Attachment F
Planning Level Cost Study for Twelve Dam Removals

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Stantec

Memo

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Project/File:	175578493	Date:	January 10, 2025

Reference: Planning Level Costs for Twelve Dam Removals

1 Introduction

Stantec Consulting Services Inc. (Stantec) was contracted by Troutman Pepper LLP (Troutman) to provide planning level opinion of probable construction costs (OPCCs) for the potential removal of twelve (12) Georgia hydroelectric dams, including Morgan Falls Dam, Flint River Dam, Bartletts Ferry Dam, Oliver Dam, Goat Rock Dam, Lloyd Shoals Dam, Sinclair Dam, Yonah Dam, Nacoochee Dam, Tugalo Dam, Tallulah Dam, and Terrora Dam. The twelve dams are owned and operated by Georgia Power Company (GPC) and licensed for operation by the Federal Energy Regulatory Commission (FERC). The planning level OPCCs were prepared based on evaluating construction costs of dam removal from publicly available databases and supplemented with other known projects.

Additional dams operated by GPC were excluded from the study including Langdale Dam, Riverview Dam, Estatoah Dam, Wallace Dam, Burton Dam and North Highlands Dam. Langdale Dam, Riverview Dam and Estatoah Dam were not included in this cost analysis as GPC has initiated decommissioning of these three dams. Wallace Dam, Burton Dam and North Highlands Dam were not included as a detailed cost was developed as part of the 2024 Dam Removal Feasibility Studies.

2 Background

The twelve dams are located throughout the state and are shown in Figure 1 and are described herein:

Terrora, Tallulah, Tugalo, Nacoochee and Yonah Dams are part of GPC's North Georgia Hydro Group[1]. These five dams are located generally in mountainous terrain in northeast Georgia along the Tallulah and Tugalo Rivers. Lloyd Shoals and Sinclair Dam are part of GPC's Central Georgia Hydro Group[2]. Lloyd Shoals and Sinclair Dam are located on the Ocmulgee and Oconee Rivers, respectively.

Three of the twelve dams, Goat Rock, Oliver and Bartletts Ferry Dam, are part of GPC's Chattahoochee Hydro Group[3]. These three dams are located near Columbus, Georgia along the Chattahoochee River. The remaining two dams included in this memo are Flint River Dam and Morgan Falls Dam. Flint River Dam is located in Dougherty County in southwest Georgia. Morgan Falls is north of Atlanta in Roswell, Georgia.

For each dam, parameters such as dam crest length, dam height, watershed area and mean annual discharge were gathered from various sources including drawings and reports provided by GPC, the National Inventory

[1] Burton Dam is also part of GPC's North Georgia Hydro Group, however, was not included in this memorandum.
[2] Wallace Dam is also part of GPC's Central Georgia Hydro Group, however, was not included in this memorandum.
[3] North Highlands Dam is also part of GPC's Chattahoochee Hydro Group, however, is not included in this memorandum.

of Dams (NID), aerial imagery, and the Stantec team's knowledge of each site from site visits (conducted as part of separate work).

The twelve GPC dams are concrete dams with various powerhouse, gate and spillway structures. Many of the dams also have earthen embankments or abutments, however, those features were not included in the removal costs as those features would not necessarily need to be removed to restore riverine flows. This assumption would be evaluated further if conceptual dam removal designs were developed and more detailed cost opinions were prepared. A summary of the dam height, length, watershed area and mean annual discharge parameters for the twelve sites is included as Table 1.

Table 1. Overview of Twelve GPC Hydroelectric Dams

Dam Name	Dam Height (Ft)	Dam Crest Length (Ft)[1]	Watershed Area (Square Miles)	Mean Annual Discharge (cfs)
Morgan Falls	56	898	1,370	2,305
Flint River	60	1,752[2]	5,310	6,194
Bartletts Ferry	150	752	4,260	6,064
Oliver	70	1,893	4,670	7,202
Goat Rock	75	1,202	4,535	6,993
Lloyd Shoals	105	1,109	1,400	1,747
Sinclair	105	1,378	2,920	3,018
Yonah	95	925	470	1,525
Nacoochee	73	505	136	460
Tugalo	160	865	464	1,506
Tallulah	130	400	186	629
Terrora	115	665	151	510

1. Dam crest lengths were considered the length of the dam that would likely be removed as part of a dam removal which generally consisted of the concrete dam itself. Features such as earthen abutments were not included as it was assumed those would largely remain in place during dam removal. Thus, the dam crest length presented may differ from other sources (ex: FERC).

