Waterfalls Hydropower Development: impacts to aesthetics generally and to "holy places" particularly

Visualization in Waterfalls Hydropower Aesthetics: Impact Assessment, Mitigation, and Post-facto Evaluation

1. Artworks, Industrialization, Methodologies and Venues

Since the dawn of the industrial revolution, the extraordinary kinetic energy of great volumes of water falling from great heights has always been irresistible to technological exploitation: originally for strictly mechanical devices, e.g., simple gristmills or sawmills; later on for much more elaborate belt-driven machinery installations. Such early energy usages needed, of course, to be in the immediate proximity of the waterfalls themselves. But by the 1870s, with the first relatively primitive hydroelectric turbines being installed at waterfalls, the end users of the new power plants were no longer compelled to be situated immediately nearby, as the electricity yielded could readily be "wheeled" long distances through distribution systems.

In terms of capital investment, waterfalls are especially attractive to hydropower developers: by emplacing a low barrage, say, of 10m in height, just upstream of the falls escarpment, and the flow thereby diverted to a pipe or tunnel releasing at the turbine headworks near the toe of the falls —or even far downstream from there— if the resultant gain in *hydrostatic head* was 100m, the actual yield of power was equivalent to a dam 100m in elevation for the cost of erecting a structure only a tenth of that height. The only problem was that the waterfalls itself would be terminated as a consequence.

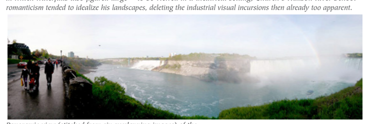
The engineering rule-of-thumb is that the design *throughput capacity* for a waterfalls hydropower installation be equivalent to approximately twice the statistically-derived *mean annual discharge* (at the damsite) of the stream so harnessed. Temporally, this implies that the entire volume previously allowed to run freely over the falls can now be exploited into energy production about 90-95% of the time. Absent any requirement for an intentional *aesthetic release regime* —which necessarily comes at considerable *opportunity cost* for un-generated, un-wheeled, and un-marketed electricity— the waterfalls will be nonexistent nearly all the time.

It would be wildly uneconomic to install a facility massive enough to process the entire streamflow known to possibly occur that remaining 5% or 10% of the time. When installed throughput capacity is exceeded —and this will only rarely be so— the necessarily bypassed over-falls excess is almost always far less than the average pre-project discharge. The visual effect of this reduction, however, may or may not be aesthetically displeasing: depending upon the setting, the morphology of the escarpment, and the expectations of tourists or viewers —if indeed there were/are/will be any.

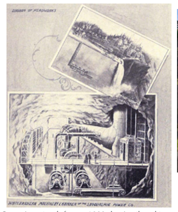
An early waterfalls hydropower scheme at Snoqualmie Falls, in Washington State USA, has been in operation since 1898. It was first to emplace the penstocks, turbines, and generators underground. In 1991 the operator, Puget Power and Light (PPL) had to re-license the facility, pursuant to requirements of the *Federal Energy Regulatory Commission* (FERC). Although since its inception the project had continuously diverted about 95% of the previous overfalls discharge through its turbines, it was still considered a natural wonder, and attracted more than a million tourists annually. The license renewal was opposed by environmentalists and by local Native Americans who regarded it as a despoliated sacred site. FERC required PPL's consultants to experiment with evaluating the visual quality at various levels of discharge, which could be completely controlled (within the existing throughput capacity), since the penstock gates were already in place and could be opened or closed at will. Comparative video and still imagery was presented, and FERC determined that the *de facto* aesthetic release regime was sufficient to maintain most of the natural beauty of the falls. Go to http://vimeo.com/5530039 *[source: PPL]*

Two grand-scale paintings entitled "Falls of Niagara", by Frederick E. Church: the horseshoe falls only from the Canadian side (1857, Corcoran Gallery, Washington, DC), and both cataracts from the American side (1867, National Gallery, Edinburgh). Intended —as with his "Heart of the Andes" (1859, Metropolitan Museum, NY), in which waterfalls also figured large— to be viewed in a theatrical setting, Church's Hudson River School romanticism tended to idealize his landscapes, deleting the industrial visual incursions then already too apparent.

