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Hydroelectric is “Dirty” Energy

Hydroelectric facilities using headponds (impoundments or diversions), and cycling and peaking operations cannot be viewed as “clean or green” energy sources. These are the usual tools of the trade utilized by developers to maximize power generation, and to take advantage of the peaking incentives offered to provide power during peak demand hours.

With the recent promulgation of the Green Energy Act (GEA), waterpower has been pitched as a green energy source, but

> *”…that doesn’t mean we shouldn’t worry about the impacts of these projects and technologies. Nor does it mean that we should allow run-of-river power projects or windmills anywhere without proper government oversight and planning. Panic shouldn’t guide policy.*
>
> *It’s ludicrous to think that we must sacrifice all environmental considerations to get green energy onto the grid. It’s not green if it causes negative ecological impacts.”* [1]

As we noted in our October 2012 letter to Deputy Minister O’Toole[2], ORA feels that a much more strategic approach to waterpower needs to be developed across the province before considering such facilities. The one-off approach that has been previously employed in Ontario and elsewhere, often leads to significant cumulative effects on the environment and ecology of watersheds, and some impacts may be irreversible.[3]

In the view of most, waterpower has many benefits, but it is incorrect to consider all waterpower as clean or green energy – a very high socioeconomic price has been paid in the past in terms of losses to other renewable benefits due to the installation of dams and waterpower.[4],[5]

The context for our presentation begins with the clear understanding that the negative effects of dams and hydropower have been well documented. Indeed:

> The World Commission on Dams found that while “*dams have made an important and significant contribution to human development, and benefits derived from them have been considerable … in too many cases an unacceptable and often unnecessary price has been paid to secure those benefits, especially in social and environmental terms, by people displaced, by communities downstream, by taxpayers and by the natural*

[1] Faisal Moola and David Suzuki 2009i: http://www.straight.com/news/david-suzuki-run-river-power-projects-may-offer-green-energy-solutions
[2] Letter to Deputy Minister O’Toole, MNR – Request for a Provincial Strategy for Waterpower Development – October 2012
[3] Gower et al. 2012
[4] Guihua Wang, Qinhua Fang , Luoping Zhang, Weiqi Chen, Zhenming Chen, Huasheng Hong. 2009. Valuing the effects of hydropower development on watershed ecosystem services: Case studies in the Jiulong RiverWatershed, Fujian Province, China
[5] Institute for Fisheries Resources.1996.Cost of Doing Nothiing: The economic burden of salmon declines in the Columbia River basin. Report No. 1 of 3. http://www.pcffa.org/CDNReport-Columbia.pdf

environment." [6] Applying a "balance-sheet" approach to assess the costs and benefits of dams that trades off one group's loss with another's gain is seen as unacceptable, particularly given existing commitments to human rights and sustainable development.

The collateral environmental damage caused by dams and hydroelectric facilities has been well known for decades,[7] including loss or serious decline in migratory fish species (hydroelectric facilities are key factors in the listing of some iconic fish species as species at risk in Ontario and elsewhere); declining biodiversity[8, 9, 10, 11, 12]; impaired water quality (including increasing mercury concentrations in fish tissue); and they are often considered to be key threats to imperilled aquatic species.[13] In the past, little attempt has been made to mitigate these effects in Ontario, despite the fact that hydroelectric facilities have been inducing ongoing harm for 50 – 100 years.

The environmental and ecological costs of waterpower are well known throughout the world. Perhaps the most famous case involves the devastating cumulative impacts of hydropower on Pacific Salmon stocks in the Columbia and Snake Rivers[14]. Similar examples occur here in Ontario where dams are considered to be factors in the extirpation of Ontario's Atlantic Salmon stock[15], and hydroelectric facilities are considered one of the important causes of significant anthropogenic mortalities and decline of Ontario's American Eel[16], and are considered to be a key threat to Ontario's declining Lake Sturgeon populations.[17, 18]