2. The Flint River project consists of two separate concrete dams and an earthen dam. The crest length presented is the summation of the two individual concrete dam lengths. It was assumed the earthen dam would remain in place.

Reference: **Planning Level Costs for Twelve Dam Removals**

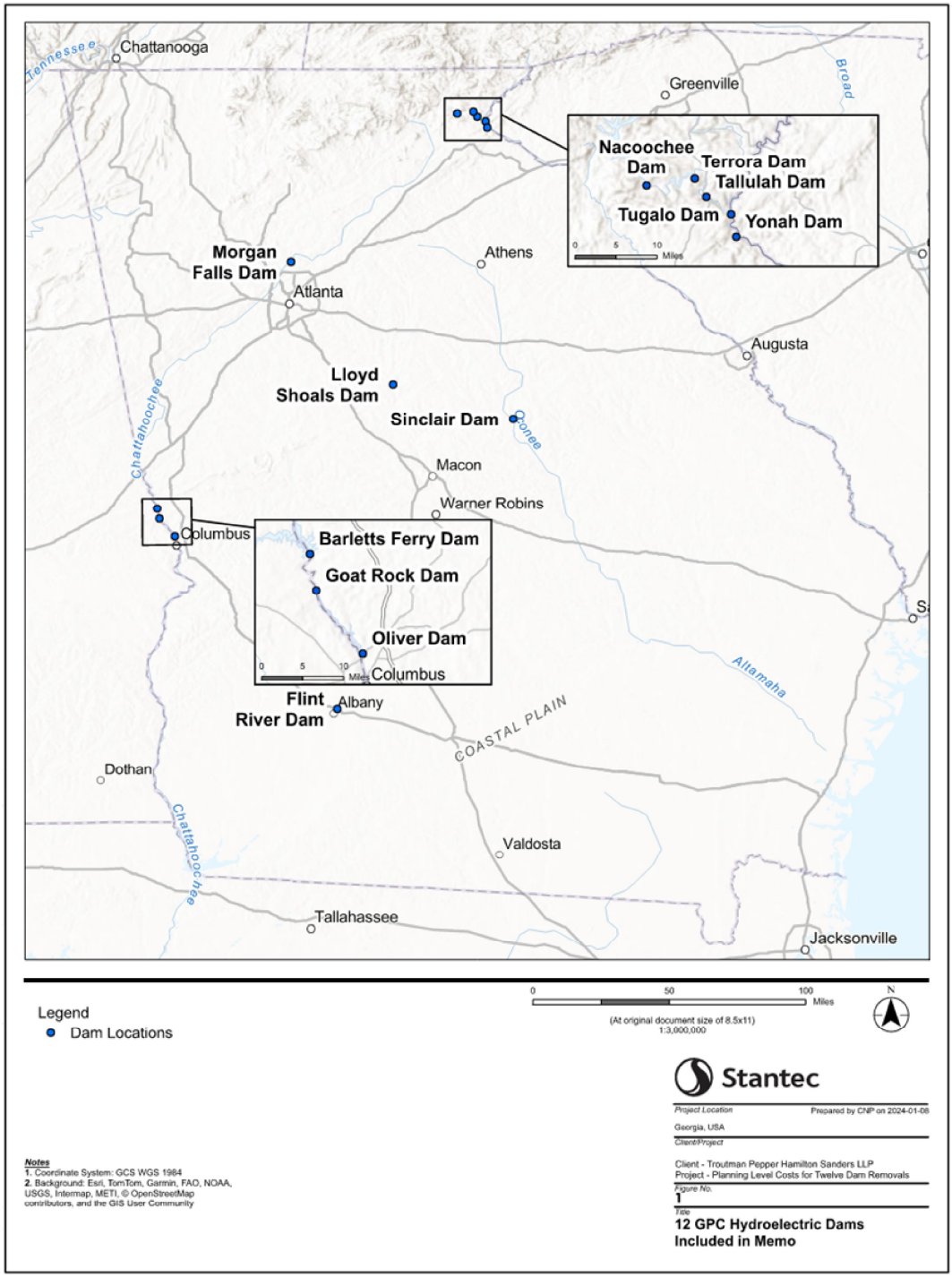

Figure 1. Location of 12 GPC Hydroelectric Dams Included in Memo

3 Methodology

The 2023 United States Geological Survey (USGS) Dam Removal Cost Database (referred to as "USGS database" herein) was used as the primary data source for past dam removal costs. This database was compiled as part of a research paper "Patterns, drivers, and a predictive model of dam removal cost in the United States" published in Frontiers in 2023 (referred to as "USGS research paper" herein). Cost estimates included in the USGS database were pulled from source material on the internet such as technical reports, books, newspaper articles, web pages, blog posts and presentations (USGS, 2023). Per the USGS database, the accuracy of cost data is not known, thus is only considered appropriate for high-level evaluations of total cost for each dam removal project. The estimates do not provide a cost breakdown based on activity (e.g. planning cost, sediment removal cost, water diversion cost, etc.). USGS notes the database assumes that most estimates represent close to the total cost or the minimum financial cost, with overestimates being rare.

The USGS database was supplemented with estimated and publicly available project costs for the $550 million removal of four hydroelectric facilities (JC Boyle, Copco 1, Copco 2, and Iron Gate Dam) from the Klamath River.

The USGS database includes a total of 667 dam removals and lists the associated dam drainage areas, lengths, height, primary dam material (ex: concrete, masonry), and removal costs in 2020 dollars. Of the 667 dams included in the database, the majority were much smaller than the twelve GPC dams included in this effort. To develop estimates for larger hydroelectric dams more similar to the twelve owned and operated by GPC, only dams with removal costs greater than $20 million from the USGS database were included in this analysis. As each of the twelve GPC dams provide power, only hydroelectric facilities from the USGS database were utilized. One of the hydroelectric dams was part of a Superfund Site, which indicates environmental contamination issues were likely driving the costs and not necessarily the physical dam removal, and