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Preliminary Plan to Study the Groundwater Portion of the Deep Creek Lake Water Budget

1. There is good evidence that groundwater contributes to the recharge of the lake. The best available evidence is the recharge that occurs during periods twenty-four hours after a rainfall event, and between release events. This effect can be seen on the lake level charts found on http://deepcreekanswers.com/ . The biggest unknowns regarding the groundwater dynamics are: (a) the groundwater contributing to the flow in Deep Creek below the dam as well as directly into the Youghiogheny River, and (b) the dynamics of the groundwater contribution to the lake.

2. Flow isolation in the Youghiogheny River can afford a view of the groundwater that is conveyed away by critical reaches of these streams. Three measurements in a cluster around the nexus of Deep Creek and the river, and one between the nexus and the gage at Hoyes will provide a gross look at the leakage through and around the dam in Deep Creek, and how much groundwater is entering the river between Deep Creek and the tailrace. Subtracting the flows at a point upstream of the tailrace from the flows at the Hoyes gage will yield the added flows both when the plant is resting and when it is running. The proposed locations are shown on the attached map (DropBox, Geo18312WB207Dam.pdf)

The results of these measurements may raise more questions, such as what is the distribution of the groundwater contribution from the toe of the dam embankment to the nexus with the river. We also may need to measure flows upstream from the nexus in several locations.

The flows at these locations could be measured by establishing a pair of field measured cross sections fifty feet apart in a reach that is as uniform as possible. The distance between them could be adjusted to suit the stream channel. The stream velocity could be measured by timing floats, or a flow probe such as the Model AA, which is the primary unit used by the USGS, with a Digimeter. The estimated cost of the flow meter is $2,500. The flow can be calculated for each section using the relationship Flow=Area x Velocity. The two sections should yield similar flow rates.

Additionally, a check on the work would be to use Manning's Equation (V = 1.49/n times $R^{0.0.6667 \text{ times}}$ $S^{0.5)}$ and the section geometry to solve for the velocity between the two sections. These procedures are described in "Open-Channel Hydraulics" by Ven Te Chow, PhD, McGraw-Hill, 1959. Multiplying the computed velocity by the average cross-section area will yield the flow rate. The most important variable in the process is the location of the sections on a uniform reach to yield reliable results.

If the sections were extended horizontally the flow could be calculated at different water levels by measuring or calculating the velocity and the water level through the sections. Local benchmarks should be established when the sections are measured. We are working on an estimate of the cost of the field work, and how it can best be accomplished.

3. There are several free groundwater modeling programs from the USGS online at http://water.usgs.gov/software/lists/groundwater. The state has been collecting groundwater data for many years in the form of Well Completion Reports, which are on file for most of the wells in Garrett County. These completion reports are a wealth of information about each well. The data that is immediately useful is the static water level and the pumped yield. The static

water level is the depth from the top of the casing to the water in the well when it is resting.

Hope exists that at least some of these well completion reports exist in a digital format. Completion reports will have an address for the site and a sketched well location. By looking at the address site on Google Earth and the sketch on the completion report, the well location could be approximately georeferenced. It could be plotted on the 1953 Maryland Geologic Survey map (DropBox Geo20812WB.pdf), and other mapping tools used for other aspects of the study.

USGS did a groundwater study in the county in 2009.

Once the existing data is compiled one or more of the appropriate software programs could be applied to create a model. The predictability of lake recharge from the model could be compared to measured recharge. If the agreement is poor, more ground water data could be obtained from the record, or acquired in the field. Apparently Maryland Geological Survey is in the process of collecting additional groundwater data in the county. It is not apparent that the existing groundwater data has been mined enough.

Some of the computer models on the USGS website can integrate rainfall into groundwater recharge and runoff. There are several methods available to analyze runoff for a given rainfall event. The best analysis would integrate runoff, infiltration, groundwater recharge, and evapo-transpiration components.

4. Concurrently we should be working on the outflow side of the equation. The outflow from the power plant and other subsurface discharge can be measured at the Hoyes gage by subtracting the flow at the downstream nexus section. The downstream section would indicate the stream base flow. The difference would be the Deep Creek contribution.

The rainfall can be measured and entered into the runoff model. Less certain will be the losses from evaporation on the land and from the lake. Even more uncertain will be water lost to transpiration. However, given several years worth of observation a very good model of lake levels based on groundwater levels and rainfall could be developed.

The goal is to be able to ascertain with a reasonable degree of certainty what the lake levels will be several weeks or a month into the future. If the lake levels were required to be maintained in the median of the rule band instead of bouncing along the bottom in July, August, and September all of the above studies would not be needed.

Respectfully submitted,

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