Timm, Gwen

From: [redacted]
Sent: Monday, September 29, 2008 2:42 PM
To: Brennan, Bob
Subject: Hydraulics Report - Update

Attachments: [redacted]k - Manitoba Hydro Lake Operations Sep 2008.pdf

This is exhibit " 48 " referred to in the affidavit of Andrew David Cormie sworn before me this 18th day of February A.D. 2010

A NOTARY PUBLIC IN AND FOR THE PROVINCE OF MANITOBA

[redacted]
Manitoba Hydr...

Hello Mr. Brennan,

As a preface to the project outline for the two Hydraulic Reports, I wanted to update you on what has transpired in this report preparation since completion of the LTC Report on Jul 31st. Also, to avoid confusion, I wanted to confirm my understanding that for work not in "final-report-format" which comes from the Middle Office, is treated as Confidential - as Vince has always done - and is not circulated to the Front Office until a completed final report is vetted and approved and ready for distribution. Therefore, the contents of this email, are sent to you with the understanding that it would be treated as CONFIDENTIAL as pertains to the Middle Office, and please not to be circulated in this format to the Front Office until final issuance of the report. Thank you for your trust on this matter.

First, once the LTC Risk Report was handed in on Jul 31st, I proceeded to take a few days off to recover. On August 4th, I returned to work on the Hydraulic Reports, and that week (Aug 4th - Aug 10th) I infact worked a lighter schedule - approximately 20 hours that week - and started revisiting and tidying up much of the completed text for the 35 pages of Hydraulic Reports.

On around August 11th (I had emailed Vince to no avail) - I was verifying what seemed like innocuous points in my reports to do with "data discrepancies" being used as input to Hermes. It also pointed to statistical data anomalies and overwrites being used as input to run Hermes. It was a fairly benign sentence, that I thought required clarification for the EPRMC to take action on. I thought the sentence wasn't specific on data anomalies since it wouldn't point out where to look or what to look for.

I remember, I decided to clarify my thought by providing one or two examples, and so I went back to look at a couple of old files - and for some reason - I referred to the low-flow 4041 year run in the Hermes archive, as one example. As I checked the files, the data looked "odd" - and so, to be sure, I ran this copy of the low-flow year independently through my risk system. Of great shock, this data was causing my system to enter "forced" blackouts and was not meeting the reliability constraints in the Province even with gas running on full.

As you can imagine, my first reaction was to assume that I had done something wrong, or that I had overlooked something (Or I was using wrong data) - so, for the next couple of days, (while still waiting for Vince to get back to me) Aug 12 - 14th, I started to look in absolute and thorough detail to see what was causing the problem.

On around August 15th, I was sure that the parameters in my system had been set adequately - and there was clearly a problem.

Now more worried and still in disbelief, I decided then to double check the low-flow year version in Splash. (This 94 year record had been sent to me in its entirety in 2006). I was able to extract out their version of 4041 records from here, including their reservoir operations. In that process I could see clearly another set of problems, and the impact to Hydro, now running Splash low-flows (as is) was significantly worse - even worsening the rule curve reliability to the Province. It was very apparent that the amount of GWH in storage, as portrayed by PSO given the methods of operating the reservoirs and storage

amounts - would not be met under the proposed levels of running reservoirs as low as 832.25 and 712.50 feet.

It was now around August 18th.

Because of the way the storage reservoirs and lake levels are being operated in both Front Office systems, I decided, that for me to be sure that I was looking at the right facts - I needed to make my system run the optimization completely "independently" for this low flow year to calculate what exactly would happen. Up to that time, the LP optimization had been using the results of either Hermes and Splash - and for this run - it was apparent the nuances between both systems were not accurately representing the risks. In fact it also became apparent that your notion of a 5 year Drought may also have been misrepresented and that "blackout" conditions had not adequately been integrated. In some cases an incredulous 1000% overstatements or discrepancies of input flows in 4041 were evident between Hermes and Splash.

For the next 2 weeks, at lightning speed, I hired 2 of my top programmers to reconstruct the entire LP optimization routine to be able to independently operate and optimize Lake Winnipeg and Cedar Lake given all flow-years as inputs with an independent focus on 4041.

As part of this process, and as I completed the analysis, an alarming set of conclusions and considerations have come to light. These have taken a front row in identifying the issues in the Hydraulic Reports.

Therefore, for your understanding of the Hydraulic Reports, below is bullet summary of the highlights :-

1. The 4041 reliability run in Hermes is not adequate or complete for ascertaining Hydro's true Provincial low-flow year requirements. The analysis supporting this run has fundamental oversights - now leaving Hydro in "shortfall" regions. In fact, if Hydro operates and drops its reservoirs close to 832.25 and 712.50 as proposed by PS&O in the lake-ending levels for FY0910, Manitoba Hydro would result in forced black-outs for the following year if that is a low-flow year and rule curve requirements are not being determined adequately. This is now of utmost seriousness Manitoba Hydro and the levels should be revised urgently and expeditiously.

