SUMMARY RESULTS FOR MAGNOLIA BRIDGE REPLACEMENT COST AND SCHEDULE UNCERTAINTY EVALUATION:

UPDATE FOR SELECTED ALTERNATIVE (ALTERNATIVE A)

APRIL 19, 2007

Assumptions for this analysis:

1. The Project is fully funded with no delays (i.e., there are no funding constraints or other funding uncertainties). Potential funding contributions from the Port of Seattle have not been included. Incorporation of funding uncertainty may be done in a different (future) scenario.

2. For a given alternative, there are no significant changes to the alignment (minor changes are included).

Other notes:

1. The process followed for this cost and schedule uncertainty evaluation is similar to the Cost Risk Assessment® methodology employed by the Washington State Department of Transportation.

2. The original "base" and "risk" factors were developed during a four-day workshop in October 2004, when five project alternatives were considered. During a one-day update workshop during November 2006, the risk assessment was updated for the selected alternative (Alternative A, previously called "A-Ramps"), which was at approximately 10% design. The values represent the consensus of the subject-matter experts in attendance, based on available information. The analysis was updated in early March, 2007, based on updated inflation-rate information developed by the City of Seattle. The analysis was updated again in mid-April, 2007, to incorporate a few changes in base costs (e.g., excluding sales tax).

3. Previous project costs of $5.77M (consultant and City) are included in the cost results shown in this report.

Report Outline

1. Workshop Attendees

Attendee	Organization
John Buswell	Seattle Department of Transportation
Jerry Dorn	HNTB Corporation (Cost Lead)
Mike Johnson	Seattle Department of Transportation
Kirk Jones	Seattle Department of Transportation (Project Manager)
Yuling Teo	Seattle Department of Transportation
Travis McGrath	Golder Associates (Risk Lead)
Forest Dill	Atkinson Construction
Dirk Bakkar	KPFF Engineers
Pete Smith	HNTB Corporation (Consultant Project Manager)
Tom Schnetzer	HNTB Corporation (structures)
Jim Wu	Shannon & Wilson

2. Key Project Assumptions and Notes

- The bridge needs to be replaced for structural/safety reasons. The current structure is essentially four separate structures: one coming off the Magnolia Bluff; a viaduct through the Port of Seattle (POS) property; a railroad crossing; and another viaduct over/connecting with 15th Avenue W and Elliott Avenue on the east.

- The bridge must remain standing after the design earthquake (whatever that earthquake and its return period are). Damage may occur and result in closure to traffic, but the damage must be repairable.

- The current bridge is adequate for projected traffic demand. Assumes 1%/year growth for the Magnolia community. Assumes undeveloped area (now zoned industrial, but which could be rezoned) stays industrial, but will be fully developed by POS – uncertain how will develop, but could be more traffic (POS property Terminal 91).

- Selected alternative: Alternative A (formerly called A-Ramps). Structure type is a rectangular concrete box for most of the central viaduct (where have low structure height and structure is not visible from afar). Structure type is a haunched concrete box at the west end (bluff structure) and east end (over 15th Avenue W) where the structure is more visible. The alignment is essentially the same as for the 2004 risk assessment. The maximum span length for the bluff structure is approximately 360 feet (longer than assumed in 2004), which eliminates impact on City park property through fewer pier locations.

- The alternative is currently at approximately 10% design (through the TS&L phase).

- Every pier from the 15th Avenue W overcrossing west to Port Pier 91 (existing bridge pier 46) gets ground improvement to control liquefaction and lateral spreading.

- Single design contract. Single Design/Bid/Build construction contract.

- Working on the Environmental Assessment (EA) now (previously thought would need an EIS). The preliminary draft EA is in WSDOT and FHWA review. The EA will not be circulated until the Biological Assessment is approved. This will probably be late 2007 or early 2008.

- The Port of Seattle (POS) is redeveloping. The gate at 21st Avenue W will open and a new road will go through the POS property near the base of Magnolia Bluff. Existence of the new surface road through POS property is assumed prior to Magnolia Bridge construction; however, this is not critical. POS must provide access as part of their development plan. POS is currently behind Magnolia Bridge project in terms of development, but may catch up and pass. However, if the Magnolia Bridge project is built before the POS redevelopment is completed, the City will be responsible for this new surface road. POS has agreed to connect to Magnolia Bridge in some feasible fashion. However, a formal agreement between the City of Seattle and POS has not yet been reached.

- Alternative A essentially replaces the existing bridge "in place", although offset slightly to the south of existing bridge, allowing for maintenance of some traffic on the existing bridge during construction. Nominally the longest bridge-closure time of all alternatives. Higher cost for traffic control and detours. Also other potential impacts: anecdotal information for lost business for reduced traffic when bridge traffic is disrupted (1997 slide and 2001 earthquake) – could be community resistance. Fire/Life/Safety issue for reduced bridge traffic (currently emergency medical service comes from James Street next to Harborview hospital). Impacts recently-purchased park

property at west end–moving bridge to the south which impacts this property more than existing (up on bluff at 'view site' and down below). Bridge span across lower park property was increased to 360 feet to minimize impact at surface. Also may impact FAA electronics site leased from City at upper park site. May have fish window and shoreline impacts in Smith Cove west of Pier 91 for this alternative.

- Other features of Alternative A include the following:
    - Replace entire bridge structure.
    - Access to and from Elliott Ave and 15th Avenue W on the east end. Tie into existing east approach (Galer flyover) and 15th Avenue W; essentially the same as existing.
    - Access to W Galer Street on the west end
    - Access to a new surface street (to be constructed by the Port of Seattle (POS), and to to 23rd Avenue W south of the bridge.
    - Combined bicycle and pedestrian lane (approximately 10 feet wide) on one side of bridge.
    - 6.5% grade coming off Magnolia Bluff.
    - Similar geometry to the existing 15th Avenue W at-grade connection
    - Similar grade at railroad crossing
    - Same basic three-lane roadway section at west end, off bluff (two uphill, one downhill).
    - Same basic four-lane roadway section in the middle, west of new surface road/ramps to 15th Avenue W (two in each direction).
    - Same basic roadway section at east end. Eastbound to 15th Avenue W is two lanes (one becomes RT merge onto 15th; one is a signal-controlled left turn onto 15th Avenue Wand through on W Garfield Street). Westbound is single lane from northbound Elliott Avenue W over 15th Avenue W, combining with another from the ramp from surface 15th Avenue W to get two westbound lanes.
    - Tight curves at west and east ends, which affects structure types.
    - Variation in widths also affects structure type.
    - Low-level structure until approach to bluff – then need different supports (70 feet in air).
    - Bridge must cross over BNSF and POS railroad tracks with adequate grade and clearance
    - Selected straight and haunched concrete box superstructure types with flared columns establish the bridge aesthetics.
    - Seattle city street; 40 mph design speed.

  - Assume deep foundations (liquefiable soils – mud flats); assuming shafts (eliminated driven piles due to noise considerations, even though slightly less expensive) with ground improvement (generally stone columns or jet/compaction grouting).

  - Function of connections at east and west ends are similar to today's connections (but will likely improve geometrics a bit).

  - Required ramp length at maximum grade is too long from Magnolia Bluff to get ramps to surface before POS piers. However, access to the waterfront park area from Magnolia Bluff will be available from the new POS north-south surface street.

  - Contaminated and/or hazardous materials: Base assumes 20% of shafts will encounter contaminated and/or hazardous materials. Groundwater is known to be contaminated in the vicinity of the proposed shafts.

- Construction staging: Because the design is conceptual at this point, not much is known about how the project will be built. While differences are anticipated between the alternatives, there are generally three stages of construction for each of the replacement alternatives: 1) construct as much of the new bridge as possible without interference from the existing bridge (i.e., most of the new structure except at the end connections); 2) demolish the old bridge where needed to complete construction of the new bridge (i.e., primarily at the railroad crossing the end connections to existing roadways), and complete construction of new bridge (i.e., primarily at the end connections), then switch traffic to the new bridge; and 3) complete demolition of the existing bridge. More detail on potential construction staging by alternative is available separately.

- Traffic control – base includes fire and police response for Dravus detour ($220k/month) during Stage 2 bridge closure.

- Utilities: King County Metro pump station and dual 8-foot-diameter lines at east end of the project (project should be able to avoid impacting this); utilities (Qwest) hang off bridge (project may have to pay to relocate); utilities along 15th Avenue W corridor; POS utilities (still not well-defined; old Navy utilities – abandoned)

- ESA not an issue.

- Stormwater collection and treatment: assume can tie drainage into existing outfalls into bay. Treatment required for all runoff from bridge, and within bridge footprint – no ponds; in-line filters assumed for treatment. Assume independent from POS future development.

- The existing lagoon (Jacobs Lake) south of the middle section of the bridge (on POS property) will likely not be filled in prior to construction of the new bridge.

- Contamination:

  - oil refinery/bulk-fuel tank farm – most above-ground structures were demolished in 2005. If contamination is encountered in excavation, assume will have to clean up area of project excavation only.

  - Lagoon south of middle section of bridge

  - Other potential hazmat issues (e.g., historical Navy usage)

- Bike paths: two north-south paths passing under the bridge (one under bridge parallel to bluff; one west of railroad tracks).

- ROW – assume acquiring title; may be opportunity to get easements instead in some areas (U.S. Navy, BNSF, Seattle Parks department and POS). Most of the required ROW is in the central portion of the bridge, some of which the City was not granted ROW (only an easement) under the Navy condemnation proceedings. Potential to trade property with POS.

- POS plans – what POS does (higher-density redevelopment under its North Bay vision; potential re-zoning) could affect how the City ties into the surface street.

- Railroad interaction – BNSF railroad is currently responsible for the portion of the bridge that crosses over the railroad. The City assumes BNSF is currently responsible for the portion of the bridge that crosses over the railroad, including the connection to 15th Ave. This is based upon records related to the cost sharing of the original construction in 1929.

- Potential additional ramp allows RT off Galer Flyover structure onto Elliott Avenue W southbound – decision has not been made (ramp needed regardless of what happens with Magnolia Bridge; needed for planned development, and City has assumed responsibility). Currently excluded from scope of this project.

- Cost escalation: Average annual inflation rates of 6-1/2% for construction, 4% for design and construction management and engineering; and 10% for ROW.

- Construction access and staging area are generally not an issue.

