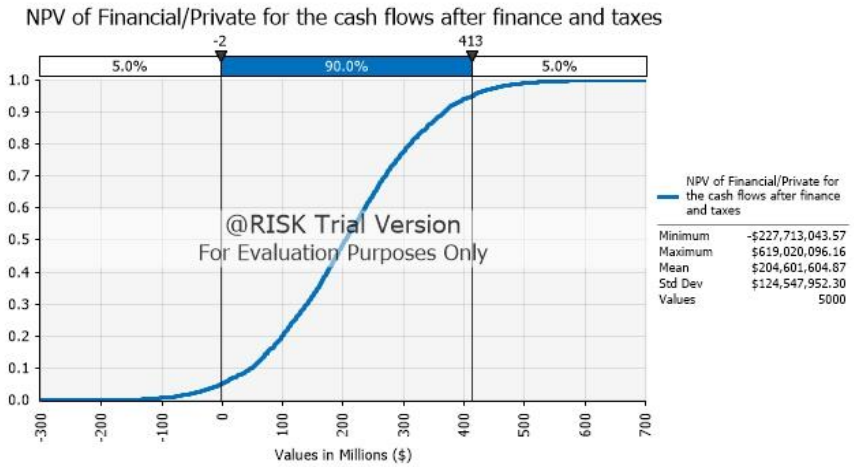
Summary Statistics	
Statistic	Value
Minimum	-$ 227,713,043.57
Maximum	$ 619,020,096.16
Mean	$ 204,601,604.87
Std. Deviation	$ 124,547,952.30
Variance	1.551E+016
Skewness	0.0269
Kurtosis	2.9369
Median	$ 203,255,170.13
Mode	$ 192,576,815.75
Left X	-$ 2,238,791.87
Left P	5%
Right X	$ 412,810,084.29
Right P	95%



Percentiles	
Percentile	Value
1%	-$ 79,339,178.55
2.5%	-$ 41,855,013.80
5%	-$ 2,238,791.87
10%	$ 47,639,065.52
20%	$ 99,204,540.89
25%	$ 118,693,475.90
50%	$ 203,255,170.13
75%	$ 288,223,332.20
80%	$ 309,657,508.13
90%	$ 366,609,166.00
95%	$ 412,810,084.29
97.5%	$ 448,109,495.83
99%	$ 494,081,819.25



Change in Output			
Rank	Name	Lower	Upper
1	Initial annual benefit	-$ 3,973,519	$ 411,959,610
2	Initial maintenance co	$ 146,375,685	$ 252,472,869
3	8 / Benefits	$ 183,705,227	$ 227,849,992
4	9 / Benefits	$ 185,437,223	$ 227,687,818
5	7 / Benefits	$ 183,703,969	$ 219,984,809
6	11 / Benefits	$ 188,107,866	$ 221,329,775
7	21 / Maintenance cost	$ 190,218,707	$ 220,058,169
8	10 / Benefits	$ 189,157,721	$ 217,566,875
9	14 / Benefits	$ 186,461,280	$ 214,703,181
10	7 / Maintenance costs	$ 188,254,937	$ 215,084,257
11	19 / Benefits	$ 191,722,772	$ 215,590,357
12	11 / Maintenance costs	$ 194,140,191	$ 215,267,519
13	8 / Maintenance costs	$ 195,237,498	$ 216,251,086



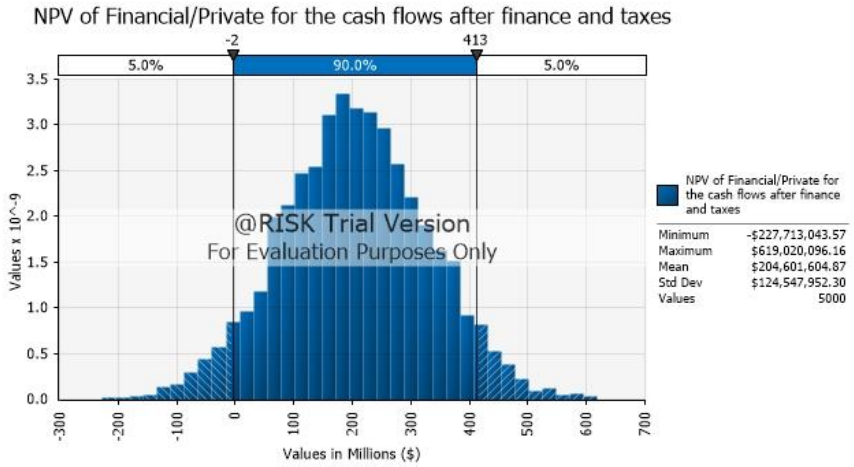
Cumulative Distribution Function of Net Present Value of Financial/Private Analysis for the cash flows after finance and taxes

Nominal Term

Financial/Private analysis(for the cash flows after finance and taxes)