The entire low-flow year reliability run is found to be not optimized correctly. An entire sub-issues list will be provided to demonstrate the breakdown.

2. The "value of water" in storage in Hermes is fundamentally incorrect and not adequately analyzed. Vince himself said to me in July that the EPRMC view was to "take the water out of storage" and "drain the reservoirs" - since this was money in the bank and with market prices the way they were, the decision is there is no value to keep the water in storage. This is in fact an incorrect analysis and assertion. It is based on fundamentally incorrect and mis-advice from results in the Hermes hydraulic system. It can now be proven. The upside and downside of water in storage has not been correctly or adequately ascertained.

Specifically Hydro's Fiscal Year returns whether starting or ending the year at (for example) 834.25 versus 838.25 as compared to both median, average and high flows show that in fact Hydro's annual revenue is infact greater, starting the year at a higher lake level. There is marginal upside to taking water out of storage.

While the results of this are initially surprising, there are clear and verifiable reasons, in part to do with the hydraulics, and LP optimization choices, which substantiate the findings. Therefore, there is an economic value LOSS to Hydro, in starting the reservoirs in any Fiscal Year too low.
This means that by dropping reservoirs below a certain point, Hydro in fact generates LOWER Fiscal Year revenue than if it had started the reservoirs at a higher operating point. This amount can be quantified in the tens of millions. In all cased the optimum value to Hydro was found at 838.25 feet and 713.72 feet. (Higher than what Hydro has anticipated before). PS&O proposed operations can even be shown to DEPLETE revenue by an excess of $30MM in the method of releasing (due to running on the least efficient parts of the rating curves), than maintaining reservoirs on full.

Further, dropping the reservoirs, including Lake Winnipeg - does not generate a fair

upside for the value of water in storage. Chasing the "bottom-of-the-reservoir" value dollars can now be quantified as less than $10MM of increased revenue whereas the downside to the company exceeds $500MM. In fact, with majority of risk in the winter months and true ice considerations, all value in reservoir operations is optimized in maintaining operations at full higher levels. This has been inadequately determined in Hermes and is leaving Hydro operating sub-terraineously.

Specifically on an average flow basis, the RM analysis picked 7 starting points of Lake Winnipeg. 714.29, 714.01, 713,72, 713.42, 713.21 and 712.90 and 712.50. The analysis was run 7 times over, (and again another 2 times) for CL at 834.25 and 838.25.

At all times the optimum reservoir operations to Hydro was determined at 713.72 feet and 838.25feet with perilous drop-offs in return once reservoirs fell below 712.92. (See Chart #1 and Chart #2)

Therefore any PS&O assertion that Hydro will generate more revenue in the short-term by dropping reservoirs is in fact an incorrect assertion. It is based on an incorrect quantification of value of water in storage, and is likely to leave Hydro losing unprecedented amounts in the next low-flow year
- between now and 2022. Even on high flows years there is no (if limited) upside.

3. For High-Flow years, the RM proceeded accordingly - and the results were even more surprising. The analysis still shows that more revenue can still be obtained with the reservoirs higher than 713.21, and optimally again at 713.72. Even in flow years such as 1965 and 2005, the greatest revenue to the Corporation would have occurred even with starting and ending the reservoirs higher. There is only less than a $0.37MM difference, in high flow years to Hydro in having operated its reservoirs with levels at 712.50, with once again surprisingly, the greater revenue occurring at 713.72 feet.
(See Chart #3)

Therefore PS&O's indication in taking water out of storage, can now be factually proven to deplete upside revenue to Hydro and significantly increase risk. Thus, the assessment shows clearly that taking the last 2 feet of water out of storage, or dropping reservoirs, has no additional value. Maybe Hydro will justify an additional $15MM, but marginal downside exceeds $500MM.

4. Vintages of Drought: PS&O analysis has not accurately categorized the financial impact (and Losses) of different Droughts. Therefore there are a variety of impacts to Hydro, depending on where the reservoirs start and whether the low-flows occur in the Northern Region of the Province or upstream or downstream of the Storage reservoirs. Also, the "tipping-point"
or Cost of Drought is directly relational to where Hydro chooses to operate its reservoirs.

Previous Front Office analysis has shown a "single" view cost of Drought for each year. This was based on a perfect sequence of flows, and known levels, and the cost for instance of a low-flow year was represented as a single number - say $300MM loss in revenue for the year.

Attached are a few graphs to show you that the "Cost of Drought" is not such a single estimate, but a range of values crucially contingent on the lake levels. The range of cost to Hydro, depending on Lake Levels on the aggregate can exceed $700MM in one Fiscal Year.