3. Summary of "Base" Estimate Review

The Magnolia Bridge Replacement selected alternative, "A – Ramps," was updated from the alternatives development task (2004 through early 2006) based on the selected bridge type and quantities developed in project Task 5, Concept Design to 10%. Several factors affected changes in the base cost of this alternative:

- Use of superstructure and substructure quantities and unit costs rather then typical bridge type area costs;
- High national and regional construction cost inflation—near or exceeding 10 percent annually—in the two year between the two estimates and the project's use of 2006 units costs rather than the previous costs representative of 2004 conditions;
- A temporary ramp for maintenance of traffic during construction would significantly reduce personnel-related traffic maintenance costs for surface street detours;
- Addition of a pedestrian structure for connection to the Elliott Bay Trail west of the BNSF Railroad;
- Use of right of way cost assumed to average $100 per square foot compared with the previous $80 per square foot; and
- Use of more compaction grouting for ground improvement rather than a lesser cost vibratory stone column treatment near existing buildings, other structures and utilities.

The result of these changes was a base cost for the selected alternative of $157.9 million in 2006 dollars, compared to the previous estimate of $134.5 million in 2004 dollars. This is an annual change over two years of 8.4 percent.

Detail on the base cost for the selected alternative is presented in Appendix B.

4. Summary of Risk Assessment Results – No Funding Delay

Results in this section assume that the remaining design funding (i.e., for design beyond 50%, as shown in the flow chart in Appendix A) is available in April 2008.

Figures 1a through 1c are the probability distributions for cost to complete the project. Figures 1d and 1e are the probability distribution for the date the project is complete. Corresponding characteristics for the cost probability distributions are presented in Table 1. Table 1 also summarizes characteristics of the probability distributions for project opening and completion date, and the design, right-of-way, and construction costs. Tables 2a and 2b present the ranked lists of cost risks and opportunities on an expected (mean) value basis. Table 3 summarizes uncertainty in the project's critical path. Tables 4a and 4b present the ranked schedule delays and opportunities by risk (on an expected-value basis). Table 5 contains the "base" activity costs, durations, and escalation rates.

The expected (mean) values in Table 1 include the expected cost of risks and opportunities as documented in the risk register. The percentiles in Table 1 account for the uncertainty in risks and opportunities documented in the risk register. All values include any simulated additional costs resulting from construction delays.

Figure 1a. Probability Distribution (Mass Function) for Total Project Cost (November 2006 $) (including previous costs of $5.77 million and simulated additional overhead costs related to project delays)

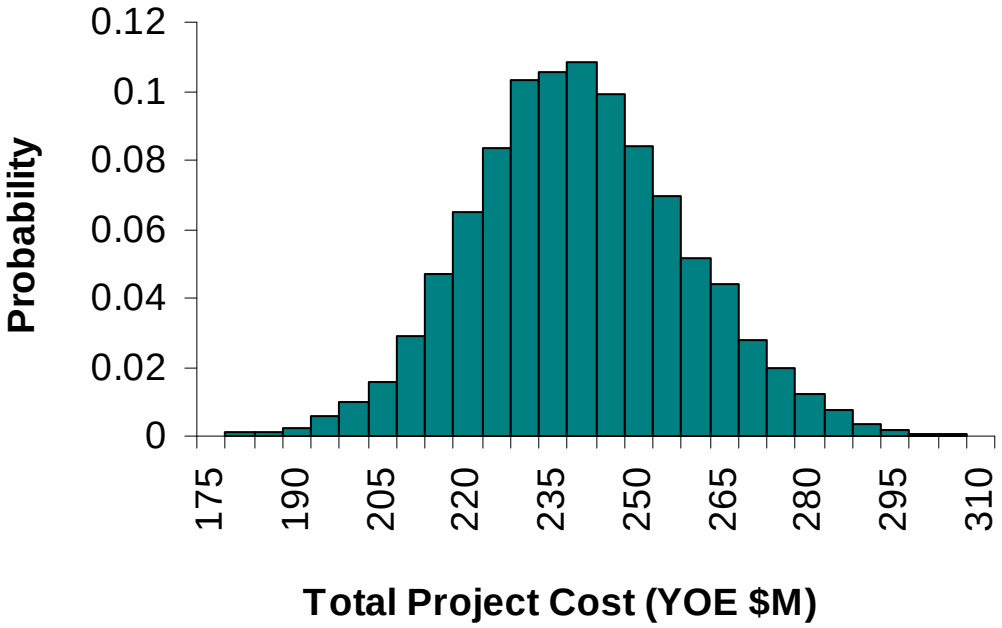


Figure 1b. Probability Distribution (Mass Function) for Total Project Cost (YOE $) (including previous costs of $5.77 million and simulated additional overhead costs related to project delays)

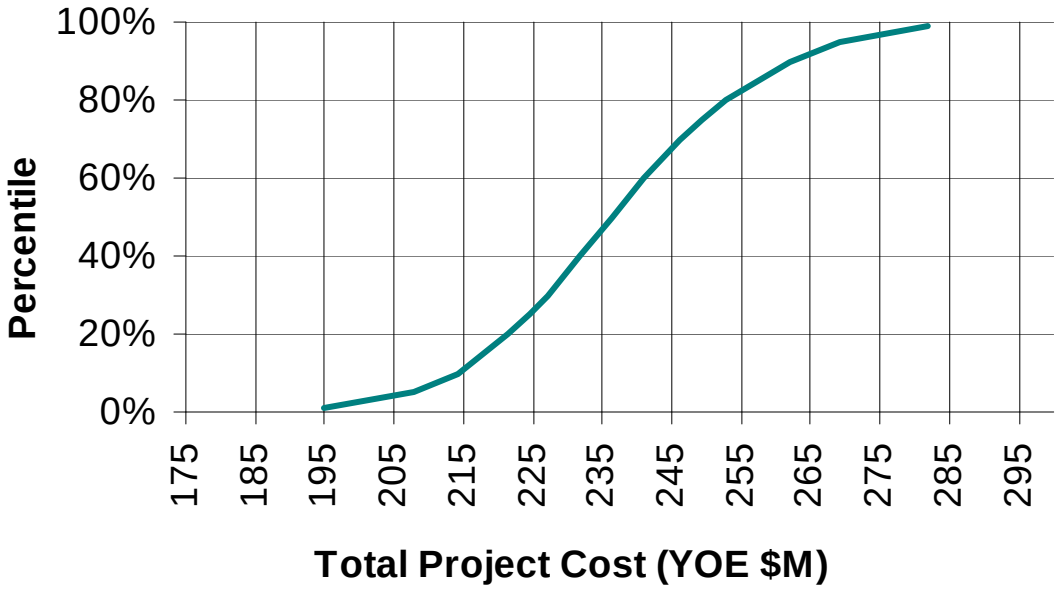


Figure 1c. Probability Distribution (Cumulative Distribution) for Total Project Cost (YOE $)
(including previous costs of $5.77 million and simulated additional overhead costs related to project delays)

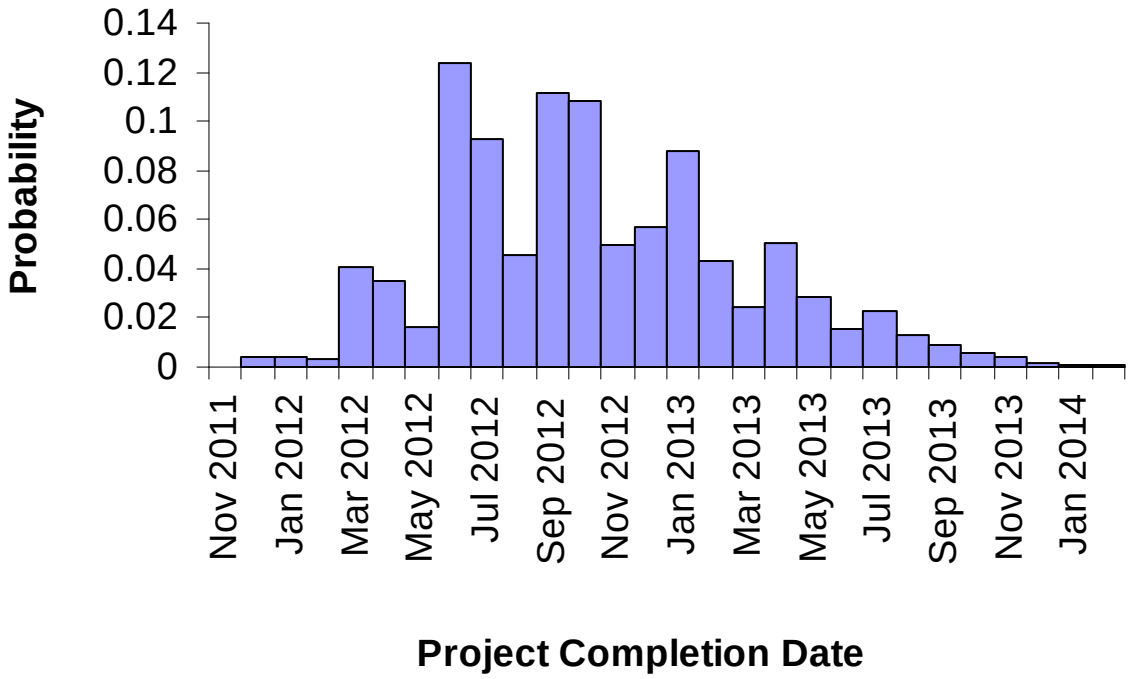


Figure 1d. Probability Distribution (Mass Function) for Project Completion Date

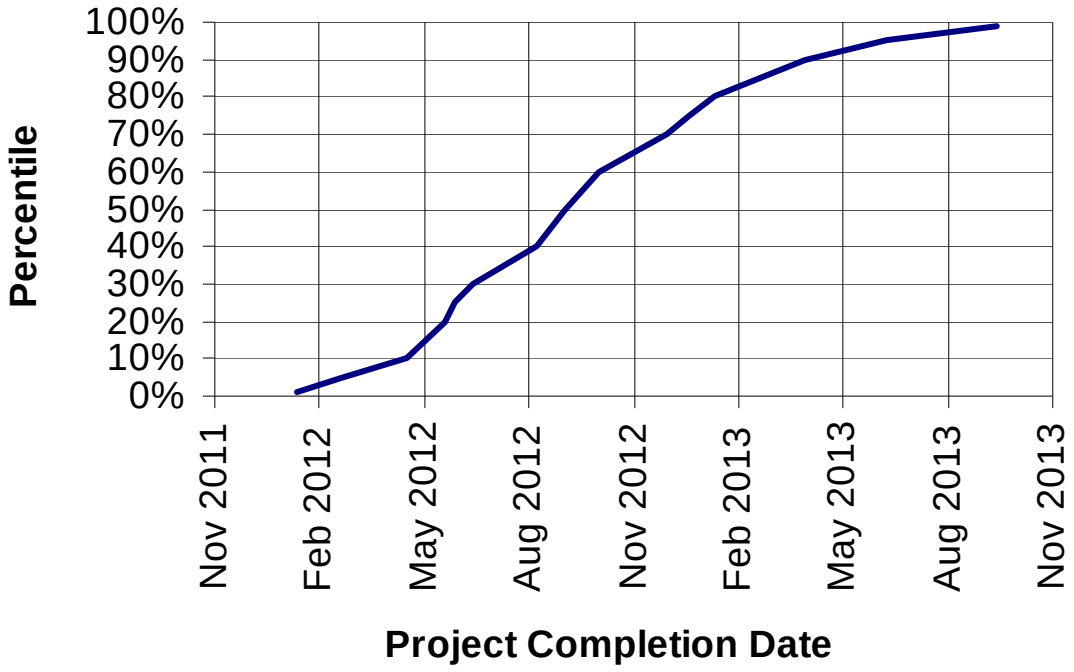


Figure 1e. Probability Distribution (Cumulative Distribution) for Project Completion Date