Year	Benefits	Costs						Total costs	Depreciation	Taxable income	Total taxes	Net benefits
		Maintenance costs	Principal paid	Interest paid	Loan balance	Debt paid	Equity paid					
1	0	0	0	0	$200,000,000	0	0	$0	0	$0	$0	$0
2	0	0	0	0	$466,000,000	0	0	$0	0	$0	$0	$0
3	0	0	0	0	$703,280,000	0	0	$0	0	$0	$0	$0
4	0	0	0	0	$909,542,400	0	0	$0	0	$0	$0	$0
5	0	0	0	0	$919,959,923	0	$162,345,869	$162,345,869	0	$0	$0	($162,345,869)
6	$250,000,000	$80,000,000	$33,881,705	$73,596,794	$886,078,218	$107,478,499	0	$187,478,499	$61,968,214	$34,434,992	$3,202,454	$59,319,047
7	$254,166,667	$80,000,000	$36,592,242	$70,886,257	$849,485,976	$107,478,499	0	$187,478,499	$61,968,214	$41,312,195	$3,842,034	$62,846,133
8	$258,402,778	$80,000,000	$39,519,621	$67,958,878	$809,966,355	$107,478,499	0	$187,478,499	$61,968,214	$48,475,686	$4,508,239	$66,416,040
9	$262,709,491	$80,000,000	$42,681,191	$64,797,308	$767,285,164	$107,478,499	0	$187,478,499	$61,968,214	$55,943,968	$5,202,789	$70,028,202
10	$267,087,982	$80,000,000	$46,095,686	$61,382,813	$721,189,478	$107,478,499	0	$187,478,499	$61,968,214	$63,736,955	$5,927,537	$73,681,946
11	$271,539,449	$80,000,000	$49,783,341	$57,695,158	$671,406,137	$107,478,499	0	$187,478,499	$61,968,214	$71,876,076	$6,684,475	$77,376,474
12	$276,065,106	$80,000,000	$53,766,008	$53,712,491	$617,640,129	$107,478,499	0	$187,478,499	$61,968,214	$80,384,401	$7,475,749	$81,110,858
13	$280,666,191	$80,000,000	$58,067,289	$49,411,210	$559,572,840	$107,478,499	0	$187,478,499	$61,968,214	$89,286,767	$8,303,669	$84,884,023
14	$285,343,961	$80,000,000	$62,712,672	$44,765,827	$496,860,168	$107,478,499	0	$187,478,499	$61,968,214	$98,609,920	$9,170,723	$88,694,739
15	$290,099,694	$80,000,000	$67,729,686	$39,748,813	$429,130,482	$107,478,499	0	$187,478,499	$61,968,214	$108,382,666	$10,079,588	$92,541,607
16	$294,934,689	$80,000,000	$73,148,061	$34,330,439	$355,982,422	$107,478,499	0	$187,478,499	$61,968,214	$118,636,036	$11,033,151	$96,423,038
17	$299,850,267	$80,000,000	$78,999,905	$28,478,594	$276,982,516	$107,478,499	0	$187,478,499	$61,968,214	$129,403,459	$12,034,522	$100,337,246
18	$304,847,771	$80,000,000	$85,319,898	$22,158,601	$191,662,619	$107,478,499	0	$187,478,499	$61,968,214	$140,720,956	$13,087,049	$104,282,223
19	$309,928,567	$80,000,000	$92,145,490	$15,333,009	$99,517,129	$107,478,499	0	$187,478,499	$61,968,214	$152,627,344	$14,194,343	$108,255,725
20	$315,094,044	$80,000,000	$99,517,129	$7,961,370	$0	$107,478,499	0	$187,478,499	$61,968,214	$165,164,459	$15,360,295	$112,255,250
21	$320,345,611	$80,000,000	0	0	$0	$0	0	$80,000,000	0	$240,345,611	$22,352,142	$217,993,469
22	$325,684,704	$80,000,000	0	0	$0	$0	0	$80,000,000	0	$245,684,704	$22,848,678	$222,836,027
23	$331,112,783	$80,000,000	0	0	$0	$0	0	$80,000,000	0	$251,112,783	$23,353,489	$227,759,294
24	$336,631,329	$80,000,000	0	0	$0	$0	0	$80,000,000	0	$256,631,329	$23,866,714	$232,764,616
25	$342,241,851	$80,000,000	0	0	$0	$0	0	$80,000,000	0	$262,241,851	$24,388,492	$237,853,359

NPV	$206,173,183
IRR	42%
B/C ratio	1.340790858



Histogram Net Present Value of Financial/Private Analysis for the cash flows after finance and taxes

Real Term

Financial/Private analysis(for the cash flows after finance and taxes)