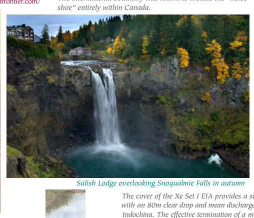
The Porter Brothers issue an "Invitation to Eastern Capitalists"; this first call to develop Niagara power on a large scale goes largely unanswered (1825). A Hydraulic Canal is completed; it is 36 feet wide and 8 feet deep; the Civil War ruins its chances for successful development (1861). Charles B. Gaskill establishes a flour mill on the Hydraulic Canal's Basin (1875). See http://www.niagarafrontier.com/



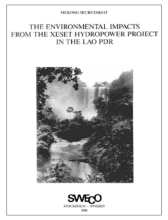
Panoramic view (stitched from six overlapping images) of the escarpment: looking north, from Niagara Falls, Ontario; with Goat Island, in New York, USA, shown here near the center. The international boundary was drawn to include the "horse-shoe" entirely within Canada.



Souvenir postcards from c. 1900 showing the subterranean hydropower installations at Snoqualmie: now a National Historic Civil Engineering Landmark.



Salish Lodge overlooking Snoqualmie Falls in autumn



MEKONG SECRETARIAT

THE ENVIRONMENTAL IMPACTS FROM THE XESET HYDROPOWER PROJECT IN THE LAO PDR

SWECO

Cultivate Understanding Multimedia Digital Conservation Facility, Laos

The cover of the Xe Set I EIA provides a superb photograph of ex-Tat Set Falls, Laos. Tat Set, with an 80m clear drop and mean discharge of 15 cumecs, was amongst the splendid waterfalls of Indochina. The effective termination of a major waterfall is considered ordinarily as an environmental impact, but the resultant "sacrifice" of Tat Set (and later, of Tat Setkhot Falls, just upstream) didn't get mentioned, even indirectly, in the project documentation. According to one of the Lao authors, "This was to avoid leading to possible public opposition."

Evaluating and ameliorating visual impacts of waterfalls hydropower on holy sites

There is no sharp line between "natural patrimony" and "cultural heritage" and commonly, sites or objects of primarily natural provenance may come to be ascribed with religious significance. Great cataracts —and sometimes even modest-sized waterfalls— are often considered as holy places and frequently are the venues for erecting shrines and temples.

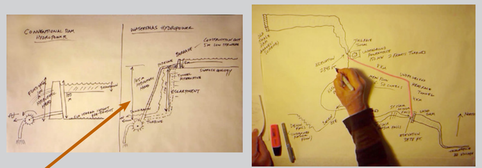
Under the original concept, the Upper Kotmale Hydroelectric Project (UKHP) in the tea country near Talawakelle, Sri Lanka, was expected to terminate five waterfalls, at which at least two were located minor shrines and the third the setting of a highly revered — amongst the "Plantation Tamil" community— miracle temple. Initially, both the Japanese funders and the national project proponents were resistant to the concept of "aesthetic releases" which should have at least partially or intermittantly conserved the beauty and spiritual character of waterfalls otherwise being sacrificed to energy development, but which would have necessarily entailed significant "opportunity costs": i.e., foregone revenues for ungenerated and unsold power.

The controversy over UKHP, largely on the waterfalls issue, delayed its construction for fifteen years, but it was eventually approved and quite recently completed., and the project as-implemented included consideration of aesthetics and cultural sensitivities. We will be presenting the original image archive produced in 1991 for the required environmental documentation, but also new interactive digital media from our December, 2013 post-facto evaluation of the UKHP's actual visual impacts.

While the loss of the waterfalls was regrettable, the task before us now is to convince the relevant authorities that such a sacrifice was necessary...*

Funded by the Japan International Cooperation Agency (JICA) and thus tied to exclusively Japanese-sourced engineering and hardware, the *Upper Kotmale Hydroelectric Project (UKHP)* — in its original conceptualization, with c. 160 MW of installed generating capacity— was a staircased, intra-basin transfer scheme which entailed bypassing the previous discharge over five waterfalls: of which at least two approached world class.

