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December 18, 2015

VIA ELECTRONIC MAIL

British Columbia Utilities Commission
Sixth Floor, 900 Howe Street
Vancouver, BC
V6Z 2N3

Attention: Ms. Erica Hamilton, Commission Secretary

Dear Sirs/Mesdames:

Re: British Columbia Hydro and Power Authority ("BC Hydro") W.A.C. Bennett Riprap Upgrade Project Application, Project No. 3698854

We are counsel for the Commercial Energy Consumers Association of British Columbia ("CEC"). Attached please find the CEC's first set of Information Requests with respect to the above-noted matter.

A copy of this letter and attached Information Requests have also been forwarded to BC Hydro and registered interveners by e-mail.

Should you have any questions regarding the foregoing, please do not hesitate to contact the writer.

Yours truly,

OWEN BIRD LAW CORPORATION

Christopher P. Weafer
CPW/jlb
cc: CEC
cc: BC Hydro
cc: Registered Interveners

COMMERCIAL ENERGY CONSUMERS ASSOCIATION OF BRITISH COLUMBIA (CEC)

INFORMATION REQUEST #1

British Columbia Hydro and Power Authority (BC Hydro)
W.A.C. Bennett Riprap Upgrade Project Application
Project No. 3698854

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1. Reference: Exhibit B-1, Page 1-5

> BC Hydro has considered such elements as the extent of remediation required, quarry and material selection, riprap weight, size, layer thickness and configuration, as well as construction considerations including an analysis of anticipated quarry yield, handling losses and quality assurance during placement of riprap on the Dam face. Both scope and cost considerations are incorporated into the Project design.

1.1. The focus BC Hydro considerations is on the riprap, to what extent do the: (1) Upper Section; (2) Toe Berm; and (3) Filter Layer portions of the project contribute to stability and durability of the upstream dam face, relative to the Riprap Layer.

2. Reference: Exhibit B-1, Page 1-8

> - "To encourage economic development and the creation and retention of jobs" (*CEA* subsection 2(k)). As described in section 3.6.2.1 of this Application, the Project's procurement strategy has been developed to ensure that First Nations in the vicinity of the Project area have the opportunity to participate in Project construction, thereby contributing to local economic development through the creation of local work and jobs.

2.1. Why when BC Hydro addresses "economic development and the creation of jobs" does BC Hydro only focus on First Nations in the vicinity?

2.2. Are there any other public interest considerations beyond the First Nations that BC Hydro should be considering in regard to economic development and job creation?

3. Reference: Exhibit B-1, Pages 1-16 and 1-17, Table 1

> The aggregate total final project costs of the nine projects in Table 1–1 is $976.4 million, which is approximately equal to (within 2 per cent of) both the aggregate total Expected Amount of $959.9 million and the aggregate total amount identified in BCUC Orders (up to $959.2 million). This aggregate outcome is reasonable considering that the Expected Amount is equal to a P50 cost or median cost estimate. A wider range of variability between the Expected Amount and the

3.1. Please confirm that the totals shown in the table and referred to above are not correct and please provide the corrected table for the evidentiary record.

3.2. Please confirm that of this sample of projects 67% are over P50 estimates and 33% are under P50 estimates.

3.3. Please confirm that the median over P50 is 7.7% over.

3.4. Please confirm that the difference between P50 and P90 for project median in this sample of projects is 8.6% and that for the project average in this sample is 18.4%.

3.5. Please confirm that BC Hydro final cost performance versus P50 estimate is a median 11% over and 12% under estimate.

3.6. Please confirm that the maximum range of BC Hydro final cost performance versus P50 estimate is 14% over estimate and 19% under estimate.

3.7. Please confirm that BC Hydro past estimating accuracy appears to be considerably less on the actual performance overestimate side than the +25% in the Class 3 estimating standard and somewhat more on the actual performance underestimate than the -10% in the Class 3 estimating standard.

3.8. Please confirm that based on this sample of historical project performances that the evidence supports little concern that BC Hydro would underestimate the cost for the project.

