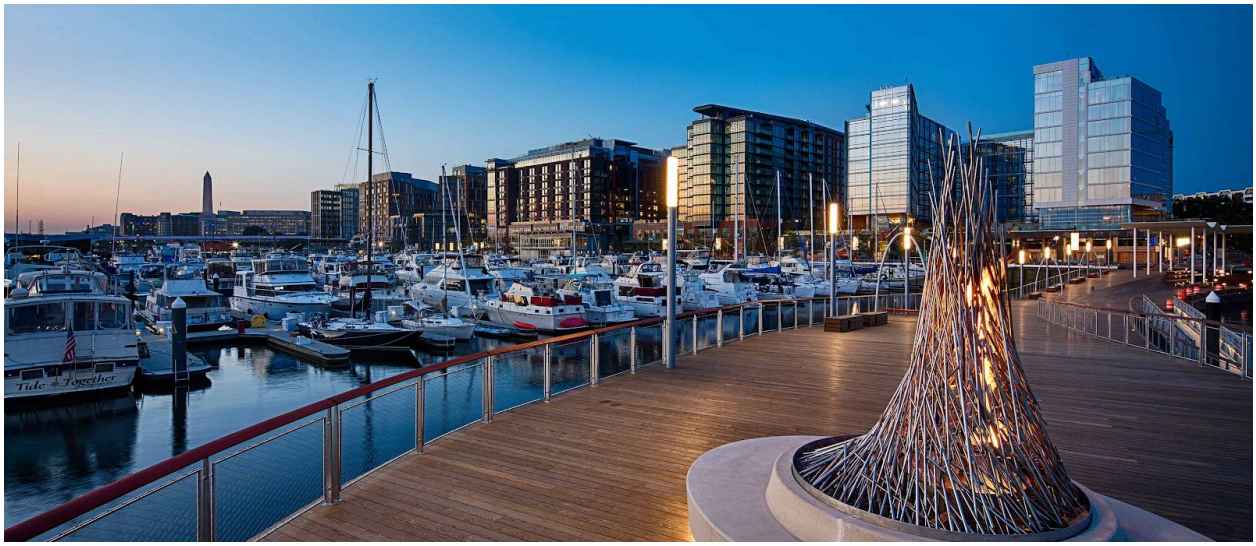
The Wharf Development Project

Risks faced by PN Hoffman and Madison Marquette



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I. Introduction and Background

The Wharf is located in D.C.'s Southwest Waterfront. This project is being managed by two major developers, PN Hoffman and Madison Marquette. Phase I of the project recently wrapped up and Phase II of the project will begin in early 2019. With an overall budget of $2.5 billion, PN Hoffman and Madison Marquette are looking at the potential risks this project will be facing as it nears the end of the project. The grace period between Phase I and Phase II will allow the developers to evaluate the upcoming risks and implement controls to adjust for these risks. The timeline for the risk analysis is from 2019 to 2025. PN Hoffman and Madison Marquette will both be greatly affected by the risks this project faces and the results of the risk analysis will help them navigate around these risks.

II. Project Structure

a. Identifying Risk Events

In brainstorming potential risks which the developers of the Wharf project could face, eight risk events were identified. Each of these risk events has the probability to lead to a financial and/or reputational loss. We used the Expert Choice Riskion software to determine the relationships between the risk events, sources, and objectives. See Figure 1.1.

1. **Not finishing project on time**: Estimated completion date is in 2022. If this event were to happen, it would lead to unrealized revenue, loss of consumers, and loss of business opportunities.
2. **Not finishing project within budget**: Estimated budget is $930,851,412. If this event were to happen, it would lead to unrealized revenue, loss of consumers, and loss of business opportunities.
3. **Low occupancy in retail property**: If this event happens, this would lead to unrealized revenue, an inability to pay the federal loans back, and an unprofitable reputation for the Wharf.
4. **Low occupancy in rental property**: If this event happens, this would lead to unrealized revenue, an inability to pay the federal loans back, and an unprofitable reputation for the Wharf.

5. **Public not interested in visiting the new development**: If the public is not interested in visiting the Wharf development, this will lead to a loss of revenue flow, a poor reputation, a loss of business opportunities, and a loss of consumers.
6. **Legal disputes with neighboring businesses**: If this event happens, this would lead to a poor reputation for the Wharf and a loss of revenue due to growing legal costs.
7. **Legal disputes amongst contractors**: If this event happens, this would lead to a poor reputation for the Wharf and a loss of revenue due to growing legal costs.
8. **Legal disputes with labor unions**: If this event happens, this would lead to a poor reputation for the Wharf and a loss of revenue due to growing legal costs.

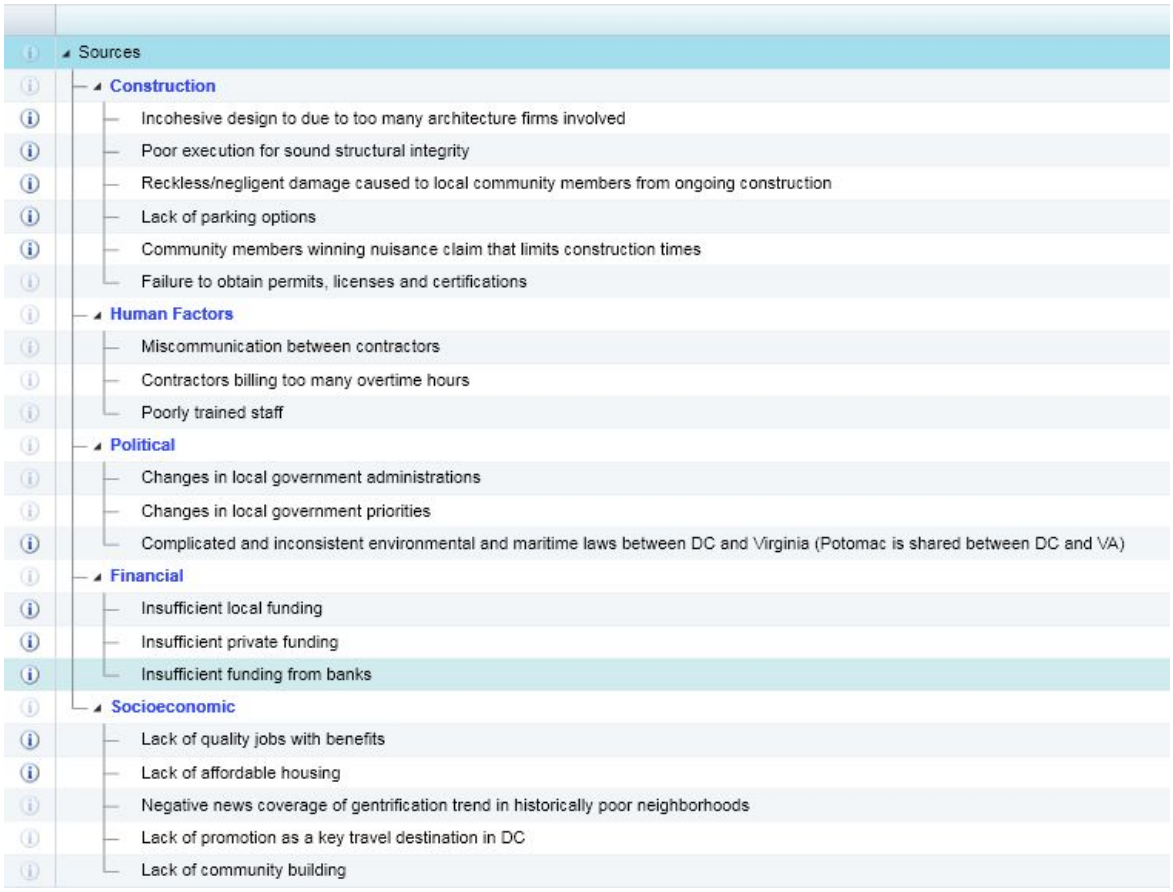
Figure 1.1: Risk Events

Unique ID		Events
[1]	ⓘ	Not finishing project on time
[7]	ⓘ	Not finishing project within budget
[2]	ⓘ	Low occupancy in retail property
[3]	ⓘ	Low occupancy in rental property
[5]	ⓘ	Public not interested in visiting the new development
[8]	ⓘ	Legal disputes with neighboring businesses
[9]	ⓘ	Legal disputes amongst contractors
[10]	ⓘ	Legal disputes with labor unions

b. Identifying Sources

Our hierarchy of sources include five major sources (or threats) that would cause an event to happen. Several sub-sources were also identified. Some of these sources can lead to one or more events to happen. See Figure 1.2.

Figure 1.2: Hierarchy of Sources



c. Identifying Objectives

We have identified several objectives that PN Hoffman and Madison Marquette wish to accomplish. These objectives have been categorized into three categories: City Development, Financial, and Public Relations. See Figure 1.3.

Figure 1.3: Hierarchy of Objectives

d. Participants and Roles

The Wharf project is being spearheaded by two major developers, PN Hoffman and Madison Marquette. Clark Construction is the lead general contractor for this project. All three parties have a vested interest in the success of the Wharf. Each participant has varying degrees of influence on the project. Roles were assigned to each participant based on the significance of their position for events and sources. See Table 1.1, Figure 1.5, and Figure 1.6.

Table 1.1: Participants and Roles

Name	Title	Affiliation	Role for Sources	Role for Events	Importance of Objectives	Event Consequences
Monty Hoffman	Chief Executive Officer	PN Hoffman	Political Financial Socioeconomic	Not finishing project on time Not finishing project within budget Legal disputes with labor unions	City Development Financial Public Relations	All events
Paul Nassetta Jr.	Chief Operating Officer	PN Hoffman	Construction Human Factors Socioeconomic	Not finishing project on time Not finishing project within budget Legal disputes with neighboring businesses Legal disputes amongst contractors	City Development Financial Public Relations	All events
Tom Ikeler	Chief Investment Officer	PN Hoffman	Financial	Low occupancy in retail property Low occupancy in rental property Legal disputes with neighboring businesses Legal disputes amongst contractors Legal disputes with labor unions	City Development Financial Public Relations	All events

Amer Hammour	Chairman	Madison Marquette	Political Financial Socioeconomic	Not finishing project on time Not finishing project within budget Legal disputes with labor unions	City Development Financial Public Relations	All events
Charlotte Wade	Chief Operating Officer	Madison Marquette	Construction Human Factors Socioeconomic	Not finishing project on time Not finishing project within budget Legal disputes with neighboring businesses Legal disputes amongst contractors	City Development Financial Public Relations	All events
David Brainerd	Chief Investment Officer	Madison Marquette	Financial	Low occupancy in retail property Low occupancy in rental property Legal disputes with neighboring businesses Legal disputes amongst contractors Legal disputes with labor unions	City Development Financial Public Relations	All events
Van Vu	Director of Construction	Clark Construction	Construction Human Factors	Not finishing project on time Not finishing project within budget Legal disputes with neighboring businesses Legal disputes amongst contractors Legal disputes with labor unions	City Development Financial Public Relations	All events
Nick Allsop	Project Manager	Clark Construction	Construction Human Factors	Not finishing project on time Not finishing project within budget Legal disputes with neighboring businesses Legal disputes amongst contractors Legal disputes with labor unions	City Development Financial Public Relations	All events

Figure 1.5: Sample of Participant Role for Sources

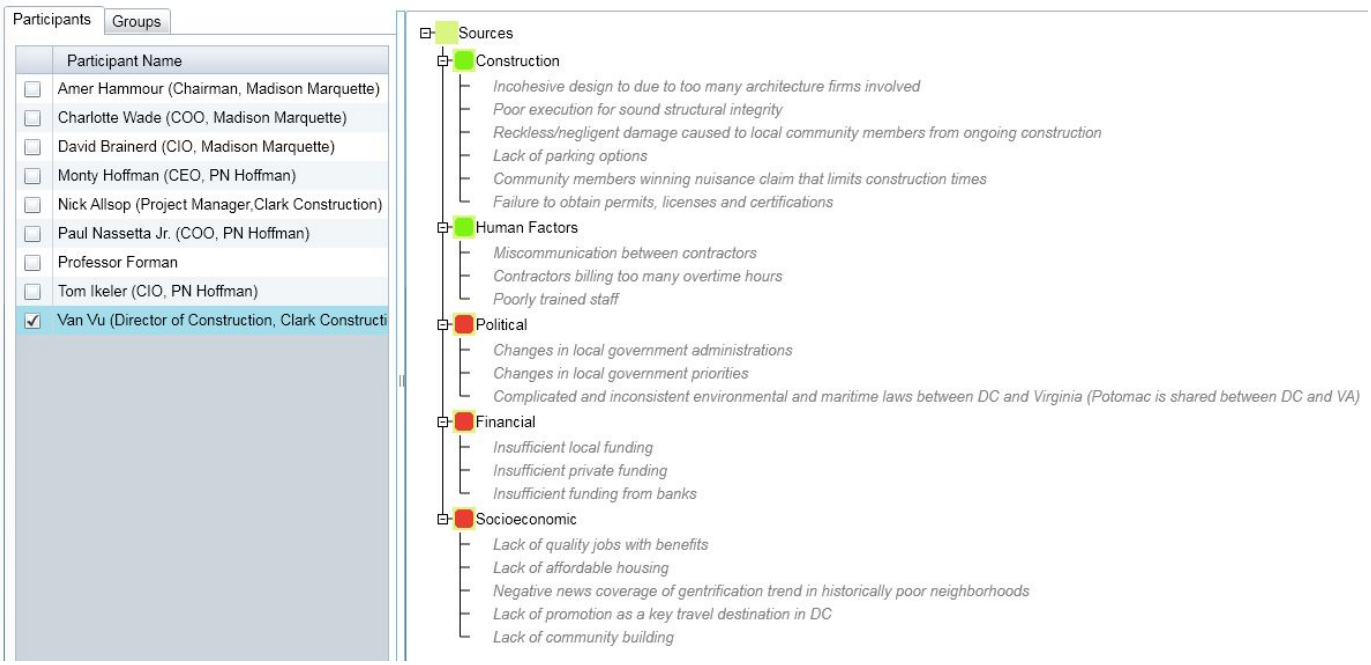


Figure 1.6: Sample of Participant Role for Events

III. Events and Sources Mapping

a. Likelihood of Events

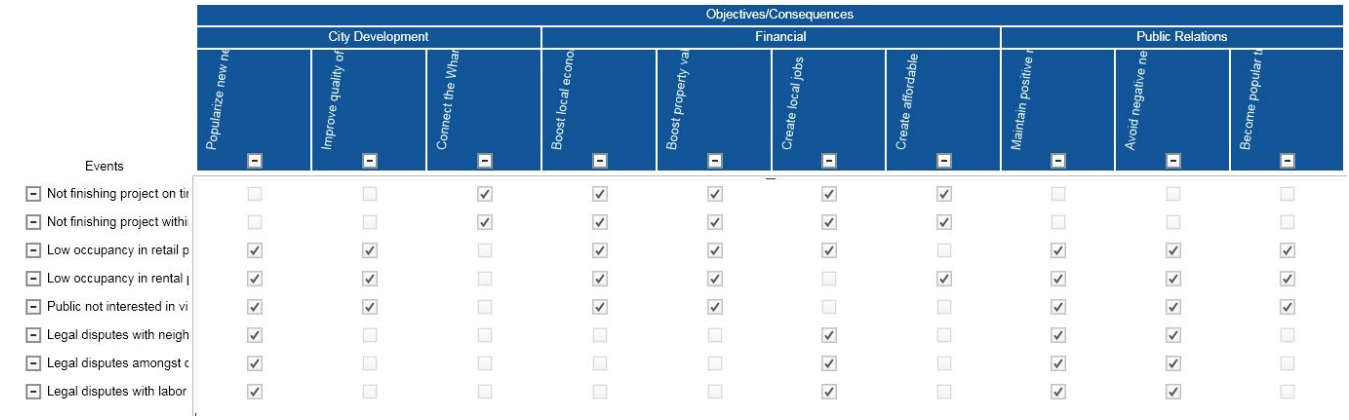
The vulnerabilities grid links sources that cause certain events to happen. One or more sources can lead to one or more events to happen. See Figure 1.7.

Figure 1.7: Vulnerabilities Grid

b. Impact of Events

The consequences grid links the events that have an impact on objectives. One or more events can impact one or more objectives. See Figure 1.8.

Figure 1.8: Consequences Grid



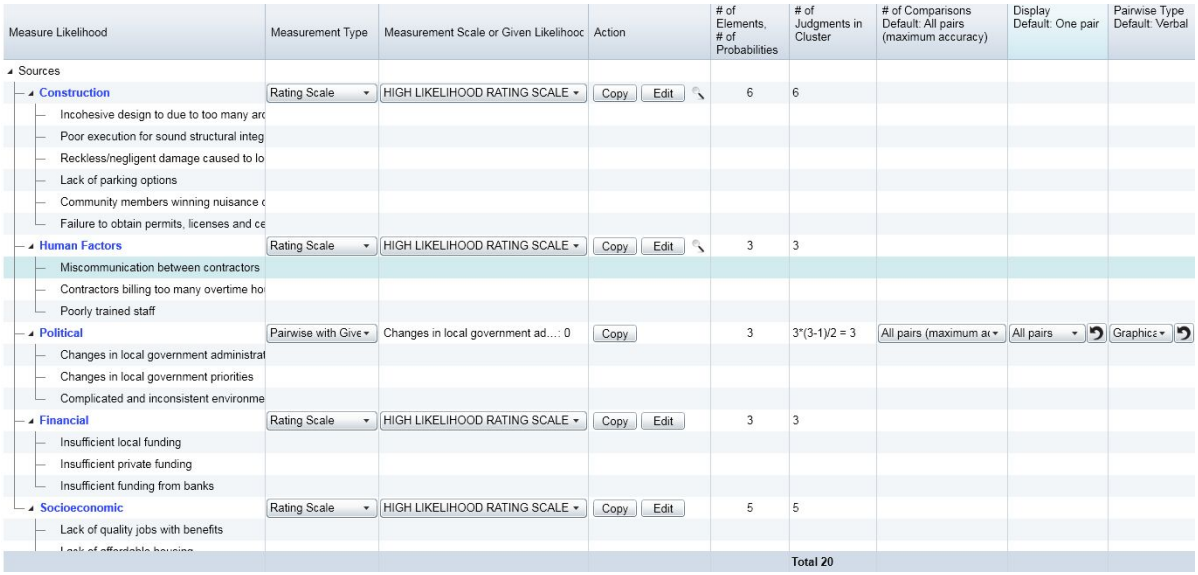
IV. Risk Measurement Methods/Scale

a. Measurement Method for Likelihood of Sources

We used Expert Choice Riskon to measure the relative and absolute measurements associated with this project. Riskion utilized Analytic Hierarchy Process, a compensatory decision theory with ratio measures that combines both mathematics and psychology to weigh all possibilities or priorities of events and objectives. The implementation of the AHP pairwise comparison process uses a mathematical model of eigenvalues and eigenvectors to evaluate the results of these pairwise comparisons and derive weights or priorities from a set of judgments and results in ratio level measurements.

