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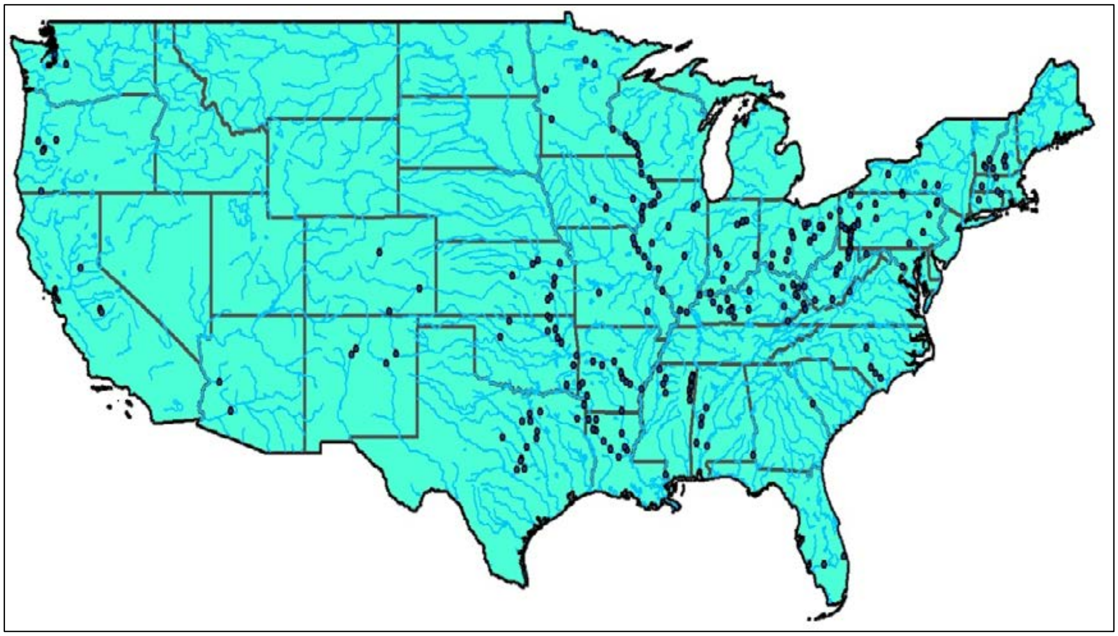
HYDROPOWER RESOURCE ASSESSMENT
AT
NON-POWERED USACE SITES



Prepared by the
Hydropower Analysis Center
for
USACE Headquarters

July 2013 Final Report

EXECUTIVE SUMMARY

The U.S. Army Corps of Engineers (USACE) is the largest owner-operator of hydropower plants in the United States, with 75 plants and an installed capability of 21,000 megawatts (MW), or about 24% of the total hydroelectric capacity. This report describes a national hydropower resource assessment study that assessed the potential and economic feasibility of adding hydroelectric power to these non-powered USACE projects over a 50-year period of analysis.

Site Selection

In selecting non-powered USACE projects with hydropower potential, the study employed a 2012 report by the Oak Ridge National Laboratory (ORNL) that identified the hydropower potential of 54,000 non-powered dams in the United States. Among these dams, 419 were USACE non-powered dams. This number was reduced to 223 sites using the following screening, as shown on the table below.

- Generate 1 MW or more of potential hydropower.
- No current Federal Energy Regulatory Commission (FERC) license.
- No obvious hindrances in developing hydropower.

Distribution of USACE Sites with Potential Hydropower Capability

Division	Total Projects Identified	FERC Preliminary or Pending Preliminary Permit		No FERC Permits	
		Total Number	Percentage of Total	Total Number	Percent of Total
Great Lakes & Ohio River (LRD)	71	40	56%	31	44%
Mississippi Valley (MVD)	50	28	56%	22	44%
Southwestern (SWD)	39	7	18%	32	82%
North Atlantic (NAD)	21	2	10%	19	90%
South Atlantic (SAD)	19	8	42%	11	58%
Northwestern (NWD)	12	5	42%	7	58%
South Pacific (SPD)	11	2	18%	9	82%
USACE Total	223	92	41%	131	59%

Data Collection

To improve the study data, the daily hydraulic head and flow values for all 223 sites were obtained. The table below shows the available data for each USACE Division. As shown in the table, the data quality was divided into three categories:

1. Daily hydraulic head and flow values for more than 3 years (full data). This was the most reliable estimation because it considers both the seasonality of the hydropower potential, the yearly hydrological variation, and the relationship between hydraulic head and flow.
2. Daily flow values for more than 3 years (constant hydraulic head). This was the second most reliable estimation because it does not consider the relationship between flow and hydraulic head, which may be significant for many projects.
3. No additional data (use ORNL data). This was the least reliable estimation because no information was available from the project's Division or District offices.

Data Quality for USACE Sites with Potential Hydropower Capability

Division	Total Projects Identified	Daily Hydraulic Head and Flow for More than 3 Years		Daily Flow for More than 3 Years		No Additional Data	
		Total Number	Percent of Total	Total Number	Percent of Total	Total Number	Percent of Total
Great Lakes and Ohio River (LRD)	71	70	99	1	1	0	0
Mississippi Valley (MVD)	50	48	96	0	0	2	4%
Southwestern (SWD)	39	36	92	3	8	0	0
North Atlantic (NAD)	21	16	76	5	24	0	0
South Atlantic (SAD)	19	6	32	1	5	12	63
Northwestern (NWD)	12	7	58	5	42	0	0
South Pacific (SPD)	11	0	0	0	0	11	100
USACE Total	223	183	82	15	7	25	12

Of the total projects, 82% had daily flow and hydraulic head values for more than 3 years. An additional 7% had at least daily flow values for more than 3 years. The remaining 12% did not have any additional data relative to the ORNL study. The Great Lakes and Ohio River Division had the most complete data, while South Pacific Division had the least.

Methodology

The methodology used in this study was developed to answer the following two questions:

1. What is the potential hydropower capacity and generation of a site?
2. What is the maximum feasible hydropower capacity of a site?

Considerations for these two questions contained both hydrologic characteristics such as seasonality of flow, and economic assumptions such as the value of the generated energy.

To determine potential capacity and generation, hydroelectric power was estimated using the water power equation and hydroelectric energy was estimated by multiplying the power equation by time. For sites with at least 3 years of daily flow values, this analysis computed potential capacity using a power exceedance curve. This method was also implemented if static hydraulic heads are used, although the hydraulic head and flow relationship is not considered.

Some sites had no additional hydrologic data available beside that acquired for the ORNL study. For these sites, a simplified approach was taken to estimate a single potential capacity value. This capacity value was determined by computing monthly power values with the site's static head and average monthly used as variables in the equation. The maximum power value over all of these months was defined as a site's potential capacity.

Benefits of New Hydropower Capacity

To test the feasibility of new hydropower capacity, benefits of the hydropower generation were calculated. These benefits included monetary benefits such as the energy value of the hydropower generation and any federal or state renewable performance incentives that may be available. A non-monetary benefit of new hydropower generation was considered and included the avoided emissions of using a non-fossil fuel based electricity resource.

Cost Estimates

This study used cost estimations for construction costs, non-construction development costs, and annual operating and maintenance costs as defined by Idaho National Engineering and Environmental Laboratory (INEEL) 2003 study, *Estimation of Economic Parameters of U.S. Hydropower Resources*. Additional costs not included in the INEEL study were taken from the Bureau of Reclamation's 2011 study, *Hydropower Resource Assessment at Existing Reclamation Facilities.*

Determining Economic Feasibility

To determine economic feasibility, two metrics were used: benefit-cost ratio (BCR) and internal rate of return (IRR). The BCR compared the net present value of benefits to the net present value of cost over a 50-year period of analysis. The present value of cost and benefits was calculated using the 2013 federal discount rate of 3.75%. The IRR of an investment is the discount rate at which the net present value of the cost equals the net present value of the benefits. For example, a project with an IRR of 3.75% would have a BCR ratio of one, using the above definition and the 2013 federal discount rate.

Results

The table below shows the potential and feasible capacity at each USACE Division. The table shows that LRD and MVD have the most potential and feasible capacity at non-powered USACE sites. Across all USACE sites, there are approximately 6,256 MW of potential energy with about 2,818 MW estimated as feasible under the current economic assumptions. The percentage of potential capacity assumed feasible varied across Divisions, ranging from about 15% in NWD to 97% in SPD.

Potential and Maximum Feasible Capacity Estimates for Non-powered USACE Sites

Division	Number of Plants	Potential Capacity (MW)	Feasible Capacity (MW)	Percent of Potential Capacity Assumed Feasible
LRD	71	1961.50	898.16	46%
MVD	50	1568.22	939.75	60%
NAD	21	288.07	63.49	22%
NWD	12	348.74	50.63	15%
SAD	19	671.92	324.51	48%
SPD	11	116.29	112.71	97%
SWD	39	1301.67	429.27	33%
USACE Total	223	6256.43	2818.54	45%

Of particular interest is the FERC permit status of the sites identified as having feasible capacity potential. Of the 146 sites identified as having feasible capacity potential, 72 have no preliminary or pending permits. However, the remaing 74 sites with pending or preliminary permits account for about 75% of the 2,818 MW of potential feasible capacity.

The table below lists the top 20 non-powered USACE sites identified as having feasible potential and no existing preliminary or pending FERC permits, ranked by BCR. Cumulatively, these top 20 sites account for 350 MW of potential feasible capacity, which is about half of the potential feasible capacity available at all 72 sites without any FERC permits. Eight of the 20 sites have a potential feasible capacity greater than 10 MW. In terms of feasible capacity, Melvin Price Lock and Dam has the greatest potential feasibility capacity at 130 MW.

Top 20 Non-powered USACE Sites with Feasible Hydropower Potential Ranked by BCR

Ranking	Plant	Plant_ID	Division	District	Data Confidence	Feasible Capacity (MW)	Estimated BCR
1	Santa Rosa Dam	SPD-10	SPD	SPA	ORNL Data	3.61	2.42
2	North Fork Dam	SPD-8	SPD	SPK	ORNL Data	4.12	2.21
3	Cochiti Lake	SPD-3	SPD	SPA	ORNL Data	11.66	1.97
4	Bluestone Dam	LRD-9	LRD	LRH	Full Data	31.09	1.69
5	Buchanan Dam	SPD-2	SPD	SPK	ORNL Data	2.98	1.68
6	Claiborne Lock and Dam	SAD-5	SAD	SAM	Full Data	38.05	1.61
7	William Bacon Oliver Replacement	SAD-20	SAD	SAM	ORNL Data	28.29	1.37
8	Bolivar Dam	LRD-10	LRD	LRH	Constant Head	8.98	1.32
9	Hidden Dam	SPD-5	SPD	SPK	ORNL Data	2.48	1.29
10	Blue Marsh Dam	NAD-4	NAD	NAP	Full Data	2.46	1.29
11	Alamo Dam	SPD-1	SPD	SPL	ORNL Data	4.16	1.22
12	Clearwater Dam	SWD-7	SWD	SWL	Full Data	2.59	1.22
13	Tioga Dam	NAD-20	NAD	NAB	Full Data	2.76	1.16
14	Howard A Hanson Dam	NWD-8	NWD	NWS	Constant Head	14.92	1.16
15	Brookville Lake Dam	LRD-12	LRD	LRL	Full Data	11.33	1.15
16	Whitney Point Dam	NAD-24	NAD	NAB	Constant Head	6.16	1.13
17	Melvin Price Locks and Dam	MVD-34	MVD	MVS	Full Data	130.65	1.13
18	Paint Creek Dam	LRD-58	LRD	LRH	Full Data	3.09	1.13
19	John C. Stennis	SAD-13	SAD	SAM	Full Data	31.31	1.12
20	Amory	SAD-3	SAD	SAM	ORNL Data	7.70	1.10

There were a number of limitations to the analysis, as discussed below, because of the large number of projects considered and the uncertainty surrounding economic estimates over the 50-year period of analysis.

