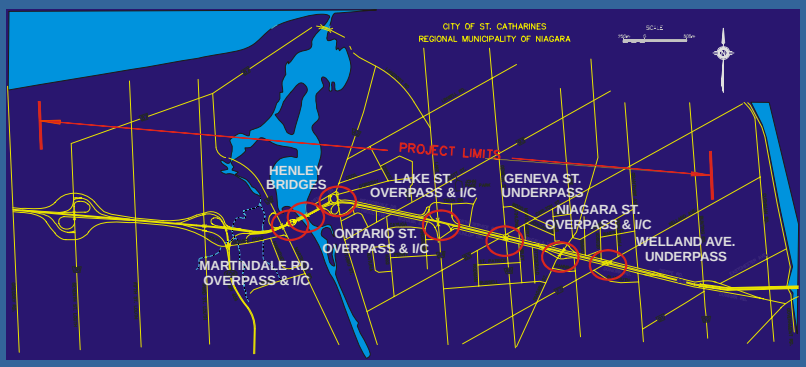


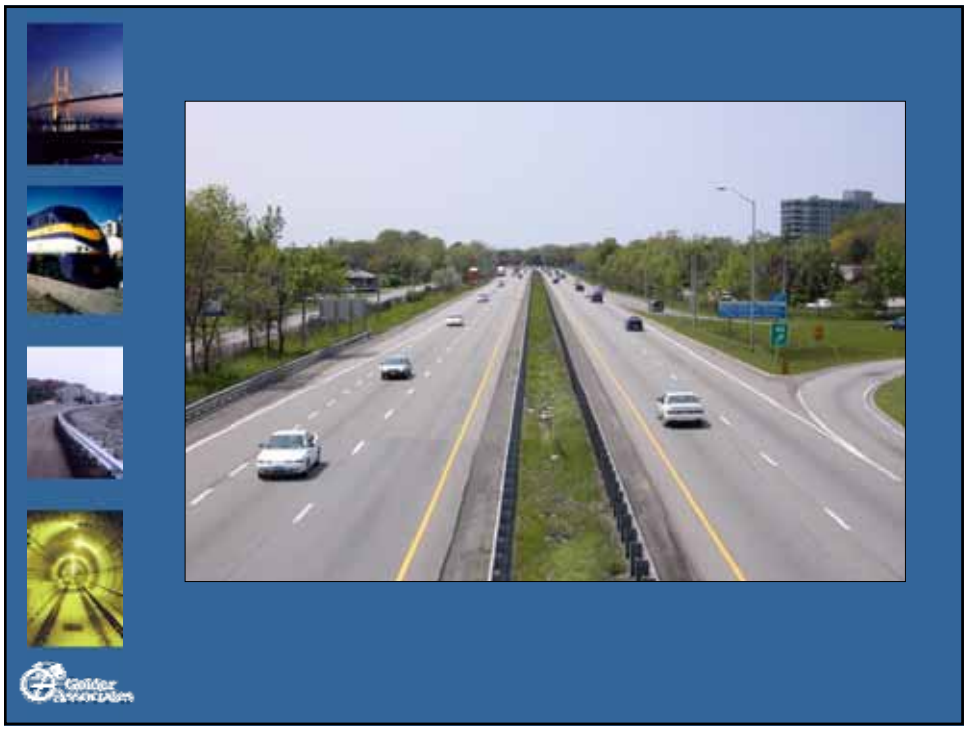

QEW Widening St. Catharines

Risk-Based Cost and Schedule Analysis



Project: Widen 7 km of Provincial highway through urban area from 4 lanes to 6 lanes






Major Project Elements




- Tendered as one contract in fall of 2006, construction sequencing remains to be determined (possibly divided into a series of smaller value contracts)
- Highway widened to three lanes per direction;
- New 8.5 m wide median, 3 m wide paved right-side shoulders for main-line lanes, 2.5 m wide paved right-side shoulders for ramp lanes;
- Concrete barriers on both sides of the roadway;
- Noise walls adjacent to residential areas (5 km of walls);
- New storm drainage & management system;
- High-mast lighting;
- Retaining walls;