appeared to be a data outlier. Thus, a total of eight hydroelectric dams from the USGS database were included as part of the data set to develop relationship equations (Glines Canyon Dam, Elwha Dam, Veazie Dam, Great Works Dam, Condit Dam, Eagle and Phenix Dam, City Mills Dam and Ceresco Dam). The maximum dam length included in the data set was 1,009 ft at Eagle & Phenix Dam, located 2.5 miles downstream of Oliver Dam along the Chattahoochee River, which had a dam height of 17 ft. The maximum dam height included in the data set was 210 ft at Glines Canyon Dam, which was located in the Olympic National Park in Washington, which had a length of 452 ft. The dam removal costs provided in the USGS database in 2020 dollars were adjusted to 2024 dollars using a 1.22 multiplier based on the consumer price index (CPI). In 2024 dollars, the maximum cost of dam removal included in the data set was approximately $365 million dollars for the removal of Glines Canyon Dam.

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The USGS research paper cited multiple factors, that on a high level, contribute to the cost of dam removals. With the largest factors in order consisting of dam height, average annual discharge, project complexity, and drainage (or upstream) area. Dam heights, average annual discharge, and drainage areas were each then plotted against dam removal costs. For the dams evaluated, average annual discharge and drainage areas did not have correlations with dam removal costs likely due to wide dispersity in site locations which have significant differences in precipitation distributions and rates. Dam heights however were found to have a high correlation with dam removal costs with coefficient of determination (R^2) value of 0.90 (scale of 0 to 1) for an exponential cost curve. As the Klamath River and USGS dams evaluated had a wide range in dam lengths (ranging from 210 ft to 1,009 ft), dam removal costs were normalized by dividing the dam cost by linear foot of crest length (y-axis) and plotting against dam heights as presented in Figure 2 below. Although the R^2 value of 0.79 is slightly lower than just comparing dam removal costs with dam heights, this methodology was considered more appropriate as it accounted for the significant range in dam crest lengths evaluated. A summary of dam and cost parameters (dam height, crest length removed, and dam removal costs) from the USGS database and the Klamath River dams utilized in this evaluation are also summarized in Table 2.