1. Incomplete hydrological data. For some sites, sufficient data was not available. In these cases, static head and flow values were used, which may over- or under-estimate hydropower potential. Even sites with complete data may require longer period of records to better quantify the annual hydrologic variability.
2. Site-specific restrictions. The analysis did not go into site-specific characteristics that may restrict hydropower development, such as environmental, water quality and other restrictions.
3. Hydropower component attributes assumptions. Turbine types and generator speeds were assumed using very general guidelines based on a site's head and flow characteristics. Correctly identifying these attributes for a specific site may add significant cost.
4. Cost estimates. The cost estimates were based on an INEEL 2003 study that developed parametric equations for cost based on general site attributes such as flow and head. These cost equations were indexed to 2012 dollars. The cost parameterizations may not sufficiently address different site-specific needs.
5. Energy value estimates. The energy value estimates were based on generation cost estimates for large geographic regions as defined by the Energy Information Administration. There are considerable uncertainties surrounding cost estimates that are projected over a long time period and a large geographic region.

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1. INTRODUCTION

The U.S. Army Corps of Engineers (USACE) is the largest owner-operator of hydropower plants in the United States. With a total of 75 hydropower facilities, the USACE has an installed capability of 21,000 megawatts (MW), approximately 24% of the total hydroelectric capacity in the United States. However, additional hydropower capability may be available across the 600 dams owned by the USACE. This report describes a national hydropower resource assessment study of non-powered USACE projects in the continental United States.

1.1. Previous Studies

Several studies of hydropower potential on USACE non-powered sites have been completed over the last three decades. In 1983, the Institute of Water Resources published a 23-volume *National Hydroelectric Power Resources Study* that identified potential capacity at both federal and non-federal sites. An update of the 1983 report, *Directory of Corps Projects with Existing Hydroelectric Power Facilities and/or the Potential for the Addition of Hydroelectric Power,* identified 261 USACE facilities with additional or new capacity potential of 6.1 gigawatts (GW).

Section 1834 of the Energy Policy Act of 2005 required the Secretary of the Army, Secretary of the Interior, and the Secretary of Energy to jointly assess the potential for increasing electric power production at federal facilities. The report, *Potential Hydroelectric Development at Existing Federal Facilities,* built off of the previous USACE studies but incorporated an economic feasibility analysis. The report identified 58 USACE sites with 1,230 MW of potential capacity that maintained a benefit-cost ratio (BCR) greater than 1.

Most recently, the Department of Energy's Oak Ridge National Laboratory (ORNL) performed a hydropower resource assessment on 54,000 non-powered dams in the United States. The report, *An Assessment of Energy Potential at Non-Powered Dams in the United States,* identified 236 USACE sites with hydropower capability greater than 1 MW. These sites were estimated to have over 8 GW of combined potential capacity.

1.1. Study Scope

The scope of this study is to assess the potential and economic feasibility of adding hydroelectric power to non-powered USACE projects over a 50-year period of analysis. The methodology defined for this report only assessed general feasibility and is not meant to fully address the characteristics and uncertainties of a particular site.

In 2010, the Department of the Interior, Department of Energy, and Department of the Army signed a Memorandum of Understanding (MOU) to establish a new approach in developing hydropower facilities. The goal of this MOU is to "meet the Nation's needs for reliable, affordable, and environmentally sustainable hydropower by building a long-term working relationship, prioritizing similar goals, and aligning ongoing and future renewable energy development efforts."

One of the initial opportunities for collaboration outlined in the MOU is to develop a hydropower resource assessment at existing USACE and Bureau of Reclamation (BOR) facilities. Following this charge, BOR issued a hydropower resource assessment study in 2011, *Hydropower Resource Assessment at Existing Reclamation Facilities*. This report represents the assessment prepared for USACE facilities.

This study looks to build off the work of the ORNL 2012 assessment by more thoroughly evaluating the 236 USACE sites that are identified as having 1 MW or more of potential capacity. This study was performed in two different phases. The first phase determined the potential capacity for individual sites by collecting the best available hydrological for each site. The second phase established the economic feasibility for site development, which consisted of establishing state energy price forecasts to calculate potential energy benefits, updating construction and annual operation and maintenance (O&M) costs from previous studies, and researching potential renewable energy benefits.

1.2. Report Content

This report is organized as follows:

- Section 1, Introduction: Provides the background and scope of the study.
- Section 2, Site Selection and Data Collection: Describes how the non-powered USACE projects with hydropower potential were selected.
- Section 3, Potential Capacity and Generation Methodology: Describes the methodology to determine potential capacity and generation for potential hydropower sites.
- Section 4, Benefits of New Hydropower Generation: Describes the methodology to quantify the benefits of new hydropower generation including energy values and avoided emissions.
- Section 5, Costs Associated with New Hydropower Generation: Describes how the cost estimates for the study were developed (construction costs, non-construction development costs, and O&M costs).
- Section 6, Economic Feasibility of New Hydropower Capacity: Describes the methodology used to determine the feasibility of USACE sites with hydropower potential.
- Section 7, Results: Provides estimated power, generation, and feasibility for USACE sites with hydropower potential by USACE Division and District.
- Section 8, Conclusion: Summarizes the results and describes the limitations of the study.

2. SITE SELECTION AND DATA COLLECTION

In selecting non-powered USACE projects with hydropower potential, the study employed the work performed by the ORNL in the 2012 report, *An Assessment of Energy Potential at Non-Powered Dams in the United States*. The ORNL identified the hydropower potential of 54,000 non-powered dams in the United States using general project attributes such as constant hydraulic head, average m flows, and regional level capacity factors. Among the 54,000 non-powered dams evaluated in the study, 419 were USACE non-powered dams. Using a threshold of 1 MW or more of potential hydropower, the ORNL study identified 236 USACE projects that are analyzed in the current study.

Before additional analysis was performed, the 236 projects were placed through a very coarse filter, which identified projects that already have an existing Federal Energy Regulatory Commission (FERC) license or that have obvious hindrances in developing hydropower. Hindrances to hydropower development were limited to planned removal of the dam or new construction that would greatly reduce hydropower capability. Limitations to hydropower capability due to hydrologic reasons, including seasonal flows, were not considered in this filter and are addressed in Section 3. Table 1 shows the 13 plants removed from the initial list of 236 projects.

Table 1. USACE Sites Removed Due to Existing FERC License or Planned Construction

Plant	USACE Division	Reason for Elimination
John W. Flannagan Dam	Great Lakes & Ohio River (LRD)	Existing FERC License
Red Rock Dam	Mississippi Valley (MVD)	Existing FERC License
Ball Mountain Dam	North Atlantic (NAD)	Existing FERC License
Gathright Dam	NAD	Existing FERC License
Jennings Randolph Dam	NAD	Existing FERC License
Townshend Dam	NAD	Existing FERC License
Pine Creek Lake	Southwestern (SWD)	Existing FERC License
B. Everett Jordan Dam	South Atlantic (Sad)	Existing FERC License
Applegate	Northwestern (NWD)	Existing FERC License
Dorena	NWD	Existing FERC License
New Savannah Bluff	SAD	Planned Fish Passage
Ohio River Lock And Dam 52	LRD	Planned Removal
Ohio River Lock And Dam 53	LRD	Planned Removal

2.1. Identified Projects by USACE Divisions

As shown in Figure 1. Map Showing USACE Divisions, the USACE is composed of eight Divisions. Each Division consists of subordinate Districts generally determined by watershed. This study is organized with results shown by USACE Divisions and Districts. The FERC coordinators for each Division and District can be found in Appendix A.

Table 2 shows the distribution of the identified projects for each of the USACE Divisions containing projects relevant to this study. The Pacific Ocean Division was not included in the ORNL study due to major data limitation, although it is recognized there is undeveloped hydropower potential in Alaska.

Also included in Table 2 is the number of FERC preliminary or pending preliminary licenses for each Division. Status of FERC permits for individual projects can be found in Section 7 for the specific Division. The Great Lakes and Ohio River Division (LRD) has the largest number of identified projects, although 56% already have at least a pending preliminary permit. Of the 223 USACE projects identified, 42% already have at least a pending preliminary permit.

Figure 1. Map Showing USACE Divisions

Table 2. Distribution of USACE Sites with Potential Power Capability by Division and FERC Status

Division	Total Projects Identified	FERC Preliminary or Pending Preliminary Permit		No FERC Permits	
		Total Number	Percentage of Total	Total Number	Percent of Total
Great Lakes & Ohio River (LRD)	71	40	56%	31	44%
Mississippi Valley (MVD)	50	28	56%	22	44%
Southwestern (SWD)	39	7	18%	32	82%
North Atlantic (NAD)	21	2	10%	19	90%
South Atlantic (SAD)	19	8	42%	11	58%
Northwestern (NWD)	12	5	42%	7	58%
South Pacific (SPD)	11	2	18%	9	82%
USACE Total	223	92	41%	131	59%

2.2. Data Requirements and Quality

To improve this study, the daily hydraulic head and flow values for all 223 identified sites were obtained. This effort involved contacting each Division's Water Management office, who then directed the data call to specific District or regional offices in charge of maintaining this data. As to be expected for a data call of this size, the quantity and quality of the data available varied greatly. Table 3 shows the available data for each Division. As shown in the table, the data quality was broken down into three categories:

1. Daily hydraulic head and flow values for more than 3 years (full data). At least 3 years of daily hydraulic head and flow values are used for the project's hydropower evaluation. This category is the most reliable estimation because it considers the seasonality of the hydropower potential, the yearly hydrological variation, and the relationship between hydraulic head and flow.
2. Daily flow values for more than 3 years (constant hydraulic head). Only flow values are available for more than 3 years. A constant hydraulic head was estimated using the constant project hydraulic head values used in the ORNL study. This category may still consider the seasonality and hydrologic variability of the hydropower potential; however, it does not consider the relationship between flow and hydraulic head, which may be significant for many projects. This category is considered the second most reliable estimation.
3. No additional data (use ORNL data). No information was available from the project's Division or District offices. Both the hydraulic head and flow values used were derived directly from the ORNL study. Although the calculations in the ORNL study used an average flow value, data is available for monthly average flows. Using monthly flows may help consider the seasonality of the hydropower generation; however, the yearly hydrologic variability and hydraulic head and flow relationship are not considered. This is considered the least reliable estimation.

Table 3. Data Quality for USACE Sites with Potential Hydropower Capability

Division	Total Projects Identified	Daily Hydraulic Head and Flow for More than 3 Years		Daily Flow for More than 3 Years		No Additional Data	
		Total Number	Percent of Total	Total Number	Percent of Total	Total Number	Percent of Total
Great Lakes and Ohio River (LRD)	71	70	99	1	1	0	0
Mississippi Valley (MVD)	50	48	96	0	0	2	4%
Southwestern (SWD)	39	36	92	3	8	0	0
North Atlantic (NAD)	21	16	76	5	24	0	0
South Atlantic (SAD)	19	6	32	1	5	12	63
Northwestern (NWD)	12	7	58	5	42	0	0
South Pacific (SPD)	11	0	0	0	0	11	100
USACE Total	223	183	82	15	7	25	12

Of the total 223 projects, 183 projects (82%) had daily flow and hydraulic head values for more than 3 years. An additional 7% had at least daily flow values for more than 3 years. The remaining 12% (25 projects) did not have any additional data relative to the ORNL study. The LRD had the most complete data, while SPD had the least.

3. POTENTIAL CAPACITY AND GENERATION METHODOLOGY

Hydroelectric power can be estimated using the water power equation defined as follows:

$$P = \frac{QHe}{11800} \quad \text{(Equation 1)}$$

Where P= power (MW), Q=flow (cfs) , H= hydraulic head (ft.), and e=efficiency.

Hydroelectric energy in terms of megawatt hours (MWh) can be estimated by multiplying the power equation by time:

$$E = \frac{QHeT}{11800} \quad \text{(Equation 2)}$$

Where E is energy in MWh and T is time defined in hours.