Major Project Elements

- Symmetrical widening of the QEW bridge over 3rd Street;
- Replacement of the Martindale Road structure over the QEW with a two-lane structure;
- Symmetrical widening of Henley Bridges (under separate contract);

- Rehabilitation of Ontario Street over-pass structure, interchange improvements;
- Replacement of Lake Street over-pass structure, interchange improvements;
- Replacing QEW structure over Geneva Street;

- Rehabilitation of QEW structure over Niagara Street (including ramp); and
- Symmetrical widening of the QEW structure over Welland Avenue

Status at Time of Analysis

- Preliminary design studies and environmental planning for widening of the QEW through St. Catharines were begun in 1994

- Bids closed for Henley Bridges widening contract on 2nd day of workshop – design fully completed ($16M)

- Preliminary design updated & completed with preliminary cost estimates of $70M for Year 2000 $ used as basis for funding/cost-sharing agreements

- Detailed design contract for remaining widening project awarded prior to workshop – detailed design nearing 30% complete



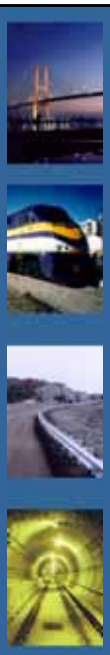

QEW Widening

- Completed Risk-Based Cost & Schedule Analysis
- Initial Plan
  - Construction cost estimate only
  - Target date for tender (bid) advertisement – Summer 2006
- Re-examined and validated "base" cost & schedule
  - took out bias and contingencies
  - added other costs such as properties, design, inflation, risks




Workshop Participants

- Risk Analysis Team
- Designer:
  - Project Manager
  - Senior Highway Eng.
- Contractor Specialist
- Construction Admin. Specialist
- MTO Project Staff
  - Project Manager
  - Assist. Proj. Mgr.
- MTO Other Staff
  - Traffic
  - Construction
  - Utilities
  - Legal/Property
  - Environmental

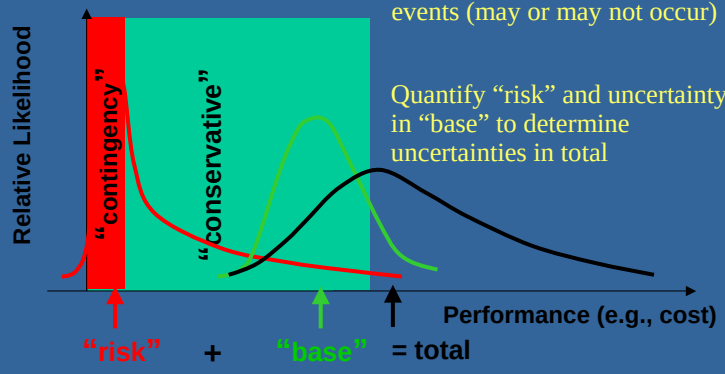


Probabilistic Cost and Schedule
RA / RM: Concept

Total ≈ "Base" + "Risk"

Replace contingency with explicit risk and opportunity events (may or may not occur)