Year	Benefits	Costs						Total costs	Depreciation	Taxable income	Total taxes	Net benefits
		Maintenance costs	Principal paid	Interest paid	Loan balance	Debt paid	Equity paid					
1	0	0	0	0	$194,174,757	0	0	$0	0	0	0	$0
2	0	0	0	0	$439,249,694	0	0	$0	0	0	0	$0
3	0	0	0	0	$643,600,826	0	0	$0	0	0	0	$0
4	0	0	0	0	$808,116,642	0	0	$0	0	0	0	$0
5	0	0	0	0	$793,565,511	0	$140,040,973	$140,040,973	0	0	0	($140,040,973)
6	$209,371,064	$66,998,741	$28,375,395	$61,636,156	$742,076,558	$90,011,551	0	$157,010,292	$51,897,404	$28,838,764	$2,682,005	$49,678,768
7	$206,660,759	$65,047,321	$29,752,841	$57,637,014	$690,709,836	$87,389,855	0	$152,437,176	$50,385,829	$33,590,595	$3,123,925	$51,099,658
8	$203,985,539	$63,152,739	$31,197,154	$53,647,366	$639,394,920	$84,844,520	0	$147,997,258	$48,918,280	$38,267,154	$3,558,845	$52,429,435
9	$201,344,949	$61,313,339	$32,711,579	$49,661,741	$588,060,188	$82,373,320	0	$143,686,659	$47,493,476	$42,876,393	$3,987,505	$53,670,786
10	$198,738,542	$59,527,513	$34,299,519	$45,674,578	$536,632,702	$79,974,097	0	$139,501,610	$46,110,171	$47,426,280	$4,410,644	$54,826,288
11	$196,165,875	$57,793,702	$35,964,545	$41,680,210	$485,038,079	$77,644,755	0	$135,438,457	$44,767,156	$51,924,807	$4,829,007	$55,898,411
12	$193,626,511	$56,110,390	$37,710,396	$37,672,860	$433,200,360	$75,383,257	0	$131,493,647	$43,463,258	$56,380,002	$5,243,340	$56,889,524
13	$191,120,019	$54,476,107	$39,540,998	$33,646,630	$381,041,875	$73,187,628	0	$127,663,735	$42,197,338	$60,799,944	$5,654,395	$57,801,889
14	$188,645,973	$52,889,424	$41,460,464	$29,595,485	$328,483,104	$71,055,950	0	$123,945,374	$40,968,290	$65,192,774	$6,062,928	$58,637,671
15	$186,203,954	$51,348,956	$43,473,108	$25,513,251	$275,442,527	$68,986,359	0	$120,335,315	$39,775,038	$69,566,709	$6,469,704	$59,398,936
16	$183,793,547	$49,853,355	$45,583,453	$21,393,594	$221,836,476	$66,977,047	0	$116,830,403	$38,616,542	$73,930,055	$6,875,495	$60,087,650
17	$181,414,343	$48,401,316	$47,796,242	$17,230,018	$167,578,978	$65,026,260	0	$113,427,575	$37,491,789	$78,291,221	$7,281,084	$60,705,684
18	$179,065,937	$46,991,569	$50,116,448	$13,015,843	$112,581,589	$63,132,291	0	$110,123,859	$36,399,795	$82,658,731	$7,687,262	$61,254,816
19	$176,747,931	$45,622,882	$52,549,285	$8,744,201	$56,753,228	$61,293,486	0	$106,916,368	$35,339,607	$87,041,242	$8,094,835	$61,736,727
20	$174,459,932	$44,294,060	$55,100,221	$4,408,018	$0	$59,508,239	0	$103,802,299	$34,310,298	$91,447,557	$8,504,623	$62,153,010
21	$172,201,551	$43,003,942	0	0	$0	$0	0	$43,003,942	0	$129,197,609	$12,015,378	$117,182,231
22	$169,972,405	$41,751,400	0	0	$0	$0	0	$41,751,400	0	$128,221,005	$11,924,553	$116,296,451
23	$167,772,115	$40,535,340	0	0	$0	$0	0	$40,535,340	0	$127,236,775	$11,833,020	$115,403,755
24	$165,600,308	$39,354,699	0	0	$0	$0	0	$39,354,699	0	$126,245,609	$11,740,842	$114,504,767
25	$163,456,614	$38,208,446	0	0	$0	$0	0	$38,208,446	0	$125,248,169	$11,648,080	$113,600,089

NPV	$206,173,183
IRR	38%
B/C ratio	1.340790858

Conclusion

A vital planning tool for establishing economic and financial feasibility & A feasibility study for developing a long-term financial framework

Research Plan

Long-term Financial Framework on water infrastructure, including the deep uncertainties for decision-makers

Benefit-Cost Assessment for a strategy of maximizing the efficiency for rehabilitating and improving water infrastructures

Major Objective

analyzes several methodologies according to different points of view and conducts the benefit-cost analysis in terms of private, financial, economic, and efficiency using nominal and real terms.

Contribuiton

- **The cost-benefit assessment of several scenarios for reducing the water crisis and rehabilitating and improving water infrastructures - develop a long-term financial framework and improve redevelopment decisions for maximizing the benefit of investing in water infrastructures.**
- **It can lead to minimize the associated risks of the water sector and the damages from the water crisis, improving the resiliency of the water sector infrastructures, and decreasing the vulnerability of the water service.**

Financial Framework that Maximizes Benefit of Water-Infrastructure Investment

Thank You!

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