3.1. Defining the Variables in the Water Power Equation:

The power equation consists of three variables: hydraulic head, flow, and efficiency. As discussed in Section 2.2, daily hydraulic head and flow data was sought for all 223 identified projects. The following paragraphs expand on the definitions of these variables and briefly explore the limitations of potential capacity estimates as a result of implementing a method with limited data.

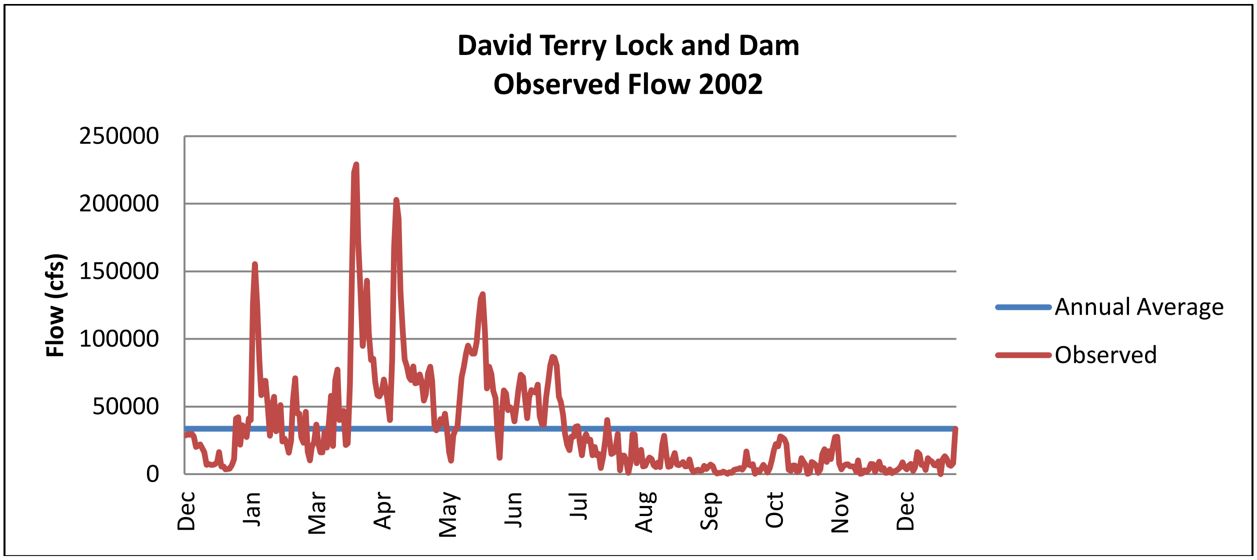
3.1.1. Flow (Q)

Flow is defined as the flow rate leaving a hydraulic structure, such as a spillway. In some hydroelectric projects with sufficient storage, flow values may change dramatically throughout the day. In some cases, the flow may be released only a few hours a day to meet peak electricity demands. It was not in the scope of this study to estimate a project's hourly operational flexibility. Conversations with plant operators suggested that this flexibility is probably very limited. In this regard, average daily flows are considered sufficient and used whenever possible.

Since the market value of hydropower generally increases during the higher summer temperatures and lower winter temperatures, the feasibility of a project may be a function of the seasonal variability of the flow. As an example, Figure 2 shows the observed flow values for David Terry Lock and Dam on the Arkansas River. The seasonal variation of the hydrology shows the largest magnitudes of flow occur during the spring months between April and May with flows significantly decreasing between the late summer and early winter period.

When average daily flow values were not available, average monthly (static) estimates of flow from the ORNL study were used. These values address the annual seasonal variation of flow, but do not address the inter-annual variability between years.

Figure 2. Hydrograph of David Terry Lock and Dam



3.1.2. Hydraulic Head (h)

Hydraulic head is defined as the height difference between headwater and tailwater elevations. This value also changes significantly throughout the year. For storage projects, headwater elevations are increased as more water is stored behind the dam, while tailwater elevations are increased as water is released filling up the river below the dam. In some cases, the tailwater elevation may also be a function of back water conditions of downstream storage or tributaries inflow. Additional head may also be obtained through penstock diversion but is not considered in this study,

As shown in Figure 3 for the David Terry Lock and Dam, as flow increases the observed head decreases, converging toward zero where hydropower potential is negligible. The use of an average head may overestimate the projects hydropower potential.

The relationship between hydraulic head and flow is not always as clear as shown in Figure 3. For the Blue Mountain Dam on the Petit Jean River in west central Arkansas, the hydraulic head does not decrease with flow (Figure 4). In this case, an average hydraulic head would be suitable to be used in a hydropower resource assessment.

Figure 3. Observed Head and Flow Relationship for David Terry Lock and Dam

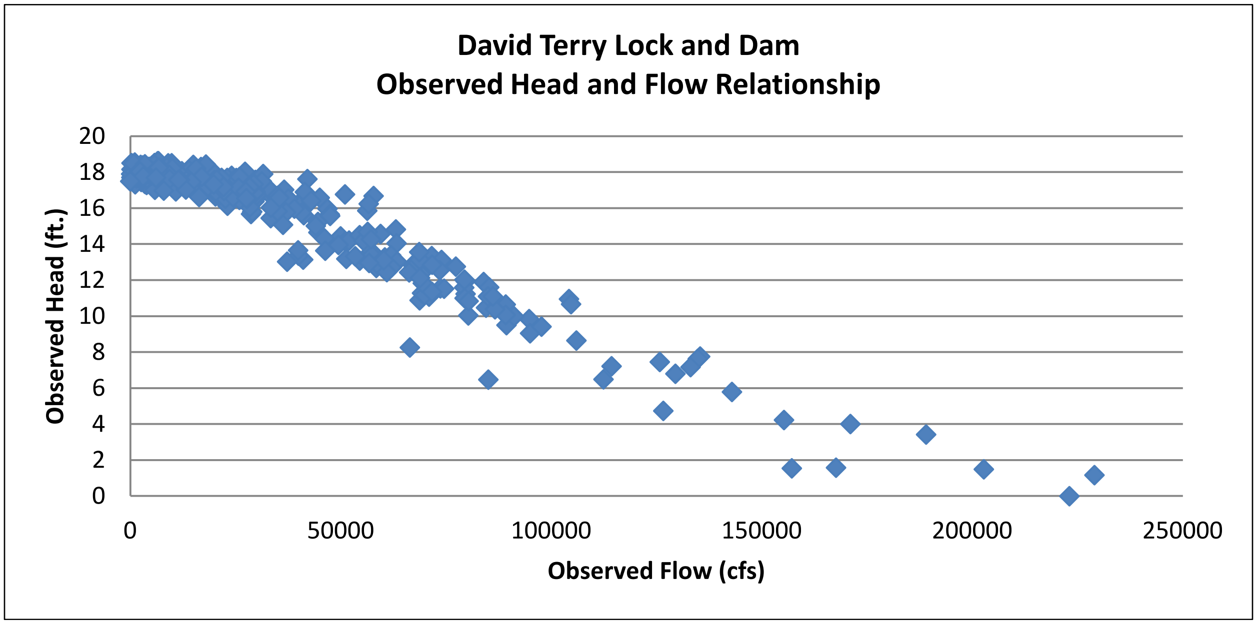
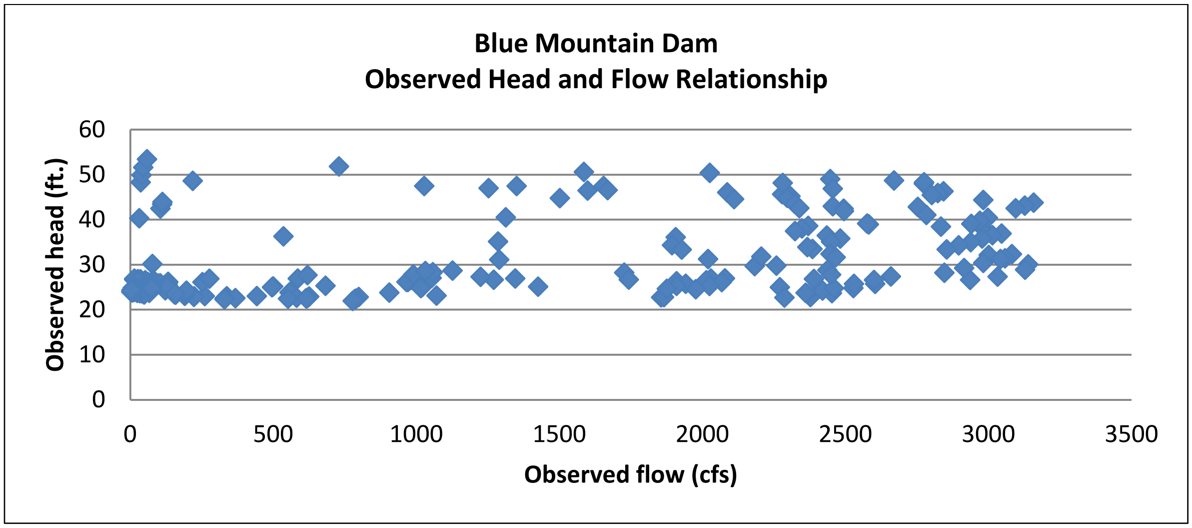


Figure 4. Observed Head and Flow relationship for Blue Mountain Dam



3.1.3. Efficiency (e)

The efficiency of hydropower generating equipment is comprised of two components: turbine efficiency and generator efficiency. The turbine converts kinetic energy into mechanical energy. Efficiency losses in this transformation can occur due to mechanical friction and heat dissipation. In general, turbine efficiency can be expressed in terms of a hill curve, representing turbine efficiency as a function of both hydraulic head and flow. The generator converts mechanical energy into electrical energy. Generally speaking, generator efficiency is a function of the generated power.

Developing a function for efficiency based on the hydrologic extremes is outside the scope of this study, therefore an 85% overall efficiency is assumed.

3.2. Determining Hydropower Capability from Power Duration Curve

To take into consideration the coupling of the variables hydraulic head and flow, this analysis computes potential capacity using a power exceedance curve (Figure 5). This curve shows the percentage of time that power levels are exceeded using daily historical records and Equation 1. This method is also implemented if static hydraulic heads are used, although the hydraulic head and flow relationship is not considered.

Using this curve, one rule-of-thumb estimate for potential capacity would be to develop a capacity value that captures 70% of the energy of the river, which would correspond to the 30% probability of exceedance shown in Figure 5. However, the goal of this study is to look beyond one capacity and to consider a possible range of capacity values and test their feasibility. To accomplish this goal, nine significant exceedance points are picked from the duration curve, corresponding to the 1%, 10%, 20%, 30%, 40%, 50%, 60%, 70%, and 80% exceedance probabilities. As an example, for the David Terry Lock and Dam the following potential capacity points are picked along with their associated exceedance probabilities (Table 4).

