North Portland Harbor Bridge Options - References

References to Appendix F – North Portland Harbor Bridge Replacement? of the "Columbia River Crossing Project Bridge Review Panel Final Report", February 3, 2011

As noted on page 141 of the above report, the following are detailed references describing the sources of the data used in Appendix F.

1. The award plaque from PCI recognizing "creative design utilizing precast and prestressed concrete" is currently displayed in the ODOT Region 1 Bridge Design Unit, Portland. The purpose of the PCI Design Awards is to recognize design excellence and construction quality using precast concrete. PCI is the Precast/Prestressed Concrete Institute.

2. The average daily traffic of 126,800 is from the ODOT 2009 Traffic Volume Tables for Interstate 5 (I-5) 0.20 miles north of Pacific Highway East (OR99E). The ODOT Traffic Volume Tables can be found at the following website:

www.oregon.gov/ODOT/TD/TDATA/tsm/tvt.shtml#Traffic_Volume_Tables

3. CEVP Costs – The acronym "CEVP®" stands for Cost Estimate Validation Process. The final report for the May 2010 CEVP workshop for the Columbia River Crossing Project included the following explanation of CEVP.

The risk based estimating process employed by Washington State Department of Transportation (WSDOT) through its Cost Risk Assessment (CRA) and Cost Estimate Validation Process (CEVP®) workshops is iterative in nature and represents a "snapshot in time" for that project and under the conditions known at that point in time.

Additionally, CEVP® normally deals with identifiable and quantifiable project-type risks – i.e. those events that can occur in planning, design, bidding, construction and changed conditions. CEVP® could also consider the larger, more difficult risks – political and management continuity and "acts of God" that can have very high impact in cost and schedule – but at this point, these types of risks have not generally been included. This is an area for review and development – in particular, how to characterize such events in a useful manner for better management of projects.

As part of the CEVP process base cost estimates are factored up based on risk and uncertainty. The exact factor used comes from a "CEVP workshop" where subject matter experts from various disciplines meet to discuss and evaluate project risks. The probability of a risk (or opportunity) occurring, type of probability distribution, and range of cost and/or schedule impacts associated with each risk are determined. All these elements are used to populate a risk register.

Once the risk register is populated, a Monte Carlo statistical simulation determines the project costs for a range of probabilities. The cost released to the public is generally provided as a range from 10% to 90% probabilities of exceedence. WSDOT uses the 60% probable cost for budgeting purposes.

The 60% CEVP markup from the LPA (Option 1) is 1.364 (obtained from CRC staff in a 1-5-11 e-mail). This markup includes budgetary uncertainty, escalation (risk adjusted schedule), event risks and additional support costs.

Base costs for BRP estimates have also been adjusted using the same 1.364 factor. Since the recommendations are expected to generally reduce project risks, it is conservative to use this same CEVP markup. However, without a separate CEVP workshop, it is impossible to justify a separate number.

<u>4. NPHB, 380' Steel Span Option</u> – The CRC team does not have a detailed estimate for a new NPHB. Their current concept for a new NPHB includes a 380' main span using steel plate girders. This concept reduces the number of piers in Oregon Slough compared to the existing bridge. Since there will be additional ramp structures that also need to cross Oregon Slough, use of longer spans will result in approximately the same number of total piers in Oregon Slough compared to the existing condition. This criterion was established to reduce potential delays/conflicts with obtaining environmental approvals. See reference xii below for potential savings if shorter spans (i.e. more piers in the water) are allowed.

The estimate for a new NPHB with 380' spans was based on $280/SF for approach spans and $335/SF for the long steel spans. See reference viii below.

The estimated base cost is $70,000,000.

With CEVP markup, $70,000,000 x 1.364 = $ 95,000,000

5. Demolition cost for NPHB – Demo cost comes from "CRC Demolition" document from HDR dated 9/10/2009. Exact cost is listed as $19,925,588.49. A 29.1667% mark-up based on risk, escalation, bond and builder risk insurance. With this mark-up, the total "Cost + Markup" is listed as $25,737,218.46.

This demolition cost is over $130/SF which is 3.5 times the average historical ODOT removal cost. This additional cost is due primarily to the need for cofferdams to facilitate foundation removal. Even with cofferdams, this estimated cost is likely on the high side.