3.9. Please confirm that this project sample represents all generation projects over $50 million finished from 2008 to 2015.

3.10. Please confirm that BC Hydro does not have any other data on its cost estimating performance which would provide a different perspective than that provided by this sample.

4. Reference: Exhibit B-1, Page 2-5

The outermost and coarsest material is a layer of armour rock, or riprap. The purpose of riprap on an embankment dam is to absorb wave energy and, in northern climates, the forces of ice movement so that the underlying dam fill is not disturbed or eroded. To do this, the riprap must be heavy enough to resist movement under wave or ice loading, knit together so that each piece is supported by adjacent pieces which will assist in resisting movement, and in northern climates, resistant to breakdown by freeze-thaw action. Additionally, a filter layer between the riprap and underlying dam fill is usually constructed to prevent erosion of underlying materials.

4.1. Please confirm that this quality of knitting together to resist movement under the stress of wave or ice loading is a key factor in the choice of riprap and method of installation.

4.2. Are there any complementary strategies for enhancing the knitting quality of the rock armor or is this strictly a property of the rock and its placement?

5. Reference: Exhibit B-1, Pages 2-6 and Page 2-7

Recent investigations completed between 2012 and 2014 conclude that a large portion of the existing riprap has failed (e.g., rock breakdown) and erosion of the underlying Zone 5 Dam fill has occurred. The existing riprap has failed due to the absence of a separate filter material between the Zone 5 surface and the riprap, the riprap is undersized, the riprap layer thickness is insufficient, and the sandstone riprap does not meet durability requirements at the Dam.

5.1. Please describe what a separate filler material between the Zone 5 surface and the riprap provides and why its absence has contributed to the failure.

5.2. Please describe quantitatively (if possible better than the Appendix D-1 damage number) what the sandstone riprap durability quality is versus what is required.

6. Reference: Exhibit B-1, Page 2-10

- Filter layer – The absence of a separate filter material between the Zone 5 surface and the riprap has contributed to erosion of the Zone 5 Dam fill;
- Riprap size – A significant proportion of the existing riprap is undersized, the existing riprap layer thickness is insufficient and the riprap is poorly interconnected with large riprap situated in a finer particle size matrix; and
- Sandstone breakdown – The existing riprap has experienced breakdown due to the freeze-thaw cycles each winter.

6.1. Please describe how a filter layer would protect Zone 5 Dam fill from erosion.

6.2. Please describe how the larger riprap in a matrix of finer particle sized material contributes to erosion prevention.

6.3. Please describe how a consistent larger size riprap layer would provide a durable protection.

6.4. Please describe how the thickness of the riprap layer works to provide protection from erosion.

6.5. Please describe how material alternatives to sandstone would provide more durable protection.

7. Reference: Exhibit B-1, Page 2-11

shallow sliding seen on the upstream face of the Dam. If the deterioration is allowed to continue, the ongoing risks associated with Dam condition will increase. The longer the riprap is left in a damaged state that does not protect the underlying Zone 5 Dam fill, the greater the chance of significant damage in a high wind event. Should localized failure of the upstream face of the Dam occur during a high wind event, BC Hydro would be in a reactive response position, which would likely include emergency reservoir drawdown.

7.1. Please provide a frequency chart of high wind events at the Dam site scaled by intensity of the wind event either by year or in aggregate for a number of years to demonstrate the probability of significant damage event occurrence.

8. Reference: Exhibit B-1, Page 2-13

appropriate time to remediate the riprap condition. BC Hydro believes that the August 2012 advice from an expert engineering panel[25] that the riprap condition is a serious deficiency that should be remedied as soon as possible confirms that timing for the Project is appropriate.

8.1. Please discuss the 2012 expert engineering panel recommendation of remedy as soon as possible and what sort of timeframe the panel would have meant.

8.2. Please discuss BC Hydro's methodology for determining the timeframe in which it expects an appropriate tradeoff between risks and costs.