Table 1. Characteristics of Probability Distributions for Total Project Cost and Schedule Milestones (including previous costs of $5.77 million and simulated additional overhead costs related to project delays)

	Total Project Cost (2006 $M)	Total Project Cost (YOE $M)	Project Completion Date	Award Date	Design Costs (YOE $M)	ROW Costs (YOE $M)	Construction Costs (YOE $M)
Base (no risk)	157.91	193.55	Feb 2012	Aug 2009	13.38	29.13	151.04
Mean	187.10	237.10	Sep 2012	Jan 2010	14.85	32.11	190.15
Std Dev	13.24	18.69			1.07	7.52	16.91
Percentiles							
1%	155.78	194.76	Jan 2012	Aug 2009	13.45	19.74	150.66
5%	166.01	207.72	Feb 2012	Aug 2009	13.77	22.29	162.92
10%	170.60	214.09	Apr 2012	Oct 2009	13.84	23.78	169.24
20%	175.94	221.48	May 2012	Nov 2009	13.97	25.86	176.07
25%	178.12	224.42	Jun 2012	Nov 2009	14.05	26.65	178.89
30%	179.93	227.02	Jun 2012	Nov 2009	14.28	27.35	181.10
40%	183.53	231.88	Aug 2012	Nov 2009	14.35	28.89	185.46
50%	186.86	236.45	Sep 2012	Nov 2009	14.39	30.58	189.75
60%	190.03	241.00	Oct 2012	Jan 2010	14.43	32.70	193.91
70%	193.58	246.20	Dec 2012	Feb 2010	14.53	35.13	198.41
75%	195.62	249.27	Dec 2012	Apr 2010	16.10	36.46	200.98
80%	198.15	252.66	Jan 2013	Jun 2010	16.24	37.91	204.03
90%	204.54	261.91	Apr 2013	Jun 2010	16.65	42.36	212.10
95%	209.63	269.22	Jun 2013	Aug 2010	16.69	47.62	219.11
99%	218.34	281.82	Sep 2013	Sep 2010	16.76	53.38	230.81

Notes:

1. The xth percentile is the value that has a (100% - x%) chance of being exceeded. For example, there is a 10% chance that the 90th percentile value will be exceeded.
2. The simulated expected (mean value) additional overhead cost from construction-schedule delays is $0.95 million (2006 $) or $1.22 million (YOE $). See Risk Register for assumptions.
3. While the sum of the mean component costs (i.e., Design, ROW, and construction in YOE $) equals the mean total project cost (in YOE $), the sum of a given percentile value for Design, ROW, and Construction costs will not (in general) equal the corresponding percentile for the Total Project Cost because these three components are not perfectly correlated. For example, the sum of the 90th percentiles for Design, ROW, and Construction equals $271.1 million. This is much higher than the 90th percentile for total project cost ($261.9 million in YOE); it corresponds in this case to approximately the 96th percentile for total project cost. This follows from the probabilistic theorem called the Central Limit Theorem.
4. The extreme percentiles (less than 10th percentile and greater than 90th percentile) are increasingly uncertain as the bounds are approached. This is primarily due to limited sampling size. However, the results shown are reasonable representations of potential values for those percentiles.

Table 2a. Ranked List of Expected (Mean) Cost Risks

Risk Rank	Contribution to Expected Cost Risk		Risk Event
	%	2006 $M	
1	28.8%	10.2	C8. Market conditions at time of bid
2	17.1%	6.1	R7. Other uncertainty in ROW (excluding items identified separately)
3	13.9%	4.9	D1g. TS&L Uncertainty - Uncertain seismic design or other criteria
4	9.1%	3.2	S3. Other scope uncertainties (excluding items included elsewhere)
5	8.5%	3.0	D1i. TS&L Uncertainty - Other uncertainty in bridge TS&L (excludes items identified separately)
6	4.5%	1.6	Identified Minor Risks (aggregate)
7	4.5%	1.6	Unidentified Risks (aggregate)
8	3.1%	1.1	C6. Encounter unanticipated contaminated or hazardous materials during construction
9	1.7%	0.6	U2. Utilities issues during construction
10	1.7%	0.6	D6. Additional design costs or delays to completion of design
11	1.4%	0.5	D8. Uncertain traffic maintenance costs
12	1.3%	0.5	E2. Challenge to environmental documentation
13	1.1%	0.4	E5. Permitting issues
14	0.7%	0.3	C11. Other construction cost or duration uncertainty
15	0.7%	0.3	C10. Construction activity damages existing bridge, buildings, or railroad
16	0.7%	0.3	C4. Force Majeure during construction
17	0.3%	0.1	C2. Difficult foundation installation or soil conditions encountered during construction
18	0.3%	0.1	D1h. TS&L Uncertainty - Uncertain ground-improvement requirements
19	0.2%	0.1	D5. Uncertainty in stormwater collection and treatment
20	0.2%	0.1	C9. Uncertain construction staging/phasing, traffic control, and detour cost and schedule
21	0.1%	0.0	D2. Uncertainty in retaining walls
22	0.0%	0.0	
		35.5	**Total**

Table 2b. Ranked List of Expected (Mean) Cost Opportunities

Opp Rank	Contribution to Expected Cost Opportunity		Opportunity Event
	%	2006 $M	
1	50.4%	-3.6	R3. Right-of-way acquisition from Port of Seattle
2	21.4%	-1.5	D7. Uncertain construction management and construction engineering costs
3	14.9%	-1.1	D4. Uncertain bridge demolition costs
4	4.5%	-0.3	Identified Minor Opportunities (aggregate)
5	4.5%	-0.3	Unidentified Opportunities (aggregate)
6	4.2%	-0.3	R4. Right-of-way acquisition at west end
7	0.0%	0.0	
		-7.2	**Total**

Table 3. Critical Path Activities

This table summarizes the schedule risks by activity (i.e., overall impact of all risks to each activity). It displays the activities that are on the "base" critical path (i.e., the critical path for the base schedule, which does not account for any risks or opportunities described in the risk register in Risk Register). It also presents the simulated probability that an activity is on the critical path, considering the risks and opportunities described in Risk Register. Activities that are not on the base critical path, but that have a reasonable likelihood of being on the critical path when considering risks and opportunities, are shown in bold red typeface. The risks affecting these activities pose a significant risk to the overall project schedule.

Activity Number	Flow Chart Activity	Is Activity on Critical Path for "Base" Schedule (without risks)?	Probability that the Activity is on Critical Path Considering Risks
0	Costs to Date	N/A	N/A
1	Alignment Alternatives	No	0%
2	Discipline Reports	Yes	0%
3	Select Preferred Alternative	Yes	0%
4	TS&L Study (to 10% design)	No	1%
5	**EA (including review)**	**No**	**86%**
6	**FONSI**	**No**	**86%**
7	Design to 50%	No	1%
8	Design Funding	No	0%
9	ROW Funding	Yes	14%

Activity Number	Flow Chart Activity	Is Activity on Critical Path for "Base" Schedule (without risks)?	Probability that the Activity is on Critical Path Considering Risks
10	Agreements	No	0%
11	**PS&E (Incl. 50% to 100% design)**	**No**	**86%**
12	Permits	No	15%
13	Finalize ROW Planning and Acquisition	Yes	14%
14	Construction Funding	No	0%
15	Ad / Bid / Award	Yes	100%
16	Private Utility Relocation (& some SCL)	No	0%
0	0		
17	Construction Stage 1	Yes	100%
18	Close Existing Bridge	Yes	100%
19	Construction Stage 2	Yes	100%
20	Traffic on New Bridge	Yes	100%
21	Construction Stage 3	Yes	100%

Table 4a. Ranked List of Expected Delay Risks

This table summarizes the expected (mean) delay from each schedule risk (see Risk Register) to all of the activities affected by that risk.

- The "expected delay" to an activity by a risk is the difference between the mean change in activity duration from the risk and the "base" floats for the activity. The expected delays from a given risk are calculated for all of the activities affected by that risk. Those values are summed and reported in this table.

- Because the project's critical path is uncertain (Table 3), and because a number of risks are expected to impact a number of activities both on and off the "base" critical path, this table may in some cases overstate the expected impact that a risk has to the overall project critical path. Hence, the values are reported as "sum of expected delays to all affected activities" and not as "delay to project".

- This table does not capture the variability in project schedule that results from the variability in schedule risks (see Table E1). For example, a low-probability, high-impact schedule risk may not delay any activities in an expected (i.e., mean-value or average) sense because the expected duration change from that risk may be less than the activity's "base" float. Values for those risks are zero in this table. However, in the probabilistic analysis of schedule, when such a risk is simulated to occur it will significantly delay the affected activities (e.g., 5% chance of a 24-month delay). This variability is not captured in Table 4.