6. Cost of Reduced Deck Area for NPHB Ramps

Comparison of Ramp Costs for Replacing NPH Bridge (Alternate V) and Retaining Existing NPH Bridge (Alternate II/III)
Prepared by ODOT Bridge Section based on Unit Costs from the CRC team,
December 2010

Ramp Segments Near NPH and on Hayden Island

				Square Foot Area		
Structure	Stucture Type	$ / SF	Alt II/III Cost	Alternate II/III	Alternate V	Alt V Cost
MD(I-5)	Concrete, 150 ft	$280	$13,108,480	46816	53618	$15,013,040
MDE-5N(VW)	Steel, 150 ft	$280	$7,201,040	25718	0	$-
MDE-5N(NPH)	Steel, Long Span	$335	$16,044,490	47894	0	$-
MDE-5N(JD)	Steel, 150 ft	$280	$17,217,760	61492	0	$-
MLK-5N	Steel, 150 ft	$280	$-	0	2925	$819,000
MDE-5N(JUMP)	Steel, 150 ft	$280	$-	0	2882	$806,960
MDE-5N(EXPO)	Steel, 150 ft	$280	$-	0	28453	$7,966,840
MDE-5N(NPH)	Steel, Long Span	$335	$-	0	57607	$19,298,345
MDE-5N(JD)	Steel, 150 ft	$280	$-	0	30086	$8,424,080
5N-HI(NPH)	Steel, Long Span	$335	$-	0	29148	$9,764,580
5N-HI(JD)	Steel, 150 ft	$280	$-	0	9502	$2,660,560
HI-5S(VW)	Steel, 150 ft	$280	$2,684,080	9586	10934	$3,061,520
HI-5S(NPH)	Steel, Long Span	$335	$12,821,790	38274	35227	$11,801,045
HI-5S(JD)	Steel, 150 ft	$280	$9,859,360	35212	38427	$10,759,560
5S-MLK(VW)	Steel, 150 ft	$280	$3,591,560	12827	12303	$3,444,840
5S-MDW(VW)	Steel, 150 ft	$280	$-	0	7515	$2,104,200
5S-MLK(NPH)	Steel, Long Span	$335	$14,866,295	44377	52603	$17,622,005
5S-MLK(JD)	Steel, 150 ft	$280	$3,260,040	11643	6646	$1,860,880
LRT(NPH)	Steel, Long Span	$335	$42,017,040	125424	64694	$21,672,490
5S/5N(JD)	Concrete, 150 ft	$280	$7,105,560	25377	16076	$4,501,280
JD-5N	Concrete, 150 ft	$280	$16,476,600	58845	36260	$10,152,800
5N-HI(TI)	Concrete, 150 ft	$280	$868,280	3101	3114	$871,920
5N(TI)	Concrete, 150 ft	$280	$2,122,960	7582	11315	$3,168,200
5S(TI)	Concrete, 150 ft	$280	$3,403,680	12156	8749	$2,449,720
5S-JD	Concrete, 150 ft	$280	$8,700,720	31074	34446	$9,644,880
LRT(TI)	Concrete, 150 ft	$280	$3,407,600	12170	11740	$3,287,200
			$184,757,335	609568	564270	$171,155,945
						$13,601,390 Reduced Cost of Ramps

			$18,552,296	Reduced Cost w/ 1.364 markup
Total, Concrete - 150 ft	197121	175318	21803	Reduced Concrete area
Total, Steel - 150 ft	156478	149673	6805	Reduced Short Steel area
Total, Steel - Long Span	255969	239279	16690	Reduced Long Span Steel area
			45298	Total Reduced Ramp Area

New North Portland Harbor Segments

5N(VW)	Steel, 150 ft	$280			30948	$8,665,440	
5N(NPH)	Steel, Long Span	$335			71211	$23,855,685	
5N(JD)	Steel, 150 ft	$280			12540	$3,511,200	
5S(VW)	Steel, 150 ft	$280			21630	$6,056,400	
5S(NPH)	Steel, Long Span	$335			72421	$24,261,035	
5S(JD)	Steel, 150 ft	$280			12697	$3,555,160	
					221447	$69,904,920	Total Base Cost for NPH Bridge
						$95,350,311	NPH Bridge w/ 1.364 markup

7. Reduced Cost Due to Reduced Deck Area of River Crossing – Per an e-mail received from CRC staff dated 1-5-11, replacement of the NPHB reduces the deck area of the main river crossing by 16,104 sq. ft. (524,379 sq. ft. if the existing NPHB is retained and 508,275 sq. ft. if the NPHB is replaced). Although the deck area is reduced, little or no impact is expected on the substructure. For this reason a unit cost of $772/SF is used based on the CRC "Base Cost Estimate" dated 11/23/2010 and prepared by RVK. The selected unit cost is for "Bridge, Columbia River, superstructure, 5-lanes".

16,104 SF x $772/SF = $ 12,400,000

$ 12,400,000 x 1.364 = $ 17,000,000

8. <u>Cost of Jump Span for Existing NPHB</u> – The cost is estimated based on the $280/SF unit cost from the "Base Cost Estimate" document dated 11/23/2010 and prepared by RVK. The assumed CEVP markup is 1.364.

The area of the jump span (25,400 SF) was taken from a 1-5-11 e-mail from CRC staff.