Figure 5. Power Duration Curve David Terry Lock and Dam

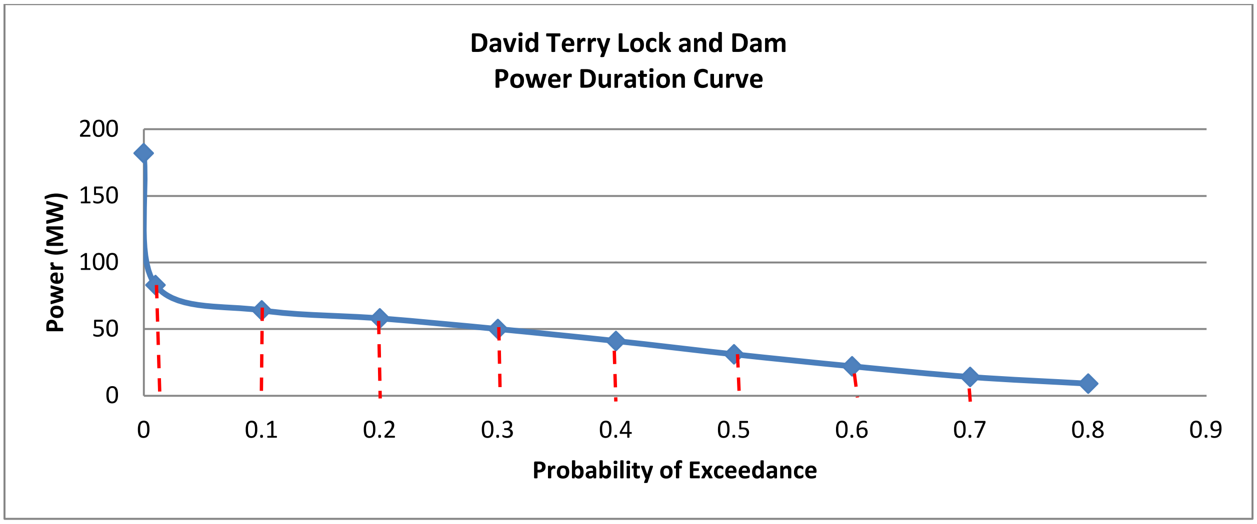


Table 4. Capacity Values Considered for David Terry Lock and Dam Based on Power Duration Curve

Exceedance Probability	1%	10%	20%	30%	40%	50%	60%	70%	80%
Capacity (MW)	83	64	58	50	41	31	22	14	9

3.3. Calculating Generation

The hydropower equation (Equation 1) provides a method for calculating an average daily power value from the average daily head and flow. However, this value is constrained by the installed capacity of the plant. Table 5 illustrates how, for the David Terry Lock and Dam, projected installed capacity constrains the average daily power value. In this example, on May 6 the head and flow values resulted in an unconstrained average daily power of 62 MW. The 1% and 10% exceedance capacities correspond to 83 MW and 64 MW, respectively. Since the daily average power was lower than those capacities, daily average power was not constrained. However, for the 80% capacity corresponding to 58 MW, the average daily power was limited to only 58 MW. On May 7, the unconstrained daily average power was 74 MW, causing both the 10% and 20% exceedance capacities to be constrained. From these constrained average daily power values, an estimated daily energy generation is calculated by multiplying the daily power value by 24 (corresponding to 24 hours in a day).

Table 5. Example Energy Calculation for David Terry Lock and Dam Under Capacity Constraints

Date	**Flow**	**Head**	**Max Capacity (MW)**	**83**	**64**	**58**	**83**	**64**	**58**
			Unconstrained Power (MW)	**Avg. Daily Power (MW)**			**Daily Energy (MWh)**		
5/6/06	100,000.0	8.56000	62	62	62	58	1,488	1,488	1,392
5/7/06	86,000.0	12.02000	74	74	64	58	1,776	1,536	1,392
5/8/06	51,000.0	12.92000	47	47	47	47	1,128	1,128	1,128

This process is continued for each day in a project's historical record, allowing for computations for both average annual and monthly generation. The average monthly generation is used to test a project's feasibility, as energy prices fluctuate seasonally. The annual generation value is used for some cost estimates described in Section 5 and for calculation of a project's capacity factor, defined as:

$$\text{Capacity Factor} = \frac{\text{Annual Average Generation (MWh)}}{\text{Installed Capacity(MW)} * 24 * 365} \quad \text{(Equation 3)}$$

3.4. Methods for Limited Data

As explained in Section 2, data for some projects were limited to the values used in the ORNL study. The values available were a static constant head and monthly average flow values. With those values, the power equation (Equation 1) can be utilized to compute average monthly power values. The estimated installed capacity is then determined as the maximum average monthly power value over the entire year. Illustrations for the computation for Alamo Dam on the Billy Williams River are shown in Table 6.

Table 6. Example Capacity and Energy Calculations for Alamo Dam

Month	Flow (cfs)	Hydraulic Head (ft)	Average Monthly Power (MW)	Days in Month	Estimated Energy (MWh)
Jan	312	185	4.16	31	3,091.40
Feb	258	185	3.44	28	2,309.75
Mar	29	185	0.39	31	288.40
Apr	16	185	0.22	30	155.37
May	15	185	0.20	31	151.44
Jun	21	185	0.29	31	212.30
Jul	31	185	0.41	31	304.38
Aug	37	185	0.50	31	370.38
Sep	75	185	1.00	30	716.50
Oct	105	185	1.40	31	1,038.24
Nov	62	185	0.82	30	591.20
Dec	4	185	0.05	31	37.80
				Average Annual Generation (MWh)	**9,267.16**

Monthly generation values are calculated as the product of the average monthly power, the number of days in the month, and 24 (corresponding to the 24 hours in a day). Table 6 illustrates these computations. The summation of monthly generation values over the year provides the average annual generation. This can be used in Equation 3 to compute a project's capacity factor. Table 7 shows the final plant attributes for Alamo Dam.

Table 7. Estimated Capacity ,Average Annual Generation and Capacity Factor for Alamo Dam

Plant Name	Alamo Dam
River	Bill Williams River
Estimated Capacity (MW)	4.16 MW
Annual Generation (MWh)	9,267.16 MWh
Capacity Factor	0.254301677

4. BENEFITS OF NEW HYDROPOWER GENERATION

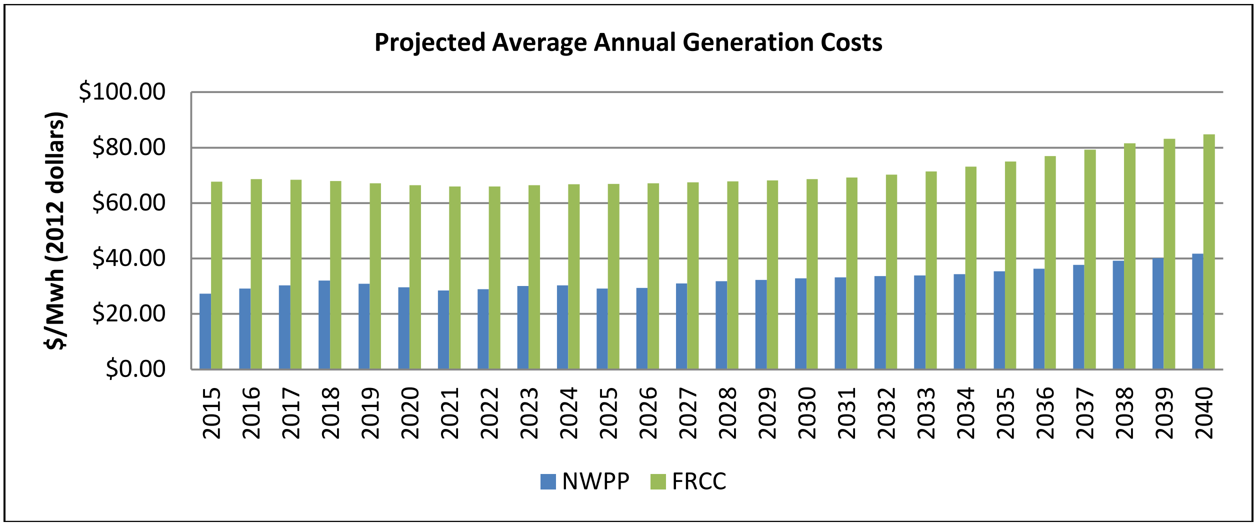
To test the feasibility of new hydropower capacity, benefits of the hydropower generation are calculated. These benefits include monetary benefits such as the energy value of the hydropower generation and any federal or state renewable performance incentives that maybe available. A Non-monetary benefit of new hydropower generation considered in this study includes the avoided emissions of using a non-fossil fuel based electricity resource.

4.1. Energy Values Benefits

The 2013 Annual Energy Outlook (early release) by the Energy Information Administration (EIA) provides projected annual end-use electricity costs to the year 2040 for 22 electric market module (EMM) supply regions using the National Energy Modeling System (NEMS) EMM. The projected annual end-use electricity costs are further broken down into generation, transmission, and distribution for each of the supply regions. For this study, long-term energy values will be based on the projected generation category of the end use price. Appendix B shows a table of the states that fall within each EMM supply region and Appendix C shows the projected generating costs for each supply region used in this study.

Figure 6 shows the EIA's projected average annual generation costs for two different EMM supply regions in constant 2012 dollars. The Northwest Power Pool (NWPP) has the lowest projected generation costs among all 22 supply regions, while the Florida Reliability Coordinating Council (FRCC) has the highest projected generating costs. Generating costs for years beyond the EIA's forecast are assumed to be constant and are set at the 2040 level.

Figure 6. Projected Average Annual Generation Costs for the Northwest Power Pool and the Florida Reliability Coordinating Council



Note: Data supplied by the Energy Information Administration (EIA).

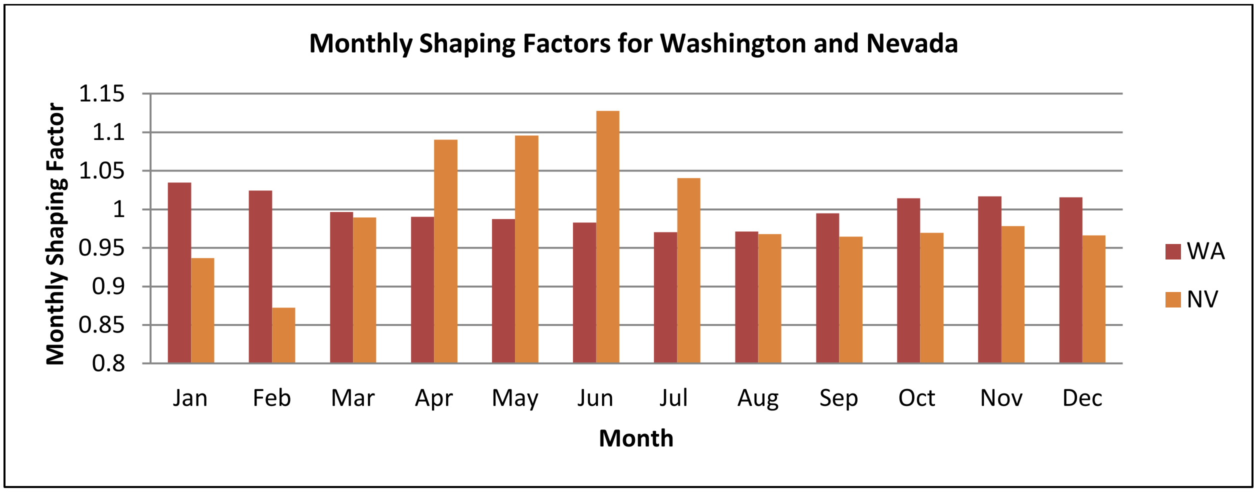
4.2. Monthly Shaping of EIA Long-term Generation Cost Forecast

Although states within the same EMM supply region are assumed to have the same annual generating costs, the energy value of additional generation from these states throughout the year may vary significantly depending on demand. For example, states with extreme high summer temperatures and mild winters would have higher demands in the summer due to the number of cooling days. This results in higher energy prices during the summer, where additional or higher costs generating sources are forced to operate in meeting demand.