The upside range is a minimum amount of $20-$30MM.

It clearly shows the risks and peril of Hydro operating the reservoirs at such a low lake-level amount.

Once again the optimum amount of lake operations is at 713.72 feet and a very pronounced "exponential drop-off" in levels below 712.92 and any analysis by PS&O to take water out of storage is fundamentally incorrect in risk versus revenue to Manitoba Hydro.

Even on an average flow basis their are very evident Fiscal Year disadvantages to Hydro in operating its reservoirs based around a lower lake ending level. (See Chart #4)

5. Optimization Routines: Having reconstructed the optimizer to independently operate the optimum water in storage, it also became apparent that the method of "Successive Linear

Programming" - or SLP - is no longer suitable and not recommended for use of managing Hydro's reservoirs and water in storage. Because of the shape of the efficiency curves, and the nature of the problem (for example with a "step function" of on/off criteria in gas reliability) the problem is clearly "non-linear".

In fact non-linear and non-smooth optimization routines (NLP - for non-linear programming) should be being used to operate and manage storage reservoir conditions. Therefore, quite simply, Hermes is not finding the maximum solution to the problem.

In fact it is not even coming close.

Below is some public text critiquing the method of SLP :-

"Linear programming is a powerful technique for optimization but the requirement that all constraints be linear can make it difficult to write models that represent the real world closely enough to produce useful answers. Unfortunately, because a linear program always finds its optimum on a constraint, if the optimum for the NLP (non-linear program) is not in fact constrained, this method will not find it! SLP is not much used for process engineering problems".

To be specific, Hermes is clearly not finding the optimum solution for operations of reservoirs.

With advances in computing power and programming, new techniques can and are now being used. In times of low-flow it is so far off-the-mark, the difference in losses to the Corporation can exceed hundreds of millions (see Charts attached). That's why SLP is not used or recommended. Essentially Hermes can't "see" a wide enough area to even find what is close to a maximum so it converges to the nearest local area. Even on a median-flow basis, it is not able to discern the optimum amount to release from storage without incurring lower revenue versus if it had maintained a balance.

Even Splash, is finding a more optimum solution, since it uses a different "local" region (starts at a different hill due to better programming
choices) and therefore creates more revenue. However neither of the support systems are finding a global optimum which is now not suitable for accurate financial projections and reservoir operations.

This is now placing substantial risk in assuming the "safety" of reliability concerns. Even on a median flow or average flow basis, the PS&O system is very visibly missing the mark in optimal reservoir operations.

6. FY0304 Drought: The RM analysis shows that the cost of Drought for this year should not have exceeded approximately $326MM declines in Fiscal Year Annual Report Revenue. If the initial forecasted FY Annual Report Forecast for that year was positive $475MM, then under all reasonable circumstances the true cost of Drought would have reduced Annual Report revenue to approximately $148MM.

The unprecedented posted Financial declines in FY0304 to show negative losses of -$476MM (over $600MM lower than the declines in rainfall - of inefficient and unnecessary losses) are directly attributable to inefficient storage and reservoir operations. This as well as uncalibrated "value of storage" and reservoir operations in PS&O.

There is no viable reason, upon detailed and careful analysis of this low-flow year that this Drought should have returned a negative Fiscal Year Return, and corroborating the charts attached, inefficient reservoir operations have an unnecessary financial loss to the Company exceeding half a billion dollars in one single year. This was also combined with ineffective and out-of-the-money gas hedging which depleted revenues by an unnecessary amount.

The Corporation should have survived this year, with a positive revenue, if accurate optimization analysis was performed.

The attached charts clearly show how reservoir operations contributed to the losses and inefficiencies in Hydraulic Operations.

7. While financial losses in a Drought are one criteria, the second more important one is the consideration of 4041 inflows and reliability constraints, which are also proven to be

fundamentally flawed in the Hermes assessments. Looking forward for the next 2 Financial Forecast Years - the amount required in Storage for the financial projections in FY0910-FY1011 is also incorrect and violating rule curve and Provincial Reliability requirements.

It is with grave seriousness that this email is written to the implication to your financial forecasts - and to clarify that the notion of taking the water out of storage has been inadequately quantified. Further, given the proposed PS&O operations for the Fiscal Year 0910, Hydro will violate rule curve criteria, and leave itself wide open for forced and regional blackouts
- due to an oversight in calibration in Hermes.

8. 5 Year Drought: Along the same lines of 4041 reliability, the RM assessment now has a real concern in Hydro's quote of a 5-Year Drought number and 5-Year Drought references in the Annual Reports. Upon more careful analysis of the flows, Hydro has a strong likelihood of not even surviving a 2-Year Drought. Since the Company has based its reliance on "perfect foresight" - knowing that the following year after a Drought would be a High Flow year - and because the flows viewed have been set to be in a fixed order, without any contingency for flow sequence changing - and lake levels have been adjusted to make the constraints fit - this does not adequately represent Hydro's risk in a 2 low-flow years consecutively.