$280/SF x 25,420 SF = $ 7,100,000

$ 7,100,000 x 1.364 = $ 10,000,000

9. Seismic Retrofit Cost for NPHB – Although the CRC team has estimated a widening plus retrofit option for the NPHB, they do not have a retrofit only estimate. In a 1-5-11 e-mail from CRC staff, the following basis for estimating Phase II seismic retrofit was recommended:

From the "NPHB Widening Estimate (2010-02-10).pdf", the superstructure cost is estimated at $9,000,000 and the substructure is estimated at $11,000,000. However, there is $12,000,000 additional indirect cost which needs to be split between substructure and superstructure. Therefore, the adjusted costs are $14,000,000 for superstructure and $18,000,000 for substructure.

From the "NPHB Phase II Estimate (2010-02-04).pdf", the estimate for Phase II seismic retrofit with widening is $63,000,000. Subtracting the $14,000,000 superstructure cost will leave $49,000,000. This estimate includes mobilization and therefore must be reduced by 10% to get to an equivalent base cost.

Therefore, the assumed base cost for Phase II seismic retrofit is $44,000,000.

With CEVP markup: $44,000,000 * 1.364 = $ 60,000,000

10. Ground Improvement Cost – Ground improvement costs were taken from a CRC document "Ground improvement costs 09 23 10.pdf". The costs included only areas 2 and 5 (ends of the existing NPHB) as shown on "090916_RP_Ground_Improvement.pdf".

Area 2, Median Cost	$ 9,800,000
Area 5, Median Cost	$ 7,400,000
Total, Areas 2 & 5	$ 17,200,000
Total w/ CEVP Markup	$ 17,200,000 * 1.364 = $ 25,000,000

11. Concrete vs. Steel Options for new NPHB – The reduced cost of a NPHB with a concrete superstructure compared to a steel superstructure is conservatively estimated to be $16,000,000. The derivation of the cost difference is presented below. This derivation compares a hybrid concrete superstructure (some precast girders, some CIP box girders) with a typical steel superstructure.

This derivation is thought to be conservative due to:

- Long Steel Span – The historical costs below include steel spans up to 200 ft. They appear to be compatible with historical ODOT projects for spans up to 250 ft. The proposed steel span is 380 ft. Although this span length is well within what is capable for steel superstructures, there is no recent ODOT cost history for steel spans of this magnitude. Longer spans require deeper superstructures. This generally results in more steel weight and therefore higher superstructure cost. For NPH, this additional cost will be partially off-set by a reduction in foundation costs due to having fewer piers in Oregon Slough. However, the additional steel costs would generally be greater than the foundation cost savings.
- Typical Spans for Concrete - The proposed concrete bridge type would also have longer spans compared to typical ODOT projects. However, one of the ODOT CIP box girder projects has a span arrangement similar to what would be needed for NPH. The bid cost for that project (Shady Bridge) was less than the assumed hybrid concrete bridge cost in the derivation below.
- Less Risk for a Concrete Structure - The hybrid concrete bridge concept is a common bridge type for Oregon. It has a proven track record of performance and reasonable cost. Therefore, it would be expected to have less risk compared to a 380' steel span. Without a separate CEVP for this structure type, it will not be possible to capture this additional benefit.

Historical Bridge Unit Cost Data obtained from the CRC project team provides the following comparison of average costs (Jan. 2009 cost):

Precast Girders (19 projects)	$ 178 per sq. ft.
CIP Box Girders (4 projects)	$ 198 per sq. ft.
Steel Girders (4 projects)	$ 237 per sq. ft.

The costs above are based on a variety of recent bridges constructed in both Washington and Oregon and bid between 2004 and 2008. The costs are adjusted to January 2009, but they do not include any CEVP factor. They include a variety of foundation types. Some projects are river crossings while others are road crossings.

For the precast girder bridges above, the average maximum span length was 117 ft. The four CIP box girder projects had an average maximum span length of 192 ft. For the four steel girder bridges, the average maximum span length was 163 ft. The ratio of steel span length to precast girder span length is similar to the 380 ft vs. 280 ft spans used in this cost comparison.

For any bridge type option, a new NPHB will require deep foundations (probably drilled piles) in Oregon Slough. Because of this, the unit cost of any bridge over Oregon Slough is expected to be significantly higher than those listed above. However, the difference in cost between a steel superstructure and a concrete superstructure is likely to be consistent with the historical trend above. A steel bridge with longer spans will require fewer piers in the slough. However, the historical costs above also account for the longer spans (and fewer supports) associated with steel and yet result in higher unit costs.

Steel bridges also have the advantage of being lighter weight which results in fewer piles (or in this case, piles). However, we are comparing a longer span steel bridge with a shorter span concrete bridge. A steel bridge with a 40% longer main span (and deeper girders) would not be significantly lighter than a shorter concrete bridge.