To address this concern in calculating individual states projected energy value, the EIA's annual generating costs are shaped to better fit each state's demand profile using a monthly shaping factor. The shaping factor is determined using historical monthly retail energy prices for each state. These values were downloaded from the EIA's Applications Programming Interface that stores average monthly retail energy prices for each state from 2001 to 2012, although this study only utilizes data from 2008-2012. For each historical year, a monthly shaping factor is calculated as a ratio between the month's retail price and the year's average annual retail price. Each month's shaping factor is then averaged over the five years of historical records (Equation 4). Monthly shaping factor values for Washington and Nevada are shown in Figure 7. Shaping factors for each state are listed in Appendix D.

$$Shaping\_Factor_{State}(Month) = \frac{\sum_{year=2008}^{2012} \frac{\text{Retail\_price}_{\text{state}}(\text{Month, Year})}{\text{Average\_Retail\_Price}(\text{Year})}}{5} \qquad \text{(Equation 4)}$$

Figure 7. Monthly Shaping Factors for Washington and Nevada



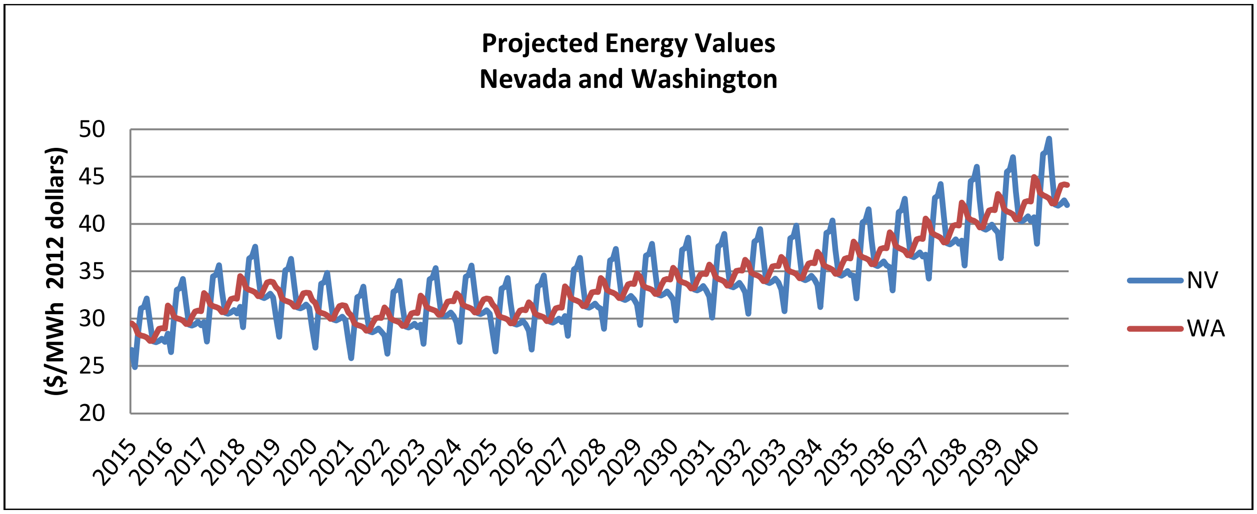
Once each state's monthly shaping factor is calculated, it can be applied to the EIA's generation cost forecast for the defined EMM supply region using Equation 5.

$$Energy\_Value_{State}(Month, Year) = Shaping\_Factor_{State}(Month) * Generation\_Cost_{EMM\_Region}(Year) \quad \text{(Equation 5)}$$

Figure 8 shows the estimated energy values for Nevada and Washington, both a part of the NWPP supply region. As illustrated in this figure and in Figure 7, the State of Nevada has expected high-energy values during the summer months and low energy values during the winter months. On the other hand, the State of Washington has much milder peaks with higher energy values during the winter months and lower energy values during the spring and early summer.

Figure 8. Projected Energy Values for Nevada and Washington

Note: Calculations are made using Equation 5.



4.3. Reduced Green House Gas Emissions

An environmental benefit associated with hydropower generation is avoided emissions. Emissions would be avoided by generating electricity from hydropower as opposed to generating electricity from a fossil fuel source. An avoided emissions factor depends on the generating resource of the power that is displaced by the hydropower project. Since different regions have different generating resource mixes, this factor is regionally dependent. This factor may also be seasonally or even hourly dependent as different mixes of generating resources are required to meet demand.

The Environmental Protection Agency's eGrid (http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html) is a comprehensive database of environmental attributes of electric power systems, incorporating data from several federal agencies. One field of data stored in the eGrid database is emission rates for 26 eGrid subregions. These regions are constrained within a single NERC region with similar emissions and generating resource mixes. Appendix B lists the associated eGrid region by state.

Emission rates from the eGrid database are defined as pounds per MWh for three greenhouse gases (GHG): carbon dioxide, methane, and nitrous oxide. These are further divided into baseload and non-baseload generating resources. Since hydropower is often used to replace the generating resources on the margin, this study uses the non-baseload emission rates.

Table 8 lists the emission rates used in this study for the three GHG calculated in the eGrid database. Also included in this table is the emission rate for equivalent carbon dioxide (CDE) for the generating resource mix. This metric is used to define the total global warming potential (GWG) from the mix of the three greenhouse gases defined by the eGrid database using the equivalent concentration of carbon dioxide as a reference.

Table 8. Greenhouse Gas Annual Output Emission Rates by eGrid Subregion from eGrid 2007

eGRID Subregion Name	Annual Non-baseload Emission Rates			
	Carbon Dioxide	Methane	Nitrous Oxide	Carbon Dioxide Equivalent
	(CO_2)	(CH_4)	(N_2O)	CDE
	(lb/MWh)	(lb/MWh)	(lb/MWh)	(lb/MWh)
ASCC Alaska Grid	1473.430	0.036	0.008	1476.749
ASCC Miscellaneous	1457.110	0.060	0.012	1462.060
WECC Southwest	1201.440	0.021	0.009	1204.512
WECC California	1083.020	0.039	0.006	1085.565
ERCOT All	1118.860	0.020	0.006	1121.044
FRCC All	1353.720	0.048	0.013	1358.746
HICC Miscellaneous	1674.150	0.338	0.051	1697.197
HICC Oahu	1855.100	0.120	0.021	1864.067
MRO East	1828.630	0.029	0.025	1837.047
MRO West	2158.790	0.046	0.035	2170.665
NPCC New England	1314.530	0.077	0.016	1321.123
WECC Northwest	1333.640	0.049	0.019	1340.481
NPCC NYC/Westchester	1525.050	0.057	0.009	1529.058
NPCC Long Island	1509.850	0.060	0.011	1514.459
NPCC Upstate NY	1514.110	0.045	0.018	1520.768
RFC East	1790.500	0.042	0.024	1798.925
RFC Michigan	1663.150	0.029	0.026	1671.902
RFC West	1992.860	0.024	0.032	2003.207
WECC Rockies	1617.710	0.022	0.020	1624.424
SPP North	2169.740	0.031	0.032	2180.312
SPP South	1379.050	0.024	0.012	1383.295
SERC Mississippi Valley	1257.100	0.030	0.010	1260.764
SERC Midwest	2101.160	0.026	0.033	2111.904
SERC South	1697.220	0.035	0.026	1706.146
SERC Tennessee Valley	1998.360	0.028	0.033	2009.140
SERC Virginia/Carolina	1781.280	0.040	0.027	1790.634

4.4. State and Federal Performance Renewable Energy Incentives

Performance based incentives can include a wide range of financial incentives from both the state and Federal level. Typically, these incentives include a utility providing financial compensation to residential and commercial members who generate energy from approved renewable energy sources. The incentive payments are based on the amount of kilowatt hour (kWh) production. Performance based incentives are often accompanied by strict limitations regarding which energy sources are accepted as well as when other incentives can be received in addition to the performance based incentives. A query of the Database of State Incentives for Renewables and Efficiency (DSIRE) showed that there are no state hydropower performance incentives currently available. In addition, the Federal Production Tax Credit (PTC) and the Investment Tax Credit (ITC) are only available to for projects that begin construction by the end of 2013. In this regard, no state and renewable energy incentives are included in this study; however, an analysis of the benefit of the federal incentives is included in Appendix G.

4.5. Other Incentives

Other renewable energy incentives include corporate or property tax credits, PACE financing, and utility rebate programs. Corporate or property tax credits are typically implemented at the state level and provide incentives through tax credits, deductions, and/or exemptions related to the renewable energy facilities. In general, individual state incentives have a maximum amount of credit or deduction available and in some cases cannot be stacked with or taken if federal tax incentives are also available. Property-assessed Clean Energy (PACE) financing is typically a form of loan that is administered by the local government. The repayment is often completed through a special assessment on the owner’s property over time. Utility rebate programs are offered by utilities to encourage the development of renewable energy and energy efficiency measures. These programs often cater to specific types of renewable energy sources and are used by utilities to meet renewable portfolio standards or other renewable power generation requirements.

5. COSTS ASSOCIATED WITH NEW HYDROPOWER GENERATION

The cost estimates included in this study are for construction costs, non-construction development costs, and annual operation and maintenance (O&M) costs. This study utilizes the cost estimations defined by the Idaho National Engineering and Environmental Laboratory (INEEL) 2003 study, *Estimation of Economic Parameters of U.S. Hydropower Resources*. Additional costs not included in the INEEL study are taken from the BOR 2011 study, *Hydropower Resource Assessment at Existing Reclamation Facilities.*

Cost estimates associated with the INEEL study were based on a historical survey of a wide range of cost components over a large number and sizes of projects at different existing facilities. The INEEL acquired historical data on licensing, construction, and environmental mitigation from a number of sources including Federal Energy Regulatory Commission (FERC) environmental assessments and licensing documents, EIA data, Electric Power Research Institute reports, and other reports on hydropower construction and environmental mitigation. Based on this historical data, cost estimating equations were derived through generalized least squares regression techniques, with capacity, generator speed, and hydraulic head acting as independent variables. Those costs included powertrain components, licensing, construction, fish and wildlife mitigation, water quality monitoring, and O&M.

5.1. Cost Estimation Parametric Equations

Cost estimates in the INEEL report are in 2002 dollars while costs estimates from the BOR study are in 2010 dollars. For this study, all cost estimates are indexed to 2012 based on applicable indices from the Civil Works Construction Cost Index System (CWCCIS) and from ENR's skilled labor index.

The direct construction costs were based on the estimates in the 2003 INEEL report. The specific indices used in this analysis were those for power plant, fish and wildlife facilities, and cultural resource preservation. The power plant index was used to index the costs associated with turbines, generators, transformers, licensing costs, and recreation mitigation. The fish and wildlife facilities index was used to escalate the costs associated with fish and wildlife mitigation. Lastly, the cultural resource preservation index was used to escalate the costs associated with historical and archeological mitigation.

Based on the power plant index, the INEEL's cost estimates are escalated from 2002 dollars to 2012 dollars using an escalation factor of 46.22%. The construction costs exclusively associated with transformers were based on the 2010 BOR report. The power plant index was used to escalate those prices from 2010 dollars to 2012 dollars using an escalation factor of 38.55%. Based on the fish and wildlife facilities index, INEEL's costs estimates are escalated from 2002 dollars to 2012 dollars using an escalation factor of 47.03%. Lastly, based on the cultural resource preservation index, INEEL's estimates are escalated from 2002 dollars to 2012 dollars using an escalation factor of 58.36%.

5.1.1. Construction Costs

Total direct construction costs include costs related to civil works, turbines, generators, mechanical and electrical balance of plants, and transformers. Additional construction costs include contingencies, sales taxes, potential licensing and mitigation costs, and engineering and construction management costs. Construction costs associated with turbines and generators were all indexed from INEEL's estimates to 2012 dollars using the power plant index reported in the Civil Works Construction Cost Index System

(CWCCIS). Similarly, these same indices were used to escalate the BOR's transformer cost estimates to 2012 dollars. Table 9 shows the cost estimate equations for direct construction costs.

Table 9. Parametric Cost Estimates for Direct Construction Costs

Direct Construction Cost	Cost Estimation Equation	c1	c2	c3	Source
Civil Works	C1*(Turbine Costs+Generator costs)	0.4			BOR
Kaplan Turbine	C1*MW^C2*hydraulic head^C3	5848677.6	0.72	-0.38	INEEL
Francis Turbine	C1*MW^C2*hydraulic head^C3	4386508.2	0.71	-0.42	INEEL
Bulb Turbine	C1*MW^C2*hydraulic head^C3	8773016.4	0.86	-0.63	INEEL
Generator	C1*MW^c2*speed^c3	4386508.2	0.65	-0.38	INEEL
Mechanical Balance of Plant	C1*turbine costs	0.2			BOR
Electrical Balance of Plant	C1*generator costs	0.35			BOR
Transformer	C1-(C2*(kW/.9)^2)+(c3*(kw/.9))	15688.31	0.0001	25.403	BOR

MW=installed capacity (MW), kW=installed capacity (kW), hydraulic head=design head (feet), speed=generator speed (rpm)

In addition to direct construction costs, total construction costs may include a variety of additional costs. Additional costs that are applicable to all projects are those of licensing costs, an estimated contingency cost, state sales tax based on project location, and an assumed engineering and construction and management cost.

