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A Water Allocation Methodology for Predicting Water Releases from Deep Creek Hydro

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Executive Summary

This report attempts to define the requirements for a water allocation methodology (WAM), also referred to as a "water budget" model along the line suggested by Morgan France and how it might be used.

Introduction

Morgan's water budget methodology has been shown to be a tool that is able to assess the historical records of water releases from the Deep Creek Hydroelectric Project [1] without a-priori knowledge of groundwater flows and rainfall.

This report examines how this methodology might be used as a forecasting tool for water releases and how it could be tested.

No tool has yet been developed to optimize the allocation of the Deep Creek Hydro Project water releases to its stakeholders. This report examines its possibility in a heuristic sense by conduct certain "gedanken" experiments, "thought" experiments, to assess feasibility. It is quite clear that no methodology is going to be perfect and satisfy everyone all the time, but it is entirely possible to have one that all stakeholders should be willing to accept.

Here at Deep Creek Lake we have a situation with contradictory demands on the waters of Deep Creek Lake. One the one hand some stakeholders want a lot of releases, on the other hand there stakeholders who want essentially no releases, except for perhaps to keep the water level just below the spillway.

Because not everyone is going to be happy at all times the methodology must be fair to all parties. The question is to "What's fair" can surely be debated.

While certain stakeholders are working tirelessly to have the waters at the Southern end of the lake dredged to gain additional water depth, chances for funding such an expensive proposition are slim, at least at this time.

The proposed water allocation methodology described in this report, based on the water budget approach described elsewhere [1], is simple and adaptive to changing climatology and water depths.

Approach.

The first tenet of the approach is that Condition 19 of the whitewater schedule in the current MDE permit with Brookfield [2] is done away with entirely as a mandatory condition. Instead it should only be used as guidance.

The TER protocol should be done away with preferably, and if not its methodology needs to be revamped because the current produces produces far too many errors for such an inherently simple problem, given current analytical tools and and instrumentation. The basic TER notion could still prevail mostly.

In addition, the purpose of both the white-water and TER releases must be reexamined in terms of their economic implications for the County and the State.

The proposed approach, WAM, hinges on the facts that a) the current water level in the lake, as measured by Brookfield[1], b) the existing lower rule band (maybe some fine tuning?), c) a few conditions that must be met and d) a set of desirable outcomes, can be used to determine the timing and duration of all releases on a daily basis.

Note that rain, creek flows, ground water flows and lake surface evaporation [3] are automatically accounted for by just considering the water level on the day of an assessment which should be done daily.

The MUST conditions will probably relate to certain mandatory white-water releases, such as for Memorial Day, July 4th, the "Friendsville Upper Yough Annual Team Race", "Gauley Week" and TER releases. As stated earlier, a TER release should be considered provisional upon a new TER model and protocol, because the existing one has too many false forecasts. A new TER model is being investigated [4].

All other white-water releases and discretionary events are subject to the predictions made with WAM. TER releases are also subject to the WAM as long as the expected exceedance of 25°C at is less than a certain amount and duration (to be specified).

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[1] NOTE: A second gage should be placed somewhere else to provide verification and redundancy.

I visualize the WAM to operate nearly autonomous, meaning it operates on a continuous basis, being activated automatically every day at say 4 am (this time is arbitrary and perhaps needs some more thought). WAM would generate for the Deep Creek Hydro operator a daily listing of possible release schedules (certain and tentative releases).

To make such an analysis possible, the following should be downloaded from various (to be designated) data sources from the Internet first:

1. Current weather conditions and short and long term forecasts; The specific location (and alternative location(s)) from which is yet to be determined. If this fails, historical data can be used to make the forecasts.
2. River flows at Oakland and other locations to be determined (and if necessary)
3. The river water temperature measurements at the Sang Run River bridge and other locations (to be determined, if necessary)

The next step is the execution of a set of applications (at 4 am; these applications are not expected to take more than just a few minutes of computer time (downloading the required data from other sources can certainly be done in less than one hour):

1. Analyzing the downloaded data from the Internet and convert them for use in the next applications. This includes considering mandatory releases and other proposed releases.
2. Compute the expected temperature at the Sang Run river bridge for today and forecasts for the next week or two. Set appropriate flags to define if a release is to occur and what the chances are for releases in the next few days, or perhaps even weeks.
3. Compute the number of days that the current stored water can be used to satisfy proposed releases.
4. Issue the appropriate notifications (phone message, emails, text messages, etc.) (all canoe easily automated)

The WAM will alert the Brookfield operator daily whether to conduct a release at a certain time and for a certain duration or specify a "no release." One of the questions to be investigated is: "How far into the future can we make the forecasts?"