Under any common-sense risk management scenario, Hydro can not assume "good luck" that any Drought will be followed by heavy rains - and therefore drain the reservoirs to the maximum. Pending rule curve requirements would then start to be in conflict with operations planning.

And - if any low-flow year event occurred following a 4041 year - Hydro again would be unable to meet rule-curve requirements and/or would be forced into a regional blackouts. Therefore any notion in Annual Reports that suggest the implications of a 5Year Drought are merely financial losses are in fact a misrepresentation. Unless suitable reservoir operations are maintained in PS&O, there is an inadequate rule curve model for 2Year blackouts and even under current assumptions, Hydro will end up in a threatened reliability conditions.

It needs to be clear therefore, that under current model assumptions, in quantifiable likelihood , Hydro would not survive a 2Year Drought - and reliance on this "perfect foresight" has misstated the Company's real vulnerability in system reliability. This again stresses the need to keep the reservoirs on MAXIMUM and as high as possible until Conowapa comes into service.

To revert briefly to my timeline and your request for status, on around Sep 8th, given the seriousness of findings and Vince's unavailability, I had contacted you directly. As for hours, I propose to stop billing hourly between August 15th - Sep 15th since I had to work solidly on the software and models for a month to to generate the accuracy of the results for this Hydraulic Report and investigate the analysis. As a fair compromise, I suggest charging a one-quarter-only one-off license for the use of the Middle Office Timetrics models for this report (approx $8,000 a month) and in exchange I will not bill at all for my hours during that month. I will resume hourly consulting after Sep 15th.

To be honest, given the utmost seriousness of the issues that arose, and implications to Hydro, I was not concerned with administrative matters - and only that the correct portrayal of the issues was sent to the EPRMC.
Factually I had to be sure these RM issues identified and results were accurate before sending them to you. Hence, I proceeded as any risk professional would, to get to the bottom of such a serious matter and make sure all supporting risk analysis was accurate. There would be unprecedented impact to Hydro if this wasn't identified and represented completely.

9. As a very definitive conclusion, the proposed reservoir operations by PS&O for Fiscal Year 0910 are perilous and far below sub-optimum. The financial forecasts for this year therefore need to be revised. If you continue with your Fiscal Year operations as suggested by PS&O to drop levels to 832 and 712.50, Hydro WILL face the real risk of forced black-outs should the following year be a low-flow year. Quite definitively, and under all circumstances, any analysis that taking water out storage will benefit or create short term gains to the Company is in fact mis-analysis. The wrong LP programming is being

used in the Hermes model to ascertain storage value.

Further, Hydro has a very real "reliability" margin issue between now and the Conowapa in-service date in 2022. Therefore for the next 14 years, it is a very serious RM conclusion that Hydro's reservoirs should ALWAYS be maintained at the highest level. This will not only INCREASE your revenue annually, but mitigate any more of your risk. If you drop your reservoirs to 712.50 and 832.25 feet as suggested by PS&O and approved, you will "black-out", in the following year. The Corporation would not survive one year of Drought.

I can not stress the seriousness of this findings. The Hydraulics Report will additionally spell out, in complete details , what is additionally wrong with the Generation Estimate Low-Flow 4041 assumptions in Hermes, and why this can not adequately support reservoir operations.

I am hopeful, that you have time now (prior to FY0910) to rectify and make the correct decisions before you proceed to take the water out of storage.

All due regards -

[redacted]

Sincerely,

[redacted]
Risk Management NYC
[redacted]

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MANITOBA HYDRO

RISK MANAGEMENT - LAKE LEVEL OPERATIONS CHARTS

SEPTEMBER 2008

PREPARED BY [redacted] RISK

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Chart #1

Manitoba Hydro - Cost of Drought

Annual Report - $ — #7 Drought on Record - Comparisons of Lake Winnipeg operations