We decided to utilize two types of measurement for sources: ‘Rating Scale’ and ‘Pairwise with Given Likelihood’. We decided to use the ‘Rating Scale’ measurement for all of the sources except for the ‘Political’ source to measure the likelihood of sources. For the sources where we used the ‘Rating Scale’, the ‘High Likelihood Scale’ was implemented. We used the ‘Pairwise with Given Likelihood” for the ‘Political” source because we knew the likelihood of changes in local government administration to be .25. The District of Columbia holds a mayoral election every four years, leading to a .25 likelihood that there would be a change in local government administration. Using this combination of scales, a total of 20 judgments can be made. See Figure 1.9.

Figure 1.9: Measurement Method for Likelihood of Sources

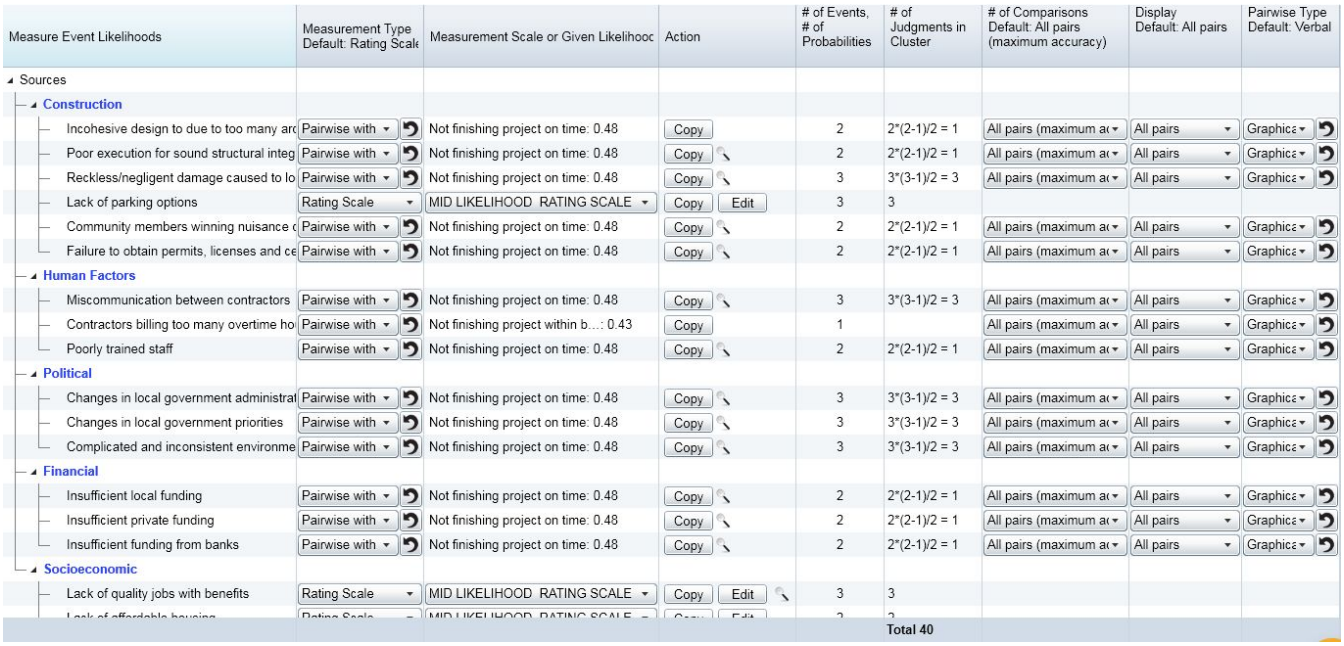


Measure Likelihood	Measurement Type	Measurement Scale or Given Likelihood	Action	# of Elements, # of Probabilities	# of Judgments in Cluster	# of Comparisons Default: All pairs (maximum accuracy)	Display Default: One pair	Pairwise Type Default: Verbal
Sources								
Construction	Rating Scale	HIGH LIKELIHOOD RATING SCALE	Copy Edit	6	6			
Incohesive design to due to too many arc								
Poor execution for sound structural integ								
Reckless/negligent damage caused to lo								
Lack of parking options								
Community members winning nuisance c								
Failure to obtain permits, licenses and ce								
Human Factors	Rating Scale	HIGH LIKELIHOOD RATING SCALE	Copy Edit	3	3			
Miscommunication between contractors								
Contractors billing too many overtime ho								
Poorly trained staff								
Political	Pairwise with Give	Changes in local government ad...: 0	Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Changes in local government administrat								
Changes in local government priorities								
Complicated and inconsistent environme								
Financial	Rating Scale	HIGH LIKELIHOOD RATING SCALE	Copy Edit	3	3			
Insufficient local funding								
Insufficient private funding								
Insufficient funding from banks								
Socioeconomic	Rating Scale	HIGH LIKELIHOOD RATING SCALE	Copy Edit	5	5			
Lack of quality jobs with benefits								
Lack of affordable housing								
					Total 20			

b. Measurement Method for Likelihood of Events Given Sources

We decided to use a combination of the ‘Rating Scale’ and the ‘Pairwise with Given Likelihood’ methods to measure the likelihood of events. For the events using the ‘Rating Scale’, the ‘Mid Likelihood Scale’ was used. We used the ‘Pairwise with Given Likelihood” for the ‘Not finishing project on time” and ‘Not finishing within budget” events because we knew the likelihood of these events to happen based on research conducted by the Project Management Institute. Based on their 2018 publication of Pulse of the Profession, there is a .48 likelihood that a project will not finish on time and a.43 likelihood that a project will not finish within budget. Using this combination of scales, a total of 40 judgments can be made. See Figure 1.10.

Figure 1.10: Measurement Method for Likelihood of Events Given Sources

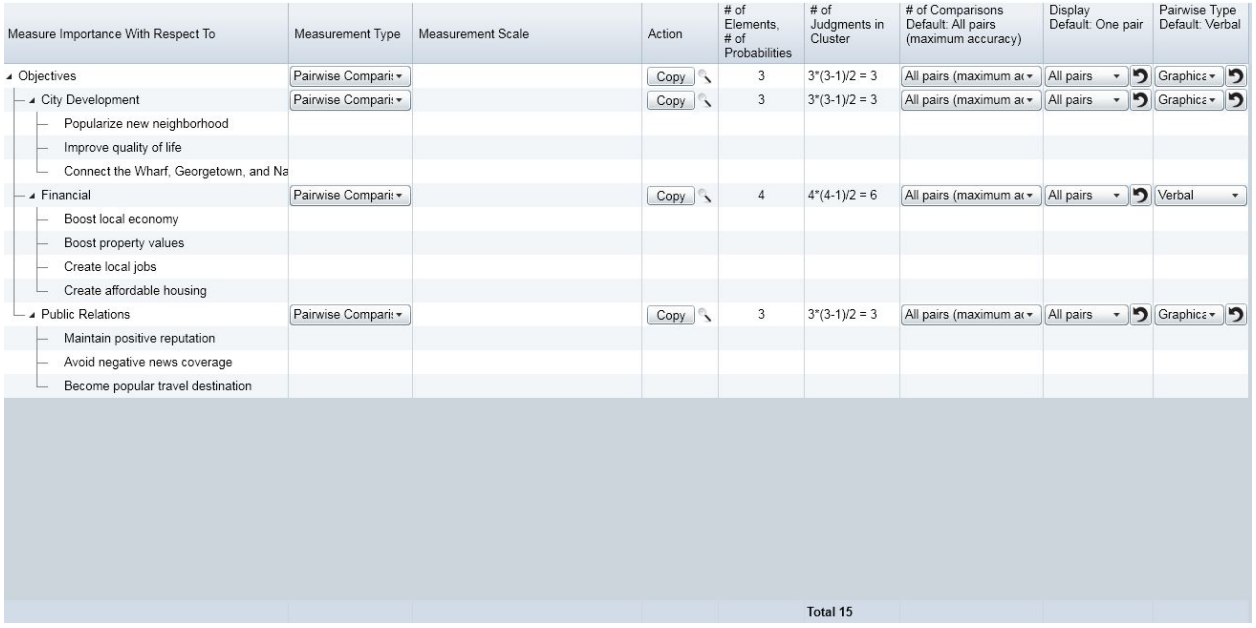


Measure Event Likelihoods	Measurement Type Default: Rating Scale	Measurement Scale or Given Likelihood	Action	# of Events, # of Probabilities	# of Judgments in Cluster	# of Comparisons Default: All pairs (maximum accuracy)	Display Default: All pairs	Pairwise Type Default: Verbal
Sources								
Construction								
Incohesive design to due to too many arc	Pairwise with	Not finishing project on time: 0.48	Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Poor execution for sound structural integ	Pairwise with	Not finishing project on time: 0.48	Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Reckless/negligent damage caused to lo	Pairwise with	Not finishing project on time: 0.48	Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Lack of parking options	Rating Scale	MID LIKELIHOOD_RATING SCALE	Copy Edit	3	3			
Community members winning nuisance (	Pairwise with	Not finishing project on time: 0.48	Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Failure to obtain permits, licenses and ce	Pairwise with	Not finishing project on time: 0.48	Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Human Factors								
Miscommunication between contractors	Pairwise with	Not finishing project on time: 0.48	Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Contractors billing too many overtime ho	Pairwise with	Not finishing project within b...: 0.43	Copy	1		All pairs (maximum ac	All pairs	Graphica
Poorly trained staff	Pairwise with	Not finishing project on time: 0.48	Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Political								
Changes in local government administrat	Pairwise with	Not finishing project on time: 0.48	Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Changes in local government priorities	Pairwise with	Not finishing project on time: 0.48	Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Complicated and inconsistent environme	Pairwise with	Not finishing project on time: 0.48	Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Financial								
Insufficient local funding	Pairwise with	Not finishing project on time: 0.48	Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Insufficient private funding	Pairwise with	Not finishing project on time: 0.48	Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Insufficient funding from banks	Pairwise with	Not finishing project on time: 0.48	Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Socioeconomic								
Lack of quality jobs with benefits	Rating Scale	MID LIKELIHOOD_RATING SCALE	Copy Edit	3	3			
					Total 40			

c. Measurement Method for Importance of Objectives

We decided to use the 'Pairwise Comparison' method to measure the impact on objectives with respect to the events. A total of 15 judgments can be made. See Figure 1.11.

Figure 1.11: Measurement for Importance of Objective

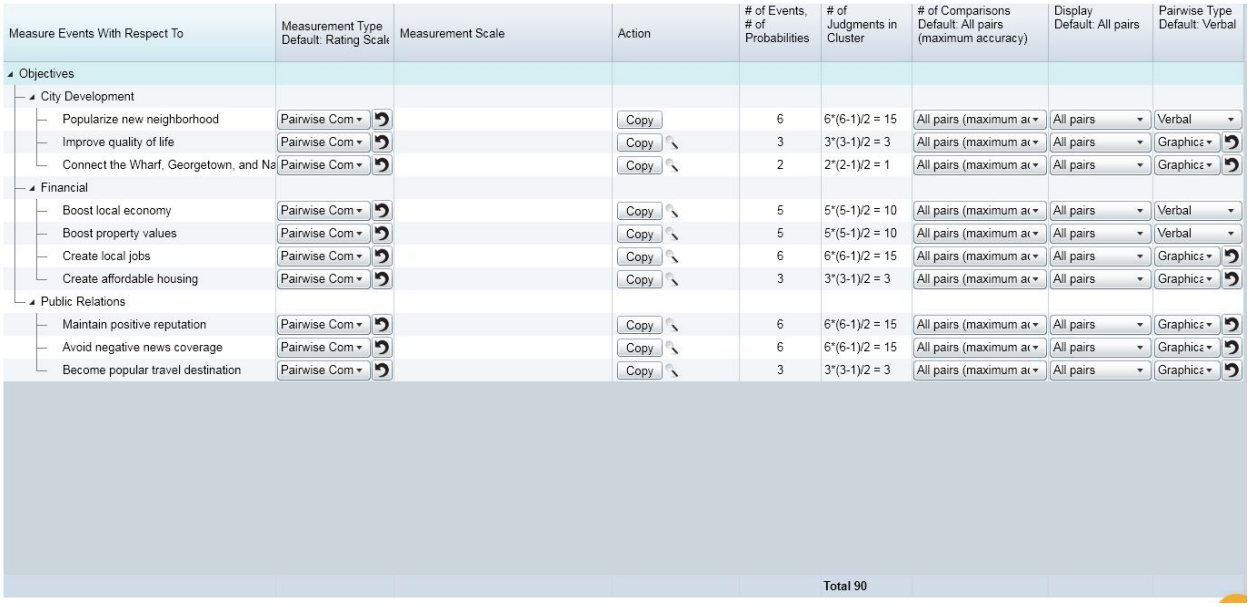


Measure Importance With Respect To	Measurement Type	Measurement Scale	Action	# of Elements, # of Probabilities	# of Judgments in Cluster	# of Comparisons Default: All pairs (maximum accuracy)	Display Default: One pair	Pairwise Type Default: Verbal
Objectives	Pairwise Compari		Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
City Development	Pairwise Compari		Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Popularize new neighborhood								
Improve quality of life								
Connect the Wharf, Georgetown, and Na								
Financial	Pairwise Compari		Copy	4	4*(4-1)/2 = 6	All pairs (maximum ac	All pairs	Verbal
Boost local economy								
Boost property values								
Create local jobs								
Create affordable housing								
Public Relations	Pairwise Compari		Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Maintain positive reputation								
Avoid negative news coverage								
Become popular travel destination								
				Total 15				

d. Measurement Method for Consequences of Events

We decided to use the ‘Pairwise Comparison’ method to measure the impact on events with respect to the objectives. A total of 90 judgments can be made. See Figure 1.12.

Figure 1.12: Measurement of Impact Method for Events



Measure Events With Respect To	Measurement Type Default: Rating Scale	Measurement Scale	Action	# of Events, # of Probabilities	# of Judgments in Cluster	# of Comparisons Default: All pairs (maximum accuracy)	Display Default: All pairs	Pairwise Type Default: Verbal
Objectives								
City Development								
Popularize new neighborhood	Pairwise Com		Copy	6	6*(6-1)/2 = 15	All pairs (maximum ac	All pairs	Verbal
Improve quality of life	Pairwise Com		Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Connect the Wharf, Georgetown, and Na	Pairwise Com		Copy	2	2*(2-1)/2 = 1	All pairs (maximum ac	All pairs	Graphica
Financial								
Boost local economy	Pairwise Com		Copy	5	5*(5-1)/2 = 10	All pairs (maximum ac	All pairs	Verbal
Boost property values	Pairwise Com		Copy	5	5*(5-1)/2 = 10	All pairs (maximum ac	All pairs	Verbal
Create local jobs	Pairwise Com		Copy	6	6*(6-1)/2 = 15	All pairs (maximum ac	All pairs	Graphica
Create affordable housing	Pairwise Com		Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
Public Relations								
Maintain positive reputation	Pairwise Com		Copy	6	6*(6-1)/2 = 15	All pairs (maximum ac	All pairs	Graphica
Avoid negative news coverage	Pairwise Com		Copy	6	6*(6-1)/2 = 15	All pairs (maximum ac	All pairs	Graphica
Become popular travel destination	Pairwise Com		Copy	3	3*(3-1)/2 = 3	All pairs (maximum ac	All pairs	Graphica
					Total 90			

V. Synthesis

Once the data has been gathered from all of the participants, we are able to synthesize the qualitative and quantitative data together.

a. Synthesis of Likelihood of Sources

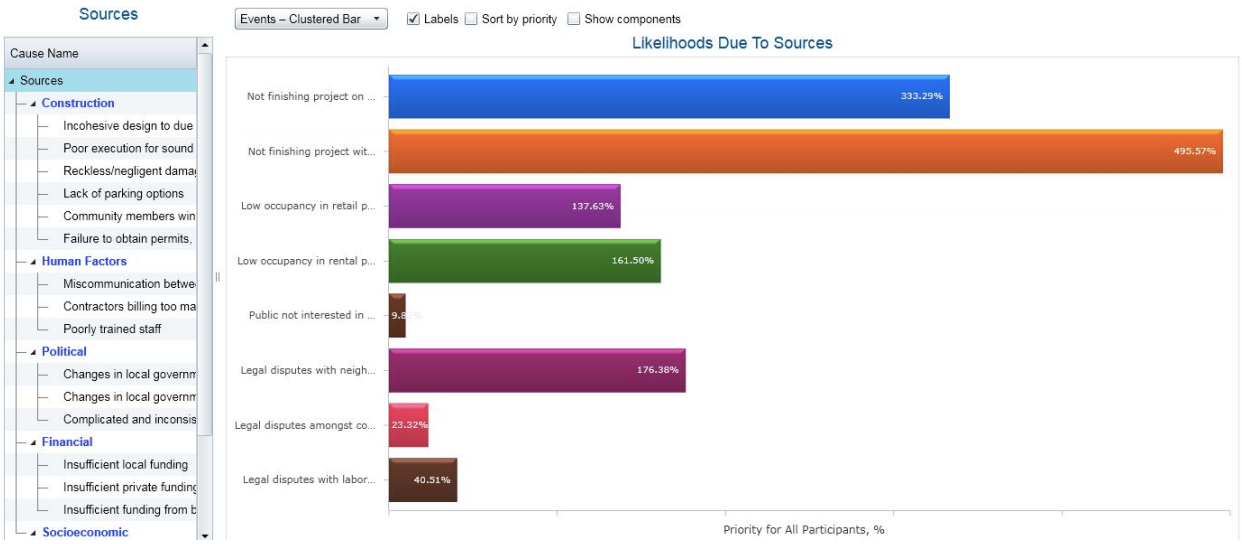
In Figure 1.14, ‘Complicated and inconsistent environmental and maritime laws between DC and Virginia (Potomac is shared between DC and VA)’ source has the highest likelihood of happening with an 88.21% chance. ‘Failure to obtain permits, licenses and certifications’ has the lowest likelihood of happening with a 3% chance.