The Project's primary impacts were on aesthetics and cultural properties, both natural and man-made. (Involuntary displacement and rehabilitation of businesses in the Project's footprint were within the brief of a separate Social Impact Assessment (SIA) consultancy.) For the mandatory environmental impact assessment (EIA), the two questions at the forefront were:



- How to determine and implement a plausible and visually-satisfactory aesthetic release regime acceptable to the Project's critics; and —given that the relatively pristine Upper Kotmale Basin venue had been promised, although never institutionalized, as the "forever-wild" mitigation region for the much larger irrigation and hydropower schemes comprising in aggregate the Accelerated Mahaweli Programme. . .
- Whether the Island's remaining waterfalls —irresistible, of course, to hydropower developers because of their attractive benefit/cost (B/C) aspects and engineering efficiencies— should in due course be similarly sacrificed, one by one, to water resource management (WRM); and by extension, who gets to make that decision in the larger national interest?

** On arrival in Colombo the impact assessment consultants were so advised by a pre-Inception Report white paper, "in light of the importance of energy to Sri Lanka's development objectives." With boundless naïveté, it was assumed that this Prime Directive was addressed to the in-house engineers and economists: rather than the expected output of the environmental reporting.*

Victoria Falls and Rapids sacrificed to Victoria Dam: (Accelerated Mahaweli Programme)

Mahaweli – Victoria Dam

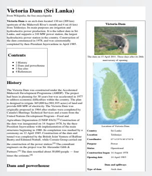
In the 1980s, based on advice and studies by British engineers, the Victoria Dam was built. It is a concrete arch dam 122m high and 507m along its crest. It was opened by Mrs Thatcher in 1985. This created the Victoria Reservoir which flooded the Mahaweli Ganga valley requiring the relocation of 80,000 villagers and the loss of fertile bottom valley land.

This was also a controversial scheme. Representations were made to the World Commission on Dams during their investigations during 1999/2000. The Commission concluded that no more schemes should be promoted that had the effects on the environment caused by Victoria: loss of Victoria Falls with too much of the water being taken for energy with no overflow resulting in the virtual disappearance of the river. (see

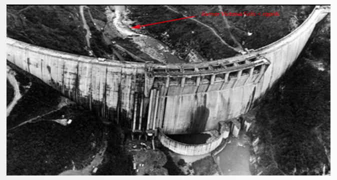
However the stored water is used for the generation by hydropower of 40% of Sri Lanka's total energy requirements. The water is then discharged downstream where it is fed to other reservoirs in the Mahaweli system for wider distribution in the north of Sri Lanka for treatment and potable use.

[source] http://www.wcmt.org.uk/sites/default/files/migrated-reports/100_1.pdf

Principles and Practices of Power Planning in Ceylon



Victoria Dam (Sri Lanka)



An aesthetic release regime for St. Clairs Falls: from outright rejection to eventual acceptance

In the early 1980s, the US Agency for International Development (USAID) conducted an in-country "capacity building" exercise in Environmental Impact Assessment (EIA) methodologies and praxis for Sri Lankan agencies expected to soon be in the forefront of their adoption. In order to avoid potential controversy by selecting for the training research venue and critique no schemes likely to be actually implemented, the USAID team —in conjunction with their Lanka counterparts— chose the then-seemingly-hypothetical Upper Kotmale Hydroelectric Project (UKHP).

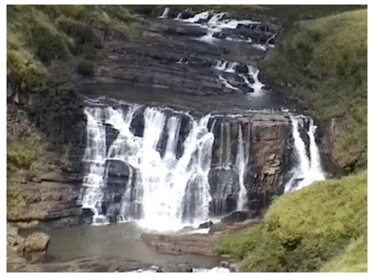
The engineering advantages of waterfalls hydropower projects were vetted in the 1950s Ceylon Power Planning Study, and indeed, two of the most favored prospective projects in that document were just above Victoria Falls on the mainstem Mahaweli, and just above St. Clair Falls on the Upper Kotmale. Both were foreseen as involving lengthy tunneling to maximize hydrostatic head at power stations erected at lower elevations far downbasin, which would have dewatered the previous channels. Victoria Dam was completed just before the EIA training, under the Accelerated Mahaweli Development Programme (AMDP) and whatever the virtues of the AMDP, it seemed clear that while environmental constraints hadn't figured heretofore in its planning and evaluation, EIA would certainly be soon coming into its own in Sri Lanka.