Risk Rank	Sum of Expected Delays to all Affected Activities (Months)	Risk Event
1	1.9	E2. Challenge to environmental documentation
2	1.0	R7. Other uncertainty in ROW (excluding items identified separately)
3	0.9	U2. Utilities issues during construction
4	0.5	C10. Construction activity damages existing bridge, buildings, or railroad
5	0.5	P6. Issues completing Ad / Bid / Award process
6	0.3	U1. Issues related to private utility relocations
7	0.2	Identified Minor Risks (aggregate)
8	0.2	Unidentified Risks (aggregate)
9	0.2	C11. Other construction cost or duration uncertainty
10	0.1	C2. Difficult foundation installation or soil conditions encountered during construction
11	0.1	C4. Force Majeure during construction
12	0.1	C6. Encounter unanticipated contaminated or hazardous materials during construction
13	0.0	

Table 4b. Ranked List of Opportunities to Activity Durations (Note: may not be on critical path for project)

Opp Rank	Contribution to Expected Time Opportunity (Months)	Opportunity Event
1	-0.8	C9. Uncertain construction staging/phasing, traffic control, and detour cost and schedule
2	0.0	Identified Minor Opportunities (aggregate)
3	0.0	Unidentified Opportunities (aggregate)
4	0.0	

Table 5. "Base" Activity Costs and Durations

Flowchart Activity Number	Project Activity	Base Cost (2006 $M)	Base Duration (months)	Inflation Rate [1] (%/year)
0	Costs to Date	5.77	1.0	0.0
1	Alignment Alternatives	0.00	0.0	0.0
2	Discipline Reports	0.19	1.0	0.0
3	Select Preferred Alternative	0.00	0.0	0.0
4	TS&L Study (to 10% design)	0.06	2.0	0.0
5	EA (including review)	0.05	8.0	0.0
6	FONSI	0.00	0.0	0.0
7	Design to 50%	3.57	15.0	0.0
8	Design Funding	0.00	0.0	0.0
9	ROW Funding	0.00	0.0	0.0
10	Agreements	0.00	0.0	0.0
11	PS&E (Incl. 50% to 100% design)	3.50	9.0	4.0 / 6.0
12	Permits	0.00	9.0	4.0
13	Finalize ROW Planning and Acquisition	24.27	12.0	10.0
14	Construction Funding	0.00	0.0	0.0
15	Ad / Bid / Award	0.15	4.0	4.0
16	Private Utility Relocation (& some SCL)	0.00	6.0	6.5
17	Construction Stage 1	53.99	12.0	6.5
18	Close Existing Bridge	0.00	0.0	0.0
19	Construction Stage 2	36.25	12.0	6.5
20	Traffic on New Bridge	0.00	0.0	0.0
21	Construction Stage 3	11.75	6.0	6.5
22	Complete	0.00	0.0	0.0
17a	CE/CM for Stage 1	9.72	12.0	4.0 / 6.0
19a	CE/CM for Stage 2	6.53	12.0	4.0 / 6.0
21a	CE/CM for Stage 3	2.12	6.0	4.0 / 6.0
	Total Base:	**157.91**	**Feb 2012**	

Notes:
1. Cost inflation rates are summarized in Table E-1 (risk register; see risk items P7 and R8). Mean values are shown in this table.

5. Discussion

The following results for the No Funding Delay scenario (see Table 1) summarize the important conclusions from the risk assessment.

Project Cost and Milestone Dates

The following ranges represent the 10th to 90th percentile range (i.e., the mid 80% confidence interval). There is only a 20% chance that the respective value will fall outside the range shown below:

- Total Project cost (2006 $M): $176M - $205M
- Total Project cost (YOE $M): $214M - $262M
- Date the project is completed: April 2012 to April 2013

The costs above include previous costs of $5.77 million.

Other key results include (see Table 1):

- Escalation without cost or schedule risk (base in YOE $ vs. base in 2006 $ for the total project): +23%.

- Cost risk without escalation (90th percentile in 2006 $ vs. base in 2006 $): +29%. This project is subject to moderate cost risk, as described in the risk register (Table C.1) and the cost risk ranking lists (Tables 2a and 2b). Calculated this way, this quantity could be compared with a traditional cost contingency normally carried in deterministic estimates.

- Schedule risk for the project completion date (90th percentile completion vs. base completion): 14 months. The group assessed relatively little schedule risk for this project (aside from funding uncertainty, which was handled via separate model scenarios).

- Cost risk plus escalation and schedule risk (90th percentile in YOE $ vs. base in 2006 $ for the total project): +66%. This number reflects the combined impact to project cost from cost and schedule risk and the corresponding escalation. This value is consistent with Golder's observations for similar projects at this stage of design.

Most of the cost uncertainty is driven by uncertainty in a few significant cost risks and schedule risks. The most significant cost risks and uncertainties are the construction-cost inflation rate (risk P7 in Table C.1), market conditions at the time of bid (risk C8; see Tables 2a and C.1), uncertainty in right-of-way acquisition (risk R7 and opportunity R3), uncertainty in seismic or other bridge design criteria (risk D1g), and scope uncertainties (risk S3).

Assuming no funding delay, the most significant schedule risk is a potential challenge to the environmental documentation (risk E2 in Tables 4a and C.1), which leads to an almost 90% chance that the EA could become the project's critical path (Table 3). Therefore, the team should investigate potential cost-effective mitigation strategies to reduce the risk of an EA challenge (either the challenge itself or its consequences). Another significant schedule risk is uncertainty in right-of-way acquisition (R7). Most of the other schedule risks were assessed to have either low likelihoods of occurrence or small schedule impacts if they occur.

Because funding for the project is uncertain, the City specified three potential funding scenarios (as described in Section 5): No funding delay; 5-year funding delay; and 10-year funding delay. A comparison of the uncertainty in total project cost (in year of expenditure dollars) for all three scenarios is shown in Figure 2a. Figure 2b is a similar comparison for schedule. The impact of a funding delay on both cost (in year-of-expenditure dollars) and schedule is significant. For example, at the 90th percentile, a 5-year funding delay has an estimated additional cost of $95 million (relative to no funding delay), while a 10-year funding delay has an estimated additional cost of $199 million (relative to no funding delay). The difference in project completion date at the 90th percentile is 4.5 years for a "5 year" funding delay (note: per the flow chart in Appendix A, there is some float in the initial part of a "5 year" funding delay, so only 4 to 4.5 years of delay results in the project completion date), and 9.5 years for a "10 year" funding delay. This increased schedule combined with the assessed construction, consultant labor, and right-of-way inflation rates lead to a substantial increase in estimated cost associated with these potential delays.

The team should seek to address the critical risks and exploit key opportunities listed above through future value engineering and cost-effective risk management efforts.

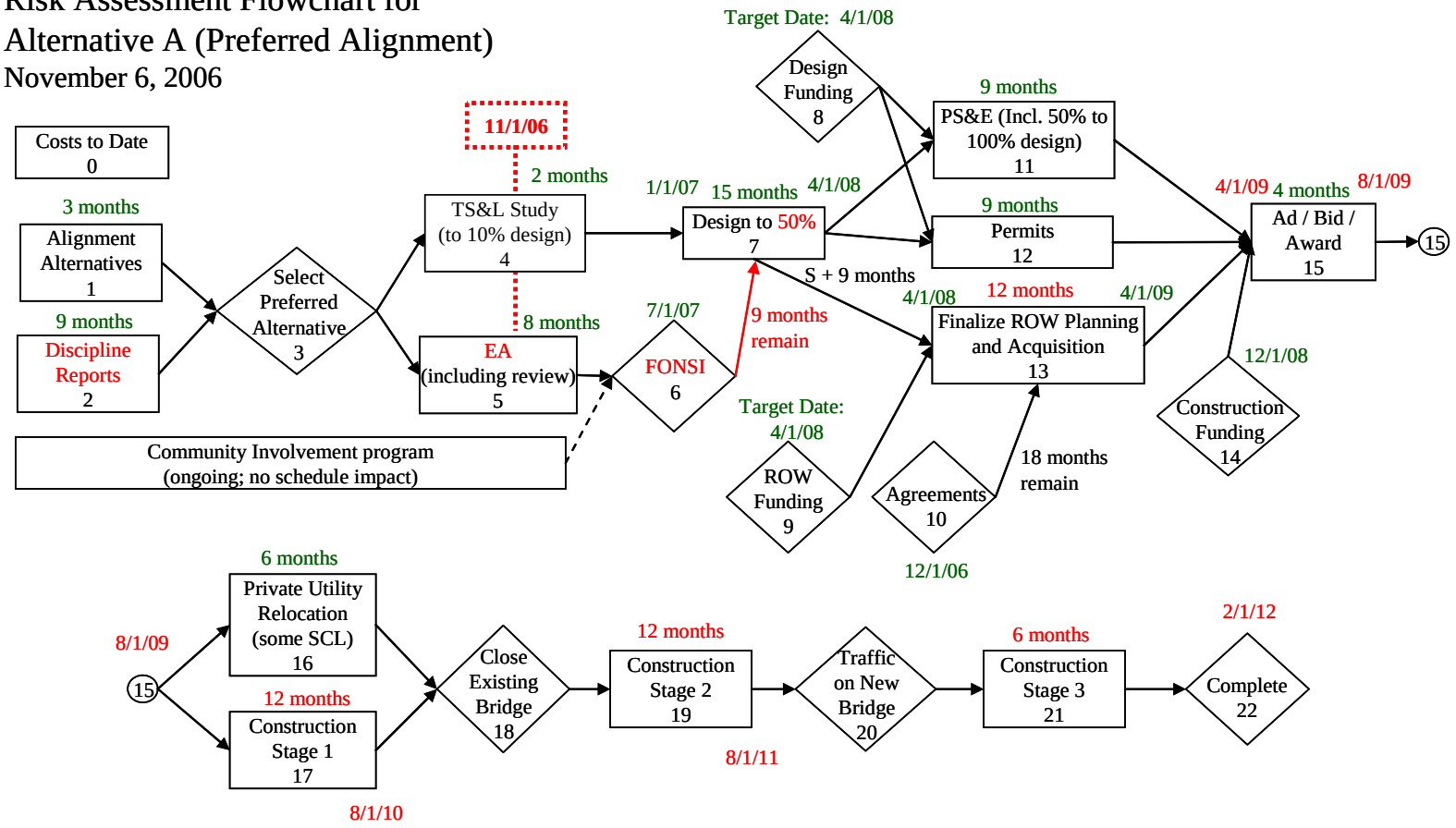
Appendix A. Risk Assessment Flow Chart

Magnolia Bridge Replacement

Risk Assessment Flowchart for Alternative A (Preferred Alignment)

November 6, 2006

Green Typeface = Base durations and Team's target dates (*risk not included*).
Red typeface and red lines = updates from 2004 to 2006.



