Attachment G
North Georgia Operations Modeling Summary

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Technical Memorandum

Date:	Thursday, December 05, 2024
Project:	North Georgia Hydroelectric Project
To:	Georgia Power Company
From:	HDR
Subject:	**Georgia Power Company North Georgia Operations Modeling Scenarios Summary**

Purpose and Background

The North Georgia Hydroelectric Project (Project), licensed to Georgia Power Company (GPC), a subsidiary of Southern Company, is located in northeastern Georgia within the region of the Blue Ridge Escarpment. The Project consists of six power generating Developments on the Tallulah and Tugaloo Rivers, listed in order from upstream to downstream: Burton, Nacoochee, Mathis (Terrora), Tallulah Falls (Tallulah), Tugalo, and Yonah. The first five Developments are located on the Tallulah River until it converges with the Chattooga River at Lake Tugalo, impounded by the Tugalo Development. The Tugaloo River begins immediately downstream of the Tugalo Development. The Tugaloo River flows out of the lake via Tugalo Dam, passing into Lake Yonah and through Yonah Dam, and ends as an arm of Lake Hartwell.

Georgia Power Company retained HDR Engineering, Inc. (HDR) to develop an operations model for the Project and to utilize this model to simulate alternative Project operations to support GPC's energy portfolio investment planning efforts. The operations model for the Project has been developed using HDR's Computerized Hydro Electric Operations Planning Software (CHEOPS™) software platform. CHEOPS is specifically designed to evaluate the effects of operational changes and physical modifications at hydroelectric projects. Over the past 30 years, the CHEOPS Model has been utilized to simulate operations at more than 300 water resource developments, 95 of which were used to evaluate physical and operational changes considered during the Federal Energy Regulatory Commission (FERC) relicensing of the developments. One of the many strengths of CHEOPS is the degree of customization each individual model contains. CHEOPS models are tailored to meet the demands of the particular system being modeled. CHEOPS models are also custom configured based on specific system constraints such as flow requirements, target reservoir elevations, and powerhouse equipment constraints. Utilizing a daily average inflow dataset as primary input, CHEOPS simulates operations to allocate water between reservoir storage and required outflow constraints (physical, environmental, and operational) while permitting generation.

Alternative Operations Scenarios

Ten alternative operations scenarios were developed to show results of simulated operations associated with potential incremental changes from Baseline operations. These scenarios were developed to simulate removal of Yonah, Tallulah, and Burton dams and the potential cascading removal of all remaining upstream dams, where applicable.

The entire stretch of river from Burton to Yonah is 36 river miles, a relatively small distance from the first to the last plant, which makes these plants operational relationship interrelated with each other. The tailwater levels of each plant from Burton to Yonah are the elevation of the next plants headwater level with relatively little natural riverbed or riverine habitat between each plant. If the Yonah dam were to be removed, for example, it would affect the upstream Tugalo station. In this instance the tailwater level of Tugalo station may see a decrease of approximately 15 feet.

Significantly changing the tailwater elevation of a hydroelectric station, such as in this example of the Tugalo station from the removal of Yonah dam, would have adverse effects on the turbine performance and operational range of that station. Decreasing tailwater elevations removes the turbine required design “back pressure” effect tailwater provides to hydroelectric units. Turbines (or units) are designed with specific operational head ranges and a loss of the tailwater back pressure would change the actual operational head of the turbine. Once this takes place, the unit will be subject to operational stress which would likely result in severe vibrations affecting the bearings and alignment of the unit and negatively impacting the operational capabilities of the units. Additionally, a decrease in tailwater levels would likely subject the unit runner to excessive cavitation, potentially resulting in significant damage to the unit runner blades and risking catastrophic failure of the runner from metal loss in high stress areas. Significant annual repairs and extensive rehabilitation would likely be required, if possible due to runner integrity, to maintain an operational unit experiencing this type of modified hydraulic conditions regime. There is also the potential that the decrease in tailwater elevation would be such that the unit draft tube exit becomes exposed to air. Exposure of the draft tube to air would cause violent surging of the water exiting the draft tube to the river. These surging would result in vibrations above safe unit operation and cause the units to be taken offline to protect from catastrophic failure.