Since UKHP would require sacrificing two of the Island's most impressive and best-known waterfalls: St. Clairs and Devon —both of which were visible from the scenic Hatton Road and the Kandy-Badulla rail line— it was widely believed within the newly strengthened regulatory agencies; within the NGOs; and the across much of general public that given the waterfalls issues at its heart, the UKHP was a pipe dream, and thus a perfectly harmless choice.

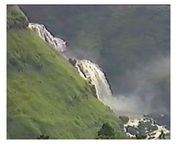
However —unaware or not of USAID's reasoning— JICA (and its consultants) and the Ceylon Electricity Board (the C.E.B., the national utility) were of a different view on the UKHP, with its technical and economic criteria determined as positive by their 1987 feasibility study, which in fact cited the regrettable loss of the waterfalls as the Project's major downside, but one expected to be manageable politically.

A *discharge duration curve* describes the percentage of time that a particular level of streamflow is reached or exceeded. Based on the hydrological data, the *design throughput capacity* of the Project —36.9 m3/second— would be expected to be reached or exceeded approximately 8% of the time. The other 92% would be that period when there would be no technical limitation on the Project operator's ability to divert all incoming streamflow through the tunnels and turbines. Under those conditions, the falls would be completely dried.

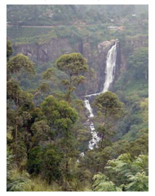
As the UKHP's design and siting came under detailed consideration, the CEB's main source of local expertise —the Central Engineering Consultancy Bureau (CECB)— was concerned over a previous project: constructing the roadway up Pidurutalagala mountain with foreseeable but unmitigated aesthetic impacts. CECB staff were instrumental in trying to convince the Japanese and the CEB to prioritize such considerations in the UKHP. The various alternatives put forward by CECB, notably the Yoxford Option —which were admittedly sub-optimal from purely engineering and economic weighing, but which would would have left St Clair's appearance essentially unchanged and have likely defanged potential opposition— were dismissed almost out of hand. The strongest legal challenge to the UKHP was exactly over "the inadequate consideration of lower-impact alternatives."



St. Clair Falls middle drop, 1994 (above); St. Clair middle and lower drops, 2001 (above right)



Devons Falls, 2001 (above); 2013 (below)



"We are made to understand that Japan has threatened the Sri Lankan Government to stop all funding for Sri Lanka if we do not agree to implement the controversial Upper Kotmale Hydropower Project...We express our great dissatisfaction with the conduct of Japanese agencies in Sri Lanka...." Environmental Foundation Ltd. (2002)

"This Project which was to be launched in the 1980s, never saw the day of light due to political expediency and various other reasons and intimidation...until the bold decision [in April, 2005] to proceed with the construction...regardless of political pressure..." Media Center for National Development of Sri Lanka (2013)

Dunsinane Oye Kovil: The Miracle Temple along the Middle Plunge Pool

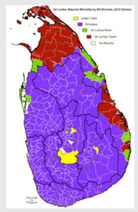
The topographic setting of the Dunsinane Tea Estate is characterized by a spectacular pinnacle that can be seen as a "*Shiva lingam*": emblematic of the procreative force of the godhead. (Similarly so with the dramatic locale of Wat Phu; originally a pre-Angkorian, Khmer Hindu holy site now in southern Laos.)

