Bear Lake plan doesn’t wash

By Roland Jeppson

There have been several news items and letters in the Herald Journal about the Hook Canyon Pump Storage Project. I have made computations similar to homework assignments that I have given students in my fluid mechanics and hydraulic design courses. I wish to few share of a these summary of - a Jeppson

compu tations with people of Utah, Idaho and anyone affected by the project.

I will only deal with the “hydraulics” of the project, since that is my area of expertise. I do not own any property in the Bear Lake area, and am not writing this because some group opposing the project has ask me to.

To help you visualize the enormity of the project you might find it useful to relate the average flow rate of 18,636 cubic feet per second (cfs) that will be pumped from Bear Lake to a man-made reservoir and returned to the lake daily with sizes you are familiar with. Visualize a one-acre lot consisting of 43,560 square feet. This average flow rate will fill this acre to a depth 25.7 ft every minute, or to a depth of 2.33 miles over an eighthour period of operation.

I will only address three concerns, any one of which suggest that the project should not go forward as expressed by the Herald Journal on April 13, “Give Hook Canyon project the hook.” These are: (1) how will the energy from the discharge pipe that brings water from the upper reservoir into Bear Lake during the power generating phase be taken care of without scouring out the lake bottom sediments, (2) the energy lost in the proposed operation will likely be much larger than its proponents indicate, and (3) how will very large pressures be prevented when the water in the pipe between the upper reservoir and power plant must be stopped rapidly because of a failure that takes the load off the turbines

1. Energy entering Bear Lake from discharge/inlet pipe

The velocity will be 26.4 ft/sec in the 30 ft diameter pipe when it carries the average flow rate of 18,636 cfs from and to the lake daily. The maximum flow of 25,000 cfs, for which the inlet/ outlet structure must be designed, produces a velocity of 34.4 ft/sec. The energy coming out the end of the pipe is equivalent to 34,800 horsepower. Visualize how much energy this is. It is equivalent to 348 one-hundred horsepower motors at full throttle. Clearly a carefully engineered structure is needed. A common means for doing this is to enlarge the pipe gradually, called a diffuser, so that the velocity is reduced. To reduce the velocity to 1 ft per second, which Symbiotics has stated will not be exceeded, the exit diameter must be 178.4 ft (larger than the depth here), and even larger if grates are placed over it to prevent fish from entering. Furthermore, it is known that the angle of expansion must not exceed 7 degrees, or the water will separate from the pipe wall and the velocity will not be reduced. To satisfy this requirement necessitates that the expanding pipe be 595 ft long. Would a 180 ft diameter pipe at the discharge/intake be allowed? Alternatives to enlarging the pipe exist, but whatever scheme is used the exit area must equal 25,000 sq ft, with the same velocity throughout this entire area. Any exit/intake structure that keeps the velocity under 1 ft/sec will not only be expensive but very large and likely viewed as unacceptable by many property owners.

2. Energy Lost by Proposed Project

Symbiotics suggests that the operation will lose 25 percent of the energy. Simulations of its operation, that I have done, indicate losses nearly three times this amount. Since no data are provided by Symbiotics about the operating characteristics of the pump/turbines I used those of large similar machines. I then used the computer to simulate filling the reservoir from its lower to its upper operating levels. This simulation is referred to as Quasiunsteady because the effects of accelerating/decelerating the water are ignored. It did include the time varying frictional losses in both the 30 ft diameter pipe between Bear Lake and the power house and the 40 ft diameter pipe between the power house and the varying water levels in the upper reservoir, and a local loss for the bend in the latter pipe. The simulation did not include losses for the manifold that connects the 14 pump/turbines into the system since no detail are given, thus the actual energy for the pumping operation will be larger than that computed. From the simulation, 9.6 hours are needed to fill the reservoir with 15,337 ac-ft, from it lower to its upper working levels. The amount of energy added to the water by this operation is 14,751 mega-watt-hours (MWH). A similar simulation was done for the turbine phase of the operation. The upper reservoir was drained of its working volume in 8.4 hours and the energy extracted from the water equals 13,755 MWH. Symbiotics suggests an efficiency of 80 percent. This efficiency consists of the product of three efficiencies: (1) that of the pump (or turbine), (2) that of the motor (or generator), and (3) that of the transmission facilities. If each of these efficiencies is 93 percent, then 80 percent efficiency would be achieved, i.e. 0.93x0.93x0.93=0.8. Using an efficiency of 80 percent, the energy required to pump the water is 14,751/0.8 = 18,438 MWH, and that obtained from the turbines is 13,755(0.8) = 11,004 MWH, or

Energy supplied to pumps =
18,438 MWH
Energy provide by turbines =
11,004 MWH
Difference (Loss) = 7,434 MWH

Therefore, the percentage lost in the daily operation is (7,434/11004)100 = 67.6 percent. This loss will be larger when one accounts for the fact that during part of the time the pump/turbines will not be operating at peak efficiency and additional energies are required to accelerate the zero velocity water in the pipe at start-up.

Questions: With the amount of energy lost equal to 70 percent (or larger), is the project economically viable? Can this project be promoted as “green” when this lost energy comes from burning coal elsewhere?

3. Water Hammer

When valves close rapidly, or the velocity in a piping system changes abruptly, the water in the pipe must decelerate rapidly and this causes increased pressure, called water hammer. Stopping water in a pipe is similar to stopping a truck. If the truck slows gradually it takes some distance and time to bring it to a stop. However, if a truck collides with something it is brought to a stop almost instantly, and in this instant its front end is crushed as the mass behind the front continues to move an instant longer. The water in the 40 ft diameter pipe between the upper reservoir and power house weighs 145,000 tons, or equal to that of 14,500 ten ton trucks. If the velocity is 19.9 ft/sec (that for the maximum flow rate), and the pipe does not expand (or burst), then the potential added water hammer pressure is 1,220 lb/sq-in (or 2,920 ft of head). This full water hammer pressure will occur if the velocity is reduced to zero in a time less than that required for the compressive wave to travel from the valve to the reservoir and back again. Add this water hammer pressure to the pressure from the 940 ft elevation of the upper reservoir and the total pressure is 1,670 lb/sq-in. Clearly surge protection in the form of large tanks, or stand-pipes, must be included in the design, or the power plant will be destroyed with devastating effects as this unconfined water gushes into Bear Lake.

In consideration of these concerns about the hydraulics of the proposed project, and many others, and all the issues related to environmental impacts on Bear Lake, it is my judgment that Symbiotics should withdraw its application to FERC.

——————————————Roland Jeppson is a Utah State University professor emeritus in civil and environmental engineering.