A possible option to mitigate a decrease in tailwater level, which may not be practical or effective at all stations, would be to install a tailrace level retaining weir, effectively re-creating a tailwater pool to maintain the water level and back pressure on the units. In the example of the removal of Yonah dam, the significant cost of tailwater mitigation may not be economically justified and may result in the decision by Georgia Power to remove the upstream dam as well. The removal of one dam most likely results in the cascading removal of all dams in the system. Consequently, the renewable energy produced by this river system would be removed from the grid.

Considering potential cascading dam removal, the following ten scenarios were simulated:

- **No Yonah –** Five scenarios were simulated to support evaluating removal of Yonah dam. The five scenarios simulated include:
    - **NoYonah** - This scenario represents the removal of Tallulah dam, including the associated storage operations, operational requirements, and powerhouse. This scenario assumes civil infrastructure related investment to retain tailwater levels of Tugalo powerhouse at or near existing levels.
    - **NoYonah-Tugalo** - This scenario represents the removal of Yonah and Tugalo dams, including the associated storage operations, operational requirements, and powerhouses. This scenario assumes civil infrastructure related investment to retain tailwater levels of Tallulah powerhouse at or near existing levels.
    - **NoYonah-Tallulah** - This scenario represents the removal of Yonah, Tugalo, and Tallulah dams, including the associated storage operations, operational requirements, and powerhouses. This scenario assumes civil infrastructure related investment to retain tailwater levels of Mathis powerhouse at or near existing levels.
    - **NoYonah-Mathis** - This scenario represents the removal of Yonah, Tugalo, Tallulah, and Mathis dams, including the associated storage operations, operational requirements, and powerhouses. This scenario assumes civil infrastructure related investment to retain tailwater levels of Nacoochee powerhouse at or near existing levels.
    - **NoYonah-Nacoochee** - This scenario represents the removal of Yonah, Tugalo, Tallulah, Mathis, and Nacoochee dams, including the associated storage operations, operational requirements, and powerhouses. This scenario assumes civil infrastructure related investment to retain tailwater levels of Burton powerhouse at or near existing levels.

- **No Tallulah** – Four scenarios were simulated to support evaluating removal of Tallulah dam. Additionally, as noted above for Yonah, without civil infrastructure related investment, the removal of Tallulah dam may result in the cascading removal of all remaining upstream dams in the system. Consequently, the renewable energy produced by these four developments would be removed from the grid. The four scenarios simulated include:

    - **NoTallulah** - This scenario represents the removal of Yonah dam, including the associated storage operations, operational requirements, and powerhouse. This scenario assumes civil infrastructure related investment to retain tailwater levels of Tugalo powerhouse at or near existing levels.
    - **NoTallulah-Mathis** - This scenario represents the removal of Tallulah, and Mathis dams, including the associated storage operations, operational requirements, and powerhouses. This scenario assumes civil infrastructure related investment to retain tailwater levels of Nacoochee powerhouse at or near existing levels.
    - **NoTallulah-Nacoochee** - This scenario represents the removal of Tallulah, Mathis, and Nacoochee dams, including the associated storage operations, operational requirements, and powerhouses. This scenario assumes civil infrastructure related investment to retain tailwater levels of Burton powerhouse at or near existing levels.
    - **NoTallulah-Burton** - This scenario represents the removal of Tallulah, Mathis, Nacoochee, and Burton dams, including the associated storage operations, operational requirements, and powerhouses at or near existing levels.

- **NoBurton** – This scenario represents the removal of Burton dam, including the associated storage operations, operational requirements, and powerhouse. No associated cascading dam removals were evaluated as there are no Project dams upstream of Burton dam.

Table 1 summarizes the simulated Project (System) total generation for each alternative scenario as compared to the simulated Baseline scenario. The following list summarizes the overall average annual generation loss for each scenario as compared to the Baseline scenario.