There are many scientific publications supporting the view that the environmental neutrality of small hydropower should not be taken for granted, and further research is required to determine the full range of possible effects that small hydro projects can have on the riverine ecosystem and how these could be mitigated.[19, 20] Indeed, a major concern is that the accumulated effects

[6] World Commission on Dams. 2000. Dams and Development: a new framework for decision making. http://www.internationalrivers.org/files/attached-files/world_commission_on_dams_final_report.pdf
[7] Baxter, R. M., 1977, ENVIRONMENTAL EFFECTS OF DAMS AND IMPOUNDMENTS: Annual Review of Ecology and Systematics, v. 8, p. 255-283
[8] Ricciardi A, Rasmussen JB. 1999. Extinctionrates of North American freshwater fauna.Conserv. Biol. 13:1220–22
[9] Vaughn, C and C. Taylor.1999. Impoundments and the Decline of Freshwater Mussels: a Case Study of an Extinction Gradient. Conservation Biology 13(4): 912-920
[10] Bunn, S. and A. Arthington. 2002. Basic Principles and Ecological Consequences of Altered Flow Regimes for Aquatic Biodiversity. Environmental Management Vol. 30, No. 4, pp. 492–507
[11] Carew-Reid, Jeremy, Josh Kempinski and Alison Clausen. 2010. Biodiversity and Development of the Hydropower Sector: Lessons from the Vietnamese Experience – Volume I: Review of the Effects of Hydropower Development on Biodiversity in Vietnam. ICEM – International Centre for Environmental Management, Prepared for the Critical Ecosystem Partnership Fund, Hanoi, Viet Nam.
[12] Jelks, H. J., S. J. Walsh, N. M. Burkhead, S. Contreras-Balderas, E. Díaz-Pardo, D. A. Hendrickson, J. Lyons, N. E. Mandrak, F. McCormick, J. S. Nelson, S. P. Platania, B. A. Porter, C. B. Renaud, J. J. Schmitter-Soto, E. B. Taylor, and M. L. Warren, Jr. 2008. Conservation status of imperiled North American freshwater and diadromous fishes. Fisheries 33(8): 372–407
[13] Wilcove DS, Rothstein D, Dubow J, Phillips A, Losos E. 1998. Quantifying threats to imperiled species in the United States BioScience 48: 607–615
[14] Blumm, M; E.J. Thorson and J.D. Smith. 2006. PRACTICED AT THE ART OF DECEPTION: THE FAILURE OF COLUMBIA BASIN SALMON RECOVERY UNDER THE ENDANGERED SPECIES ACT. Environmental Law: 36: 709
[15] OMNR 2013. Restoration of Atlantic Salmon to Lake Ontario: past, present and future. http://www.mnr.gov.on.ca/en/Business/LetsFish/2ColumnSubPage/STEL02_165905.html
[16] MacGregor, R., J. Casselman, L. Greig, W. A. Allen, L. McDermott, and T. Haxton. 2010. DRAFT Recovery Strategy for the American Eel (Anguilla rostrata) in Ontario.
Ontario Recovery Strategy Series. Prepared for Ontario Ministry of Natural Resources, Peterborough, Ontario. vii+ 78 pp.
[17] Golder Associates Ltd. 2011. Recovery Strategy for Lake Sturgeon (Acipenser fulvescens) – Northwestern Ontario, Great Lakes-Upper St. Lawrence River and Southern Hudson Bay-James Bay populations in Ontario. Ontario Recovery Strategy, Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. vii + 77 pp.
[18] COSEWIC 2006. COSEWIC assessment and update status report on the lake sturgeon Acipenser fulvescens in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xi + 107 pp. (www.sararegistry.gc.ca/status/status_e.cfm).
[19] Abbasi, T. & Abbasi, S.A (2011). Small hydro and the environmental implications of its extensive utilization .Renewable and Sustainable Energy Reviews, 15, 2134-2143.
[20] Uttley, J. (2012). http://e-futures.group.shef.ac.uk/publications/pdf/183_17.%20Jim%20Uttley.pdf

of multiple small-scale schemes could amount to similar overall environmental degradation per unit of electricity generated as is caused by larger schemes.[21]

Following are some of the studies and reports which support our comment that hydroelectric facilities using headponds, and cycling and peaking operating strategies, results in "dirty" energy. It is not "clean" energy[22] when it induces significant and ongoing collateral ecological damage.