Quantify "risk" and uncertainty in "base" to determine uncertainties in total



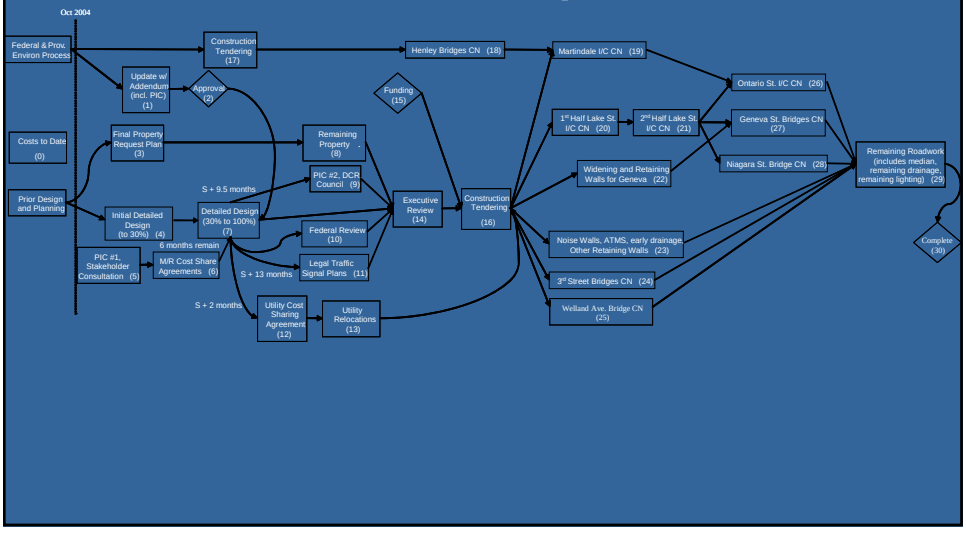
Base Project Assumptions

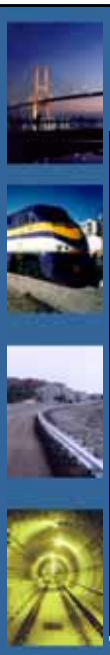
- Construction includes bridges, ramps, and related localized roadway work (service and mainline).
- Environmental permits included in Environmental Process and Update with Addendum activities.
- Approximately 50% federal funding.
- Single construction contract
- Parallel construction strategy (bridges at same time as road)
- Some utility relocation work is included in individual construction activities.
- Utility relocations are assumed to not require additional property.
- If award before Nov. 15th, construction activities may begin. If award between Nov. 15th and Apr. 1st, construction will not begin until following Apr. 1st.

Base Project Assumptions

- Cannot close adjacent on- and off-ramps;
- Roadway must be returned to “normal conditions” (i.e., lanes and capacity) for the winter shutdown period (4.5 months).
- Lake St. I/C constructed in 2 stages: 1) demolition ½ existing, construction 1st half; 2) demolition last ½ existing, construction of the second half (e.g., southbound) of the new bridge.
- 2nd ½ Lake Street I/C can’t start in same season as *start* of 1st ½ , but may start in same season of 1st ½ finish.
- Construction on Lake I/C 1st ½, or Lake 2nd ½ and Ontario St. can’t begin June 15th to maximize likelihood of completion before winter “normal conditions” requirement.

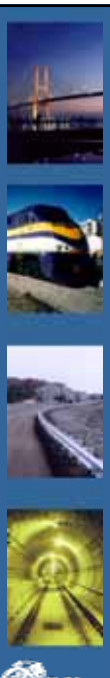
QEW Widening Flow Chart
October 7, 2004 5:00 p.m.