The existing NPHB is a hybrid design consisting of 80% precast girder spans and 20% CIP box girders. The estimated cost of a similar hybrid design is therefore estimated as:

($178/SF * 0.80) + ($198/SF * 0.20) = $182/SF

Comparing the average steel cost to this hybrid concrete cost:

$237/SF (steel) - $182/SF (hybrid concrete) = $55/SF

Multiplying this difference by the area of a new bridge:

$55/SF * 220,500 SF = $12,000,000

To get a "CEVP" cost, multiply by 1.364 (the 60% probability of exceedence value obtained from CRC staff in a 1-5-11 e-mail) we get:

$12,000,000 * 1.364 = $17,000,000 estimated savings – NPHB

Since 380' steel spans are also proposed for ramp structures crossing Oregon Slough, additional savings can be expected if those ramps are also permitted to use shorter span hybrid concrete structures. The total long-span steel segments for ramps crossing Oregon Slough are 239,279 SF (areas of ramp segments provided by CRC staff).

$55/SF * 239,279 SF = $13,000,000

$13,000,000 * 1,364 = $18,000,000 estimated savings - ramps

$17,000,000 + $18,000,000 = $35,000,000 estimated total savings

12. Replace vs. Retrofit Life Cycle Cost Analysis – The existing NPHB was built in 1987. The current structural condition of the existing bridge is "Fair". The load capacity of the existing bridge appears to be adequate for current and forecast traffic conditions assuming no policy changes and maintenance of at least fair structural conditions. The current long-term bridge condition forecast model uses NBI condition ratings, load capacity, original bridge design life, and system average observed deterioration to predict the service life of ODOT bridges. Using current ODOT predictions for service life and current bridge conditions and maintenance levels, the bridge is estimated to have a service life of 63 years. In order to achieve a total 150-year service life, this bridge will require one major rehabilitation and three deck overlays. One of these overlays will need to be in the near future, but is not currently programmed.

ODOT has yet to acquire experience and data in maintaining individual bridges for 150 years. It has been observed that major rehabilitations, while effective in improving condition ratings and extending service life, do not result in "like new" conditions. Each successive rehabilitation effort results in a shorter service life addition. It is not currently known how many rehabilitation cycles will prove to be cost effective. During a 150-year service life, we assume at least one major rehabilitation and two deck overlays can be expected for a newly constructed bridge. Bridges built with an original design life of 50 to 75 years may require as many as 2 to 3 rehabilitation cycles to achieve the 150 year service life.

Current routine maintenance costs for the existing NPHB are minimal, approximately $3,000 annually, based on ten years of data. No significant rehabilitation has been undertaken on this bridge to date. The most similar comparable steel bridge is the George Abernethy Bridge. The George Abernethy Bridge is a steel bridge built in 1970. Average routine maintenance costs for the George Abernethy Bridge are approximately $7,000 annually, also based on ten years of data. The difference in maintenance costs appears to be related to two factors; material type and age (deck condition). The remaining differences are attributable to paint maintenance and weld inspections. The George Abernethy Bridge has also received a seismic retrofit (2000) and deck overlay and joint repair (2009). The life cycle costs of a painted steel structure are assumed to always be higher than those of a comparable weathering steel or concrete structure due to the high cost of paint maintenance.

Cost estimates are not inflated. Major rehabilitation costs were estimated at $425/SF for the existing NPHB and approximately half that for a new bridge. Routine maintenance costs were assumed to remain at $3,000 annually and are assumed to be the same for both the existing and new bridge. One major rehabilitation cycle was assumed for both new and existing bridges. Cost estimates include total project costs. The projects in the table below were used as a basis for the estimates. Complete rehabilitation projects have primarily been limited to historic structures. The estimated major rehabilitation costs per square foot (above) have been adjusted to reflect differences in design and size.

BR #	Name	SF	YR	PE ($)	RW ($)	CN ($)	Total ($)	Scope
00626	Perry Arch	7K	2008	616,604	265,584	5,522,756	6,404,944	Major Scope
09403	Geo Abernethy	281K	2000	633,671	0	7,192,155	7,825,826	Seismic Retrofit
00849A	Biggs Rapid	82K	2007	744,934	0	15,808,644	16,553,578	Deck Replace
09403	Geo Abernethy	281K	2009	192,156	0	7,063,521	7,255,677	Deck Overlay
00357	Oregon City Arch	14K	2010	2,147,308	30,000	14,126,913	16,304,221	Major Rehab
00839	Old Winchester		2007	577,950	144,839	11,063,789	11,786,578	Widening, Rehab floor beams
00332A	Rogue River		2009	239,547	2,921	4,523,120	4,765,588	Historic Rehab & Repair

The last two amounts are contract amount/budget, not final costs. Biggs Rapid deck replacement project did not include detour bridge construction.