Notes:

1. Assumes single design/bid/build contract.
2. Federal money is involved. Thus, need FONSI to proceed with design beyond 50% design.
3. Construction closure periods: Fish window applies for Alternatives A (but can be staged around with no loss of schedule). Construction can generally occur year-round (with some occasional minor weather stoppages).
4. Permits include application and processing for HPA, 404 nationwide, NPDES, City of Seattle (Shoreline); no 401 permit required.
5. Agreements include: 1) POS Agreements (coordination between City of Seattle and POS on issues related to POS re-development, new surface road, access, etc.); 2) Railroad; and 3) Utilities.
6. Construction Stage 1 includes all SDOT utility relocations. Durations assume multiple, simultaneous crews and activities where feasible and not overly expensive.
7. Baseline scenario assumes funding will not delay the project. Dates for funding milestones were selected on this basis, considering potential schedule opportunity items (e.g., ROW).

Appendix B. Base Cost Detail

ITEM NO	ITEM	UNIT	QUANTITY	UNIT COST	COST (2006 Dollars)
	Mitigation				
1	Erosion and Sedimentation Control	Mo	30	$60,000	$1,800,000
	Sub total - Mitigation				**$ 1,800,000**
	Roadway Demolition				
2	Hazardous Material Abatement	CY	5,000	$300	$1,500,000
3	Misc. Demolish Existing Roadway	LS	1	$50,000	$50,000
	Sub total - Roadway Demolition				**$ 1,550,000**
	Temporary Detour				
4	Temporary Ramp Roadway	LS	1	$150,000	$150,000
	Sub total - Road Re-routing				**$ 150,000**
	Relocations				
5	Power Pole Relocation (15th Ave, Bluff)	LS	1	$500,000	$500,000
6	FAA Approach Radar & Assoc. Utilities Relocation	LS	1	$100,000	$100,000
7	Port Access Facility (to accommodate temp roadway)	LS	1	$100,000	$100,000
	Sub total - Utilities Relocations				**$ 700,000**
	Roadway				
8	MSE Wall (15th Overcrossing Ramp)	SF	6,500	$45	$292,500
9	Select Fill (15th Overcrossing Ramp)	CY	3,500	$15	$52,500
10	Gravel Base (15th OX ramp, 15th Ramp, 23rd ramps,bluff)	CY	1,500	$25	$37,500
11	Asphalt Pavement (Bluff, Misc, 23rd, 15th, Galer)	Ton	100	$110	$11,000
12	Concrete Pavement (23rd, 15th, Garfield, sidewalks, islands)	CY	2,300	$250	$575,000
13	Concrete Curb	LF	3,600	$30	$108,000
14	Pavement markings	LF	40,000	$1	$40,000
15	Site Restoration (between 23rd ramps)	LS	1	$50,000	$50,000
	Subtotal				**$ 1,166,500**
	Traffic				
16	Signals (15th Ave intersection)	LS	1	$550,000	$550,000
17	Signage	LS	1	$250,000	$250,000
18	Impact Attenuator	LS	1	$40,000	$40,000
	Subtotal - Traffic				**$ 840,000**
	Storm Drainage				
19	Catch Basin	EA	13	$3,000	$39,000
20	Drain Inlet	EA	51	$1,000	$51,000
21	Scupper Drain	EA	13	$1,000	$13,000
22	Manhole	EA	14	$4,500	$63,000
23	Water Quality Unit 1	EA	4	$10,000	$40,000
24	Water Quality Unit 2	EA	3	$50,000	$150,000
25	6" Std. Galv. Steel Pipe SD (incl.hangers/fittings)	LF	1,445	$150	$216,800
26	12" Conc. SD Pipe	LF	2,661	$50	$133,000
27	15" Conc. SD Pipe	LF	618	$75	$46,300
28	18" Conc. SD Pipe	LF	17	$75	$1,200

ITEM NO	ITEM	UNIT	QUANTITY	UNIT COST	COST (2006 Dollars)
	Subtotal - Storm Drainage				**$ 753,300**
	Sewer Relocations				
29	10" PVC SS (Port Force Main)	LF	831	$50	$41,600
30	12" PVC SS (COS CS from Elliot Ave to Metro Pump)	LF	455	$50	$22,700
31	27" RCP SS (King County Metro Trunk Sewer)	EA	1	$100,000	$100,000
	Subtotal - Sewer Relocations				**$ 164,300**
	Fire Protection				
32	8" Steel Pipe (in Ground)	LF	2,500	$70	$175,000
33	6" Steel Pipe (dry risers)	LF	500	$150	$75,000
34	Fire Hydrant Assembly	EA	10	$5,000	$50,000
35	Deluge Systems	EA	5	$150,000	$750,000
	Subtotal - Fire Protection				**$ 1,050,000**
	Sub total - Roadway				**$ 3,974,100**
	Sub total - Utilities, Drainage and Roadway				**$ 8,174,100**
	Allowances				
36	Landscaping @	**3.0%**			$246,000
37	Allowance for Unidentified @	**5.0%**			$409,000
	Sub total - Allowances				**$ 655,000**
	SUBSTRUCTURE				
38	STRUCTURE EXCAVATION CLASS A INCL. HAUL	CY	3,089	$33	$102,000
39	STRUCTURE BACKFILL	CY	1,149	$33	$38,000
40	COFFERDAM	SF	7,634	$40	$305,000
41	SHORING EXTRA EXCAVATION CLASS A	LS	1	$50,000	$50,000
42	CONC. CLASS 4000 FOR BRIDGE	CY	4,464	$600	$2,678,000
43	STEEL REINF. BAR FOR BRIDGE	LB	1,058,000	$1.25	$1,323,000
44	SOIL EXCAVATION FOR SHAFT INC. HAUL	CY	9,373	$400	$3,749,000
45	FURN. & PLACING TEMP. CASING FOR SHAFT	LF	6,186	$350	$2,165,000
46	CASING SHORING (@ 10 LF/SHAFT)	LF	800	$350	$280,000
47	ST. REINF. BAR FOR SHAFT	LB.	1,641,980	$1.25	$2,052,000
48	CONC. CLASS 4000P FOR SHAFT	CY	9,373	$200	$1,875,000
49	CSL TESTING	EA.	80	$3,000	$240,000
50	CSL ACCESS TUBE	L.F.	92,948	$3	$279,000
	SUBTOTAL SUBSTRUCTURE				**$ 15,136,000**
	SUPERSTRUCTURE				
51	CONC. CLASS 5000 FOR BRIDGE	CY	20,920	$750	$15,690,000
52	EPOXY-COATED ST. REINF. BAR	LB	1,213,800	$1.50	$1,821,000
53	ST. REINF. BAR FOR BRIDGE	LB	4,047,700	$1.25	$5,060,000
54	POST-TENSIONING PRESTRESSING STEEL	LB	1,267,800	$6.00	$7,607,000
55	STRUCTURAL LOW ALLOY STEEL (MISC. @ 10LB/LF STRUCT.)	LB	53,409	$6.00	$320,000
56	PIER PROTECTON/IMPACT ATTENUATORS	EA	8	$40,000	$320,000
57	TRAFFIC BARRIER	LF	9,771	$100	$977,000
58	TRAFFIC BARRIER RAIL	LF	9,771	$300	$2,931,000
59	PEDESTRIAN BARRIER	LF	3,780	$100	$378,000
60	PEDESTRIAN RAIL	LF	3,780	$300	$1,134,000
61	EXPANSION JOINT SYSTEM	LF	646	$400	$258,000
62	SLIDING DISC BEARING	EA	50	$3,750	$188,000
63	BRIDGE PEDESTRIAN LIGHTING	LF	3,780	$60	$227,000

ITEM NO	ITEM	UNIT	QUANTITY	UNIT COST	COST (2006 Dollars)
64	BRIDGE ROADWAY LIGHTING	LF	8,444	$30	$253,000
	SUBTOTAL SUPERSTRUCTURE				**$37,164,000**
	SUBTOTAL BRIDGE				**$52,300,000**
	Allowance for Unidentified	**5%**			**$2,615,000**
	BRIDGE DECK AREA	SF	262,928		
	BRIDGE SQUARE FOOT COST (with 10% Mobilization)		**$219**		
	Ground Improvement				
65	Compaction Grouting - Mainline	CY	158,800	$60	$9,528,000
66	Compaction Grouting - 15th Overcrossing	CY	10,700	$60	$642,000
	SUB-TOTAL		**169,500**		**$ 10,170,000**
67	**Pedestrian Connection (14'x700')**	SF	10,000	$300	**$3,000,000**
	SE Walls				
68	Mainline at Low Level	SF	2160	$45	$97,000
69	23rd Ave Off Ramp	SF	5150	$45	$232,000
	SUB-TOTAL		**7310**		**$ 329,000**
	Moment Slab and Barrier				
70	Mainline at Low Level	LF	254	$300	$76,000
71	23rd Ave Off Ramp	LF	490	$250	$123,000
	SUB-TOTAL		**744**		**$ 199,000**
	Approaches - Select Fill				
72	Mainline at Low Level	CY	1,800	$15	$27,000
73	23rd Ave Off Ramp	CY	880	$15	$13,000
	SUB-TOTAL		**2,680**		**$ 40,000**
	Bridge Approach Slabs				
74	Mainline at Low Level	SY	160	$225	$36,000
75	Mainline at Bluff	SY	162	$225	$36,000
76	23rd Ave On Ramp	SY	95	$225	$21,000
77	23rd Ave Off Ramp	SY	64	$225	$14,000
78	15th Ave	SY	64	$225	$14,000
	SUB-TOTAL		**545**		**$ 121,000**
	Demolition				
79	Smith Cove Wharf Phase 1	SF	26,400	$30	$792,000
80	Magnolia Bridge Phase 1	SF	34,100	$30	$1,023,000
81	23rd On Ramp Phase 1	SF	9,400	$30	$282,000
82	Magnolia Low Level Bridge Phase 2	SF	39,200	$30	$1,176,000
83	15th Ave Ramp Overcrossing Phase 2	SF	26,900	$30	$807,000
84	15th Ave Ramp Approach Fill Ramp Phase 2	SF	15,100	$30	$453,000
85	23rd Off Ramp Phase 3	SF	8,000	$30	$240,000
86	Magnolia Bluff Phase 3	SF	68,100	$30	$2,043,000
87	Magnolia Low Level Bridge Phase 3	SF	30,200	$30	$906,000
	SUB-TOTAL		**257,400**		**$ 7,722,000**
	Work Bridge				