A simple schematic of the overall process is shown in Figure 1.

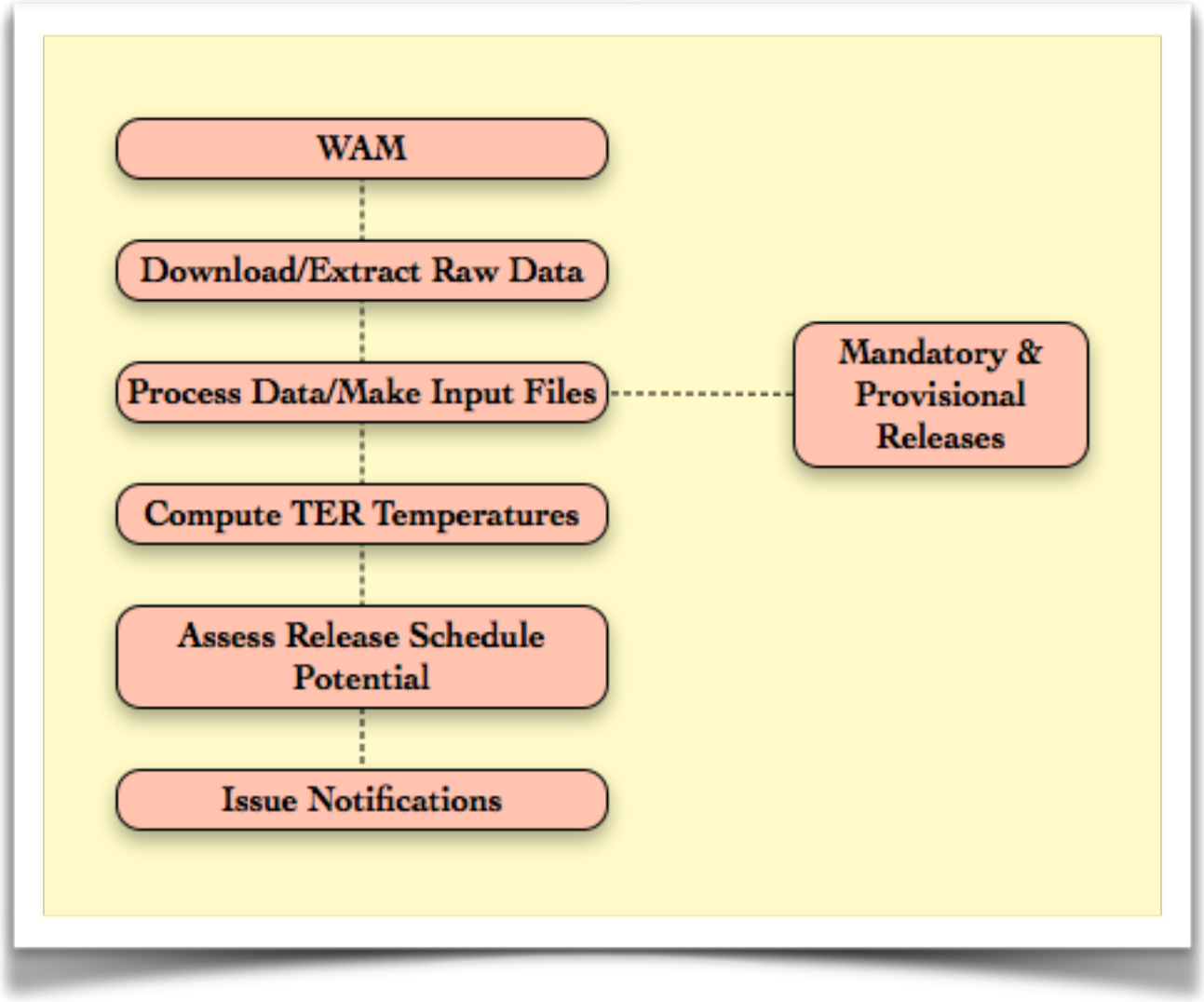

Figure 1 - Simple Schematic of the Predictive WAM

The WAM should be able to provide a forecast, much like forecasting cloudy conditions and rain, meaning, do so with a certain probability. The probabilistic approach may take a few years to mature, but good estimates based on past performance should already be doable.