8.3. Please discuss what considerations go into BC Hydro's assessment of the appropriate tradeoff between risks and costs for remediating the riprap.

9. Reference: Exhibit B-1, Page 3-3

In 2002 BC Hydro evaluated two concrete armour types including the modified cube and the stabit (saddle shaped unit) and determined that riprap was the more cost effective option. The cost of concrete armour types was revisited in 2011 for the use of tetrapod units (four legged star shaped unit) which would be randomly placed in two layers similar to the concrete cube or stabit previously evaluated in 2002. The

9.1. What is the quantitative nature of the wave forces that would drive the criteria for armour design and give rise to the concrete product performance?

10. Reference: Exhibit B-1, Pages 3-4 and Page 3-5

Based on empirical methods, the proposed riprap would have a minimum stone weight of 850 kg, a minimum stone diameter of 800 mm and would be placed in a 2 m thick layer.

Based on site-specific performance modelling of the empirical results and alternate riprap characteristics, it was determined that riprap with a minimum weight of 650 kg, a minimum diameter of 730 mm and a riprap layer thickness of 1.8 m will meet the design criteria. This is the recommended weight / diameter and layer thickness for the riprap remediation and upgrade. For further discussion, refer to the Preliminary Design Report (Appendix D-1).

10.1. In adopting these design criteria has BC Hydro ensured that there is a margin above the basic design requirements built into the final design choice to account for possible unknown situations in the future and or to provide a degree of engineering conservatism in the design?

10.2. What is BC Hydro's estimate of the margin of safety in the design?

10.3. Please provide the calculation for the stone weight and stone diameter with an explanation that is more complete that that discussed in Appendix D-1

11. Reference: Exhibit B-1, Appendix D-1, Page 26 of 74

Table 2: Design Wind Speed (Northwest Direction)

Annual Exceedance Probability	Estimated Over-water Wind Speed (km/hr) at Standard 10 m Height for Different Wind Durations		
	1 hour	2 hour	3 hour
1/100	78	73	69
1/1,000	89	81	74
1/10,000	96	87	78

Table 3: Significant Wave Heights for Design

Design Method	Significant Wave Height (m)		
	1/100 AEP	1/1000 AEP	1/10,000 AEP
SWAN, 2014	1.9	2.23	2.47
SEBJ, 1997	1.74	2.11	2.37

11.1. If these probabilities for exceedance of wind speeds have been established from wind data over two years, what is BC Hydro's estimate of the potential range of error in these results as they might be established over much longer timeframes?

11.2. What is BC Hydro's estimate of the potential range of error in these estimates of wave heights?

11.3. What would be the significance of a .1 meter wave height estimate change for the design size and weight of the riprap and the cost of the project?

11.4. Has BC Hydro examined any wave attenuation solutions and if so please describe the review?

11.5. What would be the impact on the cost and the proposed design if the wave height exposures were reduced by 25%, 50%, 75%.

12. Reference: Exhibit B-1, Appendix D-1, Page 28 of 74

Table 4: Expected Riprap Damage Levels with Riprap Sizes

Riprap Gradation	Riprap Size/Thickness			Damage Level (S)		
	W_{min} (kg)	D_{min} (mm)	Thickness (m)	1/100	1/1000	1/10000
Narrow Graded	850	800	2.0	1.1	2.4	3.9
Narrow Graded	650	730	1.8	1.7	3.8	6.1
Narrow Graded	500	675	1.7	2.7	5.9	9.4
			Design Target Criteria (<)	2	5	8

12.1. Please describe the damage level measure and its meaning.

12.2. Please describe where the design criteria targets are derived from and how they were determined.

13. Reference: Exhibit B-1, Appendix D-1, Page 41 of 74

Riprap Yield Rate

In the 2013 trial blasting (KP, 2013) at Sand Flat quarry, a total of eight trial blasts were completed along two 10 m high rock benches at the trial quarry site, including three initial trial blasts on the upper bench and five more trial blasts on the lower bench. The results indicated that an average 15% yield rate (after handling loss) could be achieved for the design of a narrow graded riprap from the trial quarry using the optimized blasting design.