Figure 1.14: Synthesized Sources Likelihood Chart

b. Synthesis of Likelihood of Events

In Figure 1.13 below, it can be stated that ‘Not finishing project within budget’ event has the highest likelihood of happening. The data shows that there is a 495.57% likelihood. The ‘Public not interested in visiting the new development’ event has the lowest likelihood of happening with a 9.82% chance. The high percentages for these computed likelihoods are present due to the multiple counting that is happening. An event that has multiple sources can be triggered by any of the sources. Once it is triggered, it cannot be triggered again; however, the computed likelihoods are accounting for multiple triggerings. We use Riskion to run Monte Carlo simulations to account for only one event triggering per trial. The simulated results are reflected in Figure 1.18.

Figure 1.13: Synthesized Events Likelihood Chart

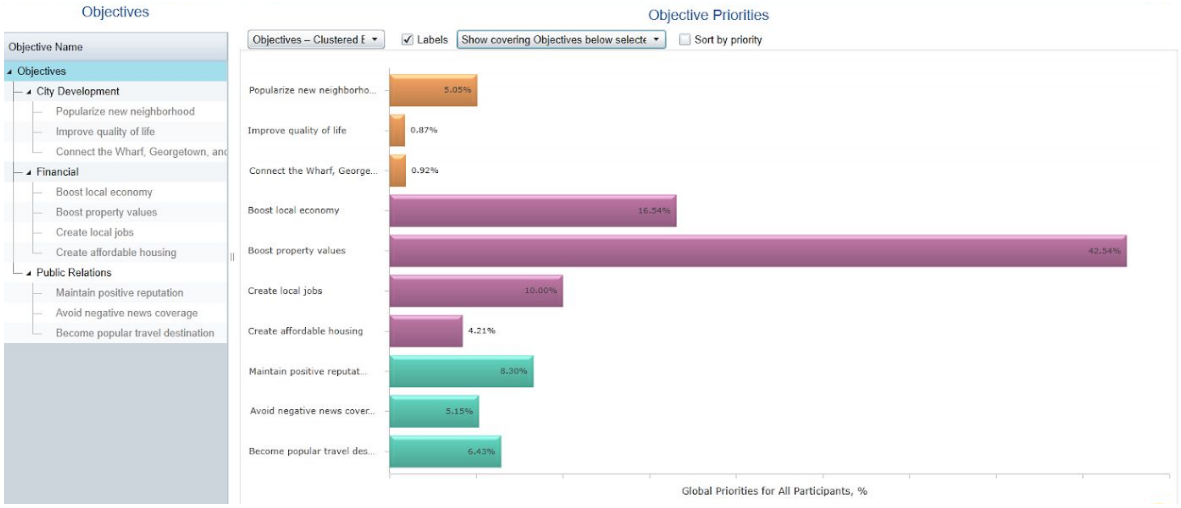


c. Synthesis of Priorities of Objectives

Figure 1.16 shows us that the Financial objective is the most impacted objective of the three. When we drill down further in Figure 1.17, we can see that ‘Boost property values’ sub-objective is the one most heavily impacted.

Figure 1.16: Objective Priorities Chart

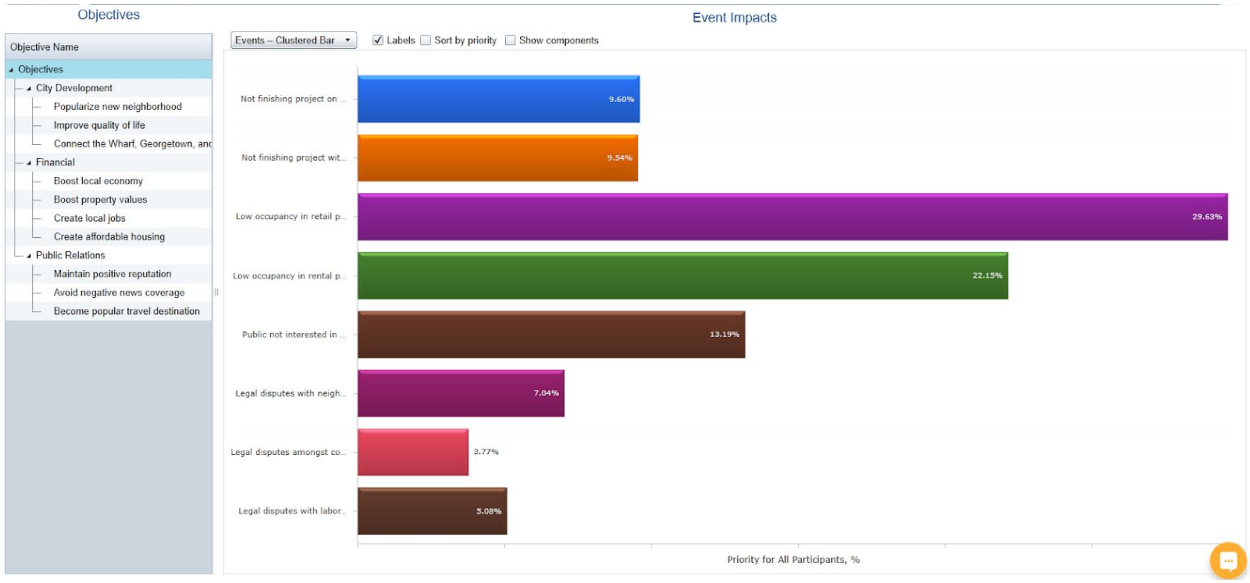
Figure 1.17: Objective Priorities Chart Showing Sub-Objectives



d. Synthesis of Impact of Events

In Figure 1.15, the ‘Low occupancy in retail property’ event would have the greatest impact on the objectives. The ‘Legal disputes amongst contractors’ event would have the least amount of impact on the objectives.

Figure 1.15: Synthesized Events Impact Chart



VI. Risk Analysis without Controls

a. Risk Results Without Monetary Values

Figure 1.18 shows us the percentage of risk each of the events faces. The two events with the highest risk percentages are:

- ‘Low occupancy in retail property’ has an 85.73% likelihood of occuring, with a 36.87% impact, resulting in 31.61% risk.
- ‘Low occupancy in rental property’ has a 90.73% likelihood of occuring, with a 29.17% impact, resulting in 26.46% risk.

The total risk this project faces is at 95.62%, making it a highly risky project to complete.
Note that the following results have been simulated via Monte Carlo simulations to account for the flaws of averages and disregard any double counting that occurs due to threats or sources that are not mutually exclusive (Forman, Forman, & Ludden).

Figure 1.18a: Risk Register of Overall Risk of Each Event Without Controls (Simulated)

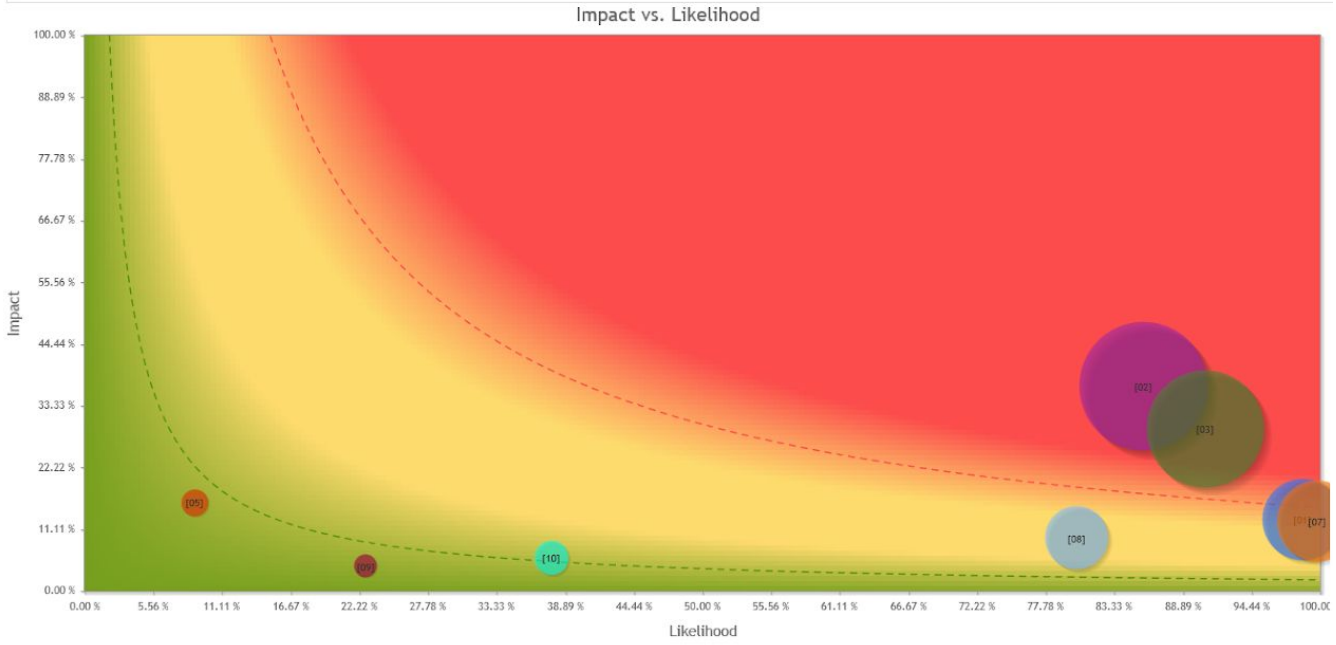
Overall Likelihoods, Impacts, and Risks for RM Project 2018_NA_VV_The Wharf Development-P

No. ▲	Event	All Participants Likelihood Simulated	Impact Simulated	Risk Simulated
[01]	Not finishing project on time	98.60%	12.84%	12.66%
[02]	Low occupancy in retail property	85.73%	36.87%	31.61%
[03]	Low occupancy in rental property	90.73%	29.17%	26.46%
[05]	Public not interested in visiting the new development	8.93%	15.99%	1.43%
[07]	Not finishing project within budget	99.80%	12.54%	12.51%
[08]	Legal disputes with neighboring businesses	80.33%	9.54%	7.66%
[09]	Legal disputes amongst contractors	22.80%	4.49%	1.02%
[10]	Legal disputes with labor unions	37.80%	5.96%	2.25%
			Total Risk Simulated	95.62%

a.1. Risk Map

Figure 1.19 is another iteration of the information provided above. It is showing us that ‘Low occupancy in retail property’ and ‘Low occupancy in rental property’ are the riskiest events, having the largest circles on the map (purple and green, respectively). It also helps to visualize them as having the most impact with a high probability of occuring.

Figure 1.19: Risk Map of Events Without Controls



a.2. Bow-Tie Diagrams

Figure 1.20 shows us the likelihood of the sources that can lead to the event of ‘Low occupancy in retail property’ to occur. On the left side of the diagram, the diagram shows us that ‘Negative news coverage of gentrification trend in historically poor neighborhoods’ has the highest likelihood at 74.17% chance of happening. On the right side of the diagram, the diagram shows us the impact of having the event occur. The sub-objective “Boost property value”, which has a 100% consequence rate, will be one of the most affected by this event occuring. This means that if negative news coverages of gentrification trend in historically poor neighborhoods causes a low occupancy in retail property at the Wharf, it will lead to low property values.

Figure 1.20: Bow-Tie Diagram for "Low occupancy in retail property" Event Without Controls

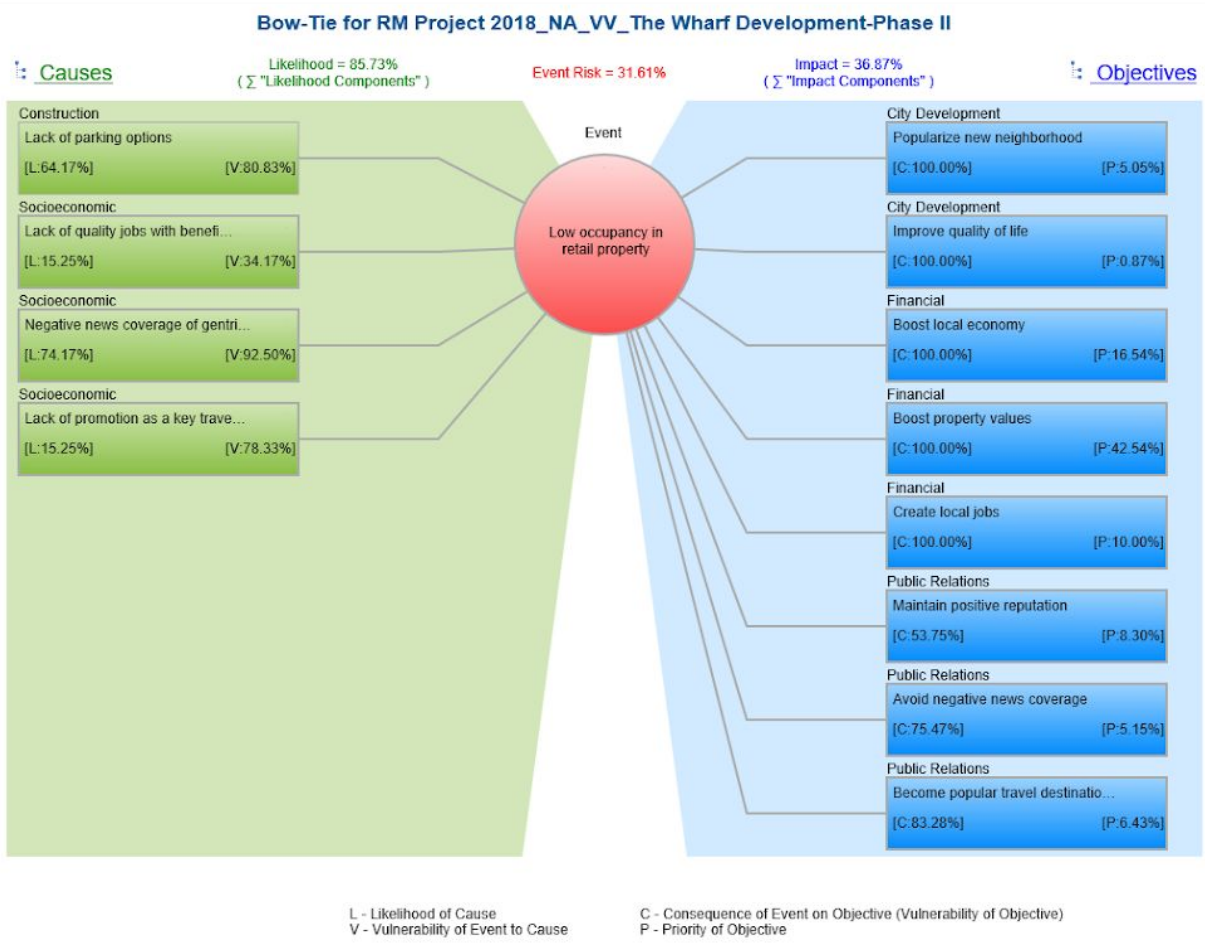
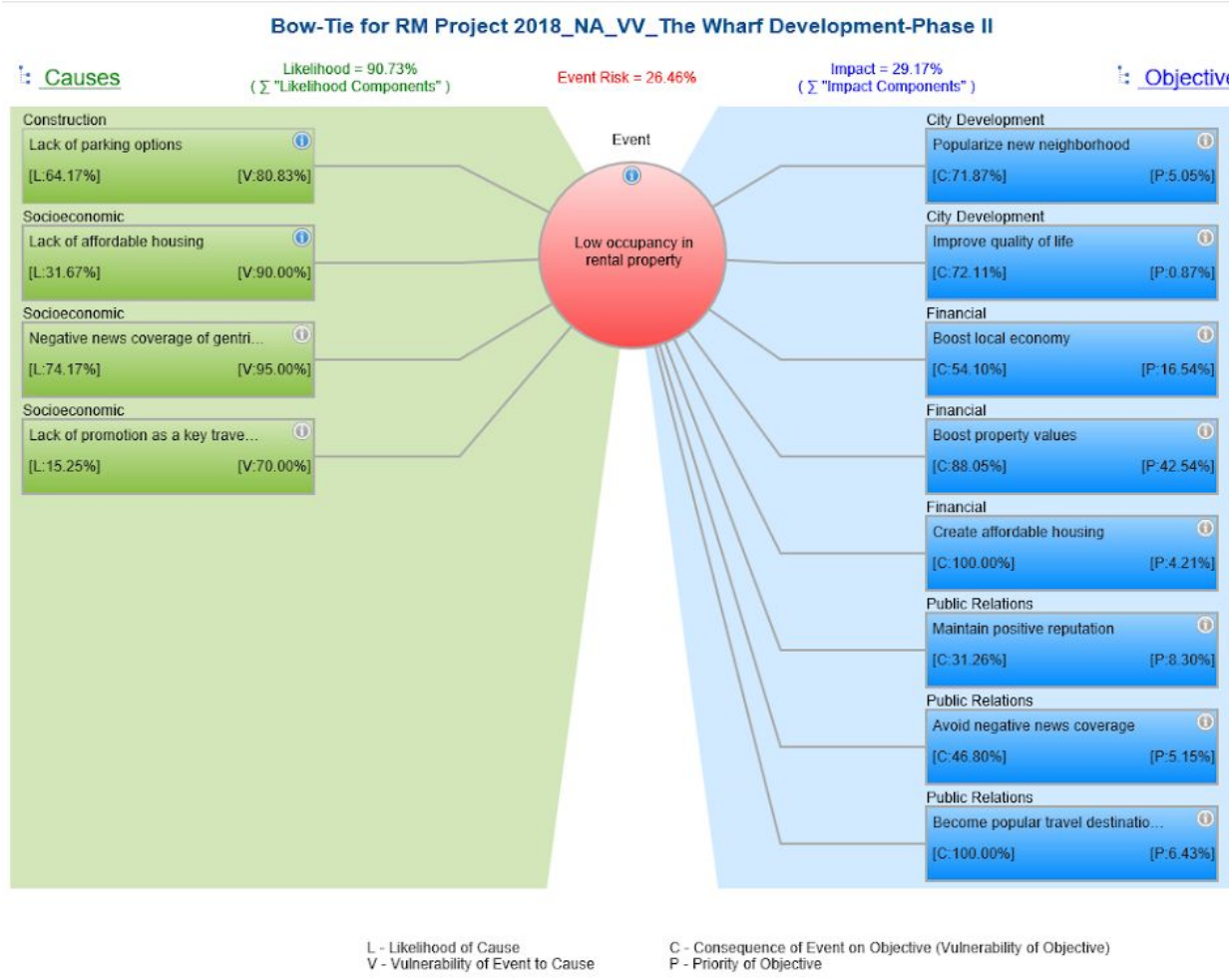


Figure 1.21 below shows us the likelihood of the sources that can lead to the event of 'Low occupancy in rental property' to occur. On the left side of the diagram, the diagram shows us that 'Negative news coverage of gentrification trend in historically poor neighborhoods' has the highest likelihood with a 74.17% chance of happening. On the right side of the diagram, the diagram shows us the negative impact of having the event occur. The sub-objective "Become popular travel destination", which has a 100% consequence rate, will be one of the most affected by this event occuring. This means that if negative news coverages of gentrification trend in historically poor neighborhoods causes a low occupancy in rental property at the Wharf, it would negatively impact the sub-objective of becoming a popular travel destination.