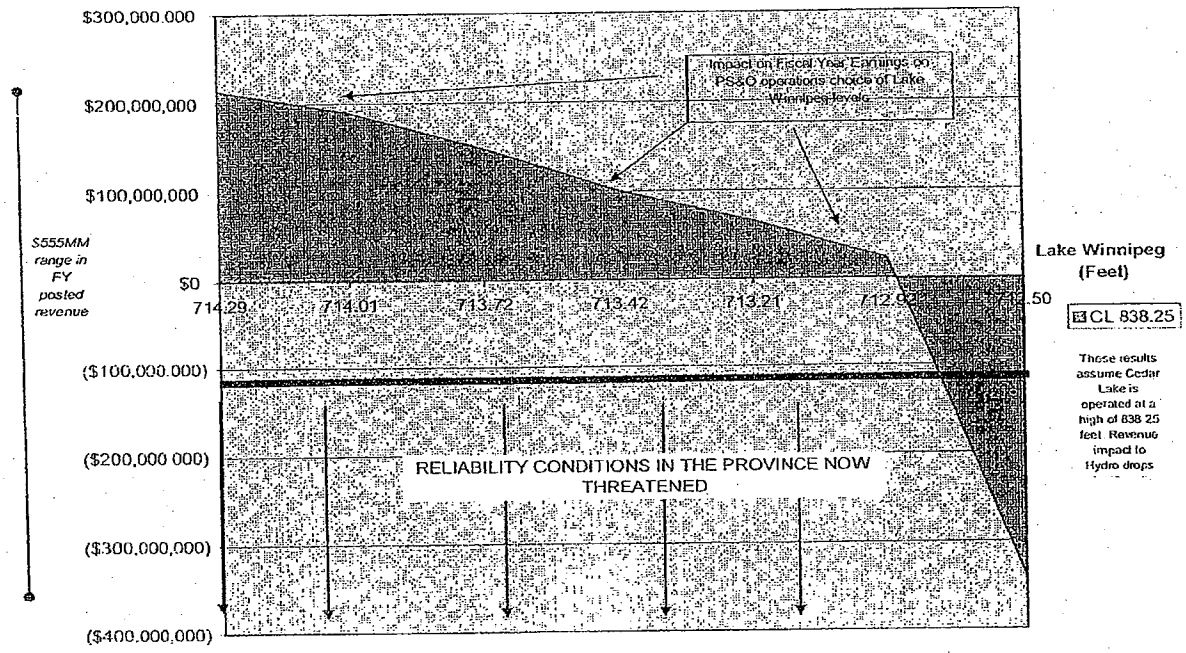

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Chart #2

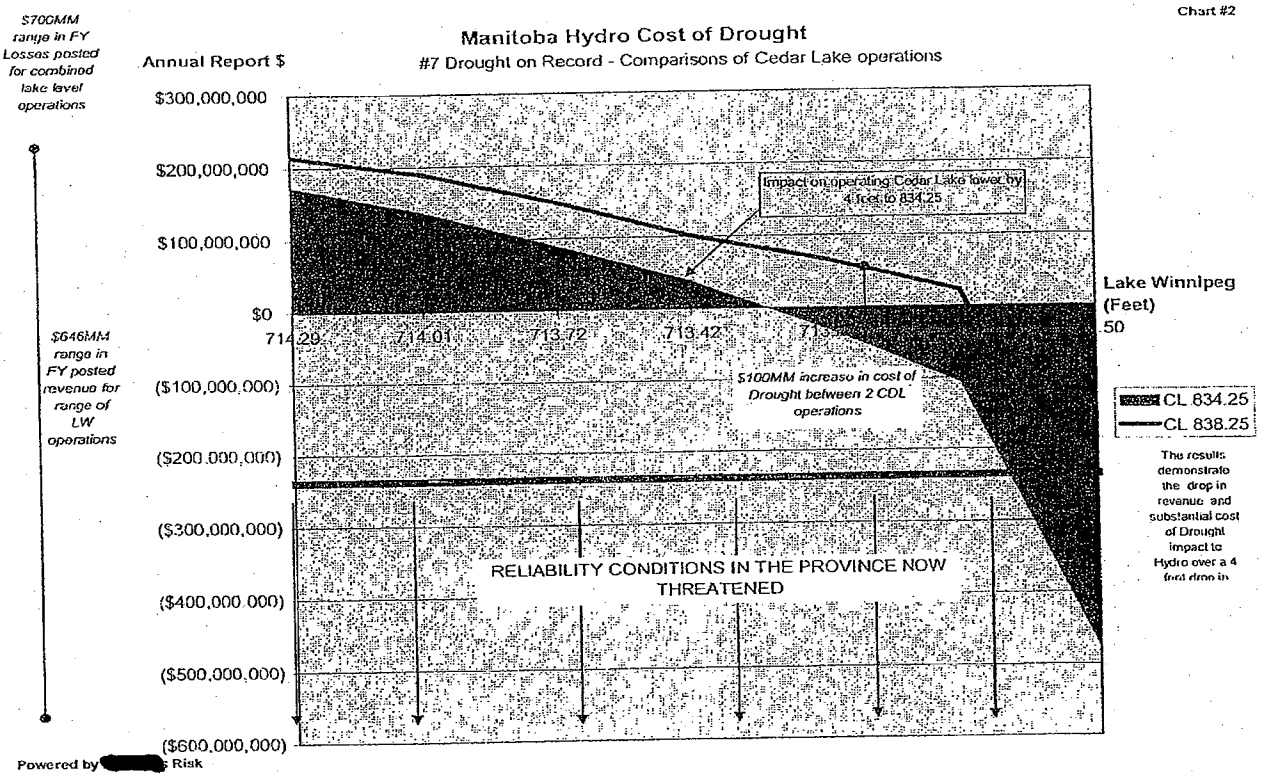