13.1. Has BC Hydro determined if there are any suitable methods for achieving higher yields than 15% from the quarry blasting and what alternative options if any were examined?

14. Reference: Exhibit B-1, Appendix D-1, Page 42 of 74

> Based on the above, KP estimated that the production quarry should be able to produce riprap at an average yield rate of 10 - 15 % (after a handling loss of 20%) from the unweathered rock.
>
> Based on KP's riprap yield evaluation results, it is therefore recommended that an average yield rate of 13% be used as the basis for project cost estimation and for evaluation of contractor's bids for the quarry production work. This yield

14.1. What is the impact on the costs of material from the quarry for a 1% change in the yield?

14.2. What is the impact on the costs of material from the quarry for a 1% change in the handling loss rate?

15. Reference: Exhibit B-1, Page 3-7

> - 1/100 year Annual Exceedance Probability (**AEP**) wind event should result in no damage to the riprap, where no damage is defined as less than 5 per cent damage;

15.1. Is the referenced damage from one single event damage and not a cumulative damage from many events?

16. Reference: Exhibit B-1, Page 3-7

> - 1/1000 year AEP wind event should result in acceptable damage to the new riprap, where acceptable damage is defined as damage that does not require emergency repair;
> - 1/10000 year AEP wind event should not result in upstream slope failures that could lead to dam breach; and

16.1. Does this mean that over an entire 100 year period we should expect acceptable damage with up to a probability of 10% and a more serious damage, which would not lead to failures up to 1%?

16.1.1. If not please describe the 100 year probability for the above two event types.

17. Reference: Exhibit B-1, Page 3-8

Table 3-1 Comparison of Riprap Characteristics for Critical Erosion Zone

Riprap Design	Original Design (1962)	Current State[28]	Project Design
Material	Sandstone	Sandstone	Limestone
Stone Weight (kg)	455 (median)	146 (median)	650 to 3250
Stone Gradation (mm)	305 – 1127 (well graded)	100 – 1000 (well graded)	730 – 1260 (narrow graded)
Layer Thickness (meters)	0.9	0 to 0.9	1.8

17.1. Please describe the toughness of the Limestone versus the Sandstone in quantitative units.

17.2. Please describe how each of the stone weight, stone gradation and layer thickness perform in sensitivity to changes in specification relative to potential damage and to potential cost.

17.3. Please confirm that these tradeoffs are among the key factors driving the design.

17.4. Are the relationships between damage and these specifications somewhat linear, please discuss?

18. Reference: Exhibit B-1, Page 3-11

Mountain East. BC Hydro compared the production and transport costs for these three quarries; the results of this evaluation indicated that sourcing riprap from the Lemoray quarry would have a higher cost than the other two quarry sites due to the relatively high transport costs resulting from the 162 km distance from the Dam. As a result, the Lemoray quarry site was eliminated from further evaluation.

18.1. What was the BC Hydro assumption with regard to the cost per cubic meter of rock transported per kilometer to be transported?

19. Reference: Exhibit B-1, Page 3-17

- Limited riprap breakdown was observed when riprap was placed by an excavator. Breakdown did occur when riprap was dropped from elevated heights. As the riprap was placed from the bottom of the slope to the top, there was limited disturbance of the underlying material. The final slope of the riprap face was well interlocked with a smooth surface and uniform thickness. Based on these findings, BC Hydro determined this as the most viable method of placement for the Project. Placement losses of 10 per cent, commensurate with this approach, have been reflected in the Project cost.

19.1. Please describe the excavator type (including physical characteristics) and how this will work for placement of the material from trucking to the dam site to placement on the dam face.

19.2. Did BC Hydro examine the potential for a rail and trolley conveyor approach to placement of the new material on the dam face?