Figure 1.21: Bow-Tie Diagram for "Low occupancy in rental property" Event Without Controls



a.3. Loss Exceedance

Figure 1.22 shows us the first simulation that ran out of 1500 simulations which helps us analyze the risks for the Wharf project. The first column shows us all of the sources we have determined for the project. Each source is assigned a random number and a priority number. If the priority number is greater than the random number, it means that the source will occur (causes that fired) and will lead to the event to occur (events that fired). In the simulation below, eight causes fired which led to three events to fire. For example, the 'Reckless/negligent damage caused to local community"' cause has a priority of 0.27543029 and a random number of 0.67750001. The priority number is greater than the random number which leads to the 'Legal disputes with neighboring businesses' event to fire. This means that legal disputes with

neighboring businesses occured because there were reckless/negligent damages done on the local community. The total loss due to the three events firing is 0.64588215.

Figure 1.22: Simulation 1 of 1500 Loss Exceedance Data Without Controls

Independent events
Average loss: 95.62%
VAR, probability: 10% probability that loss will exceed -100%
VAR, loss: 99.1% chance of losing more than 50%

Loss Exceedance Curve for All Participants

Step: 1 Back to Chart

Causes (without controls)
Number of causes that fired: 8

Cause Name	Cause Random()	Probability
[6] Incohesive design to due to too many architec...	**0.50537038**	**0.70999998**
[7] Poor execution for sound structural integrity	0.61254607	0.27500001
[8] Reckless/negligent damage caused to local com...	**0.27543029**	**0.67750001**
[9] Lack of parking options	0.81482597	0.641675
[10] Community members winning nuisance claim that...	**0.41645563**	**0.70999998**
[11] Failure to obtain permits, licenses and certi...	0.33675029	0.03
[12] Miscommunication between contractors	**0.09203434**	**0.755**
[13] Contractors billing too many overtime hours	0.92782116	0.74167502
[14] Poorly trained staff	**0.09567952**	**0.641675**
[15] Changes in local government administrations	0.51217258	0.25
[16] Changes in local government priorities	0.08823193	0.04557215
[17] Complicated and inconsistent environmental an...	**0.05745535**	**0.88212287**
[20] Insufficient local funding	0.96449298	0.68334997
[18] Insufficient private funding	**0.33465937**	**0.68334997**
[19] Insufficient funding from banks	**0.35733682**	**0.60000002**
[21] Lack of quality jobs with benefits	0.85779752	0.1525
[22] Lack of affordable housing	0.61907002	0.31667501
[23] Negative news coverage of gentrification tren...	0.83475354	0.74167502
[24] Lack of promotion as a key travel destination...	0.55326191	0.1525
[25] Lack of community building	0.82929807	0.58335

Total loss of simulation: 0.64588215
Number of Events that fired: 3

Event Name	Random()	Vulnerability	Impact	Risk
Not finishing project on time C_{ID}=[6]	**0.00872262**	**0.47999999**	**0.23111404**	**0.07876**
Not finishing project within budget C_{ID}=[6]	**0.23501902**	**0.32657579**	**0.22445899**	**0.05204**
Low occupancy in retail property [No Causes]				
Low occupancy in rental property [No Causes]				
Public not interested in visiting the new dev... [No Causes]				
Legal disputes with neighboring businesses C_{ID}=[8]	**0.24671672**	**2.00303674**	**0.19030912**	**0.2582**
Legal disputes amongst contractors [No Causes]				
Legal disputes with labor unions [No Causes]				

b. Risk Results With Monetary Values

The total value of the enterprise is $2.5 billion. Once we input that data in, all objectives' impact values were assigned their respective dollar value based on the percentage value they each carried. For example, the impact on the 'City Development' objective is 6.84%. 6.84% of $2.5 billion equals $171,000,000 (this number was rounded up). See the image below.

Image 1.1.: Monetary Value Breakdown

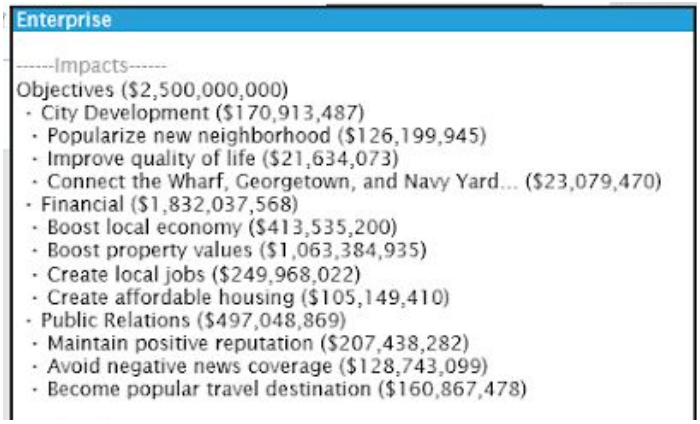


Figure 1.23 shows us the monetary value that each risk event carries. The two events with the highest risks are:

- 'Low occupancy in retail property' has an 85.73% likelihood of occuring, with a $921,767,866 impact, resulting in a risk loss of $790,262,317.
- 'Low occupancy in rental property' has a 90.73% likelihood of occuring, with a $729,135,303 impact, resulting in a risk loss of $661,568,764.

The total risk loss is $2,390,393,287. As stated previously, this is a highly risky project to complete. Note that the following results have been simulated via Monte Carlo simulations to account for the flaws of averages and disregard any double counting that occurs due to threats or sources that are not mutually exclusive (Forman, Forman, & Ludden).

Figure 1.23: Risk Register of Overall Risk of Each Event with Monetary Values Without Controls

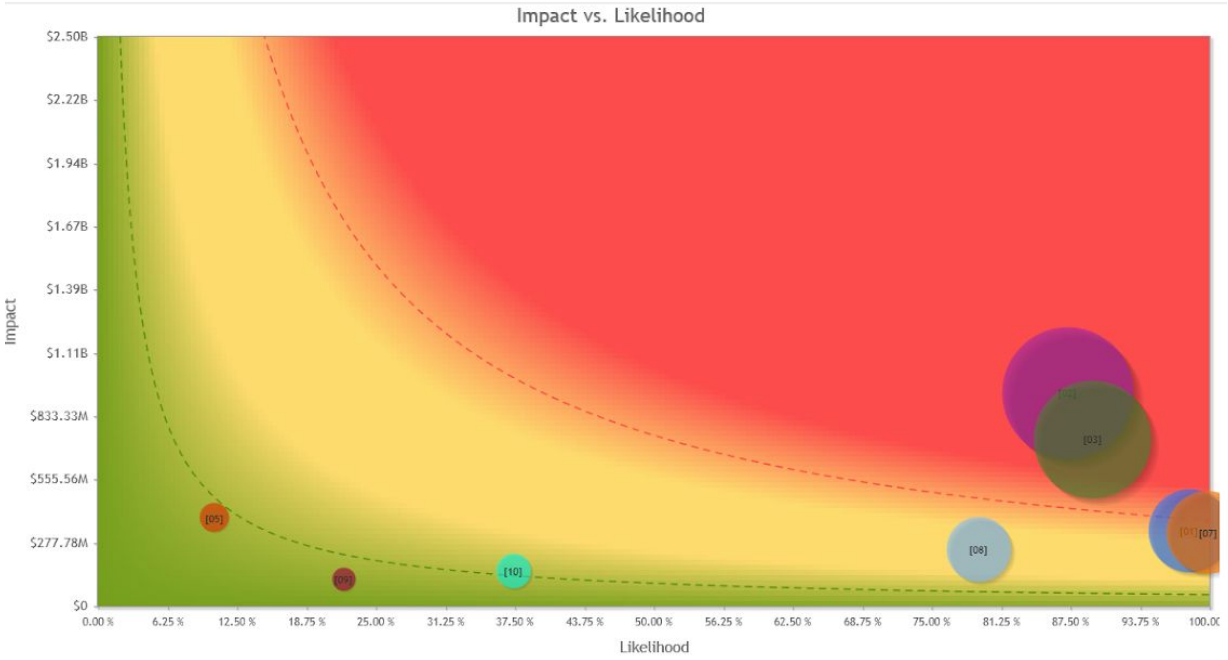
Overall Likelihoods, Impacts, and Risks for RM Project 2018_NA_VV_The Wharf Development

No. ▲	Event	All Participants Likelihood Simulated	Impact, $ Simulated	Risk, $ Simulated
[01]	Not finishing project on time	98.60%	321,073,940	316,578,905
[02]	Low occupancy in retail property	85.73%	921,767,866	790,262,317
[03]	Low occupancy in rental property	90.73%	729,135,303	661,568,764
[05]	Public not interested in visiting the new development	8.93%	399,802,386	35,715,679
[07]	Not finishing project within budget	99.80%	313,378,865	312,752,108
[08]	Legal disputes with neighboring businesses	80.33%	238,449,670	191,554,568
[09]	Legal disputes amongst contractors	22.80%	112,345,449	25,614,762
[10]	Legal disputes with labor unions	37.80%	149,063,969	56,346,180
				Simulated
			Total Risk	$2,390,393,287

b.1. Risk Map with Monetary Values

Figure 1.24 is another iteration of the information provided above. It is showing us that 'Low occupancy in retail property' and 'Low occupancy in rental property' are the riskiest events, having the largest circles on the map (purple and green, respectively). It also helps to visualize them as having the most monetary impact with a high probability.

Figure 1.24: Risk Map of Events with Monetary Values Without Controls



b.2. Bow-Tie Diagrams with Monetary Values

The diagrams below show us the relationship between the causes, events and objectives. These bow-tie diagrams are similar to the ones above but they now show us the monetary value of each event risk. Figure 1.25 shows us that if 'Low occupancy in retail property' occurs, it will lead to a loss of $790.26 million. Figure 1.26 shows us that if "Low occupancy in rental property' occurs, it will lead to a loss of $661.57 million.

Figure 1.25: Bow-Tie Diagram with Monetary Value for "Low occupancy in retail property" Event Without Controls

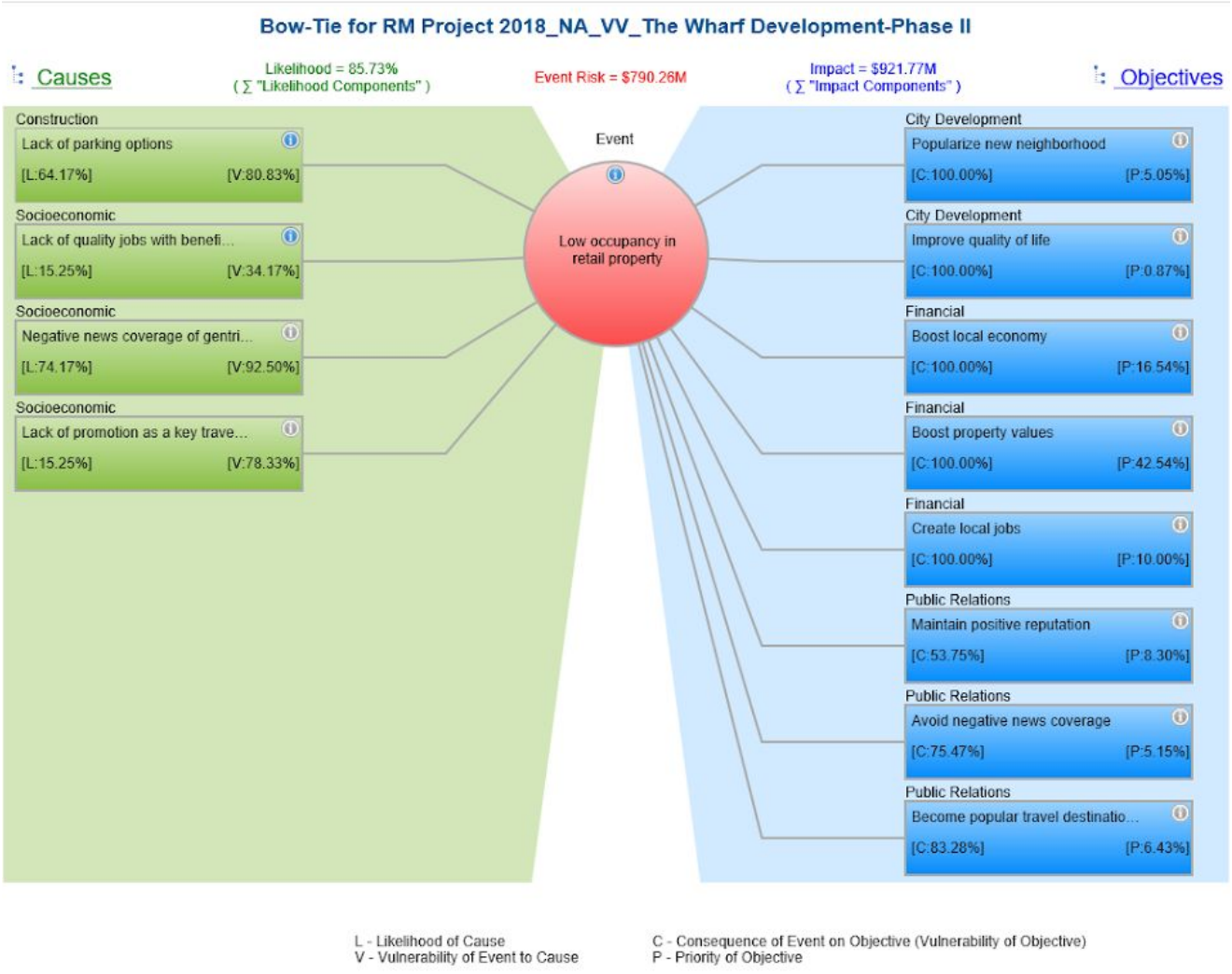
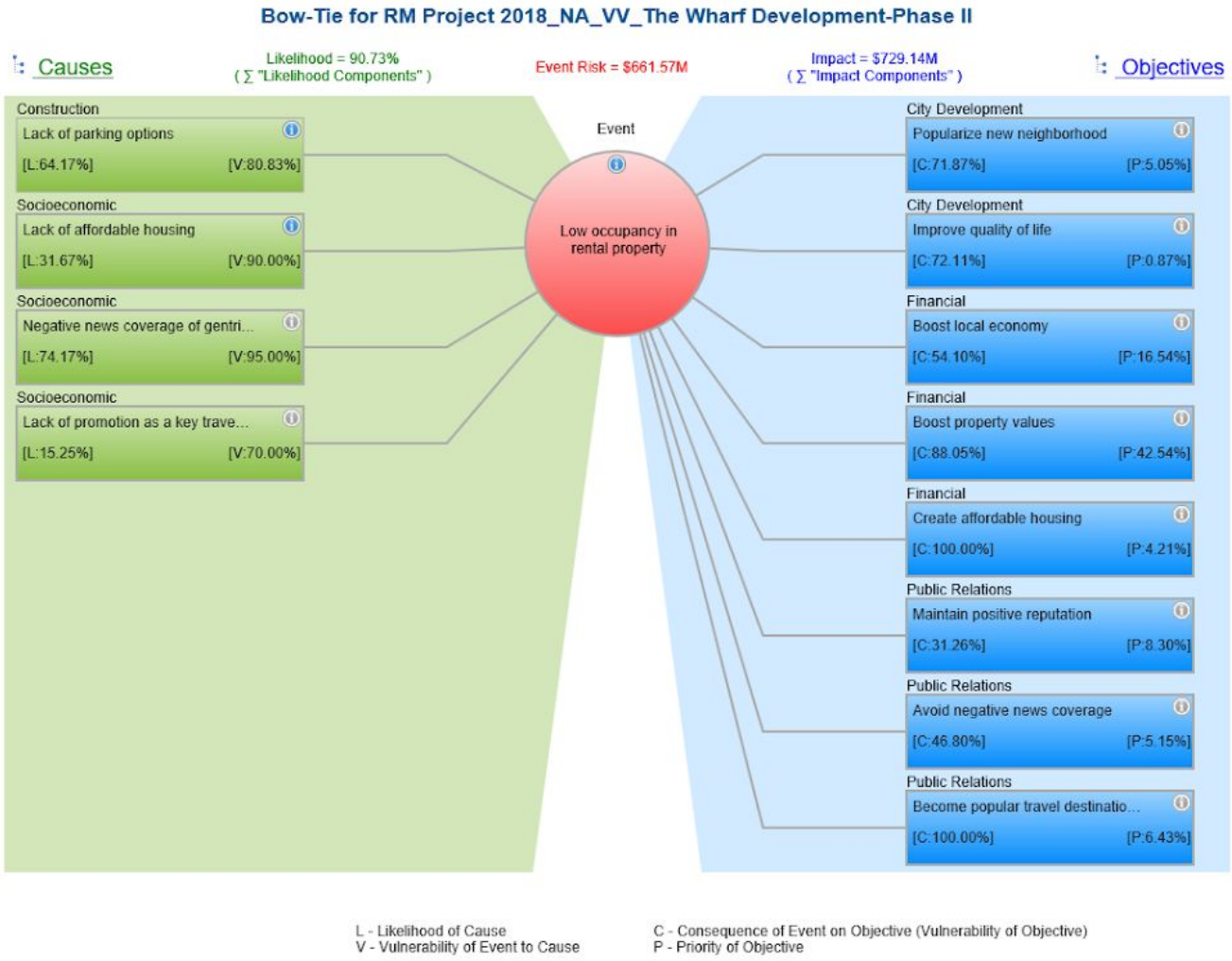


Figure 1.26: Bow-Tie Diagram with Monetary Value for "Low occupancy in rental property" Event Without Controls



b.3. Loss Exceedance with Monetary Values

Figure 1.27 below shows us the values at risk for the project. The overall project is worth $2.5 billion. There is a 95% probability that the loss of this project will exceed $1.69 billion and a 92.27% chance of losing more than $2 billion on finishing this project. The average loss is $2.39 billion. Figure 1.28 shows us the first simulation's total loss of the three events firing to be $1.61 billion.