1. Hydroelectric with Diversions/Headponds:

"Regardless of their intended use, impoundments can have many negative environmental effects, including exacerbating water quality and other environmental effects of other land uses within the watershed." [23]

"*Since 2002, most new renewable electricity projects in British Columbia (BC) are built and owned by private developers. Most projects are river diversions – commonly known as "run-of-river" or "small hydro." While it is often assumed that these projects have smaller environmental impacts than traditional hydropower dams, the impacts of river diversion projects can be severe, especially when multiple projects are clustered within single valleys. The sheer number of river diversions approved and proposed, combined with a lack of land-use planning to ensure appropriate siting, are threatening some of BC's fish and wildlife populations, and reducing their ability to cope with stresses caused by climate change, urbanization, resource extraction, pollution and other threats. Impacts to social and cultural values are also an issue. The practice of diverting rivers for hydroelectricity is relatively new in BC, and many of the potential impacts are still not well understood or considered."* [24]

"*River diversion projects are sometimes seen as "greener" than large hydro dams because water is more quickly returned to the channel, and because they don't necessarily flood large areas of land to create reservoirs. However, when all the various impacts are examined, there is little reason to believe that river diversion projects are less harmful than big dams."* [25]

The environmental impacts of big hydropower dams have been well documented since their widespread construction began in the early 1900s. While large hydro gets much of the attention, small hydro carries many of the same impacts per unit of power generated.[26] That being said, many of the hydro facilities on smaller rivers use peaking strategies to maximize power generation. So the *"comparisons between river diversions and large dams can be difficult to make, given that "run-of-river" power is intermittent while large dams can provide stable year-round power.*" [27]

"Most of our current knowledge of the impacts of water quantity changes on water quality is based on studies of the effects of Canada's more than 600 dams and 60 large

[21] Abbasi and Abbasi 2011
[22] Fearnside, P. 2007. Why hydropower is not clean energy. C:\Users\Rob\Documents\dams and waterpower effects\Why Hydropower is Not Clean Energy - Scitizen.html
[23] Winter and Duthie. 1998. Canadian Water Resources Journal: 23(2): 245-257.
[24] Gower, T., A. Rosenberger, A. Peatt, and A. Hill. 2012. Tamed Rivers: A guide to river diversion hydropower in British Columbia. Prepared for Watershed Watch Salmon Society. 64 pages.
[25] Abbasi, T. & Abbasi, S.A (2011). Small hydro and the environmental implications of its extensive utilization .Renewable and Sustainable Energy Reviews, 15, 2134-2143.
[26] Abbasi and Abbasi. 2011
[27] Gower, T., A. Rosenberger, A. Peatt, and A. Hill. 2012. Tamed Rivers: A guide to river diversion hydropower in British Columbia. Prepared for Watershed Watch Salmon Society. 64 pages.

interbasin diversions, which makes the nation the world leader in water diversion (Day and Quinn 1992). Most Canadian dams store water during peak flow periods and release flow to generate power during winter, low-flow periods. Such changes to water quantity also modify various water quality parameters within the reservoir and downstream, the effects decreasing with distance from the impoundment. Major examples include: thermal stratification within the reservoir and modification of downstream water temperatures; eutrophication; promotion of anoxic conditions in hypolimnetic water and related changes in metal concentrations in outflow; increased methylation of mercury; sediment retention; associated changes in TDS, turbidity and nutrients in the reservoir and discharged water; increased erosion/deposition of downstream sediments and associated contaminants." [28]

2. Impacts of Silt, Turbidity and Suspended Sediments:

Dams and reservoirs act as a settling basin for silt and other suspended materials. There are numerous direct and indirect impacts of silt, suspended sediments and associated turbidity.[29] These include changes to water quality, reduced light penetration diminished recreational values and aesthetics as well as direct and indirect impacts to fish, invertebrates, aquatic plants. [30,31]