20. Reference: Exhibit B-1, Page 3-21

Table 3-3 Project Cost Range Breakdown ($ million)

Cost Components	Upper Bound (P90)	Cost Estimate (P50)	Lower Bound (P10)
Implementation Phase Costs (Note 1)	143.3	112.3	87.6
Inflation (Note 2)	8.0	6.3	4.9
Sub-total: Implementation Phase Direct Costs	151.3	118.6	92.5
Capital Overhead (Note 3)	2.6	2.0	1.6
Interest During Construction (Note 4)	4.8	3.7	2.9
Sub-total: Implementation Phase Costs (Loaded)	158.7	124.4	97.0
Total Identification and Definition Phase Costs (Loaded) (Note 5)	12.7	12.7	12.7
Total Project Cost Range	171.4	137.1	109.7

Notes:

1. Includes anticipated direct construction and quarry reclamation costs as well as project management, engineering, construction management, contingency and other costs.
2. The inflation rate is 2 per cent.
3. Capital overhead rate is 2 per cent and is calculated and applied on the total direct costs.
4. IDC rates are 4.06 per cent (F2016), 4.03 per cent (F2017), 4.11 per cent (F2018), 4.2 per cent (F2019) and 4.37 per cent (F2020) and are applied to the sum of direct costs and capital overhead accumulated in each year.
5. All costs shown in Table 2-1 are capital costs with the exception of $1 million related to the Identification Phase of the Project.

20.1. Does BC Hydro believe that this project is significantly different, from a general project management of costs perspective, than its other generation projects have been or does BC Hydro expect that its normal cost management practices will be as effective as they have been in the past?

20.2. Are there opportunities built into the cost estimating for the project, aside from contingencies, to make refinement decisions during the execution of the project, which would enable some degrees of cost control without compromising the project end goals of providing a permanent solution for protection of the dam face.

20.3. Given the weakening of the Canadian economy and the world economy would BC Hydro expect to find contract bids for this project to be robustly competitive and have the potential to produce actual cost either at or below these cost estimates.

21. Reference: Exhibit B-1, Page 3-22

The Project schedule has been developed to achieve a Completion Date of July 2021. The schedule is the result of a combination of required Project elements and construction period constraints. The key schedule constraint is that reservoir elevations must be below 661 m (2170 ft) for the placement of riprap in the critical erosion zone. Therefore, the construction window is limited to the three month low reservoir period between March and early June each year. It is anticipated that the Project will be implemented over a five year period as follows:

21.1. What is the probability that global warming will be advancing the snowmelt dates and change the low reservoir period during the term of this project.

22. Reference: Exhibit B-1, Page 3-24

The ECI process will lead to establishing a negotiated contract price whereby the proponent will disclose to BC Hydro their costs, profit, and overheads on subcontractor prices and supplies. Additional cost prudency will be attained through a fair market value assessment of the agreed contract price by BC Hydro.

22.1. Will BC Hydro have any alternatives to go to during this negotiation process such that it will have some leverage in the contract negotiation, to ensure cost-effective outcomes for customers?

23. Reference: Exhibit B-1, Page 3-30

> BC Hydro anticipates that the Project will not result in any adverse environmental or social impacts.

23.1. Please provide an approximate quantification of the positive socio-economic and environmental impacts that will be achieved by the project.

24. Reference: Exhibit B-1, Page 5-2

> There is a risk that the contracting community will become unavailable or not interested in the Project, which could result in limited response to the RFP and increased contract cost. To address this risk, the following treatment plans have been completed, are in progress or are planned:

24.1. Please explain what the contracting community will be bidding on in terms of price and how that would provide a control on costs and the degree to which there is a risk that the ECI process will create the price/cost negotiation which may put cost estimates at risk.

24.2. Please explain how BC Hydro will be managing change order issues to avoid cost escalations during the project.

24.3. Please explain why BC Hydro is not looking to have the ECI process done with a short list of bid contractors in order to have some leverage in the outcome of this process.