Figure 1.27: Loss Exceedance Curve with Monetary Values Without Controls

Figure 1.28: Loss Exceedance with Monetary Values Without Controls

Cause Name	Cause Random()	Probability
[6] Incohesive design to due to too many architec...	0.50537038	0.70999998
[7] Poor execution for sound structural integrity	0.61254607	0.27500001
[8] Reckless/negligent damage caused to local com...	0.27543029	0.67750001
[9] Lack of parking options	0.81482597	0.641675
[10] Community members winning nuisance claim that...	0.41645563	0.70999998
[11] Failure to obtain permits, licenses and certi...	0.33675029	0.03
[12] Miscommunication between contractors	0.09203434	0.755
[13] Contractors billing too many overtime hours	0.92782116	0.74167502
[14] Poorly trained staff	0.09567952	0.641675
[15] Changes in local government administrations	0.51217258	0.25
[16] Changes in local government priorities	0.08823193	0.04557215
[17] Complicated and inconsistent environmental an...	0.05745535	0.88212287
[20] Insufficient local funding	0.96449298	0.68334997
[18] Insufficient private funding	0.33465937	0.68334997
[19] Insufficient funding from banks	0.35733682	0.60000002
[21] Lack of quality jobs with benefits	0.85779752	0.1525
[22] Lack of affordable housing	0.61907002	0.31667501
[23] Negative news coverage of gentrification tren...	0.83475354	0.74167502
[24] Lack of promotion as a key travel destination...	0.55326191	0.1525
[25] Lack of community building	0.82929807	0.58335

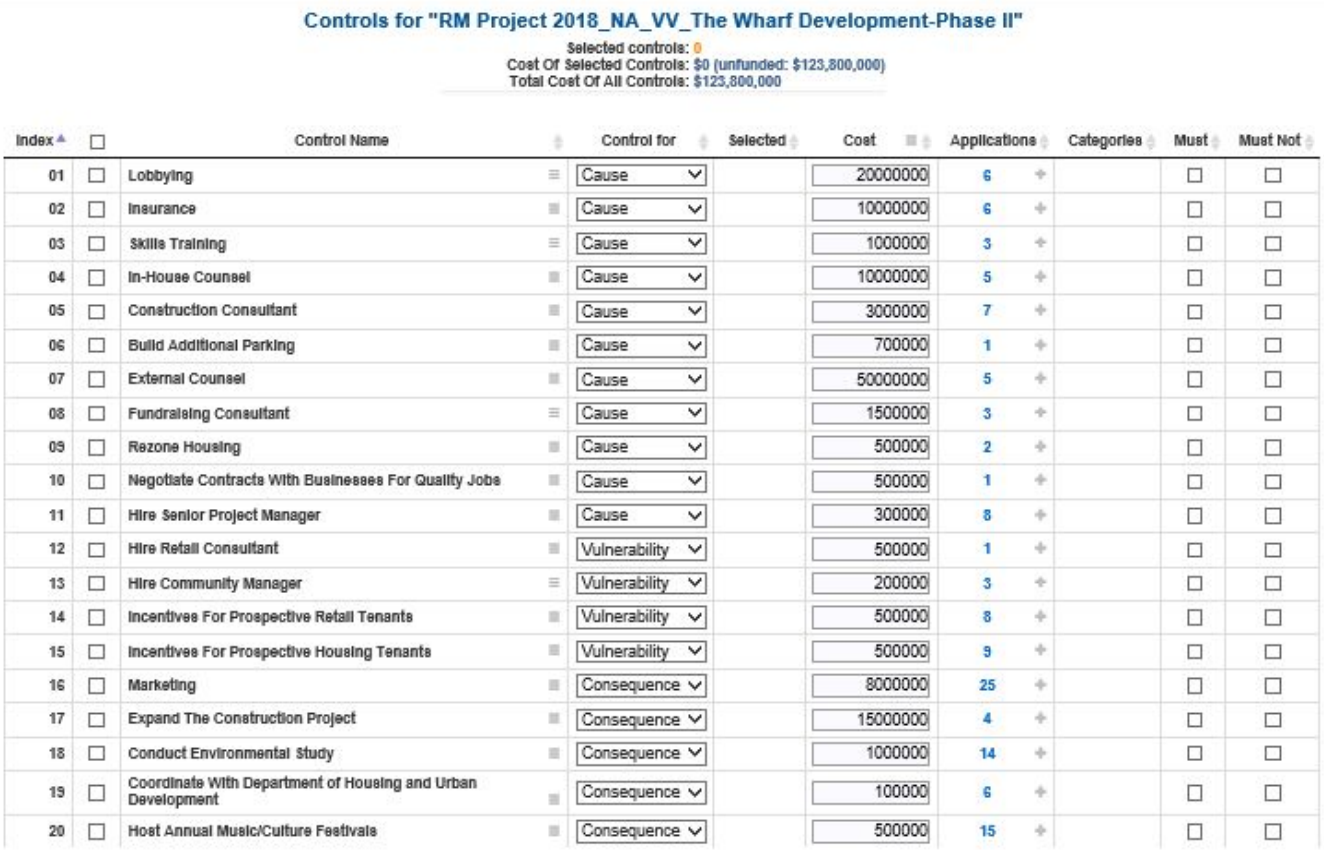
Event Name	Random()	Vulnerability	Impact	Risk
Not finishing project on time C_{ID}=[6]	0.00872262	0.47999999	$577.79M	$196.91M
Not finishing project within budget C_{ID}=[6]	0.23501902	0.32657579	$561.15M	$130.11M
Low occupancy in retail property [No Causes]				
Low occupancy in rental property [No Causes]				
Public not interested in visiting the new dev... [No Causes]				
Legal disputes with neighboring businesses C_{ID}=[8]	0.24671672	2.00303674	$475.77M	$645.65M
Legal disputes amongst contractors [No Causes]				
Legal disputes with labor unions [No Causes]				

VII. Controls

a. Identifying and Selecting

We were able to identify a total of 20 controls to help reduce risk loss. We determined the cost of each control. The total cost of all controls is $123,800,000. See Figure 1.29.

Figure 1.29: Control Register



Controls for "RM Project 2018_NA_VV_The Wharf Development-Phase II"

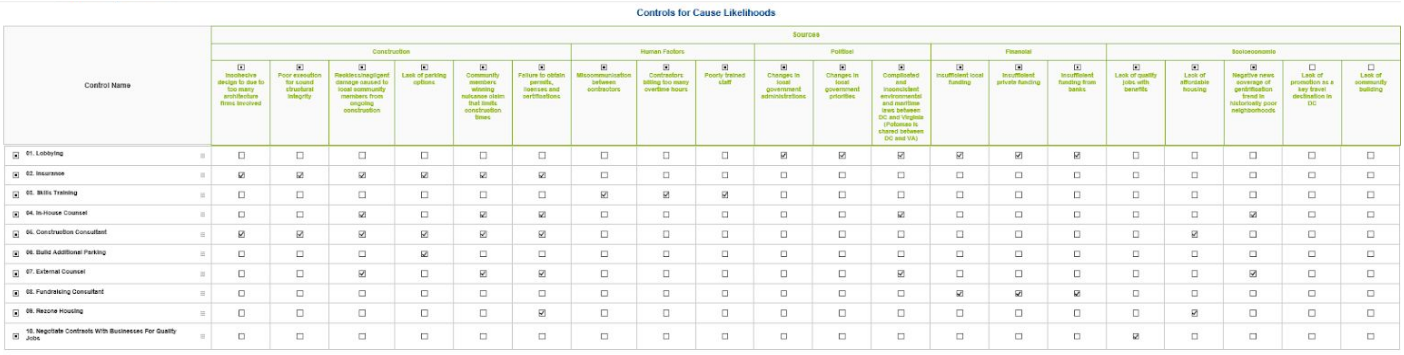
Selected controls: 0
Cost Of Selected Controls: $0 (unfunded: $123,800,000)
Total Cost Of All Controls: $123,800,000

Index		Control Name	Control for	Selected	Cost	Applications	Categories	Must	Must Not
01	☐	Lobbying	Cause		20000000	6		☐	☐
02	☐	Insurance	Cause		10000000	6		☐	☐
03	☐	Skills Training	Cause		1000000	3		☐	☐
04	☐	In-House Counsel	Cause		10000000	5		☐	☐
05	☐	Construction Consultant	Cause		3000000	7		☐	☐
06	☐	Build Additional Parking	Cause		700000	1		☐	☐
07	☐	External Counsel	Cause		50000000	5		☐	☐
08	☐	Fundraising Consultant	Cause		1500000	3		☐	☐
09	☐	Rezone Housing	Cause		500000	2		☐	☐
10	☐	Negotiate Contracts With Businesses For Quality Jobs	Cause		500000	1		☐	☐
11	☐	Hire Senior Project Manager	Cause		300000	8		☐	☐
12	☐	Hire Retail Consultant	Vulnerability		500000	1		☐	☐
13	☐	Hire Community Manager	Vulnerability		200000	3		☐	☐
14	☐	Incentives For Prospective Retail Tenants	Vulnerability		500000	8		☐	☐
15	☐	Incentives For Prospective Housing Tenants	Vulnerability		500000	9		☐	☐
16	☐	Marketing	Consequence		8000000	25		☐	☐
17	☐	Expand The Construction Project	Consequence		15000000	4		☐	☐
18	☐	Conduct Environmental Study	Consequence		1000000	14		☐	☐
19	☐	Coordinate With Department of Housing and Urban Development	Consequence		100000	6		☐	☐
20	☐	Host Annual Music/Culture Festivals	Consequence		500000	15		☐	☐

a.1. Cause Controls

Controls 1-11 will help reduce the likelihood of sources. We manually selected which source each control would help reduce risk loss. See Figure 1.30.

Figure 1.30: Controls for Cause Likelihoods



Controls for Cause Likelihoods

Control Name	Sources																				
	Construction						Human Factors			Political			Financial			Socioeconomic				
	Inadequate design to due to too many architecture firms involved	Poor execution for sound structural integrity	Reckless/negligent damage caused to local community members from ongoing construction	Lack of parking options	Community members winning nuisance claim that limits construction times	Failure to obtain permits, licenses and certifications	Miscommunication between contractors	Contractors billing too many overtime hours	Poorly trained staff	Changes in local government administrations	Changes in local government priorities	Complicated and inconsistent environmental and maritime laws between DC and Virginia (Potomac is shared between DC and VA)	Insufficient local funding	Insufficient private funding	Insufficient funding from banks	Lack of quality jobs with benefits	Lack of affordable housing	Negative news coverage of gentrification trend in historically poor neighborhoods	Lack of promotion as a key travel destination in DC	Lack of community building
01. Lobbying	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☑	☑	☑	☐	☐	☐	☐	☐
02. Insurance	☑	☑	☑	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
03. Skills Training	☐	☐	☐	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
04. In-House Counsel	☐	☐	☑	☐	☑	☑	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☐	☐
05. Construction Consultant	☑	☑	☑	☑	☑	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐
06. Build Additional Parking	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
07. External Counsel	☐	☐	☑	☐	☑	☑	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☑	☐	☐
08. Fundraising Consultant	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☑	☑	☐	☐	☐	☐	☐
09. Rezone Housing	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐
10. Negotiate Contracts With Businesses For Quality Jobs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☑	☐	☐	☐	☐

a.2. Vulnerabilities Controls

Control 12-15 will help reduce the likelihood of various events from happening. See Figure 1.31 and 1.32 for examples.

Figure 1.31: Controls for Vulnerabilities of event "Low occupancy in retail property" to causes

Figure 1.32: Controls for Vulnerabilities of event "Public not interested in visiting the development" to causes

a.3. Consequences Controls

Control 16-20 will help reduce the impact on objectives. We manually selected which controls would help reduce risk on selected objectives. See Figures 1.33 and 1.34 for examples.

Figure 1.33: Control "Marketing" to mitigate consequences of events to objectives

Control "Marketing" to mitigate consequences of events to objectives

t a control: 13. Marketing

Event Name	Objectives									
	City Development			Financial				Public Relations		
	Popularize new neighborhood	Improve quality of life	Connect the Wharf, Georgetown, and Navy Yard waterfronts via boardwalk	Boost local economy	Boost property values	Create local jobs	Create affordable housing	Maintain positive reputation	Avoid negative news coverage	Become popular travel destination
1. Not finishing project on time			☐	☐	☐	☐	☐			
7. Not finishing project within budget			☐	☐	☐	☐	☐			
2. Low occupancy in retail property	☑	☐		☐	☑	☑		☑	☑	☑
3. Low occupancy in rental property	☐	☐		☑	☑		☐	☑	☑	☑
5. Public not interested in visiting the new development	☑	☐		☑	☑			☑	☑	☑
8. Legal disputes with neighboring businesses	☑					☐		☑	☑	
9. Legal disputes amongst contractors	☐					☐		☑	☑	
10. Legal disputes with labor unions	☐					☑		☑	☑	

Figure 1.34: Control "Expand The Construction Project" to mitigate consequences of events to objectives

Control "Expand The Construction Project" to mitigate consequences of events to objectives

ct a control: 14. Expand The Construction Project

Event Name	Objectives									
	City Development			Financial				Public Relations		
	■ Popularize new neighborhood	■ Improve quality of life	■ Connect the Wharf, Georgetown, and Navy Yard waterfronts via boardwalk	☐ Boost local economy	☐ Boost property values	☐ Create local jobs	☐ Create affordable housing	☐ Maintain positive reputation	☐ Avoid negative news coverage	☐ Become popular travel destination
■ 1. Not finishing project on time			☑	☐	☐	☐	☐			
■ 7. Not finishing project within budget			☑	☐	☐	☐	☐			
☐ 2. Low occupancy in retail property	☐	☐		☐	☐	☐		☐	☐	☐
☐ 3. Low occupancy in rental property	☐	☐		☐	☐		☐	☐	☐	☐
■ 5. Public not interested in visiting the new development	☑	☑		☐	☐			☐	☐	☐
☐ 8. Legal disputes with neighboring businesses	☐					☐		☐	☐	
☐ 9. Legal disputes amongst contractors	☐					☐		☐	☐	
☐ 10. Legal disputes with labor unions	☐					☐		☐	☐	

b. Measuring

Once the controls were identified and selected, all participants were invited to provide their judgement on how effective each control is. We selected the 'Direct' measurement method to measure the effectiveness of each cause, vulnerability, and consequence control. Figure 1.35 shows the measurement method used for the cause controls.

Figure 1.35: Measurement Methods for Controls for Causes

Measurement Methods for Controls for Causes

Control Name	Sources											
	Construction						Human Factors			Political		
	Incohesive design to due to too many architecture firms involved	Poor execution for sound structural integrity	Reckless/negligent damage caused to local community members from ongoing construction	Lack of parking options	Community members winning nuisance claim that limits construction times	Failure to obtain permits, licenses and certifications	Miscommunication between contractors	Contractors billing too many overtime hours	Poorly trained staff	Changes in local government administrations	Changes in local government priorities	Con in en an laws ar (F sha D
01. Lobbying										Direct	Direct	Dire
02. Insurance	Direct	Direct	Direct	Direct	Direct	Direct						
03. Skills Training							Direct	Direct	Direct			
04. In-House Counsel			Direct		Direct	Direct						Dire
05. Construction Consultant	Direct	Direct	Direct	Direct	Direct	Direct						
06. Build Additional Parking				Direct								
07. External Counsel			Direct		Direct	Direct						Dire
08. Fundraising Consultant												

c. Effectiveness

Once all judgements were collected, Riskion calculated the effectiveness of each control. The ‘Hire a Senior Project Manager’ has the highest efficiencies across the various sources it can have an effect on. Figure 1.36 shows the effectiveness of each cause control.

Figure 1.36: Effectiveness of Cause Controls

Effectiveness of Cause Controls

Control Name	Sources										
	Construction						Human Factors			Political	
	Incohesive design to due to too many architecture firms involved	Poor execution for sound structural integrity	Reckless/negligent damage caused to local community members from ongoing construction	Lack of parking options	Community members winning nuisance claim that limits construction times	Failure to obtain permits, licenses and certifications	Miscommunication between contractors	Contractors billing too many overtime hours	Poorly trained staff	Changes in local government administrations	Chang governm
01. Lobbying										0.76	
02. Insurance	0.35	0.534	0.386	0.359	0.451	0.62					
03. Skills Training							0.734	0.676	0.789		
04. In-House Counsel			0.457		0.54	0.61					
05. Construction Consultant	0.634	0.64	0.565	0.635	0.464	0.615					
06. Build Additional Parking				0.7							
07. External Counsel			0.531		0.626	0.566					
08. Fundraising Consultant											
09. Rezone Housing						0.411					
10. Negotiate Contracts With Businesses For Quality Jobs											
11. Hire Senior Project Manager	0.93	0.869	0.866	0.894		0.895	0.902	0.864	0.872		

Figure 1.37 shows the effectiveness of the vulnerabilities control, ‘Hire Retail Consultant’. According to the data, on a scale of 0 to 1, hiring a retail consultant has a 0.542 effectiveness of reducing the source of ‘lack of parking options’ from occurring. As a reminder, this source can lead to the ‘Low occupancy in retail property’ event to occur. In short, hiring a retail consultant can reduce the likelihood of a lack of parking options to occur, which can lead to a decreased likelihood of low occupancy in retail property to occur.