Additional costs that may not be applicable to all projects include fish passage, historical and archeological studies, water quality monitoring, fish and wildlife mitigation, and recreational mitigation. Since these costs may not be applicable to all projects, they are not included in the final BCR calculations. Table 10 shows the cost estimate equations for other construction costs.

Table 10. Parametric Equations for Other Direct Construction Costs.

Note: Mitigation, water quality monitoring, and fish passge are not included in final BCR calculations.

Other Construction Costs	Cost Estimation Equation	c1	c2	source
Contingency	c1*Direct Construction Costs	0.2		BOR
Sales Tax	c1*Direct Construction Costs	State defined		BOR
Engineering and Construction Maintenance	c1*Direct Construction Costs	0.15		BOR
Licensing Costs	c1*MW^c2	453272.51	0.7	INEEL
Fish and wildlife mitigation	c1*MW^c2	294050.62	0.96	INEEL
Recreation Mitigation	c1*MW^c2	248568.8	0.97	INEEL
Historical and Archeological Mitigation	c1*MW^c2	134607.22	0.72	INEEL
Water Quality Monitoring	c1*MW^c2	294050.62	0.44	INEEL
Fish Passage	c1*MW^c2	19113290.3	0.56	INEEL

5.1.2. Operating and Maintenance Costs

The O&M costs encompass a variety of expenses that are expected for most projects. Among these expenses are fixed and variable annual O&M, FERC charges, insurance, taxes, management, and the long-term funding of major repairs. The estimates for these expenses are dependent on either the installed capacity or the total construction costs. Similar to development costs, O&M costs were escalated from INEEL's estimates of 2002 dollars to 2012 dollars using the Engineering News-Record's (ENR) skilled labor index. Table 11 shows cost estimation equations for annual O&M costs.

Table 11. Parametric Equations for Operation and Maintenance Cost Estimates

Operation and Maintenance Costs	Cost Estimation Equation	c1	c2	Source
Fixed O& M	c1*Mw^c2	34409.24	0.75	INEEL
Variable O&M	c1*Mw^c2	34409.24	0.8	INEEL
FERC Annual Charge	kw+c1*Gwh	112.5		BOR
Insurance	c1*total direct construction	0.003		BOR
Taxes	c1*total direct construction	0.012		BOR
Management	c1*total direct construction	0.005		BOR
Major repairs	c1*total direct construction	0.001		BOR

5.2. Turbine and Generator Selection

The cost estimation equations listed above for direct construction cost require some assumptions to be made about both the turbines and generators selected for each project. Consultation with USACE's Hydroelectric Design Center (HDC) yielded the following assumptions.

- Design head. Design head should be calculated from the head duration curve at the 30% probability of exceedance level.
- Generator rotational speed. Generator rotational speed in revolutions per minute (rpm) is estimated using the following equations taken from the BOR report, *Selecting Hydraulic Reaction Turbines*.

$$n = \frac{n_s h^{5/4}}{p^{1/2}} \quad \text{(Equation 6)}$$

Where n= generator speed (rpm), h=design head (ft), p=installed capacity (hp);
specific speed (n_s) is estimated as:

(Equation 7) $n_s = \frac{850}{\sqrt{h}}$ for $h \le 80\,\text{ft}$ or $n_s = \frac{632}{\sqrt{h}}$ for $h > 80\,\text{ft}$ (Equation 8)

- Turbine-type selection. Turbine-type selection was based on the design head using the following categorization:

$$\text{Turbine Type}=\begin{cases} Head < 50\,ft & Bulb \\ 50\,ft < Head < 70\,ft & Kaplan \\ Head > 70\,ft & Francis \end{cases} \qquad \text{(Equation 9)}$$

- Turbine and generator capacity limits. Turbines and generators are limited to the following maximum capacity values:

    1. Bulb Turbines: < 40 MW;
    2. Francis Turbine: < 40 MW; and
    3. Kaplan Turbine: no constraint.

Installed capacity for a project exceeding those limits will include enough additional turbines to satisfy these constraints assuming equal distribution among the units.

6. ECONOMIC FEASIBILITY OF NEW HYDROPOWER CAPACITY

The analysis considers the economic feasibility of new hydropower generation over a 50-year planning horizon. The assumption is that new construction will begin in 2014 and last 3 years until 2016. Total construction cost is distributed equally over the 3 years. Upon completion of construction, energy value benefits, green incentives, and operation and maintenance costs are accrued annually until the final year 2063. All associated costs and benefits are in 2012 dollars.

To determine economic feasibility two metrics are considered:

1. Benefit-cost Ratio (BCR): The BCR compares the net present value of benefits to the net present value of cost over a 50-year period of analysis. The present value of cost and benefits is calculated using the 2013 federal discount rate of 3.75%. In general, a BCR greater than 1.0 suggests the quantified benefits are greater than the quantified costs. In this regard, all projects with a BCR greater than one are determined as feasible.

2. Internal Rate of Return (IRR): The IRR of an investment is the discount rate at which the net present value of the cost equals the net present value of the benefits. For example, a project with an IRR of 3.75% would have a BCR of ratio of one, using the above definition and the 2013 federal discount rate. Projects with an IRR greater than 3.75% would have a BCR greater than one. For this study, projects with an IRR less than zero are denoted as negative.

For projects with at least 3 years of daily flow records, the BCR and IRR are calculated for 10 capacity values based on a project's power duration percent exceedance, as described in Section 3.2. From this analysis, minimum, maximum and optimal feasibility are determined for each project.

Figure 9 shows a graph of the BCR versus capacity levels for David Terry Lock and Dam. In this example, the maximum feasible capacity is about 64 MW, while the optimal capacity is about 23 MW. The detailed output for the feasibility analysis of David Terry Lock and Dam is shown in Table 12.

Figure 9. BCR vs. Capacity Levels for David Terry Lock and Dam

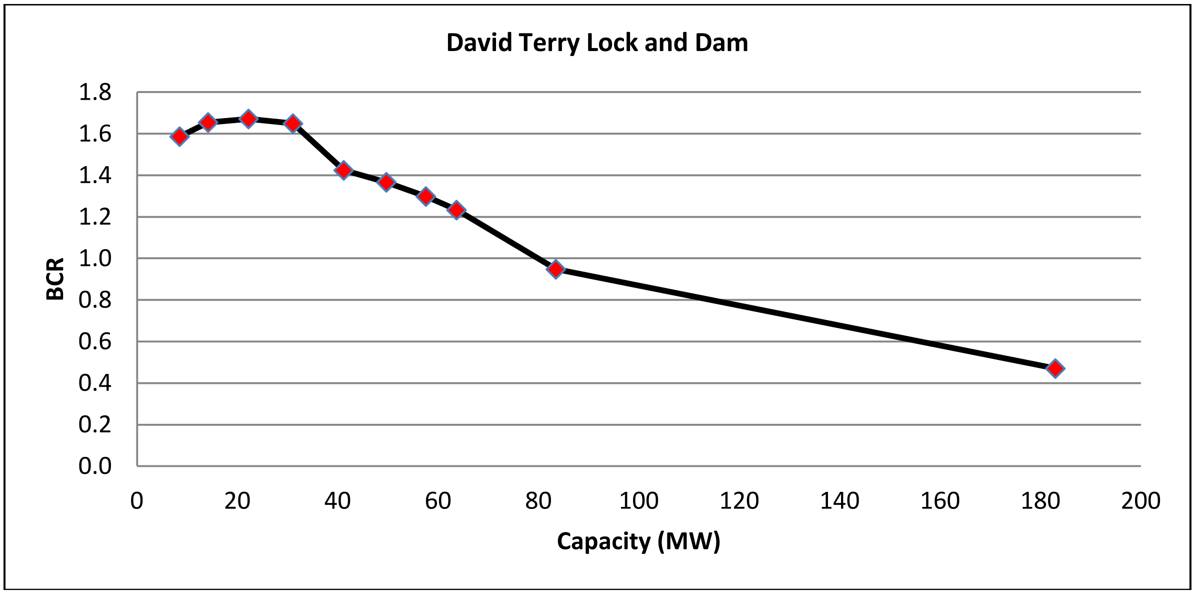


Table 12. Detailed Output for Feasibility Analysis of David Terry Lock and Dam

Power Duration Exceedance Probability	Max Cap (MW)	Estimated Construction Costs	Estimated O&M Costs	Average Annual Generation (MWh)	BCR	IRR
1%	83.46	$243,239,595	$7,275,003	279707	0.95	3.3%
10%	63.68	$181,568,699	$5,574,089	274282	1.23	5.6%
20%	57.57	$167,534,590	$5,148,132	266599	1.30	6.0%
30%	49.70	$148,994,367	$4,584,010	249830	1.37	6.5%
40%	41.20	$128,336,679	$3,953,766	224561	1.42	6.9%
50%	31.09	$90,038,256	$2,902,822	185984	1.65	8.4%
60%	22.24	$68,957,071	$2,228,273	144715	1.67	8.6%
70%	14.19	$48,301,095	$1,564,479	100568	1.65	8.5%
80%	8.52	$32,305,603	$1,048,178	64621	1.59	8.0%

7. RESULTS

This section presents the results of the analysis for each of the USACE Divisions. The results are further divided by District, with each District's set of results containing a map of the dams considered and two data tables. The first of these two data tables shows power potential and basic hydrologic statistics. Specifically, for each dam in the District, the power potential table shows estimated potential capacity, corresponding average annual generation, capacity factor, average annual head value, average annual flow value, and the CO_2 emissions avoided by developing the proposed amount of hydropower capacity at the project. The capacity value presented in the first table is taken from the calculated power duration curve, with a cap at the 1% probability level. That is, the capacity value represents capturing 99% of the power of the river.

The second of the two data tables displays the results of the economic feasibility aspect of this study. These tables present a range of capacity values, BCRs, and IRRs for hydropower development; more specifically, minimum feasible, maximum feasible, and optimal levels for each of these metrics.

In the economic feasibility tables, "NF" appears for certain dams. This is an indication that the addition of hydropower capacity to the dam in question is judged not feasible by the current model. In both the economic feasibility tables and the power potential tables, there are dams for which the calculated benefit cost ratio indicates feasibility, but the estimated potential capacity is less than 1 MW. In these cases, potential capacity is simply listed as "< 1," reflecting that the model and study are not intended to measure capacity values on this scale.

In addition to the two District data tables described in the previous paragraphs, there is a summary table for each Division, containing a list of the Division's dams with information about each project. In particular, for each dam, these tables list the quality of the data associated with that dam, as well as the current FERC license status, and the waterway associated with the structure. Data quality in this report falls into three categories: full data, constant head data, and ORNL data. The full data designation indicates that daily average flow and head values were used for calculation of results for the dam in question. The constant head designation indicates that daily flow data was utilized, but only a constant head value was available. Finally, an ORNL data designation means that only the data utilized by ORNL in their study of non-powered dams was available. This consists of an estimated constant head value, and an average monthly flow value.

Lastly, the FERC designations in these Division summary tables are either "N" indicating no permit exists or has been applied for, or "P" indicating that a FERC license is pending.

7.1. Great Lakes and Ohio River Division

The Great Lakes and Ohio River Division (LRD) consists of seven Districts. In this report, 71 non-powered LRD dams spread across four Districts are considered. These dams represent approximately 1,962 MW of potential capacity, of which about 898 MW (46%) is feasible. Table 13 shows all 71 of the dams from LRD and their corresponding data status for this report. Full data was utilized for all but one of the 71 LRD dams, with the one remaining having a constant head designation. Of the 71 dams, 39 currently have a pending FERC license, while the remaining 32 have no FERC license.