ITEM NO	ITEM	UNIT	QUANTITY	UNIT COST	COST (2006 Dollars)
88	Smith Cove	SF	17,000	$75	$1,275,000
89	Jacob's Lake	SF	8,000	$75	$600,000
	SUB-TOTAL		**25,000**		**$ 1,875,000**
	Temporary Detour Ramp				
90	SE Walls	SF	16000	$30	$480,000
91	Select Fill	CY	5410	$15	$81,000
92	Beam Guardrails on Fill and SE Walls	LF	1120	$20	$22,000
93	Temporary Bridge (including Beam Guardrails)	SF	4210	$150	$632,000
	SUB-TOTAL		**26740**		**$ 1,215,000**
94	**Traffic Maintenance**				**$2,215,000**
	Additional Items and Allowances				
95	Hazardous materials (not included in Item No. 2)	CY	2,000	$300	$600,000
96	Archeologist	LS	1	$100,000	$100,000
97	Railroad flagging	mo	5	$40,000	$200,000
98	Temporary measures	mo	30	$40,000	$1,200,000
					$ 2,100,000
	PROJECT SUB-TOTAL				**$ 92,730,100**
	Mobilization	10%			**$9,273,000**
	SUB-TOTAL				**$102,003,100**
	Engineering during construction	3%			**$3,060,100**
	Construction Management	15%			**$15,300,500**
	TOTAL (2006 $)				**$120,363,700**
	Right of Way				**$ 24,272,000**
	Environmental and Design				13,276,000
	GRAND TOTAL				**$157,911,700**

Appendix C. Risk Register

Table C.1. Risk and Opportunity Register for Alternative A-Ramps

Note: unless indicated otherwise, all uncertainties, risks, and opportunities have been defined to be independent of one another.

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Construction				
C1 Minor	**New Port of Seattle surface road construction or other redevelopment plans not completed in time for Magnolia Bridge construction** *Design-related issues are handled under a separate design issue (D1b).* Construction-related impact of the POS road not being completed on time. For example, City of Seattle may have to build the surface road. Alternatively, City could temporarily use existing Marina Road. Sidewalk (how to move pedestrians and bicycles through the area if use temporary road) and drainage are only possible issues.				
C2	**Difficult foundation installation or soil conditions encountered during construction** Construction issues only. *Excludes design-related foundation uncertainty and ground-improvement uncertainty (D1i, D1h) and contaminated/hazardous materials (C6). Includes/considers changes to bridge cost that result from uncertainty item D1i.*	17	10%	Uniform (0%,5%) of bridge structure cost 5% of bridge cost is 20% of foundation costs,	Uniform(0,4) Duration change perfectly correlated with cost change

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Base assumes oscillator for drilled-shaft foundation installation (cuts through many obstructions). Includes: • Deep foundations significantly longer or otherwise different than assumed in design • Significant obstructions encountered (e.g., slide debris; obstructions in fill) • Construction quality problems (e.g., voids in placed concrete) • Ground improvement different than assumed in design • Additional cofferdams required			which are in turn 25% of bridge cost	
C4	**Force Majeure during construction** For example (there are many possible sources): • Significant earthquake during construction damages old or new bridge • Labor strike affecting construction schedule • Terrorist attack impacting schedule	17	5%	5	3
C5 Minor	**Issues related to construction over 15th Ave W** Construction-related issues only. *Excludes geometry and access constraints, which are accounted for in design (D1b and/or D1f).* Includes: • Lifeline issues (15th Ave W is lifeline)				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
C6	**Encounter unanticipated contaminated or hazardous materials <u>during construction</u>** Design or construction-related impacts (now includes former E7). *Excludes hazardous materials associated with structure demolition where included as part of ROW cost (R6).* Base assumes extensive testing ($100k) during design to characterize contamination. Base assumes all excavated materials are contaminated (single handling). Treatment or disposal at $300/cy for hazardous materials. For Alternative A, approximately 7,000 cy for $2.1M. Based on current information, nature and extent of contamination are uncertain at the following: • Decommissioned oil refinery; • Tank farm (removed vs. not removed at time of construction); • Historical operations by US Navy (e.g., TCE use); • Lagoon • Other industrial use				
	Summarize uncertainties with <u>three issues</u>, which are related as described below: <u>Issue #1</u>: Contamination hot-spots exist (probability = 80%). If hot spots exist, then one of two possible outcomes: A. Able to characterize the nature and extent of contamination during investigation and design phase (probability = 90%). Additional cost of 60% of base contamination excavation/removal	17	See left	See left	0 (can be done within existing schedule)

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	cost (10% additional volume at 6 times the cost. B. Unable to characterize fully during design (probability = 10%), so must characterize / test / stockpile during construction. Costs for outcome A <u>plus</u> additional cost of $1M and delay of 1 month. <u>Issue #3</u>: Less non-hot-spot contamination than assumed in base cost, particularly at the west end of the project (probability = 25%). Save 15% of base contamination excavation/removal cost.				
C7 Minor	**Encounter unanticipated cultural resources during construction:** Potential sites along bluff on west side; fill elsewhere.		very low		
C8	**Market Conditions at time of bid** Includes competition in contracting market; size of contract (including bonding capacity), and type of construction. Excludes uncertainty in material costs (captured by inflation-rate uncertainty). Big enough project for regional interest, but many other projects at same time. Labor shortage with cost premium (2% - 5%); Steel / cement material costs cyclic.	17, 19,21 perfectly correlated across activities	100%	For base assumption of full funding now: Normal distribution (10^{th} percentile = 0% (base), 90^{th} percentile = +20%) of base construction cost *Does not apply if funding is delayed substantially*	0

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
				(more than 6 years): assume other local projects are winding down, so more competitive market (minor risk and uncertainty)	
C9	**Uncertain construction staging/phasing, traffic control, and detour cost and schedule** *Excludes other duration uncertainties captured under separate items*. Includes both <u>design-related issues</u> (i.e., what are the staging, traffic-control, and detour plans?) <u>and construction-related problems</u> (i.e., the proposed plans do not work and need to be modified). The proposed construction staging and detour plans are based on limited design work and construction planning. Uncertain whether the proposed plans will work as intended. Build temporary work structures or roadway to reduce closure time? build other access (e.g., by North bay). temp bridge at $50/sf East end use Galer (w/ signal) and temp ramp Additional cost (e.g., $300k for additional falsework) to accelerate Stage 2 construction (perhaps overlapping	19	25%	0.3	-3 (but also reduce closure time from 12 months to 0 months)

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	with Stage 1). *Complete bridge closure and replacement is different alternative – not considered here.*				
C10	**Construction activity damages existing bridge, buildings, or railroad** Includes: Excessive settlement and/or cracking of existing facilities. For example, because of the proximity of Alternative A to the existing structure, foundation installation (oscillator) or ground improvement for Alternative A could impact existing foundations (e.g., liquefy soils beneath existing bridge). Additional monitoring costs and/or shoring	17	25%	1	3
C11	**Other construction cost or duration uncertainty** ("base" uncertainty and risks and opportunities not captured elsewhere) • Contractor / owner relationship issues (primary issue) • Contractor performance • POS security requirements (base assumes $0.5M/year) • Labor or material procurement or supply issues (minor from roadway perspective) – *excluded; see market conditions (C8)* • Work-hour restrictions or other production-rate inefficiencies (e.g., railroad operational schedule; noise restrictions)	17	5%	5	6

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	• Construction-management cost (base assumes 15% of construction cost), *excluding related delay costs, which are simulated directly*. • Design support during construction (3% of base construction is in base cost) • City costs • Other miscellaneous items (e.g., temporary measures) • Contractor staging area				
-	**Additional costs that accumulate during construction delays** (*If not already included under other risks*) Monthly accrual rate for delay-related costs to project (excludes costs that contractor absorbs): • City overhead • Construction management • Design support during construction • Detour and traffic maintenance • TESC Note: these costs are assumed to not be saved when the construction duration decreases below the base value.	17, 19, 21	Simulated directly as function of construction delay relative to base schedule	$380k/month for Stages 1, 2, 3 plus $60k/month for Stage 2 (traffic control)	0
-	**Fish window for Alternative A** Can work around this window in Stage 1 (will be stated in the bid documents – only 7 shafts) – Minor issue				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Design				
D1a Minor	**TS&L Uncertainty - Required traffic capacity of new bridge** New bridge is being designed for same capacity as current bridge, which is forecast to have adequate capacity. Potential impact is change of design to accommodate additional capacity. Uncertainties: • Future growth of Magnolia community (current assumption is 1%/year). Will likely cause additional congestion but not degrade service substantially. • Development activities by POS could lead to additional commercial and public access/traffic. City has limited right-of-way for expansion. Also, increasing bridge size for future growth, especially given current mandate to limit growth / increase high-occupancy ridership, is unlikely.				
D1b Minor	**TS&L Uncertainty – Alignment uncertainty** Assumption for the risk assessment: only minor adjustments to the alignment for each alternative occur. *Construction cost uncertainty for alignment changes is included under item D1i. Time uncertainty in decision process is addressed here.* Includes uncertainty in: • Proposed Port of Seattle redevelopment and surface road – ultimate outcome/decision on				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	what the redevelopment plan is and how it affects Magnolia Bridge design. Formal agreement between City of Seattle and POS is needed to address a number of issues (access for POS redevelopment; configuration of new POS surface street and connection with Magnolia Bridge and its impact on bridge design). At some point, indecision could delay design of this project. *Excludes right-of-way acquisition /easement issues, which are covered under a separate item (R3). Excludes construction impacts if road is not done as planned (captured in C1).*				
	• Alignment and tie-in with Elliott Ave • Alternative A – move alignment slightly to south to improve constructability • Intersection ramp location Base includes 3 months for review and revision in response to alignment tweaking during the TS&L study. Risk is that unforeseen changes in alignment (due to requests by POS or others for changes) could cause additional delay due to decision cycles, design time, review time, etc. <u>2006 update: POS is now planning around this project, so minor risk of change.</u>				
D1c	**TS&L Uncertainty - Uncertain bridge aesthetics** Potential impact on structure type and/or appearance				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Included in D1i				
D1d Minor	**TS&L Uncertainty - Mitigating known stability issues at west end with design** Design issue; *excludes problems encountered during construction (C3).* Need more-robust design (e.g., resist larger lateral force) than currently assumed in base				
D1e	**TS&L Uncertainty – Uncertainty in structure over Railroad** *Excludes related right-of-way or easement issues (R5).* These uncertainties are included in D1i. Base includes at-grade service crossing, flagging, etc. Issues include the following (with resulting uncertainty in structure unit price and quantity): • grade restrictions • clearance requirements • foundation placement				
D1f	**TS&L Uncertainty - Curvature and/or width constraints at west and east ends (for assumed alignment) lead to uncertainty in structure type** Included in D1i				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
D1g	**TS&L Uncertainty - Uncertain seismic or other design criteria** City's seismic design standard – moving toward 975-yr earthquake (from 500-year with ground improvement, which is what the TS&L design is based on): • 10% additional MSE wall costs *(including / considering changes to wall costs that result from uncertainty item D2)*. • Additional ground improvement required under all structures (deeper since depth of liquefaction increases in this area). 15% additional ground improvement cost *(including / considering changes to ground-improvement costs that result from uncertainty item D1h)*. • Other structure cost (including foundations): 5% additional structure cost *(including / considering changes to bridge cost that result from uncertainty item D1i).*	17, 19, 21	100% for all issues described at left (i.e., *will become part of the base project plan, but are included as risks here for convenience*), perfectly correlated across cost components and activities	See left	0
D1h	**TS&L Uncertainty - Uncertain ground-improvement requirements** Design issue. *Excludes construction / installation issues (C2). Excludes uncertainty in foundation TS&L (D1i). Some other uncertainties in this register compound on the changes introduced by this uncertainty – see those items for descriptions.* Base assumes: • Not likely to use stone columns where the ground or groundwater is known to be contaminated (easier to get permits and reduce	17	A1. 5.6% A2. 50.4% A3. 1.4% A4. 12.6% B. 30%	A1. 0 (base) A2. +25% of base compaction-grouting cost A3. -20% of base compaction-grouting cost A4. 0 (base due to canceling of effects) B. -3 (-25% of base compaction-grouting cost)	Minor