Figure 1.37: Effectiveness of Vulnerabilities Control for “Low occupancy in retail property” Event

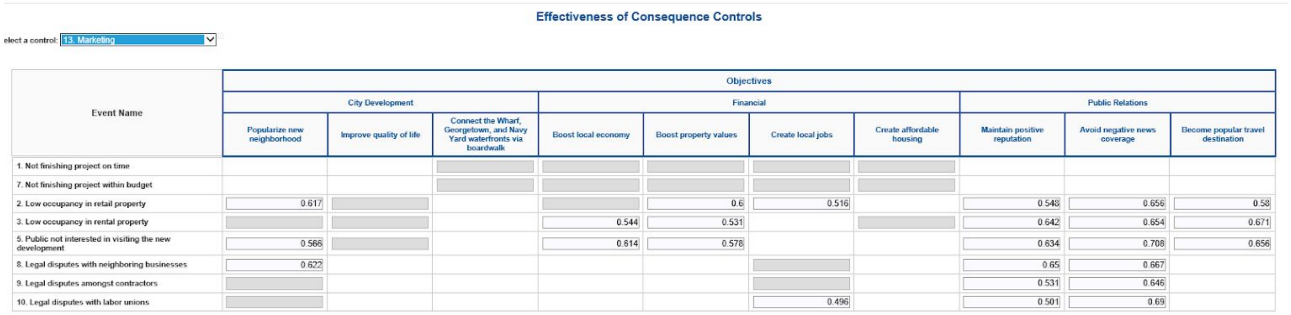
Effectiveness of Vulnerabilities Controls

Select an event: 2. Low occupancy in retail property

Control Name	No specific Cause	Sources														
		Construction						Human Factors			Political			Financial		
		Incohesive design to due to too many architecture firms involved	Poor execution for sound structural integrity	Reckless/negligent damage caused to local community members from ongoing construction	Lack of parking options	Community members winning nuisance claim that limits construction times	Failure to obtain permits, licenses and certifications	Miscommunication between contractors	Contractors billing too many overtime hours	Poorly trained staff	Changes in local government administrations	Changes in local government priorities	Complicated and inconsistent environmental and maritime laws between DC and Virginia (Potomac is shared between DC and VA)	Insufficient local funding	Insufficient private funding	
11. Retail Consultant					0.542											

Figure 1.38 shows the effectiveness of the consequence cause ‘Marketing’ on the project’s objectives.

Figure 1.38: Effectiveness of Consequence Control for "Marketing"



Effectiveness of Consequence Controls

elect a control: 13. Marketing

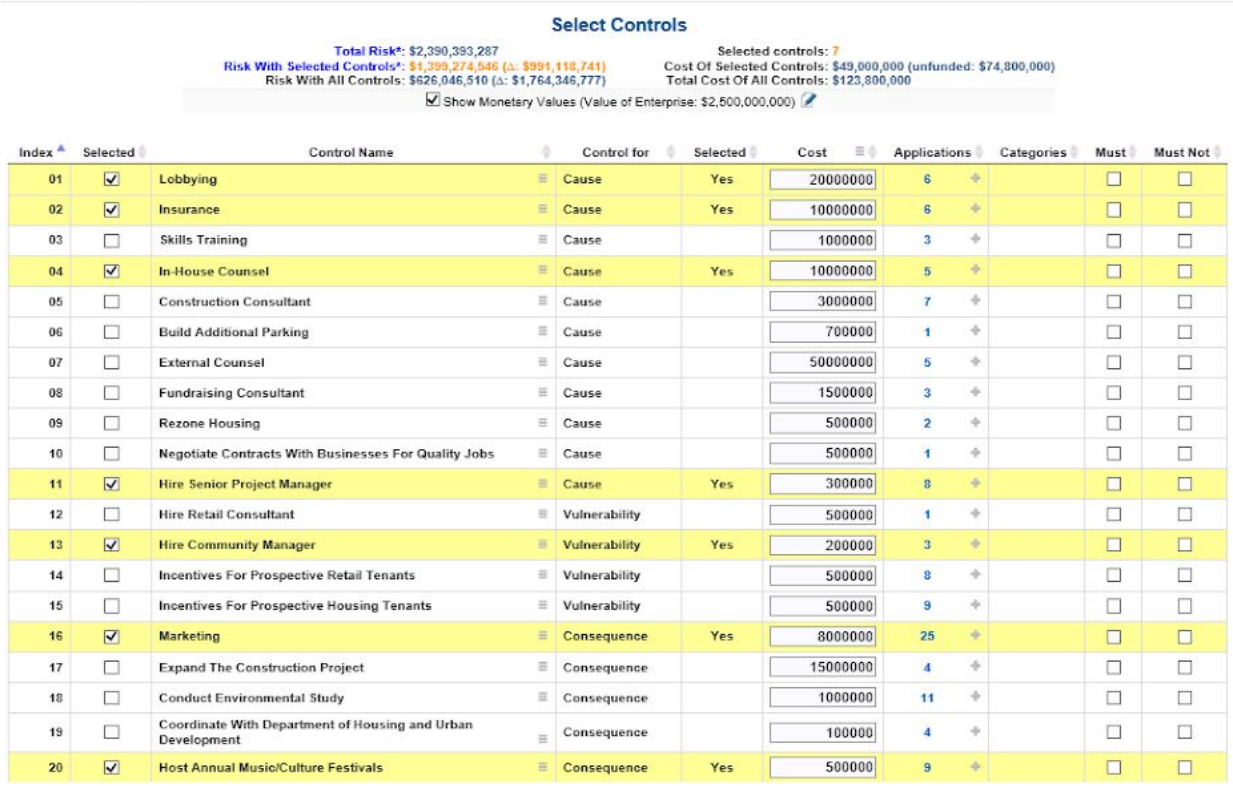
Event Name	Objectives									
	City Development			Financial				Public Relations		
	Popularize new neighborhood	Improve quality of life	Connect the Wharf, Georgetown, and Navy Yard waterfronts via boardwalk	Boost local economy	Boost property values	Create local jobs	Create affordable housing	Maintain positive reputation	Avoid negative news coverage	Become popular travel destination
1. Not finishing project on time										
7. Not finishing project within budget										
2. Low occupancy in retail property	0.617				0.6	0.516		0.548	0.656	0.58
3. Low occupancy in rental property				0.544	0.531			0.642	0.654	0.671
5. Public not interested in visiting the new development	0.566			0.614	0.578			0.634	0.708	0.656
8. Legal disputes with neighboring businesses	0.622							0.65	0.667	
9. Legal disputes amongst contractors								0.531	0.646	
10. Legal disputes with labor unions						0.496		0.501	0.69	

VIII. Risk Analysis With Controls

a. Risk Results with Manually Selected Controls

Now that we know how effective each control is, we can determine which controls to apply to the project to reduce risk loss. With a budget of $50 million we selected 7 out of 20 controls. These 7 controls cost a total of $49,000,000. The risk reduction of applying the manually selected controls is $991,118,741. The previous total risk was $2,390,393,287, which is 59% higher than the model with manually selected controls applied. See Figure 1.39 and 1.40. The likelihoods, impacts, and risks for our riskiest events have significantly changed as well. Table 1.2 is a summary of the differences. In this scenario, 'Low occupancy in retail property' is still one of our riskiest event and 'Not finishing project within budget' is our new riskiest events.

Figure 1.39: Manually Selected Controls for "RM Project 2018_NA_VV_The Wharf Development Phase II"



Select Controls

Total Risk*: $2,390,393,287
Risk With Selected Controls*: $1,399,274,546 (Δ: $991,118,741)
Risk With All Controls: $626,046,510 (Δ: $1,764,346,777)
Selected controls: 7
Cost Of Selected Controls: $49,000,000 (unfunded: $74,800,000)
Total Cost Of All Controls: $123,800,000
Show Monetary Values (Value of Enterprise: $2,500,000,000)

Index	Selected	Control Name	Control for	Selected	Cost	Applications	Categories	Must	Must Not
01	☑	Lobbying	Cause	Yes	20000000	6		☐	☐
02	☑	Insurance	Cause	Yes	10000000	6		☐	☐
03	☐	Skills Training	Cause		1000000	3		☐	☐
04	☑	In-House Counsel	Cause	Yes	10000000	5		☐	☐
05	☐	Construction Consultant	Cause		3000000	7		☐	☐
06	☐	Build Additional Parking	Cause		700000	1		☐	☐
07	☐	External Counsel	Cause		50000000	5		☐	☐
08	☐	Fundraising Consultant	Cause		1500000	3		☐	☐
09	☐	Rezone Housing	Cause		500000	2		☐	☐
10	☐	Negotiate Contracts With Businesses For Quality Jobs	Cause		500000	1		☐	☐
11	☑	Hire Senior Project Manager	Cause	Yes	300000	8		☐	☐
12	☐	Hire Retail Consultant	Vulnerability		500000	1		☐	☐
13	☑	Hire Community Manager	Vulnerability	Yes	200000	3		☐	☐
14	☐	Incentives For Prospective Retail Tenants	Vulnerability		500000	8		☐	☐
15	☐	Incentives For Prospective Housing Tenants	Vulnerability		500000	9		☐	☐
16	☑	Marketing	Consequence	Yes	8000000	25		☐	☐
17	☐	Expand The Construction Project	Consequence		15000000	4		☐	☐
18	☐	Conduct Environmental Study	Consequence		1000000	11		☐	☐
19	☐	Coordinate With Department of Housing and Urban Development	Consequence		100000	4		☐	☐
20	☑	Host Annual Music/Culture Festivals	Consequence	Yes	500000	9		☐	☐

Figure 1.40: Risk Register of Overall Risk of Each Event with Monetary Values with Manually Selected Controls

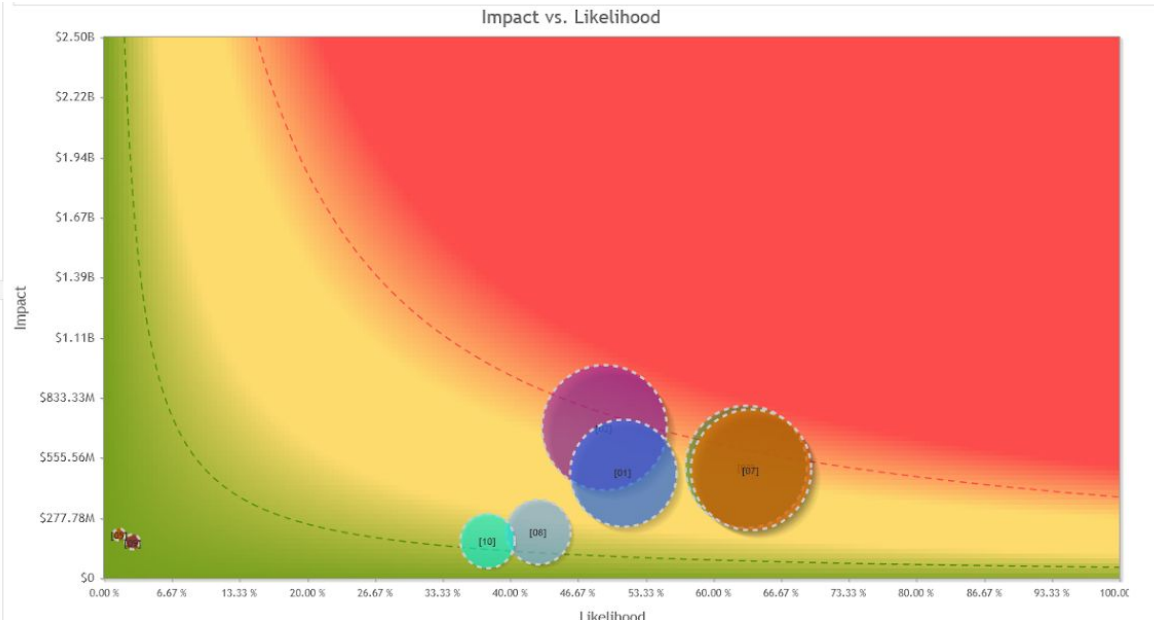
Table 1.2: Likelihoods, Impacts, and Risks Comparisons between 'Without Controls' and 'With Manually Selected Controls'

Event	Without Controls	With Manually Selected Controls
Low occupancy in retail property	85.73% likelihood $921,767,866 impact $790,262,317 risk loss	49.27% likelihood $694,948,087 impact $342,377,757 risk loss
Not finishing project within budget	99.80% likelihood $313,378,685 impact $312,752,108 risk loss	$63.73% likelihood $499,199,192 impact $318,156,285 risk loss

a.1. Risk Map with Manually Selected Controls

Figure 1.41 is another iteration of the information provided above. In comparison to the scenario without controls, the likelihood of all of the events has drastically decreased. It is showing us that 'Low occupancy in retail property' is still one of our riskiest events. and 'Not finishing project within budget' is the new second riskiest events. They both having the largest circles on the map (purple and orange, respectively) and it helps to visualize them as having the most impact with a high probability of occuring in this scenario.

Figure 1.41: Risk Map of Events with Monetary Values with Manually Selected Controls



a.2. Bow-Tie Diagrams with Manually Selected Controls

Figures 1.42 shows us the effectiveness of each control and how it affects the likelihood of sources and events and how it eventually impacts the objectives. For example, one control, ‘Insurance’ with a 0.359 effectiveness, was applied to the ‘Lack of parking options’ source. This controls helped reduce the likelihood of ‘Lack of parking options’ to occur from 64.17% to 4.37%, which in turn, reduces the likelihood of ‘Low occupancy in retail property’ event to occur. No controls were applied to the event. Prior to applying the manually selected controls, the ‘Boost property values’ sub-objective was identified as one of the sub-objectives most likely to be impacted by the ‘Low occupancy in retail property’ event occurring. In this scenario, we have applied the ‘Marketing’ control with a 0.516 effectiveness to that sub-objective, lowering the consequence from 100% to 40%.

Figure 1.42: Bow-Tie Diagram for “Low occupancy in retail property” Event with with Monetary Values with Manually Selected Controls

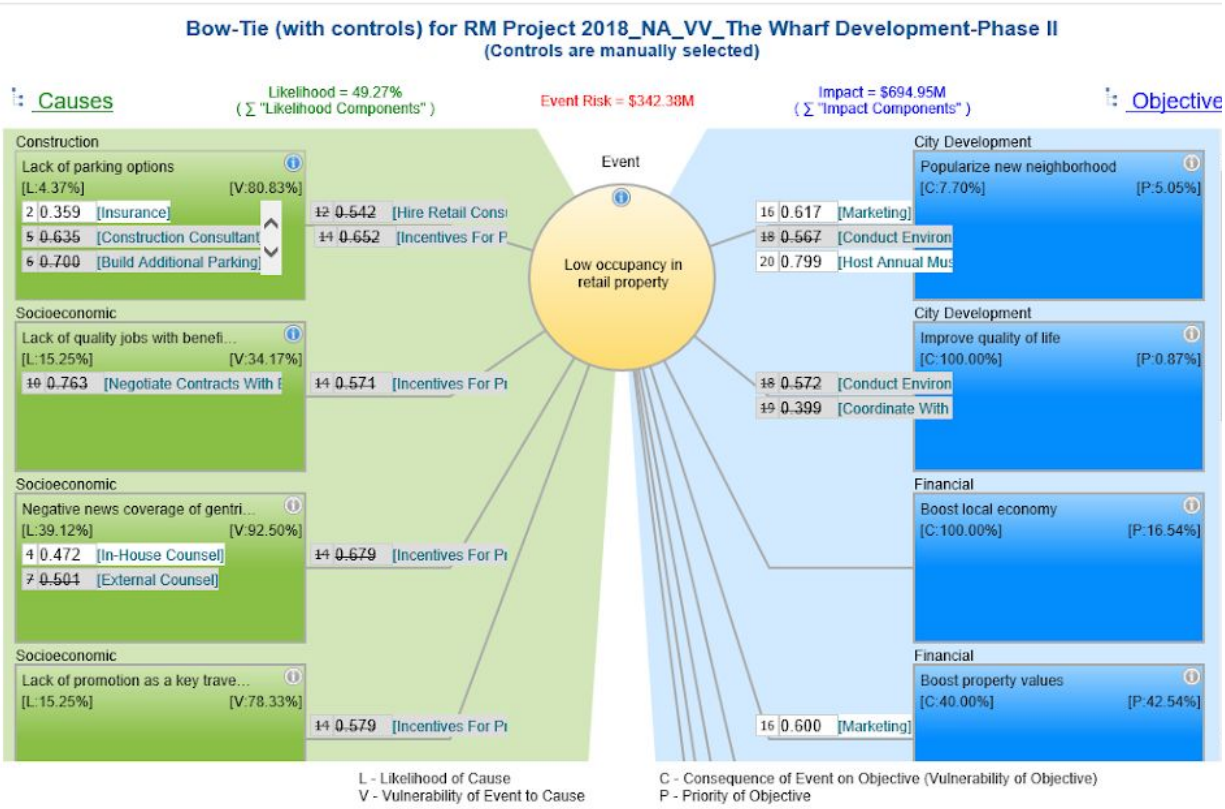
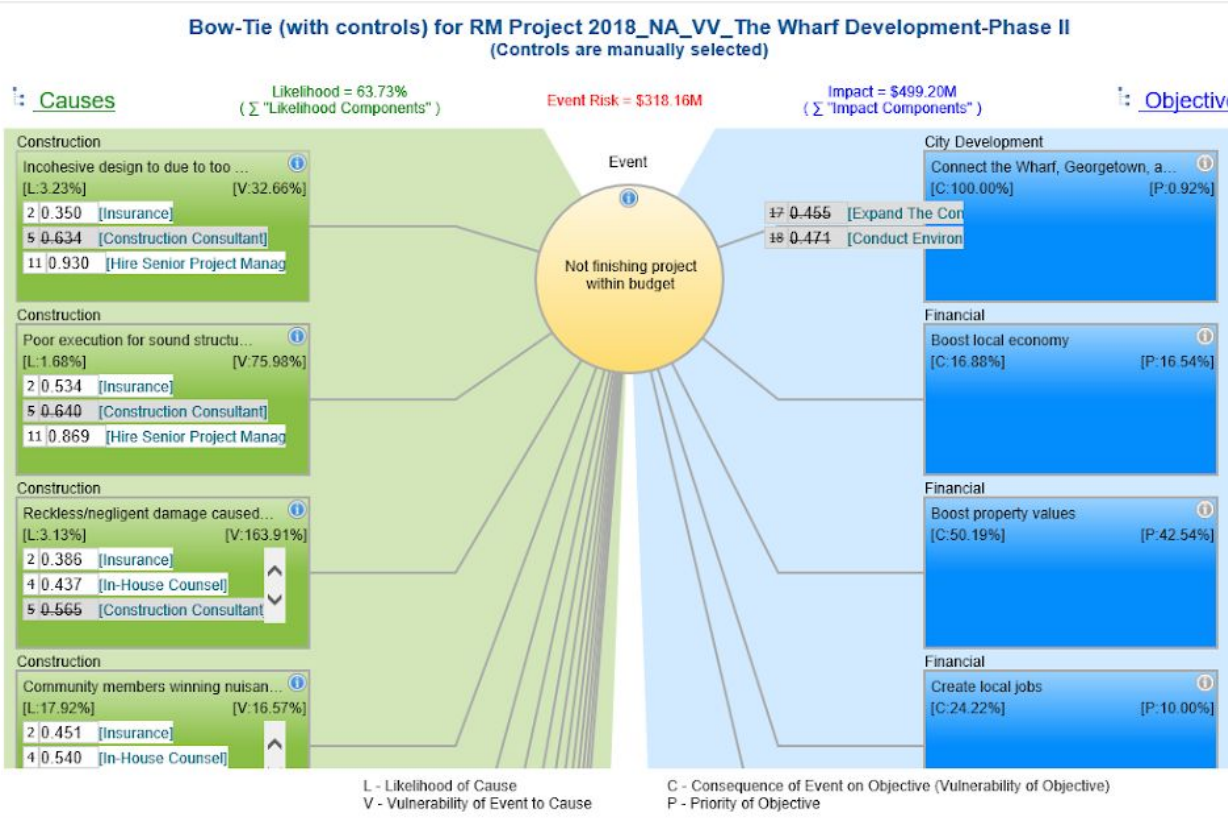


Figure 1.43 shows us that two controls were applied to ‘Incohesive design to due too many architects’ source. ‘Insurance’ with a 0.359 effectiveness and ‘Hire Senior Project Manager’ with a 0.930 effectiveness were applied. These controls helped reduce the likelihood of ‘Incohesive design to due too many architects’ to occur from 71% to 3.23%, which in turn, reduces the likelihood of ‘Not finishing project within budget’ event to occur. No controls were applied to the event or objectives.