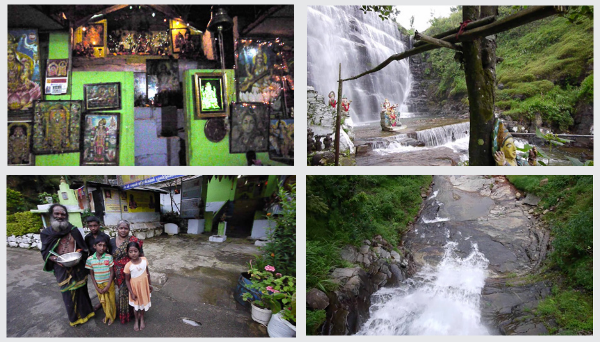
The falls at Dunsinane Oye, divided by a large plunge pool between the upper and lower drops, is thus already a portentous religious venue and —according to interviews conducted during the original UKHP EIA research— after several tea estate laborers had recurrent dreams of *swayu linga*, i.e., natural rock forms identifiable as precious *Shiva linga* immersed within that plunge pool, three large such stones were recovered by divers, and an enclosed devotional temple (or *kovil*, in Tamil) was in due course constructed with an altar to properly present them — handsomely decorated and enhanced with colors and textiles— for local worship.

Over several decades, the Dunsane Oye kovil came to be viewed as a "miracle shrine" where through healing prayer, vision could be restored to the blind; the lame could be made to walk, etc. One of the original estate laborer-visionaries established himself —with his family— as the resident priest, notwithstanding his non-Brahmin origins. Eventually, since the shrine was easily accessible by public buses, Indian Tamil pilgrims from throughout the upcountry plantations came to offer their devotions.

The founding and popularization of the Dunsinane Falls kovil corresponded with the first feasibility study (1987) and the later elaboration and design formalization of the Japanese (i.e., JICA-funded) Upper Kotmale Hydroelectric Project. Until the Project implementation was stalled for nearly fifteen years over domestic environmental conflicts —primarily waterfalls-related— the dewatering of Dunsinane Falls and its flow rediversion directly to the Upper Kotmale reservoir was an engineering feature that wasn't withdrawn until the bitter end; even though it's maximum contribution to the aggregate energy yield of the entire scheme was only about one megawatt: roughly the power demand of a single modern hotel.

In interviewing the kovil priest in 1993, he was adamant that if indeed Dunsinane falls were dewatered (as they would have been no less than 90-95% of the time) by the UKHP, he would self-immolate in protest by jumping from the upper escarpment.





Visualization in Waterfalls Hydropower Aesthetics: Impact Assessment, Mitigation, and Post-facto Evaluation

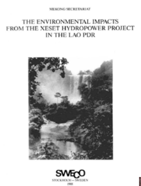
2a. Upper Kotmale Hydroelectric Project, Talawakelle, Sri Lanka: Environmental Reporting + Public Participation (1993-2002) + eBook

In development planning and project evaluation, two sharply contrasting implementation strategies may be applied to almost any engineering scheme likely to prove contentious on environmental or social grounds:

The first could be called accommodationist. Central to this approach is identifying —well in advance of design finalization— the source and the substance of opposition likely to arise against the proposed project; to determine whether such a critique appears valid, reasonable, and subject to negotiation; and then to devise mutually agreeable solutions, in a context of transparency and presumed good faith. Wherever such solutions cannot be found, a frank and candid analysis of the unresolvable issues should be prepared and then either incorporated directly into the EIA, or otherwise distributed appropriately.

Alternatively, the proponents may choose a confrontational approach; total or partial. Here, project critics are seen as the enemy and a military-style strategy is applied to achieve speedy, unconditional implementation; i.e., "victory". Nothing is voluntarily supplied to potential opponents which may strengthen their tactical position or facilitate their intelligence-gathering; and project resources are specifically deployed to maximize momentum towards construction.

That may prove an opportune game plan where decision-making is monopolized by a political or technocratic elite; where potential critics are socially marginalized; where ironclad financing is already secured; where the news media is certain to be antipathetic to project opponents; and where recourse to judicial or administrative means of obstruction is unavailable. If any of these conditions are absent, the confrontational mode of development planning risks backfiring: often very expensively —in terms of money, time, and institutional credibility.



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SWECO

The agenda of the Lao PDR government—which tolerates zero domestic opposition to State planning—is to become the "battery of Asia." Protecting waterfalls is a non-issue.

Snoqualmie Falls, near Seattle, USA, was the site of the first underground hydroelectric station in North America: built in the late 19th century. In 1994, it was necessary to apply to FERC for a new operating license. The central conflict was the appropriate aesthetic discharge.