Simulated System Total Average Annual Generation Loss (1965-2023) as compared to Baseline:

- NoYonah – 10.7%
- NoYonah-Tugalo – 39.1%
- NoYonah-Tallulah – 81.6%
- NoYonah-Mathis – 92.1%
- NoYonah-Nacoochee – 95.2%
- NoTallulah – 42.5%
- NoTallulah-Mathis – 52.8%
- NoTallulah-Nacoochee – 55.8%
- NoTallulah-Burton – 61.2%
- NoBurton – 7.1%

The simulated removal of Burton dam indicates an increase in generation in some months with an overall annual loss in generation as compared to the Baseline scenario. This shift in generation on a monthly basis is due to the removal of Burton impoundment (Lake Burton) operations. Lake Burton is the primary storage for the Project and is operated based on a rule curve to reduce/prevent downstream spilling during high inflows typically experienced during winter and spring months. Lake Burton is drawn down between November 1st and February 1st and subsequently refilled after February 1st. The increase in simulated generation with the removal of Burton dam occurs during the period when Lake Burton would typically be refilling, where the removal of Lake Burton storage from the system shifts the timing of the water in the system, as shown in Figure 1 for the Baseline scenario (BaselineR1). Figure 1 is a "Haze Plot" of the simulated end of day elevations for each day for each year for the simulated period 1965 through 2023, where each line represents a year of simulated results.

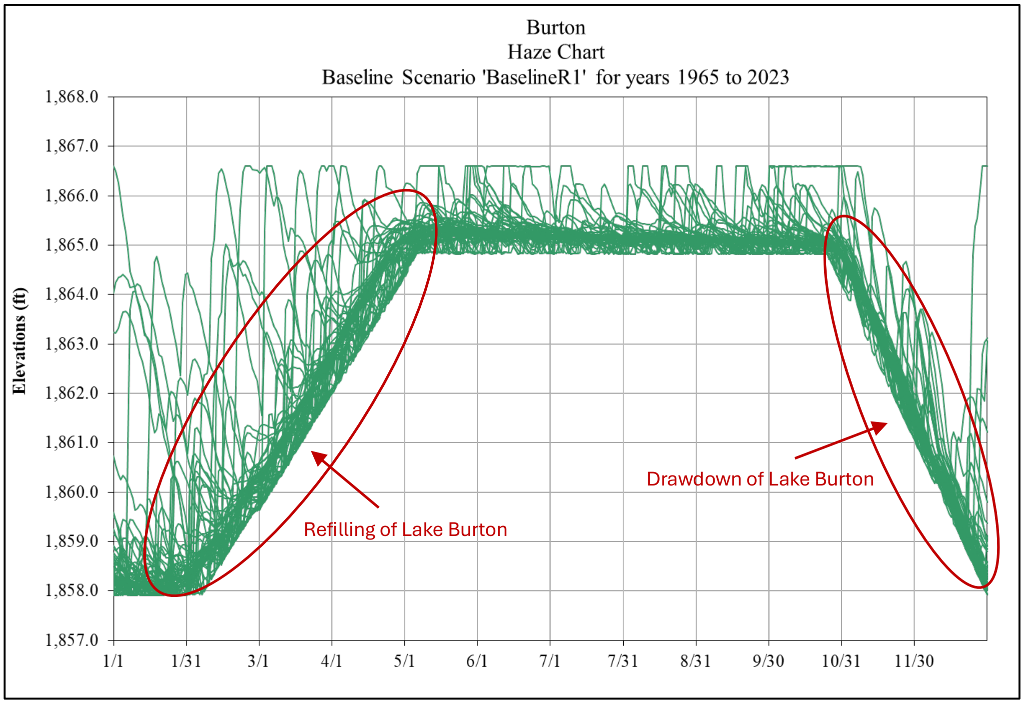

Figure 1. Simulated Baseline Lake Burton End of Day Elevations

As noted, Lake Burton is the primary storage for the Project and the rule curve operations reduce/prevent downstream spilling during high inflows experienced during winter and spring months. In addition to impacting generation, the removal of this storage also removes the ability of the System to dampen high flow events and would potentially result in increased spilling and downstream flooding. For example, the simulated volume of water spilled at Nacoochee more than doubles under the NoBurton scenario as compared to the Baseline scenario.

Conclusions

As stated above, the removal of one dam most likely results in the cascading removal of all remaining upstream dams in the system. Consequently, the renewable energy produced by this river system would be removed from the grid. Additionally, removal of storage operations also has the potential to increase spilling and downstream flooding due to the inability to buffer high inflows to the System.

The removal of Yonah dam has the highest potential impact. As noted above, without civil infrastructure related investment in the upstream dams, the removal of Yonah dam may result in the cascading removal of all dams in the system. The next highest potential impact would be the removal of Tallulah dam, which may result in the cascading removal of all remaining upstream dams (Mathis, Nacoochee, and Burton) in the system.