Figure 1.43: Bow-Tie Diagram for “Not finishing project within budget” Event with with Monetary Values with Manually Selected Controls



a.3. Loss Exceedance with Manually Selected Controls

Figure 1.44 below shows us the values at risk for the project. The overall project is worth $2.5 billion. The green line shows us the independent events with the manually selected controls applied. There is a 10% probability that the loss of this project will exceed $1.95 billion and a 4.92% chance of losing more than $2 billion on finishing this project. The average loss is now $1.40 billion, instead of $2.39 billion. This is extremely good news for the project. Figure 1.45 shows us the first simulation's total loss of the one event firing to be $718.58 million.

Figure 1.44: Loss Exceedance Curve with Monetary Values With Manually Selected Controls

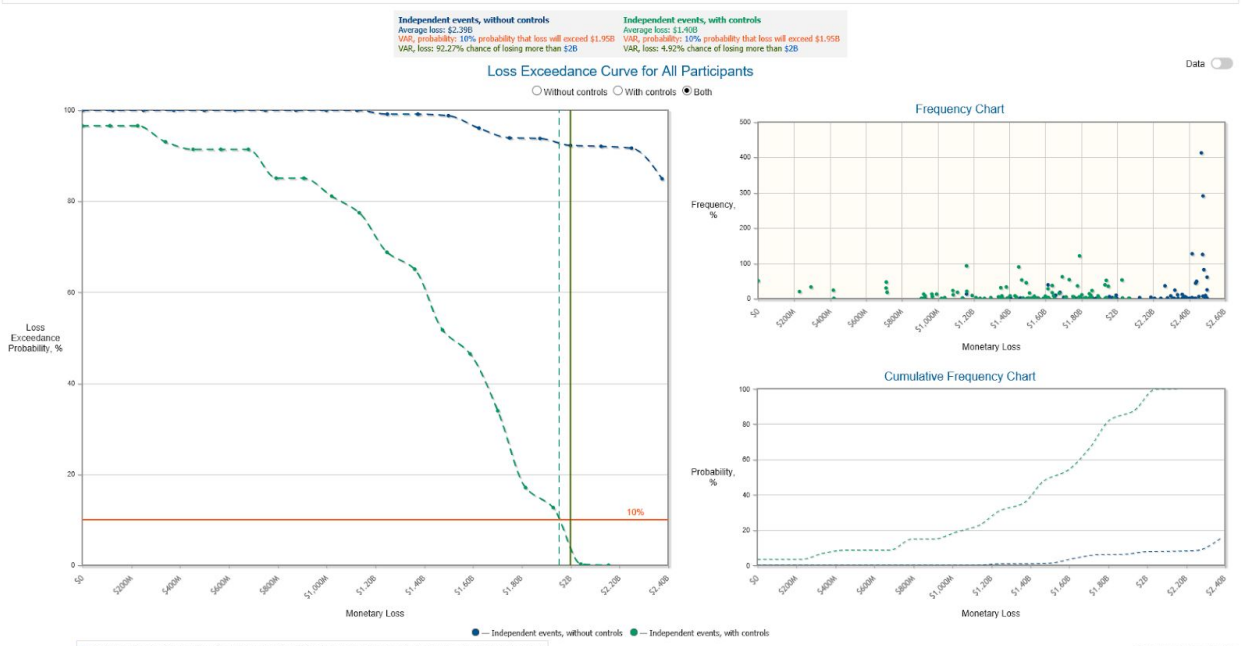


Figure 1.45: Loss Exceedance with Monetary Values With Manually Selected Controls

Cause Name	Cause Random()	Probability
[6] Incohesive design to due to too many architec...	0.50537038	0.70999998
[7] Poor execution for sound structural integrity	0.61254607	0.27500001
[8] Reckless/negligent damage caused to local com...	0.27543029	0.67750001
[9] Lack of parking options	0.81482597	0.641675
[10] Community members winning nuisance claim that...	0.41645563	0.70999998
[11] Failure to obtain permits, licenses and certi...	0.33675029	0.03
[12] Miscommunication between contractors	0.09203434	0.755
[13] Contractors billing too many overtime hours	0.92782116	0.74167502
[14] Poorly trained staff	0.09567952	0.641675
[15] Changes in local government administrations	0.51217258	0.25
[16] Changes in local government priorities	0.08823193	0.04557215
[17] Complicated and inconsistent environmental an...	0.05745535	0.88212287
[20] Insufficient local funding	0.96449298	0.68334997
[18] Insufficient private funding	0.33465937	0.68334997
[19] Insufficient funding from banks	0.35733682	0.60000002
[21] Lack of quality jobs with benefits	0.85779752	0.1525
[22] Lack of affordable housing	0.61907002	0.31667501
[23] Negative news coverage of gentrification tren...	0.83475354	0.74167502
[24] Lack of promotion as a key travel destination...	0.55326191	0.1525
[25] Lack of community building	0.82929807	0.58335

Cause Random()	Probability
0.50537038	0.032305
0.61254607	0.01682871
0.27543029	0.03128363
0.81482597	0.04371912
0.41645563	0.17922173
0.33675029	0.00046683
0.09203434	0.0736125
0.92782116	0.10105322
0.09567952	0.08181356
0.51217258	0.06
0.08823193	0.01139304
0.05745535	0.13566361
0.96449298	0.23404737
0.33465937	0.23319317
0.35733682	0.24975
0.85779752	0.1525
0.61907002	0.31667501
0.83475354	0.39123359
0.55326191	0.1525
0.82929807	0.58335

Event Name	Random()	Vulnerability	Impact	Risk
Not finishing project on time C_{ID}=[6]	0.00872262	0.47999999	$577.79M	$196.91M
Not finishing project within budget C_{ID}=[6]	0.23501902	0.32657579	$561.15M	$130.11M
Low occupancy in retail property [No Causes]				
Low occupancy in rental property [No Causes]				
Public not interested in visiting the new dev... [No Causes]				
Legal disputes with neighboring businesses C_{ID}=[8]	0.24671672	2.00303674	$475.77M	$645.65M
Legal disputes amongst contractors [No Causes]				
Legal disputes with labor unions [No Causes]				

Random()	Vulnerability	Impact	Risk
0.41237729	0.47999999	$718.58M	$46.79M

b. Risk Results with Optimized Controls

Using the optimization tool and setting ourselves with a $50 million budget, it seems that we can apply 16 out of the 20 controls, instead of the 11 we chose earlier. These 16 controls cost a total of $48.6 million. See Figure 1.46.

Figure 1.46: Controls Optimization for "RM Project 2018_NA_VV_The Wharf Development Phase II"

Index	Selected	Control Name	Control for	Selected	Cost	Applications	Categories	Must	Must Not
01	☑	Lobbying	Cause	Yes	20000000	6		☐	☐
02	☐	Insurance	Cause		10000000	6		☐	☐
03	☑	Skills Training	Cause	Yes	1000000	3		☐	☐
04	☑	In-House Counsel	Cause	Yes	10000000	5		☐	☐
05	☑	Construction Consultant	Cause	Yes	3000000	7		☐	☐
06	☑	Build Additional Parking	Cause	Yes	700000	1		☐	☐
07	☐	External Counsel	Cause		50000000	5		☐	☐
08	☑	Fundraising Consultant	Cause	Yes	1500000	3		☐	☐
09	☑	Rezone Housing	Cause	Yes	500000	2		☐	☐
10	☑	Negotiate Contracts With Businesses For Quality Jobs	Cause	Yes	500000	1		☐	☐
11	☑	Hire Senior Project Manager	Cause	Yes	300000	8		☐	☐
12	☑	Hire Retail Consultant	Vulnerability	Yes	500000	1		☐	☐
13	☐	Hire Community Manager	Vulnerability		200000	3		☐	☐
14	☑	Incentives For Prospective Retail Tenants	Vulnerability	Yes	500000	8		☐	☐
15	☑	Incentives For Prospective Housing Tenants	Vulnerability	Yes	500000	9		☐	☐
16	☑	Marketing	Consequence	Yes	8000000	25		☐	☐
17	☐	Expand The Construction Project	Consequence		15000000	4		☐	☐
18	☑	Conduct Environmental Study	Consequence	Yes	1000000	11		☐	☐
19	☑	Coordinate With Department of Housing and Urban Development	Consequence	Yes	100000	4		☐	☐
20	☑	Host Annual Music/Culture Festivals	Consequence	Yes	500000	9		☐	☐

The risk reduction of applying the optimized controls determined by Riskion is $1,610,194,545. The previous total risk was $2,390,393,287, which is 33% higher than the model with controls applied. See Figure 1.47. The likelihoods, impacts, and risks for our riskiest events have changed significantly as well. Table 1.3 is a summary of the differences. In this scenario, 'Low occupancy in retail property' events is no longer the riskiest events. 'Not finishing project within budget' remains as one of the riskiest events and 'Not finishing project on time' is now our newest riskiest event.

Table 1.3: Likelihoods, Impacts, and Risks Comparisons between 'Without Controls','With Optimized Controls', and 'With Optimized Controls'

Event	Without Controls	With Manually Selected Controls	With Optimized Controls
Not finishing project within budget	99.80% likelihood $313,378,685 impact $312,752,108 risk loss	$63.73% likelihood $499,199,192 impact $318,156,285 risk loss	33.27% likelihood $578,976,140 impact $192,606,062 risk loss
Not finishing project on time	98.60% likelihood $321,073,940 impact $316,578,905 risk loss	51.13% likelihood $488,328 impact $249,698,716 risk loss	29.73% likelihood $581,123,115 $172,787,272 riks loss

Figure 1.47: Risk Register of Overall Risk of Each Event with Monetary Values with Optimized Controls

Overall Likelihoods, Impacts, and Risks (With Controls) for RM Project 2018_NA_VV_The Wharf Development-Phase II
(Controls are optimized based on simulated input and output)

No. ▲	Event	All Participants Likelihood Simulated	Impact, $ Simulated	Risk, $ Simulated
[01]	Not finishing project on time	29.73%	581,123,115	172,787,272
[02]	Low occupancy in retail property	17.67%	825,108,547	145,769,176
[03]	Low occupancy in rental property	18.53%	548,402,627	101,637,287
[05]	Public not interested in visiting the new development	1.53%	221,209,201	3,391,874
[07]	Not finishing project within budget	33.27%	578,976,140	192,606,062
[08]	Legal disputes with neighboring businesses	42.67%	241,470,202	103,027,286
[09]	Legal disputes amongst contractors	0.60%	170,292,227	1,021,753
[10]	Legal disputes with labor unions	32.27%	185,820,335	59,958,028

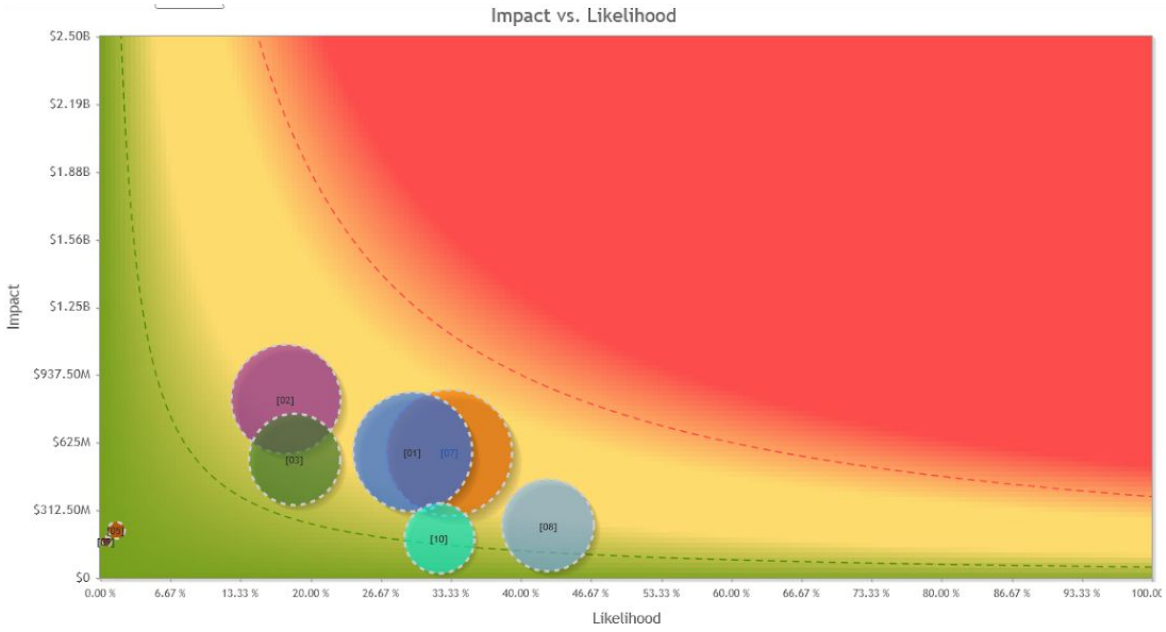
# Controls	Cost of Controls	How Selected
16	$48,600,000	Optimized based on simulated input and output with budget of $50,000,000

	Simulated
Total Risk	$2,390,393,287
Risk Reduction	$1,610,194,545
Residual Risk	$780,198,742

b.1. Risk Map with Optimized Controls

Figure 1.48 is another iteration of the information provided above. It is showing us that ‘Low occupancy in retail property’ and ‘Low occupancy in rental property’ are no longer the riskiest events. The riskiest events are ‘Not finishing project on time’ and ‘Not finishing project within budget’ as they now have the largest circles on the map (blue and yellow, respectively). It also helps to visualize them as having the most monetary impact with a high probability. The impacts and the likelihoods of the events have decreased when applying the optimized controls.