3. Methylmercury and Greenhouse Gas Emissions:

a. Changes in methyl mercury concentrations in zooplankton from four experimental reservoirs with differing amounts of carbon in the flooded catchments:
"*This study demonstrated dramatic increases (10X to 20X) in both methyl mercury and greenhouse gases (carbon dioxide and methane) production in response to flooding of wetland vegetation. Clearly, the microbial breakdown of dead plants and organic soils resulted in the methylation of mercury already present in the system, and the production of significant quantities of carbon dioxide and methane*." [32]

b. Impacts of Reservoir Creation on the Biogeochemical Cycling of Methyl Mercury and Total Mercury in Boreal Upland Forests
The Flooded Upland Dynamics Experiment (FLUDEX) at the Experimental Lakes Area (ELA) in northwestern Ontario was designed to study the greenhouse gas and mercury impacts of flooding forested upland areas, and to test the hypothesis that methyl mercury (MeHg) production in reservoirs is related to the amount, and subsequent decomposition, of flooded organic matter. *"After five years of flooding, the experiment confirmed that flooded upland soils and vegetation could also produce significant quantities of methyl mercury and greenhouse gases. However, the production of greenhouse gases seems to dissipate more quickly than in wetland systems, probably because there is less stored carbon, particularly in a form that is readily decomposed by bacteria."* [33]

[28] Environment Canada. 2001. Threats to Sources of Drinking Water and Aquatic Ecosystem Health in Canada. National Water Research Institute, Burlington, Ontario. NWRI Scientific Assessment Report Series No. 1. 72 p. - Page 69 – 15.
[29] *Appleby and Scarratt 1989 - European Inland Fisheries Advisory Commission 1965*
[30] Kerr, S.J. 1995. Silt, turbidity and suspended sediments in the aquatic environment: an annotated bibliography and literature review. Ontario Ministry of Natural Resources, Southern Region Science & Technology Transfer Unit Technical Report TR-008. 277
[31] *Baxter 1977*
[32] Impacts of Reservoir Flooding 1991 to Present, Experimental Lakes Area
[33] Impacts of Reservoir Flooding 1991 to Present, Experimental Lakes Area

4. Dams and Blue-green Algae

There are numerous studies that associate impoundments with inducing blue-green algae (cyanobacteria) blooms. *"The building of dams and regulation of rivers has created more habitats suitable for cyanobacteria. The general opinion now is that "cyanobacterial blooms" are increasing in frequency worldwide. Exposure to hepatotoxins (microcystins, nodularins and cylindrospermopsins) has been reported to induce several health disorders depending on the route of exposure, the quantities absorbed and the toxicity of the cyanobacterial strain. Harmfulness ranges from minor disorders (headaches, nauseas, diarrheas) to lethal deterioration of hepatic functions. It is also thought that chronic exposure to low concentrations can promote liver cancer. In 1996, 60 patients died in Brazil after haemodialysis with contaminated water (Pouria et al. 1998). WHO considers that freshwater contamination by cyanobacteria, and the toxins they synthesize, constitutes a major worldwide threat that can limit utilization of water resources (Chorus & Bartram 1999)."* [34]

5. Impacts on Fisheries:

"The effects of dams and hydroelectric facilities on fisheries have been well documented over the past century, and include the loss or serious decline of many iconic fish species (note: fish are also renewable resources important to the economy and to Ontario's natural and cultural heritage). Effects include barriers to fish migration, often preventing access to critical habitat (e.g spawning and rearing areas), changes in water temperature and water quality to conditions unsuitable for many native fish species, mortality of fish due to turbines etc.. Indeed, the effects can be so severe that hydroelectric facilities are often described as important reasons for their decline and/or significant threats to the recovery of species at risk." [35,36,37,38,39,40]