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	likelihood of cross-contamination) or where near existing buildings. Therefore, almost all ground improvement is now assumed to be compaction grouting. • Compaction grouting at $60/cy; total 120,000 sf x 50 feet deep = 197,000 cy) = $11.8M. Note: unit price for ground improvement has gone up substantially in the last 12 months.				
	Uncertainties include: • For the assumed compaction grouting, uncertainty in quantity (volume) and unit price, including: o Quantity of ground improvement ▪ Use of ground improvement near existing structures (vibration issues, but *excludes damage during construction (see C10)*) ▪ Less use of ground improvement in areas likely to be contaminated (e.g., use concrete mat foundation instead) ▪ Number of foundation locations requiring ground improvement (have not yet done liquefaction analysis; uncertainty in pier locations) ▪ Depth of ground improvement (range is 40 ft. – 60 ft.) ▪ 20% chance to reduce volume by 20% ("Q") (i.e., by 40,000 cy). o Uncertainty in unit price for compaction grouting. Unlikely for unit cost to decrease below $60/cy because it's being used on more projects (limited supply; not included in market conditions C8). 90% chance to				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	increase by 25% ("U") (i.e., to $75/cy), independent of potential reduction in quantity. • Opportunity to use stone columns (at 25% of the unit price for compaction grouting) instead of compaction grouting if encounter less contamination than assumed (i.e., DNAPL cross-contamination concerns would be reduced) and/or vibration issues are not a concern. 30% chance to change approximately 1/3 of ground improvement to stone columns; save $3M. Summarize with the following mutually-exclusive outcomes (event tree): A. Use compaction grouting as assumed in the base estimate (70% chance): 1. No quantity reduction (Q'; 80% chance) AND No unit price increase (U'; 10% chance) = (70%)(80%)(10%) = 5.6% probability of base compaction-grouting cost. 2. No quantity reduction (Q'; 80%) AND unit price increase (U; 90% chance)): (70%)(80%)(90%) = 50.4% chance of +25% of base compaction-grouting cost. 3. Quantity reduction (Q; 20% chance) AND No unit price increase (U'; 10% chance) = (70%)(20%)(10%) = 1.4% chance of -20% of base compaction-grouting cost. 4. Quantity reduction (Q; 20% chance) AND unit price increase (U; 90% chance)): (70%)(20%)(90%) = 12.6% chance of (1-				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	20%)*(1+25%) – 1 = 0% change (i.e., the changes cancel and get base compaction-grouting cost). B. Replace some compaction grouting with stone columns 30% chance). 30% chance to save $3M.				
D1i	**TS&L Uncertainty - Other uncertainty in bridge TS&L including unit prices and quantities** (excluding items identified separately) *Excludes other uncertainties which are captured separately (see below). Some other uncertainties in this register compound on the changes introduced by this uncertainty – see those items for descriptions.* Base values, which do not include ground improvement (captured separately): • Average bridge cost per square foot is $202/sf. Generally uses unit prices from the high end of WSDOT cost schedule. • Substructures (drilled shafts): $860/cy (excavation, installation, and testing) for drilled shafts (on the high end of WSDOT's rate schedule, and $60/cy higher than estimates from two contractors). Includes uncertainty in the following: • Foundation TS&L (e.g., piles instead of shafts) and unit price (excludes ground improvement) *YES* • Risk item D1a? *NO* • Risk item D1b (alignment)? YES for cost only • Risk item D1c (aesthetics)? YES				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	• Risk item D1d (west-end stability)? YES • Risk item D1e (structure over railroad)? YES • Risk item D1f (curvature and geometry constraints)? YES • Risk item D1g (seismic design criteria)? *NO* • Risk item D1h (ground improvement)? *NO* • Risk item D2 (retaining walls)? *NO* • Risk item D3 (on- and off-ramps)? YES				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Changes since 2004: Now have selected a structure type; now have selected foundation type (shafts); now have quantity estimates. Unit prices reflect urban Seattle construction. Summarize the uncertainty in unit price and quantity for structure cost (structure = substructure plus superstructure) as shown at right. These uncertainties are in addition to market conditions risk and construction cost-inflation uncertainty. Uncertainties in structure costs are perfectly correlated among structure types. Uncertainties in unit price and quantity are assessed to be largely independent.	17 (most cost is in this activity)	Distributions (see right)	Cost change = base cost * (1+sim % change in unit price) * (1+sim % change in quantity) – base cost Unit price uncertainty (as percent of base total bridge structure cost): 10th percentile = -5%; 90th percentile = +15% Quantity uncertainty (as percent of base total bridge structure cost): 10th percentile = -5%; 90th percentile = +5%	0
D2	**Uncertainty in retaining walls** *Excludes seismic design criteria changes (D1g) and other separate wall-related risks. Some other uncertainties in this register compound on the changes*	17, 19, 21; perfectly correlated across activities	Distribution	Triangular (-10%, 0, 25%) of retaining wall costs	0

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	introduced by this uncertainty – see those items for descriptions. Includes design and construction-related uncertainty in: • TS&L for retaining walls (including unit price; base assumes $45/sf wall face for MSE) • Quantity of retaining walls (planned and actual) • Ground-improvement cost for walls (stone column or potential compaction grouting in limited areas) • Aesthetics			Largely independent of structure cost uncertainty (D1i)	
D3	**Uncertainty in bridge on- and off-ramps** Includes design and construction uncertainty in ramp superstructure and related foundations: • Quantities of structure versus retained fill • Unit price for ramp structure (base is $150/sf) • Unit price for retained fill (including related walls and ground improvement), considering building over compressible soils <u>Included in D1i</u>				
Minor	**Other uncertainty in other earthwork, TESC, and roadwork** (excludes walls) TESC allowance included in the base estimate.				
D4	**Uncertain bridge-demolition costs** Base has $11.6M (raw $).	19	A. 40%	As a percent of base bridge-demo costs: A. -25%	

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
			B. 40% C. 20%	B. -10% (base) C. 0 (base)	
D5	**Uncertain stormwater collection and treatment system** Combines design and construction issues Base assumes use existing outfalls (either POS or City) and do not need detention. Assumes can use in-line canister filters for quality treatment. Includes uncertainty in: • Change in requirements (code is changing in 2007) (e.g., increased treatment) • Quantity requiring collection and treatment (function of alternative and applicable standards, and POS runoff) • Whether can tie into existing POS drainage and outfall system (particularly Alternative C), or need to modify planned drainage system to connect to existing outfall • Groundwater levels vs. vaults • Other components, like piping, pumping, filter for treatment • Raised roadway might affect drainage and temporary ponds • Other temporary measures	17	40%	+25% of stormwater base cost	0
D6	**Additional design costs or delays to completion of design** *Excludes other items identified separately*.	11	30%	2	7

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Consultant and City costs for environmental process, site investigation, design, and PS&E are higher than originally anticipated. Base adjusted to $12M based on status as of later 2004 ($6M through TS&L). Risk is further increase due to design changes, additional mitigation or investigation, etc. Some change is accounted for under other items (e.g., during TS&L in item D1b).				
D7	**Uncertain Construction Management and Construction Engineering costs** Base for the combination is 18% of base construction costs.	Split among 17,19,21	100%	As % change of base construction management and base construction engineering cost: 10^{th} percentile = 14% (-20%); 90^{th} percentile = 18% (+0%)	
D8	**Uncertain traffic maintenance costs** Base is $2.1M. Potential additional cost for Dravus detour (additional police or fire support). Fire support is $160k/month for 12 months.	Split between 17 and 19	25%	2	