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Chart #3

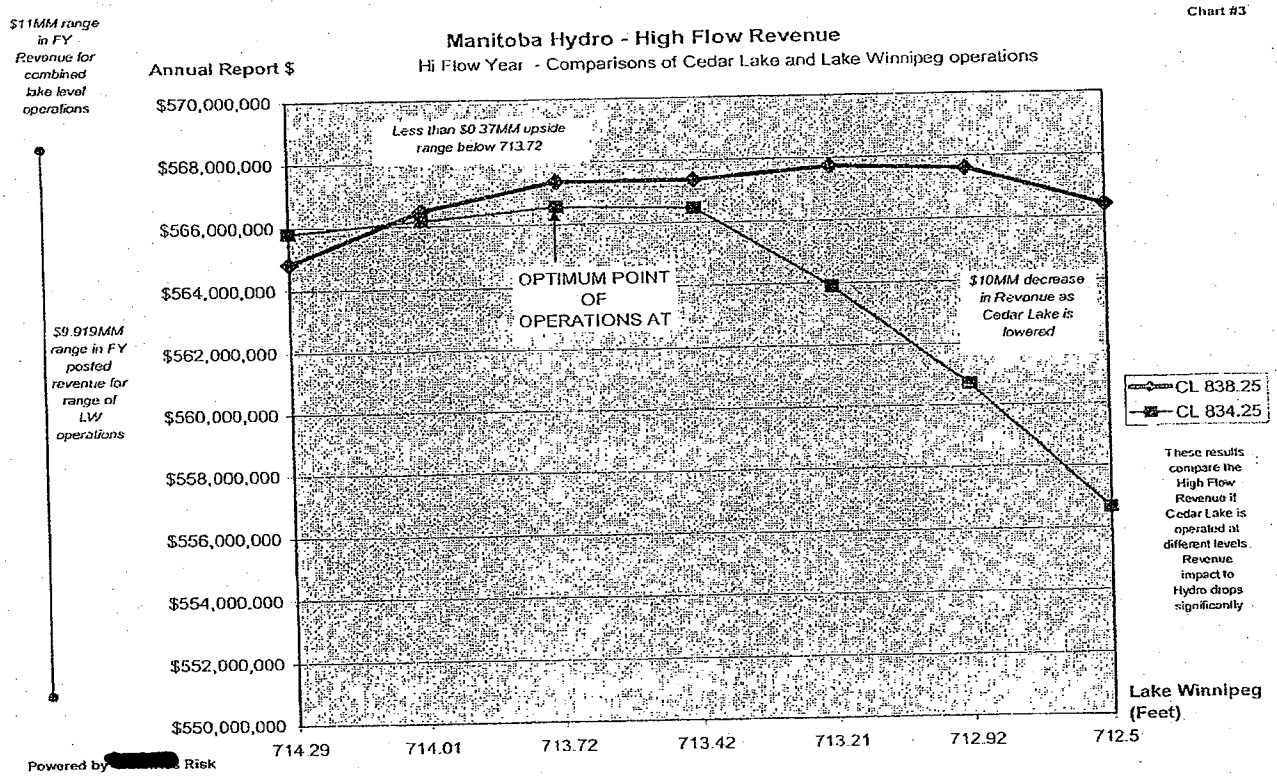