Figure 2. Dam height compared to dam removal cost per linear foot of dam crest length

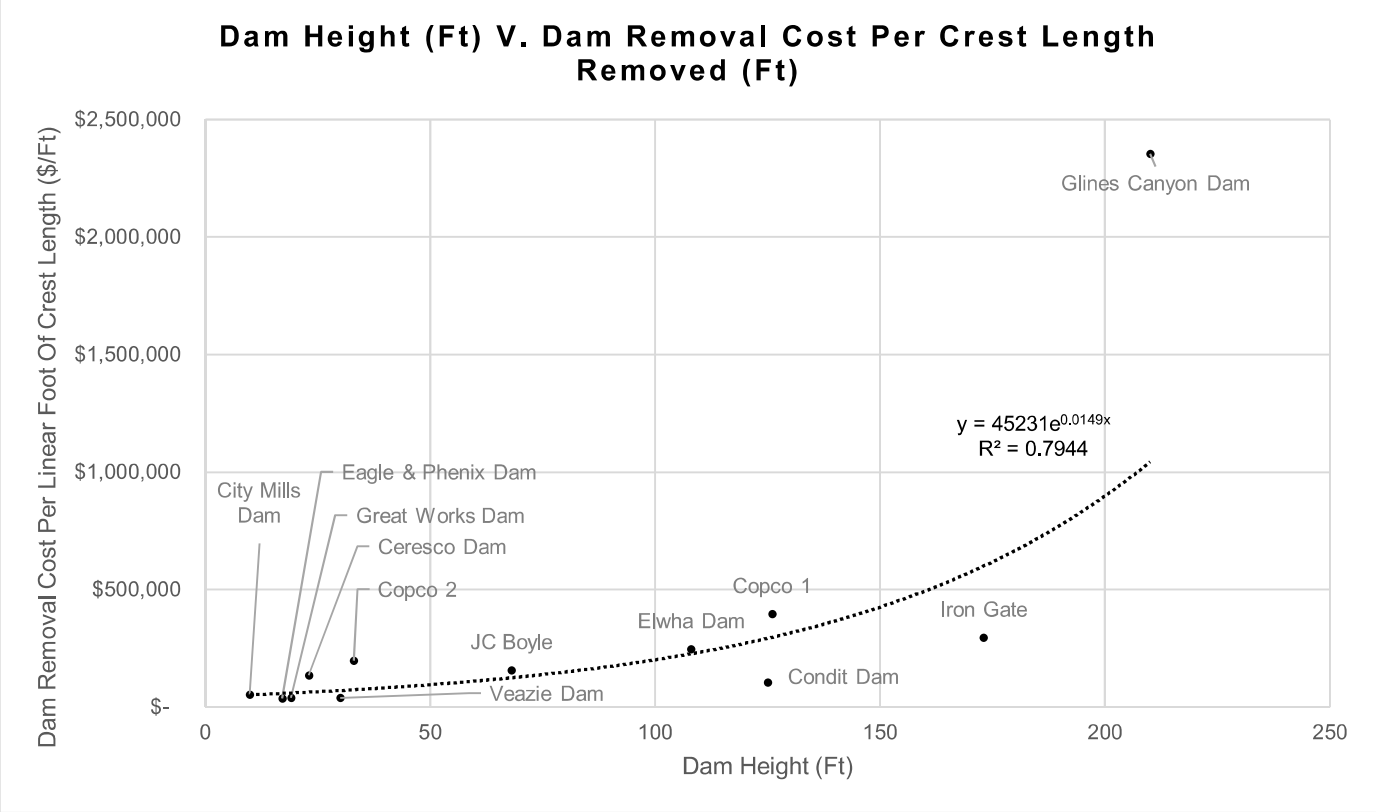

Table 2. Overview of Removed Dams

Dam Name	Dam Height (Ft)	Crest Length (Ft)	Dam Removal Costs ($M) [1, 2]
Glines Canyon Dam	210	155	365
Elwha Dam	108	490	122
Veazie Dam	30	1,075	42
Great Works Dam	19	1,060	42
Condit Dam	125	425	45
Eagle & Phenix Dam	17	1,009	37
City Mills Dam	10	540	29
Ceresco Dam	23	185	25
JC Boyle	68	693	110
Copco 1	126	415	165
Copco 2	33	278	55
Iron Gate	173	740	220