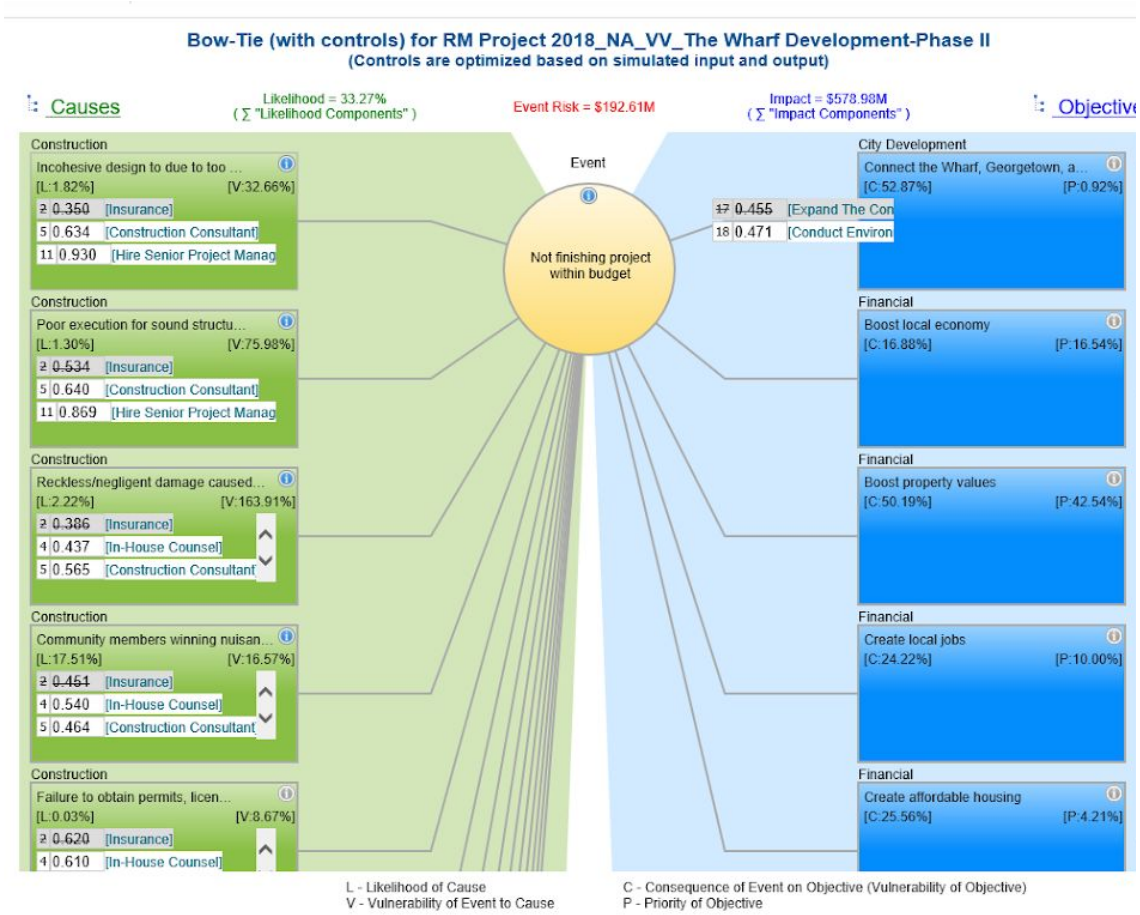
Figure 1.48: Risk Map of Events with Monetary Values with Optimized Controls



b.2. Bow-Tie Diagrams with Optimized Controls

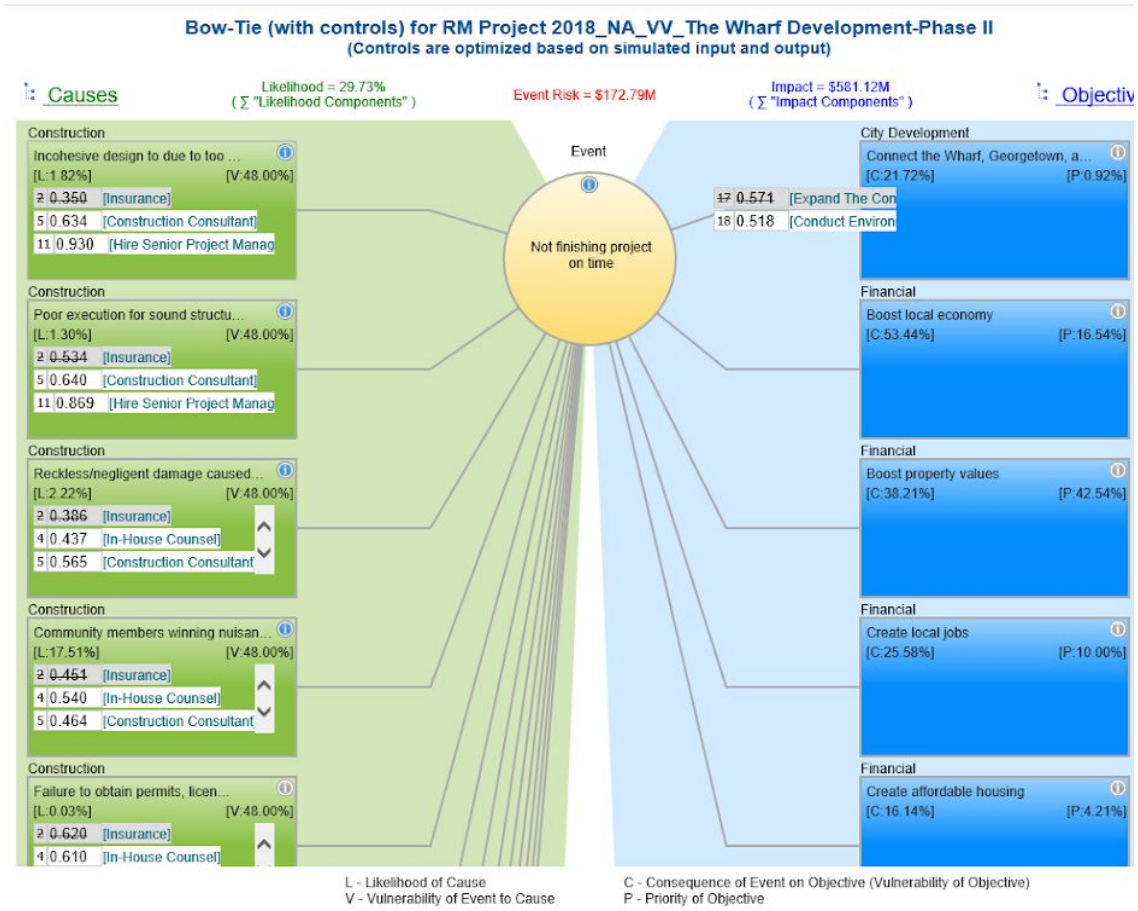
Figures 1.49 shows us the effectiveness of each control and how it affects the likelihood of sources and events and how it eventually impacts the objectives. For example, two controls have been applied to the ‘Poor execution for sound structural integrity’ source. The ‘Construction Consultant’ control has a 0.640 effectiveness and the ‘Hire Senior Project Manager’ control has a 0.869 effectiveness. The two controls help reduce the likelihood of ‘poor execution for sound structural integrity’ to occur from 27.50% to 1.30% , which in turn, reduces the likelihood of ‘Not finishing project within budget’ event to occur. No controls were applied to the event. In this scenario, we have applied the ‘Conduct Environmental Study’ control with a 0.471 effectiveness to the ‘Connect the Wharf, Georgetown, and Navy Yard Waterfronts via boardwalk’ sub-objective lowering the consequence from 100% to 52.87%.

Figure 1.49: Bow-Tie Diagram for “Not finishing project within budget” Event with with Monetary Values with Optimized Controls



Figures 1.50 shows us the effectiveness of each control and how it affects the likelihood of sources and events and how it eventually impacts the objectives. For example, two controls have been applied to the ‘Reckless/negligent damage caused to local community members from ongoing construction’ source. The ‘Construction Consultant’ control has a 0.565 effectiveness and the ‘In-House Counsel’ control has a 0.437 effectiveness. The two controls help reduce the likelihood of ‘Reckless/negligent damage caused to local community members from ongoing construction’ to occur from 67.75% to 2.22%, which in turn, reduces the likelihood of ‘Not finishing project on time’ event to occur. No controls were applied to the event. In this scenario, we have applied the ‘Conduct Environmental Study’ control with a 0.471 effectiveness to the ‘Connect the Wharf, Georgetown, and Navy Yard Waterfronts via boardwalk’ sub-objective lowering the consequence from 45.01% to 21.72%.

Figure 1.50: Bow-Tie Diagram for “Not finishing project on time” Event with with Monetary Values with Optimized Controls



b.3. Loss Exceedance with Optimized Controls

Figure 1.51 below shows us the values at risk for the project. The overall project is worth $2.5 billion. The green line shows us the independent events with the optimized controls applied. There is a 10% probability that the loss of this project will exceed $1.53 billion and an 11% chance of losing more than $1.5 billion on finishing this project. The average loss is $780.20 million. This is extremely good news for the project. Figure 1.52 shows us the first simulation's total loss of the one event firing to be $713.20 million.

Figure 1.51: Loss Exceedance Curve with Monetary Values With Optimized Controls

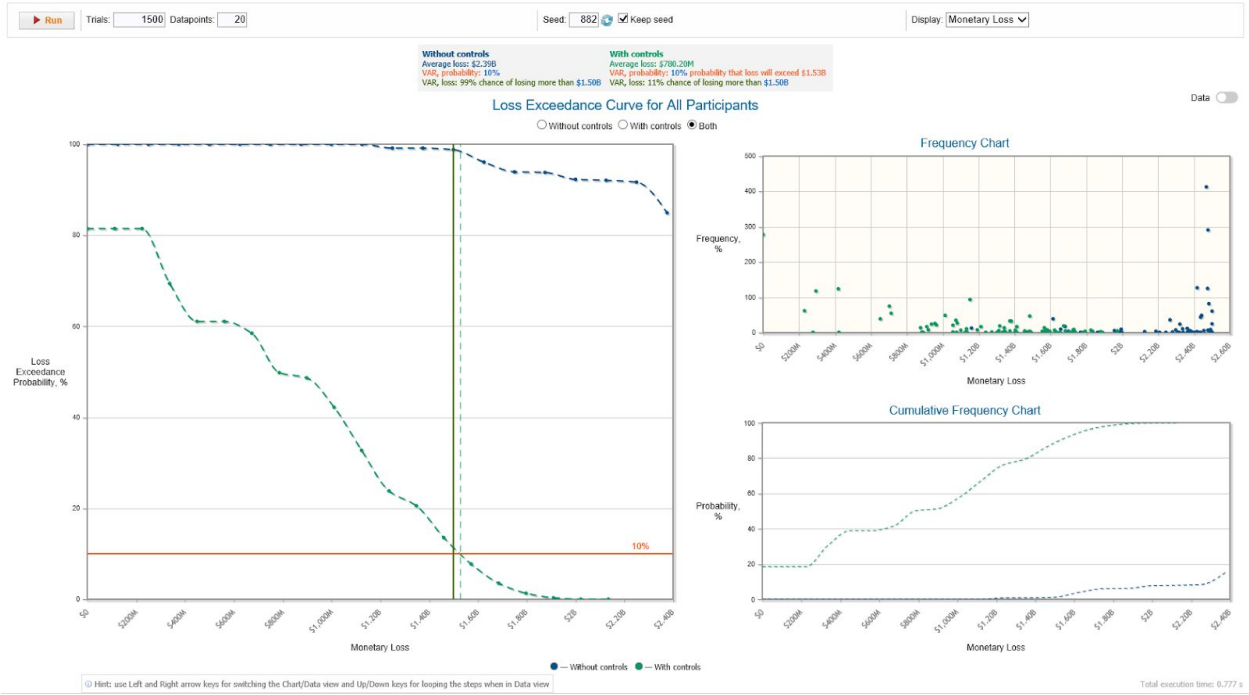


Figure 1.52: Loss Exceedance with Monetary Values With Optimized Controls

b.4. Additional Optimization Scenarios

As the table below suggests, the smaller our budget, the higher the risk residual and the average loss becomes. Interestingly, ‘not finishing project within budget’ and ‘not finishing project on time’ remain to be the riskiest event in the majority of these scenarios.

Table 1.4: Optimization Comparisons

Budget	# of Controls Selected	Risk Reduction	Risk Residual	LEC at 10%	Riskiest Events
$50,000,000	16 out of 20	$1,610,194,545	$780,198,742	Average loss: $780.20M VAR, probability: 10% probability that loss will exceed $1.53B VAR, loss: 11% chance of losing more than $1.50B	Not Finishing Project Within Budget Not Finishing Project on Time
$40,000,000	14 out of 20	$1,350,056,604	$1,040,336,683	Average loss: $1.04B VAR, probability: 10% probability that loss will exceed $2.04B VAR, loss: 33% chance of losing more than $1.50B	Low Occupancy in Retail Property Not Finishing Project Within Budget
$30,000,000	11 out of 20	$1,295,725,578	$1,094,667,709	Average loss: $1.09B VAR, probability: 10% probability that loss will exceed $1.68B VAR, loss: 23% chance of losing more than $1.50B	Not Finishing Project Within Budget Not Finishing Project on Time
$20,000,000	13 out of 20	$1,097,481,514	$1,292,911,773	Average loss: $1.29B VAR, probability: 10% probability that loss will	Not Finishing Project Within Budget

				exceed $2.08B VAR, loss: 43% chance of losing more than $1.50B	Not Finishing Project on Time

c. Efficient Frontier

The efficient frontier graph below, Figure 1.53, shows us the optimization at various budget points. Each point represents an optimum combination of controls that reduce the risk (shown on the y axis) for a specific cost of controls (on the x axis) (Forman, Forman, & Ludden). For example, if our budget is $99.04 million, we are able to apply $98.60 million on controls. In this scenario, the risk tolerance the developers are willing to face or accept is valued at $838 million. Figure 1.54 shows us exactly which controls are applied for each budget points. At the $99.04 million budget, we apply the following 17 controls:

- Lobbying
- Skills Training
- In-House Counsel
- Construction Consultant
- Build Additional Parking
- External Counsel
- Fundraising Consultant
- Rezone Housing
- Negotiate Contracts With Businesses for Quality Jobs
- Hire Senior Project Manager
- Hire Retail Consultant
- Incentives for Prospective Retail Tenants
- Incentives for Prospective Housing Tenants
- Marketing
- Conduct Environmental Study
- Coordinate With Department of Housing and Urban Development
- Host Annual Music/Culture Festivals

Figure 1.53: Efficient Frontier Graph for "RM Project 2018_NA_VV_The Wharf Development Phase II"

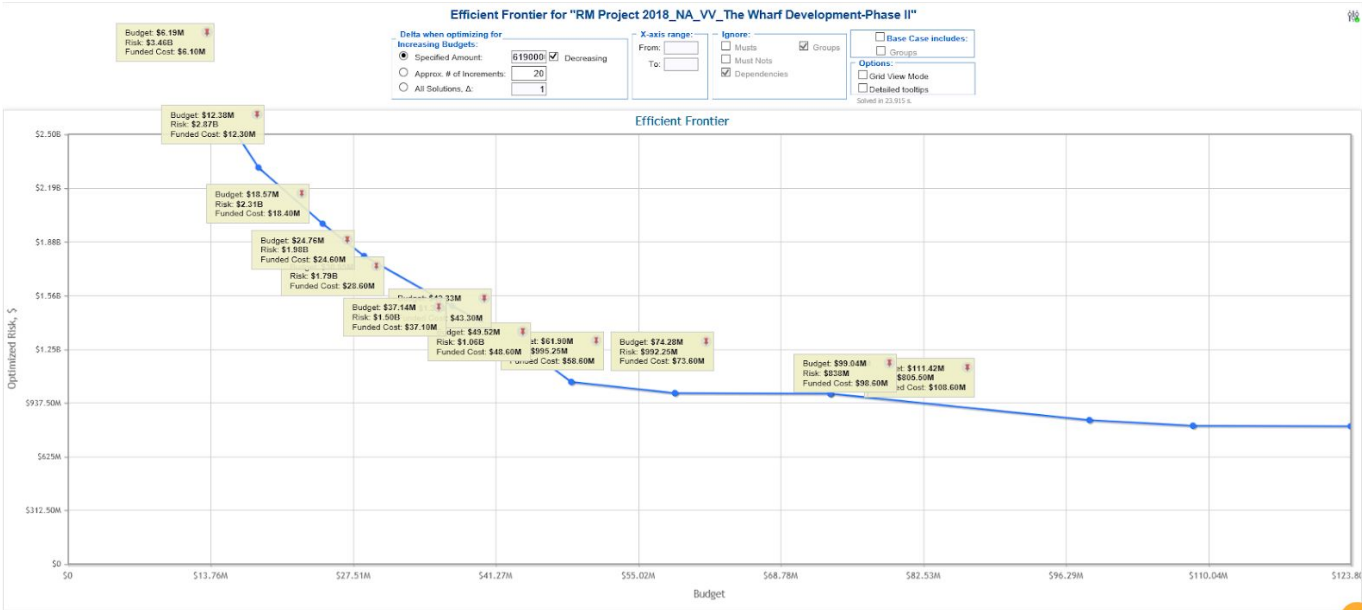


Figure 1.54: Efficient Frontier Data for "RM Project 2018_NA_VV_The Wharf Development Phase II"

Index	Controls/Budget	$0	$6.19M	$12.38M	$18.57M	$24.76M	$30.95M	$37.14M	$43.33M	$49.52M	$55.71M	$61.90M	$68.09M	$74.28M	$80.47M	$86.66M	$92.85M	$99.04M	$105.23M	$111.42M	$117.61M	$123.80M
	Risk with Selected Controls, $	$12.91B	$3.46B	$2.87B	$2.31B	$1.99B	$1.79B	$1.50B	$1.30B	$1.06B	$1.06B	$995.25M	$995.25M	$992.25M	$992.25M	$992.25M	$992.25M	$838M	$838M	$805.50M	$805.50M	$802.75M
	Funded Cost	$0	$6.10M	$12.30M	$18.40M	$24.60M	$28.60M	$37.10M	$43.30M	$48.60M	$48.60M	$58.60M	$58.60M	$73.60M	$73.60M	$73.60M	$73.60M	$98.60M	$98.60M	$108.60M	$108.60M	$123.80M
1.	Lobbying							FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
2.	Insurance											FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED			FUNDED	FUNDED	FUNDED
3.	Skills Training		FUNDED	FUNDED	FUNDED			FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
4.	In-House Counsel				FUNDED	FUNDED	FUNDED		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
5.	Construction Consultant				FUNDED	FUNDED	FUNDED	FUNDED		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
6.	Build Additional Parking		FUNDED				FUNDED	FUNDED		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
7.	External Counsel																	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
8.	Fundraising Consultant		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
9.	Rezone Housing		FUNDED		FUNDED		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
10.	Negotiate Contracts With Businesses For Quality Jobs		FUNDED		FUNDED		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
11.	Hire Senior Project Manager		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
12.	Hire Retail Consultant						FUNDED			FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
13.	Hire Community Manager					FUNDED																FUNDED
14.	Incentives For Prospective Retail Tenants		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
15.	Incentives For Prospective Housing Tenants		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
16.	Marketing			FUNDED		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
17.	Expand The Construction Project													FUNDED	FUNDED	FUNDED	FUNDED					FUNDED
18.	Conduct Environmental Study						FUNDED			FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
19.	Coordinate With Department of Housing and Urban Development		FUNDED		FUNDED	FUNDED	FUNDED	FUNDED		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED
20.	Host Annual Music/Culture Festivals		FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED	FUNDED

IX. Conclusion

Any major construction project is bound to be risky, and the Wharf project is no exception. All of the risks that this project faces can lead to a loss in revenue. By using the Expert Choice Riskion software, we were able to identify just how risky the project is. We have learned that applying controls will help reduce the likelihood and impact of risk events. The software even calculates for us how to best optimize those controls. However, even with optimized controls applied, the financial risks this project faces are still high. What we cannot see in this analysis is the future revenue income stream. If this project is successful, retail and rental properties could bring in enough revenue to undo the damage of some of these risks.

X. Appendix

Forman, Ernest H, et al. Risks-We-Face and Risks-We-Take Enterprise Risk Management – A New Paradigm. *forman.s3.amazonaws.com/RisksFaceTake.pdf*.