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Chart #4

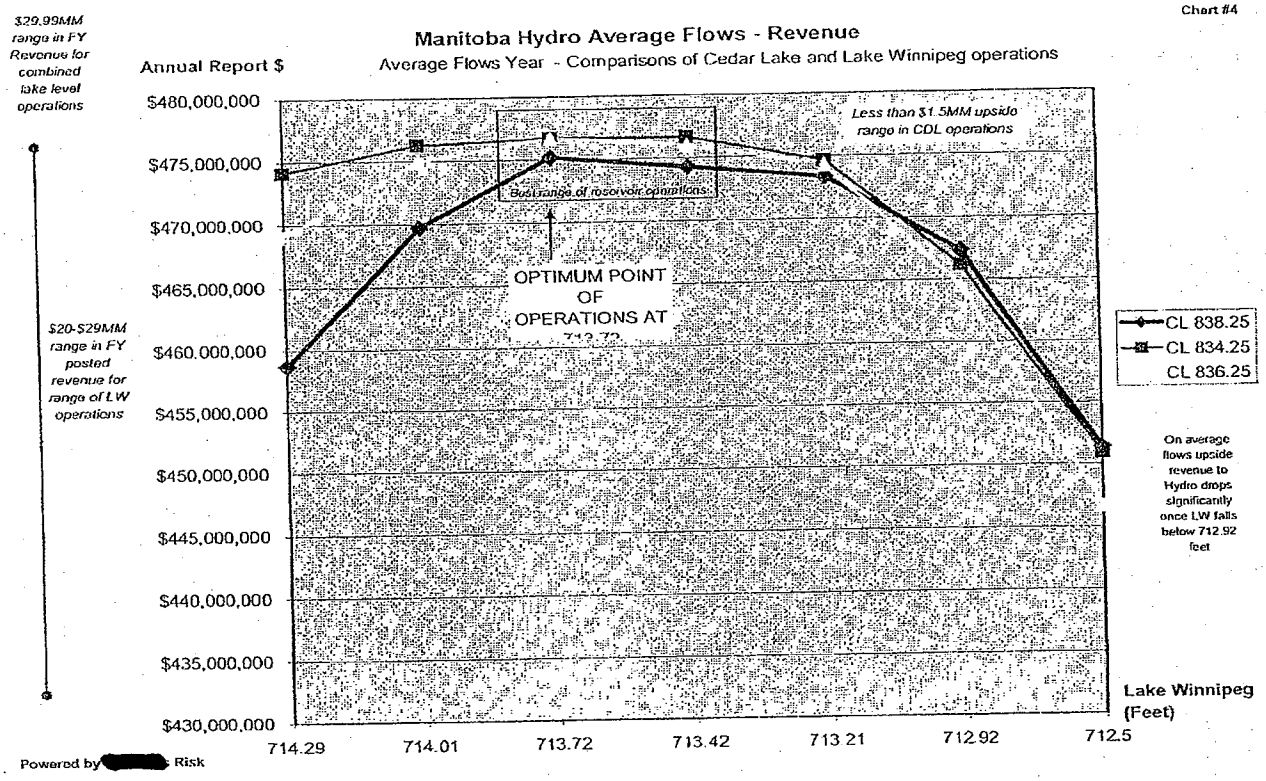
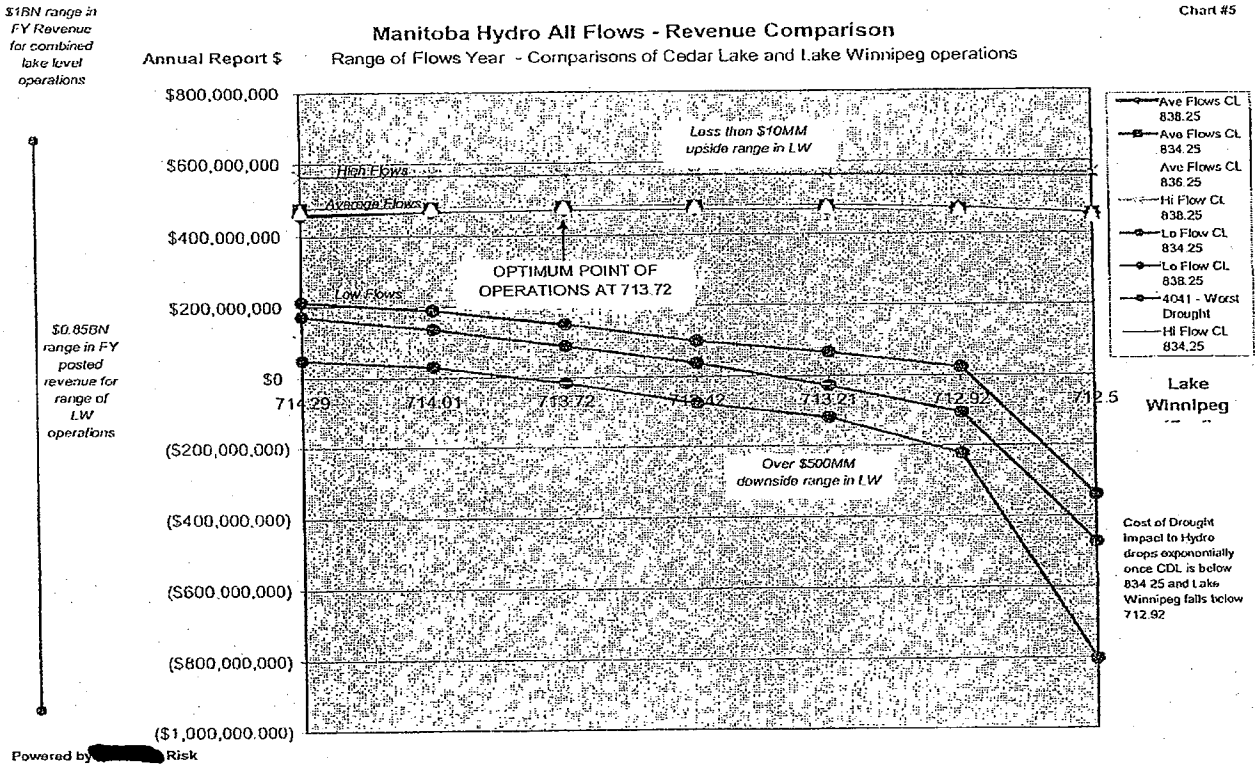


