Research Project #1
Modeling the Dynamics of the Water Level of the Lake

Deep Creek Lake is is a manmade lake. By law, the lake is designated to be used for recreation. However, there are a number of competing processes for the use of the water thereby possibly limited the use of the lake for boating purposes because the water level is too low. This can have a significant economic impact on the region.

The purpose of this study is model the dynamic behavior of the lake's water level and recommend operating procedures to maximize the use for recreation.

The water level of the lake at any time is determined by a number of complex processes. The processes that determine the water level of the lake are the following:

Sources:

1. Rain fall - Rain falls on the lake directly, but also on the watershed. Some of the rain is absorbed in the soil, some directed towards streams and storm water drainage systems, some in natural drainage towards the streams and lake, and some by evaporation back into the air.
2. Streams - Water flows into the lake from multiple streams. The water in the streams comes from drainage during and after storms and from springs.
3. Percolation - Water comes in the lake from percolation through the lake bottom as a result of hydraulic pressures. This includes some natural underwater springs.
4. Culverts - Storm water management systems connect to the lake to dump water collected from rain storms.
5. Runoff - This is water from rain the runs directly into the lake bypassing the storm water management systems.
6. Condensation - When humidities are high and water temperatures low compared to air temperatures, water vapor condenses into the lake.

Sinks:

1. Evaporation - Lake water evaporates into water vapor when certain conditions prevail. The main conditions are:
    1) The temperature of the water at the air-water surface
    2) The humidity of the air
    3) The area of the air-water surface
    4) The temperature of the air (more on this below)

In a real-world situation of evaporating water, none of these three quantities above remains constant because the process of evaporation itself changes them. Water evaporating takes quite a lot of heat away -- 540 calories per gram -- when it evaporates. That's enough to cool down 540 grams of water by a degree, or 50 grams of water a little more than ten degrees. If you are not very careful to replace the lost heat energy during the evaporation, the temperature will go down, and even then the temperature right at the surface will be lower than elsewhere in the water and it will depend on

5) Water currents convecting heat and the ability to keep the temperature constant at 100 degrees F.
6) Airflow past the water/air surface.
7) Water surface activity created by boating traffic

2. Power Generation - The Brookfield power plant is allowed to use lake water to generate hydroelectric power. The permit stipulates a set of conditions and rules that must be followed.
3. Wicket Gate Leakage - these gates control the amount of water that enters the power generating turbines. Because of age they do not close perfectly and leak water constantly through the turbine.
4. Dam Leakage - Because of hydraulic pressures ome water always penetrates the ground and leaks through at the other side of the dam
5. Controlled Releases - Water is purposely released from the lake to satisfy certain regulatory requirements. At present there are two requirements that override the ability to generate power:
    1. Release for white water rafting concerns
    2. Water temperature releases for maintaining trout stock (Temperature Enhancement Releases - TERs).
6. Extraction Permits - There are several permits that allow the extraction of water from the lake for commercial purposes.
    1. Wisp - to extract water for snowmaking
    2. ASCI - to operate their recirculating white water course.
7. Absorption - Water is continually absorbed by certain areas of the lake bottom surface and drains into the ground water system.
8. Volume Change - The lake volume changes as a result of the influx of sediments.

The dynamic model should compute the hourly value of the lake water level. To accomplish requires the modeling of the processes identified above, some of which operate constantly, others occasionally, some affecting the whole lake, some only parts of the lake. It's expected that a lot of assumptions must be made because of the lack of data. The model, therefore must allow for assessing the impact of the assumptions made. The assumptions most be documented thoroughly.

Expectations:

1. A computer model that simulates hourly the processes identified above
2. The ability to easily perform sensitivity studies to explore those variables that are highly uncertain.
3. A comparison with measured lake water level data for the past 10 to 15 years.
4. Recommendations as to how best to improve the calculations.

Starting Points:

1. Simgua - Complex Simulation Made Easy
2. http://conservancy.umn.edu/bitstream/112812/1/pr263.pdf
3. Water Quality Research Group: CE-QUAL-W2 Hydrodynamic and Water Quality Model
4. Hagg Lake Water Quality Model -- Scenarios

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