Table 13. Great Lakes and Ohio River Division Data Completeness and FERC Status

GREAT LAKES AND OHIO RIVER DIVISION				
ID	**NAME**	**FERC LICENSE**	**DATA CONFIDENCE**	**WATERWAY**
LRD-1	ALLEGHENY LOCK AND DAM 02	P	Full Data	ALLEGHENY RIVER
LRD-2	ALLEGHENY LOCK AND DAM 03	P	Full Data	ALLEGHENY RIVER
LRD-3	ALLEGHENY LOCK AND DAM 04	P	Full Data	ALLEGHENY RIVER
LRD-4	ALLEGHENY LOCK AND DAM 07	P	Full Data	ALLEGHENY RIVER
LRD-5	ALUM CREEK DAM	N	Full Data	ALUM CREEK OF BIG WALNUT CRK.
LRD-6	BARREN RIVER LAKE DAM	P	Full Data	BARREN RIVER
LRD-7	BEACH CITY DAM	N	Full Data	SUGAR CREEK OF TUSCARAWAS RVR
LRD-8	BERLIN DAM	P	Full Data	MAHONING RIVER
LRD-9	BLUESTONE DAM	N	Full Data	NEW RIVER
LRD-10	BOLIVAR DAM	N	Constant Head	SANDY CREEK
LRD-11	BRADDOCK LOCKS AND DAM	P	Full Data	MONONGAHELA RIVER
LRD-12	BROOKVILLE LAKE DAM	N	Full Data	EAST FORK OF WHITEWATER RIVER
LRD-13	BUCKHORN LAKE DAM	N	Full Data	MIDDLEFORK KENTUCKY RIVER
LRD-14	BURNSVILLE LAKE DAM	N	Full Data	LITTLE KANAWHA RIVER
LRD-15	CAESAR CREEK LAKE DAM and Saddle Dams #1 and #4	N	Full Data	CAESAR CREEK
LRD-16	CAGLES MILL LAKE DAM	N	Full Data	MILL CREEK
LRD-17	CAVE RUN LAKE DAM	P	Full Data	LICKING RIVER
LRD-18	CECIL M HARDEN LAKE DAM	N	Full Data	RACCOON CREEK
LRD-19	CHARLEROI LOCKS AND DAM	P	Full Data	MONONGAHELA RIVER
LRD-20	CHARLES MILL DAM	N	Full Data	BLACK FORK OF MOHICAN RIVER
LRD-21	CROOKED CREEK DAM	P	Full Data	CROOKED CREEK
LRD-22	DASHIELDS LOCKS AND DAM	P	Full Data	OHIO RIVER
LRD-23	DEER CREEK DAM	N	Full Data	DEER CREEK
LRD-24	DELAWARE DAM	N	Full Data	OLENTANGY RIVER
LRD-25	DEWEY DAM	N	Full Data	JOHNS CREEK OF LEVISA FORK
LRD-26	DILLON DAM	P	Full Data	LICKING RIVER
LRD-27	DOVER DAM	N	Full Data	TUSCARAWAS RIVER
LRD-28	EAST BRANCH DAM	P	Full Data	CLARION RIVER
LRD-29	EAST LYNN DAM	N	Full Data	EAST FK TWELVEPOLE CREEK
LRD-30	EMSWORTH LOCKS AND DAMS	P	Full Data	OHIO RIVER
LRD-31	FISHTRAP DAM	N	Full Data	LEVISA FORK OF BIG SANDY RIVER
LRD-32	GRAYS LANDING LOCK AND DAM	P	Full Data	MONONGAHELA RIVER
LRD-33	GRAYSON DAM	N	Full Data	LITTLE SANDY RIVER
LRD-34	GREEN RIVER LAKE DAM	P	Full Data	GREEN RIVER
LRD-35	GREEN RIVER LOCK & DAM 1	P	Full Data	GREEN RIVER
LRD-36	GREEN RIVER LOCK & DAM 2	P	Full Data	GREEN RIVER
LRD-37	GREEN RIVER LOCK & DAM 3	N	Full Data	GREEN RIVER
LRD-38	GREEN RIVER LOCK & DAM 5	P	Full Data	GREEN RIVER
LRD-39	GREEN RIVER LOCK & DAM 6	N	Full Data	GREEN RIVER
LRD-40	HILDEBRAND LOCK AND DAM	P	Full Data	MONONGAHELA RIVER

Table 13 (continued). Great Lakes and Ohio River Division Data Completeness and FERC Status

GREAT LAKES AND OHIO RIVER DIVISION				
ID	NAME	FERC LICENSE	DATA CONFIDENCE	WATERWAY
LRD-41	J. EDWARD ROUSH LAKE DAM	P	Full Data	WABASH RIVER
LRD-42	JOHN T. MYERS LOCKS & DAM	P	Full Data	OHIO RIVER
LRD-44	MARTINS FORK DAM	N	Full Data	MARTINS FORK OF CUMBERLAND R.
LRD-45	MAXWELL LOCKS AND DAM	P	Full Data	MONONGAHELA RIVER
LRD-46	MISSISSINEWA LAKE DAM	P	Full Data	MISSISSINEWA RIVER
LRD-47	MOHICANVILLE DAM	N	Full Data	LAKE FORK OF MOHICAN RIVER
LRD-48	MONONGAHELA LOCKS AND DAM 03	P	Full Data	MONONGAHELA RIVER
LRD-49	MONROE LAKE DAM	P	Full Data	SALT CREEK
LRD-50	MONTGOMERY LOCKS AND DAM	P	Full Data	OHIO RIVER
LRD-51	MORGANTOWN LOCK AND DAM	P	Full Data	MONONGAHELA RIVER
LRD-53	NEWBURGH LOCKS & DAM	P	Full Data	OHIO RIVER
LRD-54	NOLIN LAKE DAM	P	Full Data	NOLIN RIVER
LRD-57	OPEKISKA LOCK AND DAM	P	Full Data	MONONGAHELA RIVER
LRD-58	PAINT CREEK DAM	N	Full Data	PAINT CREEK
LRD-59	PAINTSVILLE DAM	N	Full Data	PAINT CREEK
LRD-60	PATOKA LAKE DAM	N	Full Data	PATOKA RIVER
LRD-61	PLEASANT HILL DAM	N	Full Data	CLEAR FORK OF MOHICAN RIVER
LRD-62	POINT MARION LOCK AND DAM	P	Full Data	MONONGAHELA RIVER
LRD-63	R D BAILEY DAM	P	Full Data	GUYANDOT RIVER
LRD-64	ROUGH RIVER LAKE DAM	N	Full Data	ROUGH RIVER
LRD-65	SALAMONIE LAKE DAM	P	Full Data	SALAMONIE RIVER
LRD-66	SHENANGO DAM	N	Full Data	SHENANGO RIVER
LRD-67	STONEWALL JACKSON DAM,WV	P	Full Data	WEST FORK
LRD-68	SUTTON DAM	P	Full Data	ELK RIVER
LRD-69	TAYLORSVILLE LAKE DAM	N	Full Data	SALT RIVER
LRD-70	TIONESTA DAM	P	Full Data	TIONESTA CREEK
LRD-71	TYGART DAM	P	Full Data	TYGART RIVER
LRD-72	UNION CITY DAM	N	Full Data	FRENCH CREEK
LRD-73	WILLIAM H. HARSHA LAKE DAM	N	Full Data	EAST FORK OF LITTLE MIAMI
LRD-74	WILLS CREEK DAM	P	Full Data	WILLS CREEK
LRD-75	YATESVILLE DAM	N	Full Data	BLAINE CREEK

7.1.1. Huntington District

Figure 10 shows a map of LRH along with the 22 dams considered in this study. These dams represent a total potential capacity of about 403 MW. About 94 MW, or about 23%, was determined to be feasible by the model.

As shown in Table 14, the highest estimated potential capacity in LRH belongs to Bluestone Dam at about 107 MW, with a corresponding average annual generation of about 138 gigawatt hours (GWh). This gives the dam a capacity factor of 0.15. Additionally, this level of capacity allows for the avoidance of about 276 million tons of CO_2. However, the maximum feasible capacity for Bluestone Dam, presented in Table 15, is about 31 MW, less than a third of the power potential result. It has a BCR of 1.59 and an IRR of 9%.