Chart #5

Manitoba Hydro All Flows - Revenue Comparison

Range of Flows Year - Comparisons of Cedar Lake and Lake Winnipeg operations



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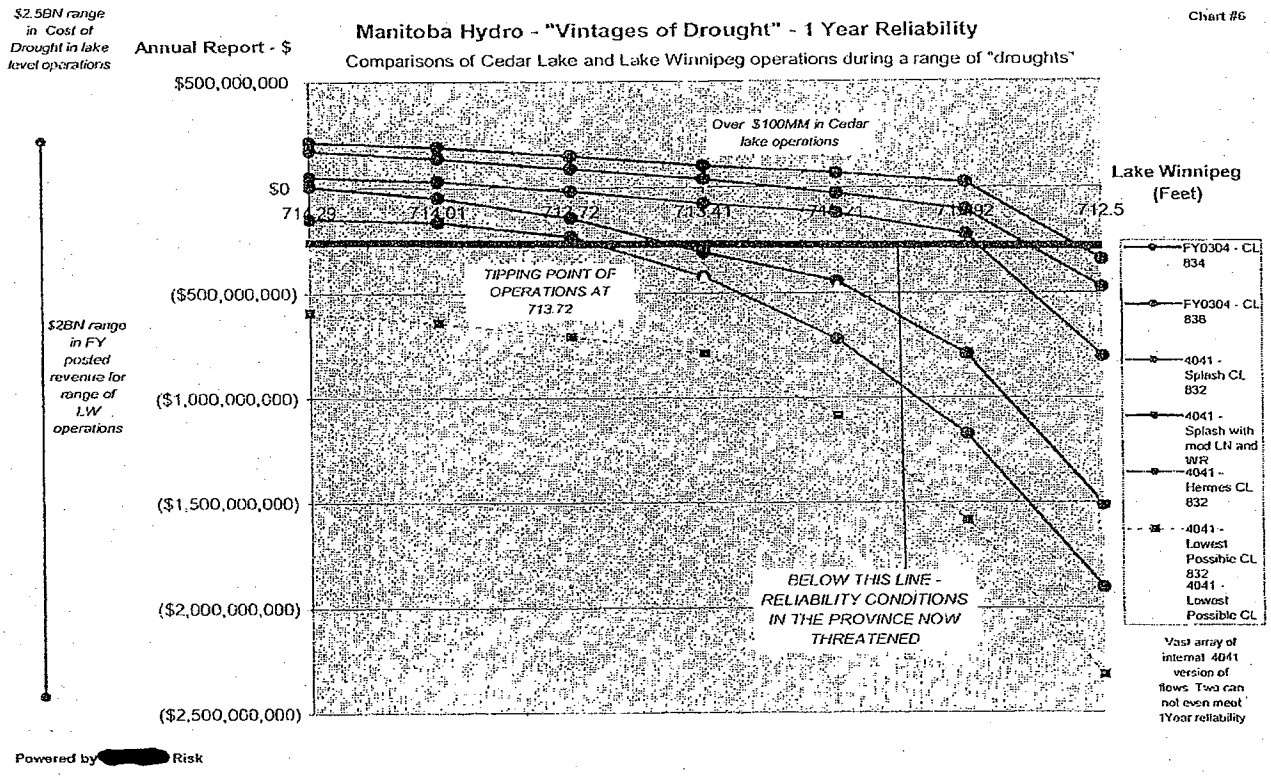
$2.5BN range in Cost of Drought in lake level operations
Annual Report - $
Manitoba Hydro - "Vintages of Drought" - 1 Year Reliability
Chart #6
Comparisons of Cedar Lake and Lake Winnipeg operations during a range of "droughts"
$500,000,000
$0
($500,000,000)
($1,000,000,000)
($1,500,000,000)
($2,000,000,000)
($2,500,000,000)
$2BN range in FY posted revenue for range of LW operations
Over $100MM in Cedar lake operations
TIPPING POINT OF OPERATIONS AT 713.72
BELOW THIS LINE - RELIABILITY CONDITIONS IN THE PROVINCE NOW THREATENED
Lake Winnipeg (Feet)
711.29
711.91
713.72
713.41
712.92
712.5
FY0304 - CL 834
FY0304 - CL 838
4041 - Splash CL 832
4041 - Splash with mod LN and WR
4041 - Hermes CL 832
4041 - Lowest Possible CL 832
4041 - Lowest Possible CL
Vast array of internal 4041 version of flows. Two can not even meet 1Year reliability
Powered by [redacted] Risk