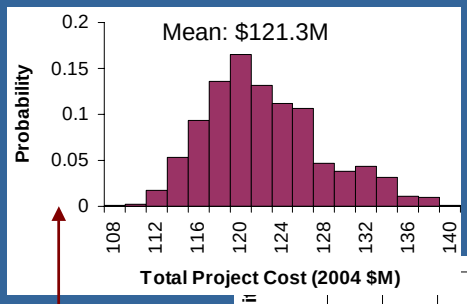


Risk Register

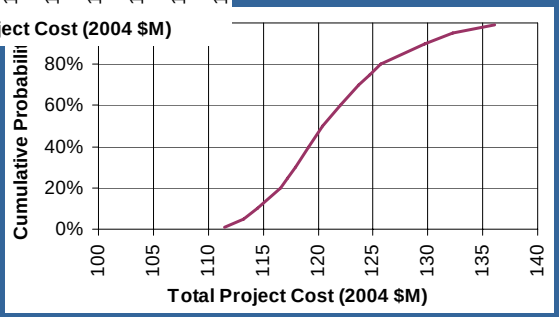
Item	Risk, Opportunity or Uncertainty	Affected Project Activities	Probability of Occurrence	Cost Change (current $M)	Duration Change (months)
	Design, Environmental, Permitting				
Dxa	**Uncertainty in structure design** (excludes construction problems, includes scope changes) Includes uncertainty in: • structure **type, size, and location** (and related quantities and unit prices) • related foundations • traffic capacity • design criteria • owner-initiated value engineering opportunities (identified during design) existing structure condition not as currently anticipated (but accounted for in final design)				
D3a	**Ontario Street structure** Base cost assumes replace deck and rehab remainder of structure for 6-lane QEW (approx. $1.2M). Survey indicates bridge may not be in good enough shape to justify rehab. May have to replace bridge instead of rehab (perhaps to accommodate 8-lane QEW). If bridge is not in good condition, rehab would likely take longer than one season. Replacement could be accomplished in one season or less (if two-stage project). Excludes construction problems (captured separately). Also, if three-stage project likely to take two seasons. Also has implications for traffic control (included here). Potential mutually-exclusive outcomes: A. Base B. Rehab but structure not in good condition C. Replace	26	A. 30% B. 60% C. 10%	A. 0 (base) B. 0.5 C. 1.0	A. 0 B. 2 C. 0 Duration change perfectly correlated to cost change