1. Dam removal costs were converted from 2020 dollars to 2024 dollars based off the CPI.
2. The costs of removing the Klamath River dams (JC Boyle, Copco 1, Copco 2 and Iron Gate) are estimated. Removal has not been completed as of August 2024.

4 Calculations

The trendline equation presented in Figure 2 was then utilized to calculate dam removal costs per linear foot of crest length (y) for each of the 12 GPC dams based on dam height (x, feet). The resulting value was then multiplied by the approximate dam crest length to estimate the base dam removal costs.

$$(1)\ y = z * 45231e^{0.0149x}$$

where x is the dam height (ft), y is dam removal cost ($USD), and z is dam crest length (ft).

Estimated planning-level dam removal costs for each of the 12 GPC dams based on Equation 1 are provided as Table 3. As the full cost to remove a dam may be impacted by a wide variety of variables that were not included as part of this planning level assessment (ex: removal methodology, access restraints, water control, sediment removal, mitigation costs), the directly calculated values are also presented as low and high range of 50% to 300% of the base cost, respectively.

Table 3. Planning Level Dam Removal Costs

Dam Name	Dam Height (ft)	Dam Crest Length (ft)	Base Cost ($M)[1]	Lower Range (50 %) Cost ($M)[2]	Upper Range (300%) Cost ($M)[2]
Morgan Falls	56	898	100	50	300
Flint River	60	1,752	200	100	600
Bartletts Ferry	150	752	320	160	960
Oliver	70	1,893	250	130	750
Goat Rock	75	1,202	170	90	510
Lloyd Shoals	105	1,109	240	120	720
Sinclair	105	1,378	300	150	900
Yonah	95	925	180	90	540
Nacoochee	73	505	70	40	210
Tugalo	160	865	430	220	1,290
Tallulah	130	400	130	70	330
Terrora	115	665	170	90	510

1. Base costs are based on Equation 1 and were rounded up to the nearest $10 million.
2. Lower range and upper range costs are rounded to the nearest $10 million. The lower range and upper range are 50% and 300% of the base cost, respectively.

In general, removing hydroelectric dams of this size is rare in the United States. Based on the planning level base dam removal costs, each of the 12 GPC dams included in this memo would be one of the most expensive hydroelectric dam removals completed in this country, as only five hydroelectric dam removals have cost or are anticipated to cost more than $100 million (Glines Canyon, Iron Gate, Copco 1, Elwha, JC Boyle) and only two hydroelectric dam removals have exceeded or are anticipated to exceed a cost of $200 million (Glines Canyon and Iron Gate).

5 Limitations

Costs for indirect impacts and mitigations, such as, loss in hydrogeneration or impacts to third-parties, are not included in the OPCCs included in this memo.

At the time this memo was completed, there were limited existing data for removal of similar hydroelectric dam projects. Review of publicly available information resulted in a total of twelve dam removal projects for dams with similar parameters to the 12 GPC hydroelectric dams evaluated in this memo. The twelve dams with available cost removal data were for eight removed dam data points from the USGS and four ongoing removal projects on the Klamath River. Detailed cost breakdowns to refine subcategories of cost were not publicly available. Cost relationships for major individual cost categories of removal, such as the powerhouse

removal, material hauling, post removal vegetation plans, sediment removal, and general project complexity, were not completed as part of this memo.

Data on height, watershed size and other dam background information were gathered by review of GPC provided documents and online published databases. These online databases were published by the USGS and U.S. Army Corps of Engineers, however, did not generally include sources for included data or detailed breakdown of the costs (for example, if the cost included design, planning, permitting, and other cost drivers or solely construction).

6 References

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Sincerely,

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