To fully understand the effect of flow reduction on habitat quality and quantity, much work is needed at an extremely fine scale – something not usually feasible for streams with complex channel geometries.[41] *Generally speaking, hydraulic modeling does not reveal flow patterns at scales that are important to fish survival,*[42] *and as such can't provide the kind of biological understanding necessary to understand how reduced flows will likely affect fish populations.*[43] *Consequently, no matter what method is used to determine instream flow requirements, an accurate prediction of the changes to the quantity and quality of the remaining habitat is not likely, and may not be possible within the constraints of a development project. In any case, the full impacts of river diversion*

[34] Cyanobacteria, cyanotoxins and potential health hazards in small tropical reservoirs
[35] Haxton, T.J., and C.S. Findlay. 2008. Variation in lake sturgeon (Acipenser fulvescens) abundance and growth among river reaches in a large regulated river. Canadian Journal of Fisheries and Aquatic Sciences. 65: 645-657. © Queen's
[36] Golder Associates Ltd. 2011. Recovery Strategy for Lake Sturgeon (Acipenser fulvescens) – Northwestern Ontario, Great Lakes-Upper St. Lawrence River and Southern Hudson Bay-James Bay populations in Ontario. Ontario Recovery Strategy, Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. vii + 77 pp.
[37] MacGregor, R., J. Casselman, L. Greig, W. A. Allen, L. McDermott, and T. Haxton. 2010. DRAFT Recovery Strategy for the American Eel (Anguilla rostrata) in Ontario. Ontario Recovery Strategy Series. Prepared for Ontario Ministry of Natural Resources, Peterborough, Ontario. vii+ 78 pp.
[38] Pratt, T.C and A. Mathers. 2011. 2010 Update on the status of American Eel (Anguilla rostrata) in Ontario. Canadian Science Advisory Secretariat, Research Document 2011/050, Central and Arctic Region, Fisheries and Oceans Canada. 18pp. Available: http://www.dfo-mpo.gc.ca/Csas-sccs/publications/resdocs-docrech/2011/2011_050-eng.pdf. .
[39] Hildebrand, L. R. and M. Parsley. 2013. Upper Columbia White Sturgeon Recovery Plan – 2012 Revision. Prepared for the Upper Columbia White Sturgeon Recovery Initiative.
129p. + 1 app. Available at: www.uppercolumbiasturgeon.org
[40] *Middle Columbia River Steelhead Recovery Plan 2009*
[41] Kondolf, G.M., E.W. Larsen, and J.G. Williams. 2000. Measuring and modeling the hydraulic environment for assessing instream flows. North American Journal of Fisheries Management 20: 1016-1028.
[42] Kondolf et al. 2000
[43] Jowett, I.G. 1997. Instream flow methods: a comparison of approaches. *Regulated Rivers: Research & Management* 13:115-127

on physical, chemical and biological conditions may take decades or centuries to become apparent." [44], [45], [46]

The decline in fish populations can have significant effects on local economies; for instance, decline and eventual closure of the commercial sport fisheries for American Eel in Ontario had an important economic impact to local communities in Ontario. American Eel landings once represented 50% of the value of the total landed catch from the lake, but the fishery was closed in 2004 due to severely reduced abundance. [36]

6. Cumulative Impacts of Multiple Projects on a Single River

To compensate for the lower output of power generation from a small river operation, developers will often opt for building several cascading units on a single river, thus multiplying the impacts. The cumulative effects of such projects can include severe fragmentation of aquatic habitats due to multiple dams, as well as fragmentation of terrestrial habitats due to the associated infrastructure (generating stations, hydro corridors and access roads). Yet cumulative effects are seldom adequately considered by the proponent led Environmental Assessment process.

For example, the Ottawa River supports 50 waterpower facilities, and their effects have not been effectively mitigated, nor has there been any meaningful attempt to do so. Adding more facilities to this watershed makes little sense without effective mitigation of existing effects. There are many more watersheds with similar cumulative environmental impacts that should be carefully examined in the context of cumulative effects before introducing more waterpower facilities. It may not be possible for instance to effectively mitigate some impacts depending on the circumstances within the watershed; and the potential for mitigation of effects should be determined before the release of sites for potential waterpower development.