24.4. Could BC Hydro pay two or more contractors to compete inside the ECI process after the RFP?

25. Reference: Exhibit B-1, Page 5-6

> The Sand Flat quarry site is partially developed. There is a risk that site conditions are different than expected, resulting in lower yield with increased costs and possible schedule delays. To address this risk, the following treatment plans have been completed, are in progress or are planned:

25.1. What opportunities has BC Hydro investigated to ensure that the project will be learning from experience as it progresses and therefore has a record of improving yields?

25.2. Will the mandated geotechnical experts working with the contractors be able to provide this learning and will they be tasked to do so?

26. Reference: Exhibit B-1, Page 5-8

There is a risk that the contractor will not effectively transport rock materials from the quarry to the stockpile at the Dam. This would result in reduced productivity with increased costs and possible schedule delays. To address this risk, the following treatment plans have been completed, are in progress or are planned:

26.1. In order to manage the risks related to contractor performance will BC Hydro have within the terms and conditions an ability to make sufficient changes to supplant poor contractor performance with better or adequate contractor performance or will BC Hydro be constrained to accepting the end performance of the contractor?

27. Reference: Exhibit B-1, Pages 5-9 and 5-10

There is a risk that geotechnical conditions on the upstream Dam face are different than expected, resulting in reduced productivity with increased costs and possible schedule delays. To address this risk, the following treatment plans have been completed, are in progress or are planned:

- The ECI process will arrive at a mutually agreeable contract structure, including the treatment of specific contract risks. The general principal that will be followed is that risks will be assigned to the party best able to manage the risk;

27.1. What does BC Hydro expect the ECI contracting process to have as terms and conditions for risks allocated to the party best able to manage them but then it becomes evident that they are not being adequately managed?

28. Reference: Exhibit B-1, Page 5-16

> The Sand Flat rock quarry is situated approximately 38 kilometres from the Dam site. Transport of materials from the quarry to the Dam will be via existing roads and result in up to 10,000 truckloads to site over three construction seasons. There is a risk of safety incidents between the transport vehicles and the public. To address this risk, the following treatment plans have been completed, are in progress or are planned:

28.1. Will the 10,000 truckloads of material be equally distributed across the 3 construction production seasons being used, making it 3,333 per season?

28.2. Given that placement is to occur in the 3 construction dry period windows, from March to June, will this result in about 27 to 30 trucks a day moving onto the dam site or 2 to 3 per hour?

28.3. Will BC Hydro and the contractor be contemplating using lighting of the dam site work areas to deal with low light or darkness considerations to accommodate these volumes of material movement?

29. Reference: Exhibit B-1-4, Volume 1, Page 17

> The Panel recommends that when designing the new top part of the dam, BC Hydro considers the effect of earthquake loading (acceleration amplification) and the potential development of cracks in the core that may initiate damaging erosion. In the top part of the dam there is no Filter and Drain on the downstream side of the Transition zone. Thus, there is no protection of the Transition zone, and the drainage capacity in the top part of the dam is much lower than deeper in the dam. The Panel recommends that the scope of the current upgrading project also considers these aspects (see Section 7.2.11).

29.1. Please describe whether or not these recommendations are being addressed in the project and if so how they are being addressed.

30. Reference: Exhibit B-1-4, Volume 1, Page 47

There appears to have been localized internal erosion at Benchmark 1 (Sinkhole 1). It is not possible to explain all the sinkhole settlement by densification (wetting compaction) of the less densely compacted fill around the benchmark casing. A certain volume of the Core in the Benchmark area must have been lost by erosion. Erosion has occurred through concentrated leaks in cracks opened by hydraulic fracture resulting from stresses lower than pore pressure in the Core, and eroded material has entered the Transition and possibly Splitter Dyke 2. The erosion of Core probably occurred only for a short period until the Transition and similarly graded material in the Splitter Dyke arrested erosion.

At Benchmark 2 (Sinkhole 2), all the settlement observed may be explained by wetting compaction of the less dense fill around the benchmark casing.

30.1. Please confirm that Sinkhole 1 is of more significant concern than Sinkhole 2, with respect to managing how it may present risks to the project.