Table 1. Simulated Generation Summary (simulated for 1965 through 2023)

Scenario		Average Generation (MWh)												
		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Baseline (BaselineR1)	***System Total Generation***	***51,400***	***46,500***	***48,700***	***44,000***	***42,300***	***34,600***	***28,200***	***27,300***	***23,600***	***25,400***	***38,800***	***51,200***	***462,000***
No Yonah	*System Total Generation*	***45,300***	***41,100***	***44,400***	***40,000***	***38,100***	***30,500***	***25,000***	***24,200***	***20,900***	***22,600***	***34,700***	***45,700***	***412,500***
	Difference from Baseline (MWh)	*-6,100*	*-5,400*	*-4,300*	*-4,000*	*-4,200*	*-4,100*	*-3,200*	*-3,100*	*-2,700*	*-2,800*	*-4,100*	*-5,500*	*-49,500*
	Difference from Baseline (%)	*-11.9%*	*-11.6%*	*-8.8%*	*-9.1%*	*-9.9%*	*-11.8%*	*-11.3%*	*-11.4%*	*-11.4%*	*-11.0%*	*-10.6%*	*-10.7%*	*-10.7%*
No Yonah and Tugalo	*System Total Generation*	***31,300***	***27,900***	***29,800***	***26,600***	***26,000***	***20,700***	***16,900***	***16,200***	***13,700***	***15,000***	***24,700***	***32,400***	***281,200***
	Difference from Baseline (MWh)	*-20,100*	*-18,600*	*-18,900*	*-17,400*	*-16,300*	*-13,900*	*-11,300*	*-11,100*	*-9,900*	*-10,400*	*-14,100*	*-18,800*	*-180,800*
	Difference from Baseline (%)	*-39.1%*	*-40.0%*	*-38.8%*	*-39.5%*	*-38.5%*	*-40.2%*	*-40.1%*	*-40.7%*	*-41.9%*	*-40.9%*	*-36.3%*	*-36.7%*	*-39.1%*
No Yonah, Tugalo, and Tallulah	*System Total Generation*	***9,300***	***7,900***	***8,400***	***7,800***	***7,900***	***6,400***	***5,200***	***5,000***	***4,300***	***4,800***	***8,100***	***10,000***	***85,100***
	Difference from Baseline (MWh)	*-42,100*	*-38,600*	*-40,300*	*-36,200*	*-34,400*	*-28,200*	*-23,000*	*-22,300*	*-19,300*	*-20,600*	*-30,700*	*-41,200*	*-376,900*
	Difference from Baseline (%)	*-81.9%*	*-83.0%*	*-82.8%*	*-82.3%*	*-81.3%*	*-81.5%*	*-81.6%*	*-81.7%*	*-81.8%*	*-81.1%*	*-79.1%*	*-80.5%*	*-81.6%*
No Yonah, Tugalo, Tallulah, and Mathis	*System Total Generation*	***4,000***	***3,300***	***3,500***	***3,300***	***3,400***	***2,800***	***2,300***	***2,200***	***1,800***	***2,100***	***3,600***	***4,400***	***36,700***
	Difference from Baseline (MWh)	*-47,400*	*-43,200*	*-45,200*	*-40,700*	*-38,900*	*-31,800*	*-25,900*	*-25,100*	*-21,800*	*-23,300*	*-35,200*	*-46,800*	*-425,300*
	Difference from Baseline (%)	*-92.2%*	*-92.9%*	*-92.8%*	*-92.5%*	*-92.0%*	*-91.9%*	*-91.8%*	*-91.9%*	*-92.4%*	*-91.7%*	*-90.7%*	*-91.4%*	*-92.1%*
No Yonah, Tugalo, Tallulah, Mathis, and Nacoochee	*System Total Generation*	***2,400***	***2,000***	***2,100***	***2,000***	***2,100***	***1,700***	***1,400***	***1,300***	***1,100***	***1,300***	***2,200***	***2,700***	***22,300***
	Difference from Baseline (MWh)	*-49,000*	*-44,500*	*-46,600*	*-42,000*	*-40,200*	*-32,900*	*-26,800*	*-26,000*	*-22,500*	*-24,100*	*-36,600*	*-48,500*	*-439,700*