To provide an overview of the extent of ORA's interests with regards to power generation, we are providing a list of ORA's recent submissions on Ministry of Energy and Ontario Power Authority policy reviews:

- EBR #011-9614 - Conservation First – A Renewed Vision for Conservation in Ontario
- EBR #011-9490 - Ontario's Long Term Energy Plan
- Feedback on the Large Renewable Competitive Procurement Process
- FIT Program Review - FIT 3

The supporting information we have offered above is by no means exhaustive, however, it should provide a good overview of why ORA has such pressing concerns over the inclusion of hydroelectric in the Long Term Energy Plan, and especially its inclusion under the Green Energy Act and FIT Program, or any other kind of incentive program.

[44] Ryan, S. 1997. Morphologic response of subalpine streams to trans-basin flow diversions. *Journal of the American Water Resources Association* 33:839-854
[45] Petts, G. and P. Calow. 1996. *River biota: diversity and dynamics*. Blackwell Science, London, UK.
[46] Tamed Rivers – A Guide to River Diversion Hydropower in British Columbia – P-15.

Table 1 – Current Waterpower Proposals under 10 MW:

Following is a list of waterpower proposals that we are aware of. There is no complete list available to the public, so this list may not reflect all current proposals, but all are under 10 MW.

	RIVER	FIT PROJECT	Installed Capacity MW	Actual Power MW
1	Kapuskasing River	Outlet Kapuskasing lake	2.5	1.25
2	Kapuskasing River	Lapinigam Rapids	8.2	4.1
3	Kapuskasing River	Middle Twp	5	2.5
4	Kapuskasing River	Near North Boundary	3.75	1.88
5	Petawawa River	Big Eddy	5.3	2.65
6	Larder Lake	Raven Falls	1.25	6.25
7	Ivanhoe River	Third Falls	5.1	2.55
8	Ivanhoe River	The Chute	3.6	1.8
9	Frederick House River	Wanatango Falls	4.67	2.34
10	Serpent River	Four Slide Falls	7.3	3.65
11	Serpent River	McCarthy Chute	2.0	1
12	Serpent River	Pecors Power Small Hydro Project	2	1
13	Blanche River	Marter Twp.	2.1	1
14	Vermilion River	McPherson Falls	2	1
15	Vermilion River	Cascade Falls	2.1	1
16	Vermilion River	At Soo Crossing	4.3	2.1
17	Vermilion River	Wabagishik Rapids	3.4	1.7
18	Wanapitei River	Allen & Struthers	2.8	1.4
19	Wanapitei River	Secord Rapids	750 kw	475 kw
20	Shaw Dam Lake	Shaw Dam GS	200 kw	100 kw
21	Little Rapids	Little Rapids GS	200 kw	100 kw
22	Clyde River	Herron Mills Waterpower Project	156 kw	78 kw
23	Grand River	Elora Hydro Electric	1	500 kw
24	Mississippi River	Almonte GS	5	2.5
25	Mississippi River	Enerdu Hydroelectric Project	1	.5
26	Twelve Mile Creek	Shickluna Small Hydro Project	4	2
27	Kawartha Lakes	Northland Power Hydropower Project	500 kw	250 kw
28	Drag River	Drag River GS	0.3 kw	0.15 kw
29	Kabinakagami River	Neeskah Project	6.5	3.25
30	Kabinakagami River	Peeshoo Project	6.5	3.25
31	Kabinakagami River	Wapoose Project	6.5	3.25
32	Kabinakagami River	Wahpeeston Project	6.5	3.25
33	Trout Lake River	Trout Lake River Hydro Project	4	2
		Total Hydroelectric Proposals - MW	110.2	55.1

Note: 33 waterpower proposals will compromise 19 Ontario rivers and their ecosystems to generate 55 MW of power under the Green Energy Act. Studies show that headponds produce significant amounts of greenhouse gas and mercury – 10 to 20 times increase.

Seasonal flows limit actual power generated to approximately 50% of Installed Capacity.