Development Aspects

To develop and subsequently validate a methodology requires observations of various parameters.

The most important set of data are those that ensure that the methodology works as expected. If we can't validate, than no matter how 'sexy' the methodology is, it's useless.

To validate the methodology we must have a set of data that is unencumbered by actual events. Unfortunately, this is not possible, since the current protocols don't provide that kind of flexibility. However, detailed data of Deep Creek Hydro's operations are collected in real time, today, and so far I have a full complement of lake levels every ten minutes for the year 2017. If a methodology can be established by the official start, or not to far beyond it, of the white-water and TER season, namely 4/15/2017, a good case could be made.

In the mean time, for development purposes, we need the same detailed level of data for the years 2011 through 2016. Fortunately, I recently acquired, courtesy of Jeff Leeks detailed (mostly 10 minute interval) lake levels and generator status as 'scraped' from the Deep Creek Hydro website. This data is available on the deepcreekscience.com website under "DataVault-> Lake Levels" menu item. An almost complete record set of similar data and a similar 'scraping' process was obtained by the author of this paper for 2012.

With the detailed records, one could role back some of the releases that are occurring one or two weeks ahead of a given analysis day by pretending to reverse the flow during that period in order to get a 'proper' starting lake level.

For example, suppose we're on May 6 and are doing our forecasts. We know the lake level on that day at the time of the analysis (perhaps take an average of the last hour). Suppose we're after a prediction period of two weeks. All releases that would have occurred during those two weeks could be rolled back into increased lake levels on the day the releases were made, and use those lake levels as part of the available storage.

The error that is introduced is the actual change in the rate ground water and creeks flows into the lake because of higher lake levels. Since groundwater flows are a function that depends on not only on what is in the ground, but also on lake levels themselves. Furthermore, there are only a few creeks flowing into the lake, all with a relatively small flow rate. This error should should hence be relatively small.

Whether this will be necessary is not certain at this time, but it is a way to generate a, more or less, truer set of operating conditions.

Weather conditions are another set of important parameters. Short-term and long-term forecast are expected to play a role in the perceive methodology, especially concerning TER releases. Whether such records are available historically is uncertain.

There are various weather stations around the lake from which real time ambient winds and temperatures can be obtained, but solar radiation, which is expected to be an important parameter for TER determinations, is not measured anywhere nearby, although this is a relatively easy measurement to make. We need solar radiation measurements!

The Plan

Since we have 10 minute interval data for lake levels and generator status for a five year period these can be used to develop the methodology. In other words, the development of WAM can get started now.

Although we have "generator status" information in the form of generators ON or OFF, it says nothing about whether the both turbines are operating or whether they are operating with the wicket gates less than full open.

However, this can be determined by looking at the USGS river flow gages. A release in these gages shows up as spikes. The hight of the spike is related to the net effect of one or two turbines operating and the setting of the wicket gates, which is all we need to determine the total amount of water being released.

This has been examined in a separate report [5]

List of References

1. P. Versteegen, "Morgan's Water Budget Model," DCL219, April 2, 2017.
2. Current Permit (01-Jun-2011) - BROOKFIELD POWER PINEY & DEEP CREEK LLC - GA1992S009(08), MDE, http://mde.maryland.gov/programs/Water/Water_Supply/Pages/DeepCreekLakePermitVersions.aspx
3. P. Versteegen, "Evaporation from Deep Creek Lake," DCL043, December 12, 2013.
4. P. Versteegen, "A Youghiogheny River Temperature Model," DCL221 (under development).
5. P. Versteegen, "Processing the USGS River Gage Data," DCL222, April19, 2017