	Difference from Baseline (%)	*-95.3%*	*-95.7%*	*-95.7%*	*-95.5%*	*-95.0%*	*-95.1%*	*-95.0%*	*-95.2%*	*-95.3%*	*-94.9%*	*-94.3%*	*-94.7%*	*-95.2%*
No Tallulah	*System Total Generation*	***29,400***	***26,300***	***27,300***	***25,000***	***24,600***	***20,100***	***16,600***	***16,000***	***14,100***	***15,200***	***22,300***	***28,900***	***265,800***
	Difference from Baseline (MWh)	*-22,000*	*-20,200*	*-21,400*	*-19,000*	*-17,700*	*-14,500*	*-11,600*	*-11,300*	*-9,500*	*-10,200*	*-16,500*	*-22,300*	*-196,200*
	Difference from Baseline (%)	*-42.8%*	*-43.4%*	*-43.9%*	*-43.2%*	*-41.8%*	*-41.9%*	*-41.1%*	*-41.4%*	*-40.3%*	*-40.2%*	*-42.5%*	*-43.6%*	*-42.5%*
No Tallulah, and Mathis	*System Total Generation*	***24,100***	***21,600***	***23,000***	***20,700***	***20,300***	***16,500***	***13,700***	***13,300***	***11,600***	***12,500***	***17,700***	***23,200***	***218,200***
	Difference from Baseline (MWh)	*-27,300*	*-24,900*	*-25,700*	*-23,300*	*-22,000*	*-18,100*	*-14,500*	*-14,000*	*-12,000*	*-12,900*	*-21,100*	*-28,000*	*-243,800*
	Difference from Baseline (%)	*-53.1%*	*-53.5%*	*-52.8%*	*-53.0%*	*-52.0%*	*-52.3%*	*-51.4%*	*-51.3%*	*-50.8%*	*-50.8%*	*-54.4%*	*-54.7%*	*-52.8%*
No Tallulah, Mathis, and Nacoochee	*System Total Generation*	***22,500***	***20,200***	***21,700***	***19,600***	***19,200***	***15,400***	***12,800***	***12,400***	***10,900***	***11,700***	***16,300***	***21,500***	***204,200***
	Difference from Baseline (MWh)	*-28,900*	*-26,300*	*-27,000*	*-24,400*	*-23,100*	*-19,200*	*-15,400*	*-14,900*	*-12,700*	*-13,700*	*-22,500*	*-29,700*	*-257,800*
	Difference from Baseline (%)	*-56.2%*	*-56.6%*	*-55.4%*	*-55.5%*	*-54.6%*	*-55.5%*	*-54.6%*	*-54.6%*	*-53.8%*	*-53.9%*	*-58.0%*	*-58.0%*	*-55.8%*
No Tallulah, Mathis, Nacoochee, and Burton	*System Total Generation*	***19,700***	***18,500***	***20,500***	***18,600***	***17,300***	***13,700***	***11,300***	***11,000***	***9,700***	***10,100***	***12,200***	***16,800***	***179,400***
	Difference from Baseline (MWh)	*-31,700*	*-28,000*	*-28,200*	*-25,400*	*-25,000*	*-20,900*	*-16,900*	*-16,300*	*-13,900*	*-15,300*	*-26,600*	*-34,400*	*-282,600*
	Difference from Baseline (%)	*-61.7%*	*-60.2%*	*-57.9%*	*-57.7%*	*-59.1%*	*-60.4%*	*-59.9%*	*-59.7%*	*-58.9%*	*-60.2%*	*-68.6%*	*-67.2%*	*-61.2%*
No Burton	*System Total Generation*	***47,600***	***46,000***	***51,200***	***46,300***	***40,800***	***32,200***	***26,500***	***25,700***	***21,900***	***23,100***	***28,300***	***39,800***	***429,400***
	Difference from Baseline (MWh)	*-3,800*	*-500*	*2,500*	*2,300*	*-1,500*	*-2,400*	*-1,700*	*-1,600*	*-1,700*	*-2,300*	*-10,500*	*-11,400*	*-32,600*
	Difference from Baseline (%)	*-7.4%*	*-1.1%*	*5.1%*	*5.2%*	*-3.5%*	*-6.9%*	*-6.0%*	*-5.9%*	*-7.2%*	*-9.1%*	*-27.1%*	*-22.3%*	*-7.1%*

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