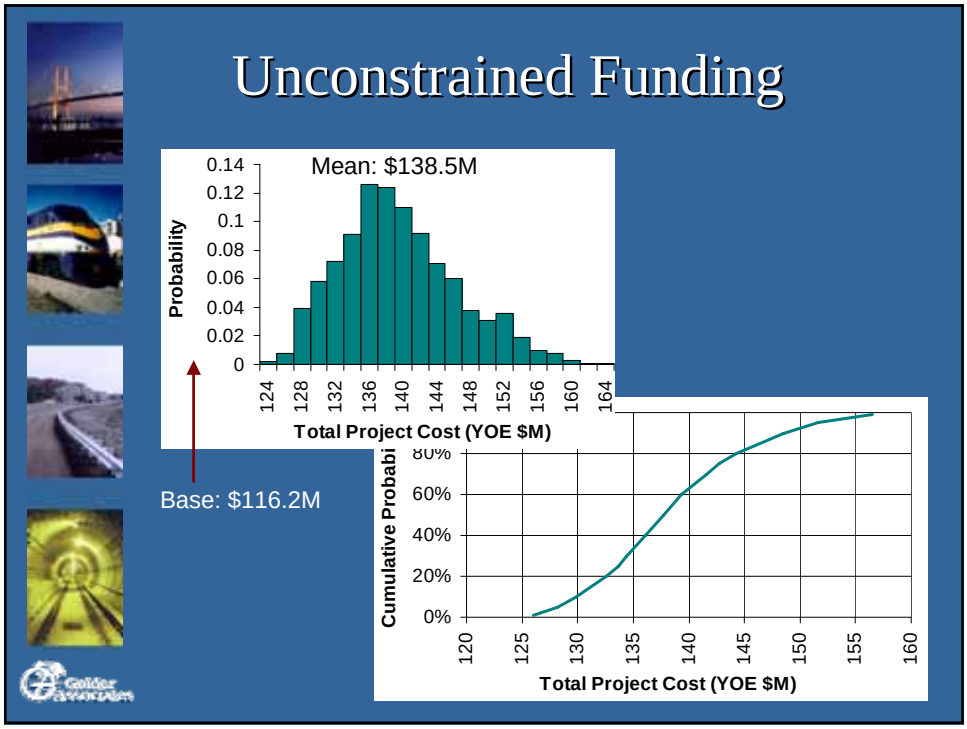


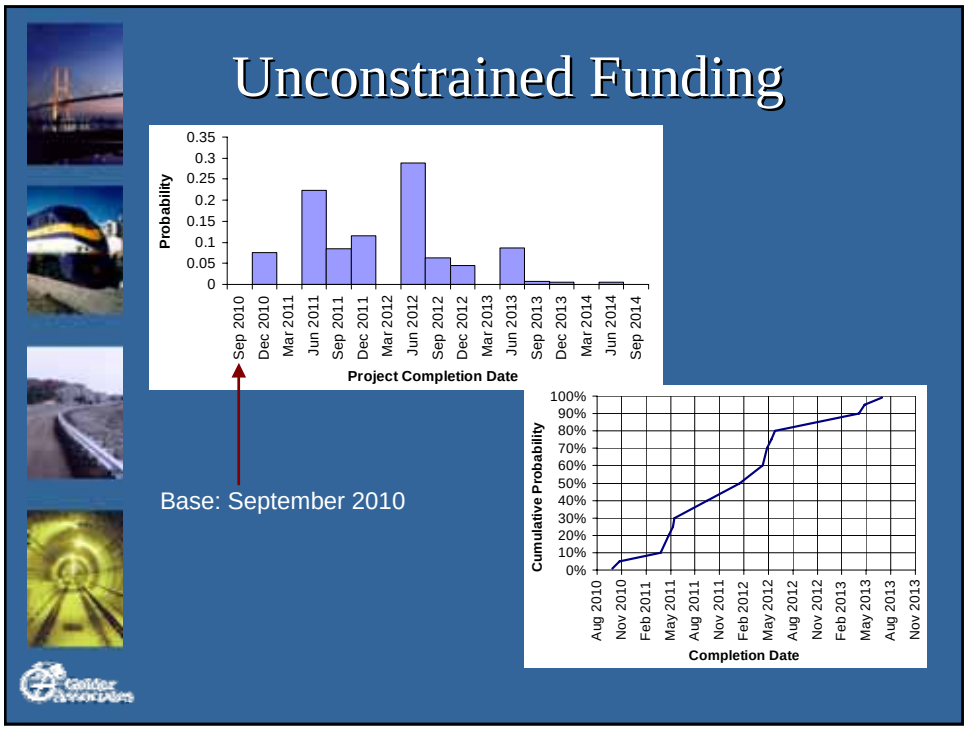
Unconstrained Funding



Base: $103.7M




Unconstrained Funding
Mean: $138.5M
Probability
0.14
0.12
0.1
0.08
0.06
0.04
0.02
0
124 128 132 136 140 144 148 152 156 160 164
Total Project Cost (YOE $M)
Base: $116.2M
Cumulative Probabi
80%
60%
40%
20%
0%
120 125 130 135 140 145 150 155 160
Total Project Cost (YOE $M)


Unconstrained Funding
Probability
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Sep 2010 Dec 2010 Mar 2011 Jun 2011 Sep 2011 Dec 2011 Mar 2012 Jun 2012 Sep 2012 Dec 2012 Mar 2013 Jun 2013 Sep 2013 Dec 2013 Mar 2014 Jun 2014 Sep 2014
Project Completion Date
Base: September 2010
Cumulative Probability
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
Aug 2010 Nov 2010 Feb 2011 May 2011 Aug 2011 Nov 2011 Feb 2012 May 2012 Aug 2012 Nov 2012 Feb 2013 May 2013 Aug 2013 Nov 2013
Completion Date




Cost Summary

Percentile	Unconstrained Funding		Constrained Funding	
	Current $ (million)	YOE $ (million)	Current $ (million)	YOE $ (million)
Base	103.7	116.2	103.7	116.2
10%	114.5	129.8	115.5	133.7
Mean	121.3	138.5	122.0	141.7
90%	129.7	148.5	129.6	151.0