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Environmental, Permitting				
E1 Minor	**Complete EIS instead of EA** No appreciable cost or schedule increase given how far the project is in the EA. Draft EA is already in for review.				
E2	**Challenge to Environmental Documentation** Base assumes EA with FONSI. Includes: • Public opposition to one or more Alternatives (e.g., related to proposed closure time for each alternative) • Loss-of-business complaints • Fire/Life/Safety challenges • Tribal issues • Challenge on documentation adequacy (e.g., due to design changes) • Mitigation (e.g., beach restoration) • Biological Assessment issues Three potential mutually-exclusive outcomes (from event tree): A. No challenge and no mitigation B. Challenge but no mitigation C. Challenge and mitigation	5	A. 20% B. 55% C. 25%	A. 0 (base) B. 0.25 C. 0.25 plus 1.0 to Activity 17	A. 0 B. 6 C. 6 Perfectly correlated to cost change
E3 Minor	**Other issues completing Environmental Documentation or obtaining FONSI** (not captured elsewhere)				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	For example, add new options for analysis at late date				
E4	**Other issues related to selection of Preferred Alternative** *Excludes challenges to Environmental Documentation (E2).* POS, Community, SDOT – 1 month decision process in base Have now selected the preferred alternative. Only remaining issue is the 4(f) issue (bridge goes over park; need good documentation that does not impact the park).	6 (sequential to independent delay in D6)	10%	Minor	3
E5	**Permitting issues** For example: • Shoreline issues for Alternative A • Approval of proposed construction method (i.e., issues related to vibration) through Smith Cove. Require additional mitigation or restoration for disturbance? • Tribal consultation (and related off-site enhancement or mitigation). • 401 issues • 404 issues	12	75%	0.5	minor
In E4	**Parks or other 4(f) issues** (not captured elsewhere) Assume prior agreements with City Parks Department for joint development exempt the City from 4(f) issues.				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Political and Other External Influences				
P1 Minor	**Other issues related to obtaining Agreements with Port of Seattle** Set up parameters for ROW and design • ROW • relocate guard shack, security, access plenty of time to work out agreement if start early *Largely included under other items.*				
P2 Minor	**Issues related to obtaining Agreements with Railroads (private and BNSF)** (excluding issues captured under separate items, e.g., ROW) Possible relocation of tracks; change in railroad crossing structure. Plenty of time to work out agreement if start early.				
P3 Minor	**Issues related to obtaining Agreements with Utilities** (excluding issues captured under separate items) • Seattle City Light – both sides of 15th (relocate few poles, some transmission lines involved) and feed to Port of Seattle • King County Metro sewer • fiber optics • Qwest Telephone only issue - plenty of time to work out agreement if start early (captured in risk U1).				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
P4	**Issues related to obtaining Agreements with US Navy** (excluding issues captured under separate items) *Covered under ROW risks*				
P5	**Funding Uncertainty** Timing of funding is uncertain for Design, ROW, and Construction. Assume fully funded when funding becomes available. Ignores potential POS funding contribution (not included in this risk assessment). *Timing uncertainty is treated with separate model scenarios.*				
P6	**Issues completing Ad / Bid / Award process** (excluding issues captured under separate items) Amendments/changes, contracting issues (non-responsive, e.g., re bonding/insurance), negotiation, protests, re-bid if bids too high.	15	20%	0	2-3
P7	**Uncertain construction cost-inflation rate** Separate from market competition risk (C8). The City has developed projections for construction-cost inflation based on city costs. These projections are 7.4% per year for 2006 and 2007, and 6.5% per year for 2008 and beyond (even long term).	All construction and design	100%	10^{th} percentile = 3%/year; 90^{th} percentile = 7.4%/year	

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	The group generally accepts this information but recognized that there is significant uncertainty in the inflation rate in any given year. The base value (6.5%/year) is the expected value from this distribution. Note for PE, CE, and CM costs: As shown in Table 5, some design costs are contracted, so inflation is zero for these costs. Remaining design costs, construction engineering costs, and construction management costs are assumed to inflate at 4%/year for city labor and 6%/year for consultant labor.				
	Right-of-Way				
R3	**Right-of-way acquisition from Port of Seattle** <u>Note: Change from 2004: this risk now combines the former R3 and R6</u>. Base assumes City buys property (fee). Net opportunity to save money on POS ROW by recovering value of land (i.e., freeing up/returning more than need to buy). Net benefit is $80/sf. High likelihood of getting approval and credit for land swap. Determination of value given decision is uncertain. However, the land could also be re-zoned, which would increase its value and therefore purchase price for SDOT. Land swap may or may not proceed if land is re-zoned.	13	A. 30% B. 30% C. 32% D. 8%	A. -7 B. 0 (base) C. -7 D. +9 <Kirk to confirm this value = half of $18M parcel cost>	

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Four potential (mutually-exclusive) outcomes from a "rolled-up event tree: A. No rezone AND land swap (30% chance) B. No rezone AND no land swap (base case) (30% chance) C1. Re-zone AND land value increases 50% AND land swap occurs (40% x 80% = 32% chance) C2. Re-zone AND land value increases 50% AND land swap does not occur (40% x 20% = 8% chance)				
R4	**Right-of-way acquisition at west end** Parks Department, FAA, US Navy, and private Base assumes acquire 100% of needed. Joint-development agreement with Parks. Possible land swap could save money on acquisition related to Parks (60% of parcels of 6 and 7) for Alternative A. Similar for US Navy (minor) – the Navy is in the process of selling the parcel with the Admiral's residence to a private developer. City has met with the Navy and new owner – new owner knows about the bridge. The only impacts to this parcel are 1) that the western abutment for the bluff structure sits at the edge of this parcel, and 2) air space (bridge runs above this parcel). Opportunity to get as a donation through subdivision.	13	20%	-1.5	
R5 Minor	**Issues related to acquiring right-of-way or easements from Railroad**				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Excludes uncertainty related to design or construction of structure over railroad (D1e) and Agreements (time issue; P2) Experience is that railroad is cooperative, so base schedule should be adequate. Base cost is based on established easement cost (50% of Just Compensation). Potential issue related to placement of column included in D1e.				
-	**<former R6 now included in R3>**				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
R7	**Other Uncertainty in ROW** (excluding items captured separately in R1 – R6 and elsewhere) Base is a preliminary City appraisal by-parcel. Just Compensation estimate at $80/sf for industrial; $40/sf for BNSF, assuming acquire all required property. Base duration for ROW is 12 months (single private owner; would file for condemnation early to avoid delay, if needed). City cannot pay for loss-of-business during construction. Includes uncertainty in: • Quantity - additional ROW requirements (e.g., identified late in design; full instead of partial takes) • Temporary easements • Unit cost for Just Compensation (base assumes $80/sf, but comparables ranged from $60/sf to $100/sf) • Condemnation cost and schedule issues (e.g., 40% of Just Compensation, but this is only included in the base for private properties; excluded for public properties) • Admin costs and labor availability • Damages and relocation costs and schedule (*excluding Snider Petroleum and Bldg 19(2), and City Ice, which are captured under separate items*) • Demolition costs (contaminated materials *not included separately in C6*, foundations)	13	Distributions	Normal (mean = +25%, 99% = +50%) of base ROW cost (resulting std dev = 11% of base ROW cost)	Triangular (Min = 0; Most Likely = 0; Max = +3) Duration change perfectly correlated to cost change
R8 Minor	**Uncertainty in ROW cost-inflation rate** Base: Use 10% per year for all years. Minor				

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	uncertainty.				
	Scope Changes				
S1 Minor	**Magnolia community "traffic calming" issue included in project** Currently outside of scope • traffic circle at west end (unlikely for arterial) • speed reductions • sign bridge Not considered feasible to address for this project or minor		NA	minor	minor
S2 Minor	**Additional ramp allowing right-turn off Galer flyover onto SB Elliott included in project** Currently outside of scope Directly related to Phase 3 Amgen development High ROW / relocation costs		v. low probability	High	high
S3	**Other Scope uncertainties** *Excludes bridge aesthetics (D1c) and capacity increases (D1a).* Potential issues: • demonstration project for corrosion protection (e.g., stainless steel rebar @ 4x, salt-resistant concrete, etc.) or for total life cycle cost considerations • drainage on west bluff • mitigate visual impacts (glare)	17	#1 90% #2 40% #3 70%	#1 0.6 #2 5.0 #3 1.0	0

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	• noise mitigation • art elements (1%) • entrance • pedestrian access to Marina Rd • transit pull out on bridge Summarize as three independent Issues: Issue #1 – Art Issue #2 – Demonstration project Issue #3 – Transit pullout on bridge (e.g., 1,000 sf)				
	Utilities				
U1	**Issues related to private utility relocations** (i.e., those not being relocated by SDOT or its contractor) Existing bridge carries trunk line for telephone. Base assumes telephone is not relocated to new bridge (primary issue). SCL "won't schedule until signed contract". Water line.	18 (delay to start of Stage 2 construction)	10%	0	3
U2	**Utilities issues during construction** Includes: • Encounter unanticipated utilities during construction (and must relocate) – abandoned military lines • Damage existing (known) utilities during construction • Other issue	17	30%	2	4

Item	Risk, Opportunity, or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (2006 $M)	Duration Change (months)
	Minor and Unidentified Risks and Opportunities Aggregate effect of items labeled "Minor" above. "Major" means the items quantified above (i.e., all items other than those labeled "Minor" above)				
	Aggregate Minor Risks	Independently to all	50%	10% of sum of "major" risks to activity	10% of aggregate "major" risks to activity
	Aggregate Minor Opportunities	Independently to all	50%	10% of sum of "major" opportunities to activity	10% of aggregate "major" opportunities to activity
	Unidentified Risks	Independently to all	50%	10% of sum of "major" risks to activity	10% of aggregate "major" risks to activity
	Unidentified Opportunities	Independently to all	50%	10% of sum of "major" opportunities to activity	10% of aggregate "major" opportunities to activity

Notes:

1. When significant dependencies among risk or opportunity events were identified during the workshop, they were generally assessed using an event tree and combined into a single event in this register. This approach ensures that the important dependencies and related conditional probabilities are assessed explicitly. Otherwise, the uncertainties, risks, and opportunities in this register have been defined to be (i.e., are assessed to be) independent of one another. Note that some events in this register are a function of base costs or durations. When those base costs or durations are assessed to be uncertain, the corresponding event should consider (include) changes to the base resulting from the simulated base uncertainty.
2. All cost impacts are assessed in current terms. Cost escalation is handled automatically through the simulation model.
3. Except for "soft cost" uncertainties that are addressed separately, and unless noted otherwise, all cost impacts in this table are "fully loaded" with appropriate markups. Potential markups include items that may be treated as a percentage of the construction subtotal in the cost estimate, such as sales tax, mobilization, construction engineering, design, and allowances for miscellaneous items.