Ranked List of Expected (Mean) Cost Risks. Unconstrained Funding Scenario

Risk Rank	Contribution to Expected Cost Risk		Risk Event
	%	Current $M	
1	18.6%	3.20	C14. Encounter unanticipated contaminated or hazardous materials during construction
2	17.2%	2.95	S1. Additional municipal enhancements required (excluding detours and design uncertainties within scope)
3	12.5%	2.15	D10. Uncertainty in retaining wall design (including scope changes)
4	9.9%	1.70	C6. Henley Bridges cost overruns and/or schedule delay
5	7.7%	1.33	D2a. Uncertainty in structure design - Martindale Road replacement structure
6	5.8%	1.00	C17. Design errors and/or omissions discovered during construction
7	4.7%	0.80	D4a. Uncertainty in structure design - Lake St replacement structure




Ranked List of Expected (Mean) Delay Risks. Unconstrained Funding Scenario

Risk Rank	Sum of Expected Delays to all Affected Activities (Months)	Risk Event
1	4.6	C4. System-wide construction staging issue
2	2.5	E9. Delay in PHM 125 approvals
3	1.9	C23. Other construction duration uncertainty (other than identified separately)
4	1.9	D4a. Uncertainty in structure design - Lake St replacement structure
5	1.6	D3a. Uncertainty in structure design - Ontario St structure




Risk Management Targets

- Encountering contaminated materials – testing underway at time of workshop (risk reduced following analysis)
- Construction staging
- Additional municipal enhancements
- Henley Bridges project delays
- PHM 125 process
- Martindale Road bridge design uncertainty

RM/VE Targets

System-wide construction staging issue

Excludes: uncertainty in duration to construct individual elements (captured under C23), and detour issues

Strategy: make sure no two adjacent bridges/interchanges are under construction at the same time.

Assumptions: Minimum capacity (not yet defined) of crossing QEW must be maintained and that the present design strategy (flowchart) will maintain capacity.

Uncertainties: base strategy cannot support the required crossing capacity. Complex staging issues in tight corridor require substandard lanes and shoulders.

There may also be additional staging approval issues (e.g., emergency services and/or public do not approve of proposed duration of Martindale Road closure).

RM/VE Targets

Martindale Road replacement structure

Base: $3.05 M (excludes contingencies); 12 months

Uncertainties: Design uncertainty. Community wants better emergency access/capacity but no cost in base. Opportunity to use new materials/technologies. There may be interest in shortening construction time by investing in more expensive technology. There may be a compromise between MTO and community interests.

Potential mutually-exclusive outcomes from event tree:

A. 2-lane bridge and no extra cost (base)

B. 2-lane bridge and some extra cost

C. 2-lane bridge and significant extra cost associated with new technologies

D. 4-lane bridge with some extra cost for new technologies




RM/VE Targets

Uncertainty in retaining wall design (including scope changes)

Base: augment existing walls ($4.5M).

Uncertainties: Rebuild the walls.

Includes uncertainty in wall types, sizes, and related noise, aesthetics, roadside protection, utility-relocation items (3 intersections at $0.4M each), and removal of existing walls.

Potential mutually-exclusive outcomes:

A. Base

B. Augment some existing, replace some existing

C. Replace all with concrete cantilever walls, with aesthetic treatment, noise walls, and allowing for roadside protection during construction (3 intersections)




Status Today?

- Design about 90% completed
- Tender in Winter 2007
- One large contract
- QEW over Welland Ave bridge – replacement not widening (not picked up, EA Addendum)
- VE completed following RBCSA – used results
- Henley Bridges $>16M, 6 mos. behind schedule (RR C6 p=10% to 20%)




Lessons Learned

- Workshop setting – greater "big picture" project exposure to stakeholders
- Development of a "big picture" project flow chart
- Good to bring in team + experts early
- Earlier use of process may have helped in funding/cost-sharing agreements
- Helped to identify more realistic costs & schedules




Lessons Learned

- Assisted with communication with senior management
- Clear evaluation of assumptions & basis of design
- May still be some "optimism" bias in estimates of "consequential costs"
- Multiple opinions/perspectives
- Clearly identified targets for VE & RM