Figure 10. Huntington District Dams

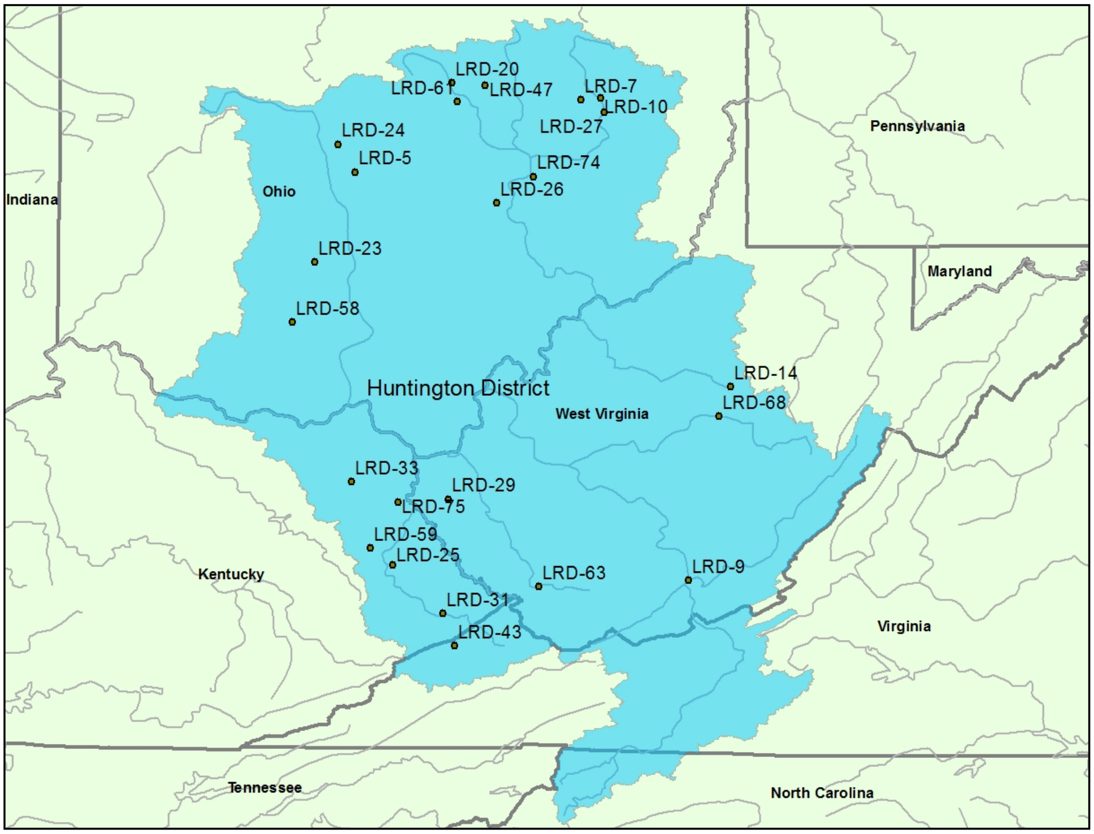


Table 14. Huntington District Power Potential

HUNTINGTON DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
ALUM CREEK DAM	LRD-5	Full Data	5.62	3803.50	0.08	64.09	100.92	7.62
BEACH CITY DAM	LRD-7	Full Data	4.19	4480.00	0.12	19.71	352.58	8.97
BLUESTONE DAM	LRD-9	Full Data	106.53	137556.17	0.15	42.58	5346.63	275.55
BOLIVAR DAM	LRD-10	Const. Head	8.98	26405.64	0.34	67.00	628.50	52.90
BURNSVILLE LAKE DAM	LRD-14	Full Data	4.48	4856.62	0.12	33.97	280.48	9.73
CHARLES MILL DAM	LRD-20	Full Data	2.23	1951.05	0.10	13.41	244.72	3.91
DEER CREEK DAM	LRD-23	Full Data	7.37	6502.94	0.10	39.25	299.78	13.03
DELAWARE DAM	LRD-24	Full Data	11.76	9767.63	0.09	34.68	466.23	19.57
DEWEY DAM	LRD-25	Full Data	7.21	7214.09	0.11	50.03	252.61	14.49
DILLON DAM	LRD-26	Full Data	18.24	18690.40	0.12	33.48	888.62	37.44
DOVER DAM	LRD-27	Full Data	12.11	9385.40	0.09	4.75	1983.73	18.80
EAST LYNN DAM	LRD-29	Full Data	4.66	4248.35	0.10	50.17	153.11	8.51
FISHTRAP DAM	LRD-31	Full Data	16.73	20454.25	0.14	85.53	453.55	41.10
GRAYSON DAM	LRD-33	Full Data	8.58	8852.90	0.12	58.33	274.20	17.79
MOHICANVILLE DAM	LRD-47	Full Data	1.61	968.32	0.07	0.72	369.62	1.94
PAINT CREEK DAM	LRD-58	Full Data	29.11	22201.35	0.09	49.69	714.18	44.47
PAINTSVILLE DAM	LRD-59	Full Data	12.23	14356.38	0.13	139.34	166.76	28.84
PLEASANT HILL DAM	LRD-61	Full Data	4.85	6738.27	0.16	51.90	210.38	13.50
R D BAILEY DAM	LRD-63	Full Data	67.40	78642.72	0.13	152.07	857.41	157.54
SUTTON DAM	LRD-68	Full Data	48.00	69577.70	0.17	111.26	1169.35	139.38
WILLS CREEK DAM	LRD-74	Full Data	14.93	14600.87	0.11	22.81	1019.70	29.25
YATESVILLE DAM	LRD-75	Full Data	6.66	8336.41	0.14	58.98	251.55	16.75

Table 15. Huntington District Economic Feasibility

LRH FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
ALUM CREEK DAM	LRD-5	NF	NF	NF	NF	NF	NF	NF	NF	NF
BEACH CITY DAM	LRD-7	NF	NF	NF	NF	NF	NF	NF	NF	NF
BLUESTONE DAM	LRD-9	6.04	2.71	0.16	31.09	1.69	0.09	6.04	2.71	0.16
BOLIVAR DAM	LRD-10	2.52	2.67	0.16	8.98	1.32	0.07	2.57	2.67	0.16
BURNSVILLE LAKE DAM	LRD-14	< 1	1.06	0.04	< 1	1.01	0.04	< 1	1.08	0.04
CHARLES MILL DAM	LRD-20	NF	NF	NF	NF	NF	NF	NF	NF	NF
DEER CREEK DAM	LRD-23	< 1	1.17	0.05	< 1	1.05	0.04	< 1	1.20	0.06
DELAWARE DAM	LRD-24	< 1	1.11	0.05	< 1	1.02	0.04	< 1	1.12	0.05
DEWEY DAM	LRD-25	NF	NF	NF	NF	NF	NF	NF	NF	NF
DILLON DAM	LRD-26	< 1	1.48	0.08	2.73	1.06	0.04	< 1	1.49	0.08
DOVER DAM	LRD-27	NF	NF	NF	NF	NF	NF	NF	NF	NF
EAST LYNN DAM	LRD-29	NF	NF	NF	NF	NF	NF	NF	NF	NF
FISHTRAP DAM	LRD-31	< 1	1.11	0.05	1.94	1.06	0.04	< 1	1.13	0.05
GRAYSON DAM	LRD-33	NF	NF	NF	NF	NF	NF	NF	NF	NF
MOHICANVILLE DAM	LRD-47	NF	NF	NF	NF	NF	NF	NF	NF	NF
PAINT CREEK DAM	LRD-58	< 1	1.50	0.08	3.09	1.13	0.05	< 1	1.51	0.08
PAINTSVILLE DAM	LRD-59	NF	NF	NF	NF	NF	NF	NF	NF	NF
PLEASANT HILL DAM	LRD-61	< 1	1.29	0.06	1.04	1.04	0.04	< 1	1.32	0.06
R D BAILEY DAM	LRD-63	1.64	2.24	0.13	22.57	1.48	0.08	3.36	2.32	0.14
SUTTON DAM	LRD-68	1.83	1.95	0.11	20.54	1.46	0.08	4.16	2.07	0.12
WILLS CREEK DAM	LRD-74	< 1	1.09	0.05	1.58	1.01	0.04	< 1	1.16	0.05
YATESVILLE DAM	LRD-75	NF	NF	NF	NF	NF	NF	NF	NF	NF

7.1.2. Louisville District

Figure 11 shows a map of LRL along with the 22 dams considered in this study. These dams represent a total potential capacity of about 652 MW. About 285 MW, or about 44%, was determined to be feasible by the model.

Table 16 shows the power potential results for LRL. The largest potential capacity belongs to John T. Myers Locks and Dam (LRD-42); it possesses about 115 MW of potential capacity. This corresponds to an average annual generation of 732 GWh, which gives the relatively high capacity factor of 0.72 and avoids about 1.5 billion tons of CO_2 from equivalent thermal generation. As shown in Table 17, the maximum feasible capacity for John T. Myers is also 115 MW. With this comes a BCR of 1.92 and an IRR of 10%. In the optimal case, also shown in Table 17, the lower capacity value of about 36 MW leads to a BCR of 3.16 and an IRR of 17%.

Figure 11. Louisville District Dams

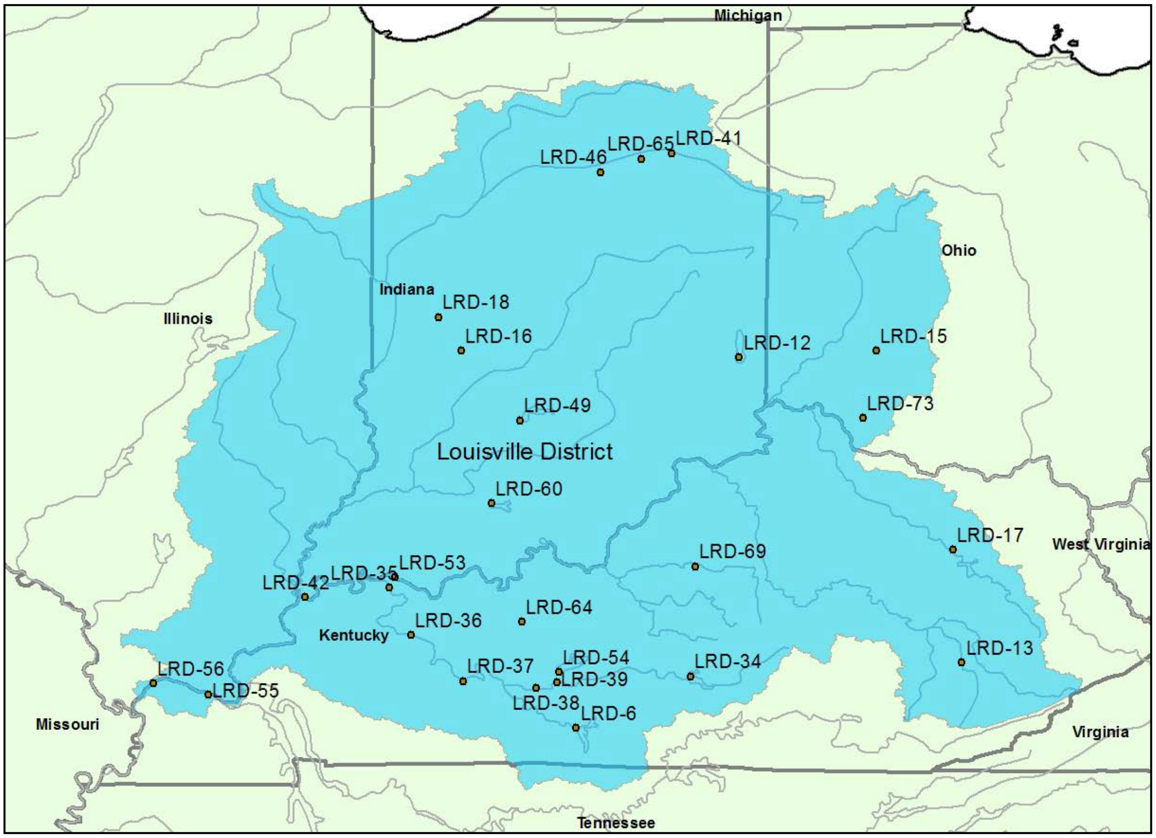


Table 16. Louisville District Power Potential

LOUISVILLE DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
BARREN RIVER LAKE DAM	LRD-6	Full Data	26.76	55005.17	0.23	72.93	1403.17	110.51
BROOKVILLE LAKE DAM	LRD-12	Full Data	31.99	36507.26	0.13	122.43	499.62	73.13
BUCKHORN LAKE DAM	LRD-13	Full Data	17.03	17215.73	0.12	60.07	533.19	34.59
CAESAR CREEK LAKE DAM and Saddle Dams #1 and #4	LRD-15	Full Data	18.28	17158.77	0.11	113.72	248.87	34.37
CAGLES MILL LAKE DAM	LRD-16	Full Data	10.77	14929.91	0.16	56.22	377.66	29.91
CAVE RUN LAKE DAM	LRD-17	Full Data	26.53	45664.38	0.20	78.72	1043.49	91.75
CECIL M HARDEN LAKE DAM	LRD-18	Full Data	7.40	9404.45	0.15	69.64	233.88	18.84
GREEN RIVER LAKE DAM	LRD-34	Full Data	34.53	50439.28	0.17	82.18	1069.11	101.34
GREEN RIVER LOCK & DAM 1	LRD-35	Full Data	6.42	27815.27	0.49	7.93	11135.21	55.88
GREEN RIVER LOCK & DAM 2	LRD-36	Full Data	9.12	31512.23	0.39	9.34	11135.21	63.31
GREEN RIVER LOCK & DAM 3	LRD-37	Full Data	9.94	43481.91	0.50	14.30	8978.04	87.36
GREEN RIVER LOCK & DAM 5	LRD-38	Full Data	39.14	58803.16	0.17	22.00	4394.16	118.14
GREEN RIVER LOCK & DAM 6	LRD-39	Full Data	6.21	19367.56	0.36	9.59	4394.16	38.91
J. EDWARD ROUSH LAKE DAM	LRD-41	Full Data	18.49	16584.12	0.10	39.64	672.78	33.22
JOHN T. MYERS LOCKS & DAM	LRD-42	Full Data	115.25	731882.07	0.72	15.60	158807.14	1466.11
MISSISSINEWA LAKE DAM	LRD-46	Full Data	26.47	33507.62	0.14	75.62	816.32	67.12
MONROE LAKE DAM	LRD-49	Full Data	9.77	17415.53	0.20	55.35	534.80	34.89
NEWBURGH LOCKS & DAM	LRD-53	Full Data	97.22	371584.86	0.44	13.80	137799.34	744.36
NOLIN LAKE DAM	LRD-54	Full Data	45.66	47088.01	0.12	92.54	940.26	94.61
PATOKA LAKE DAM	LRD-60	Full Data	4.58	7119.13	0.18	57.36	215.53	14.26
ROUGH RIVER LAKE DAM	LRD-64	Full Data	15.40	20400.06	0.15	61.39	628.88	40.99
SALAMONIE LAKE DAM	LRD-65	Full Data	23.27	24435.12	0.12	78.42	558.83	48.95
TAYLORSVILLE LAKE DAM	LRD-69	Full Data	20.62	22224.07	0.12	76.30	459.29	44.65
WILLIAM H. HARSHA LAKE DAM	LRD-73	Full Data	31.48	27849.54	0.10	116.40	386.23	55.79

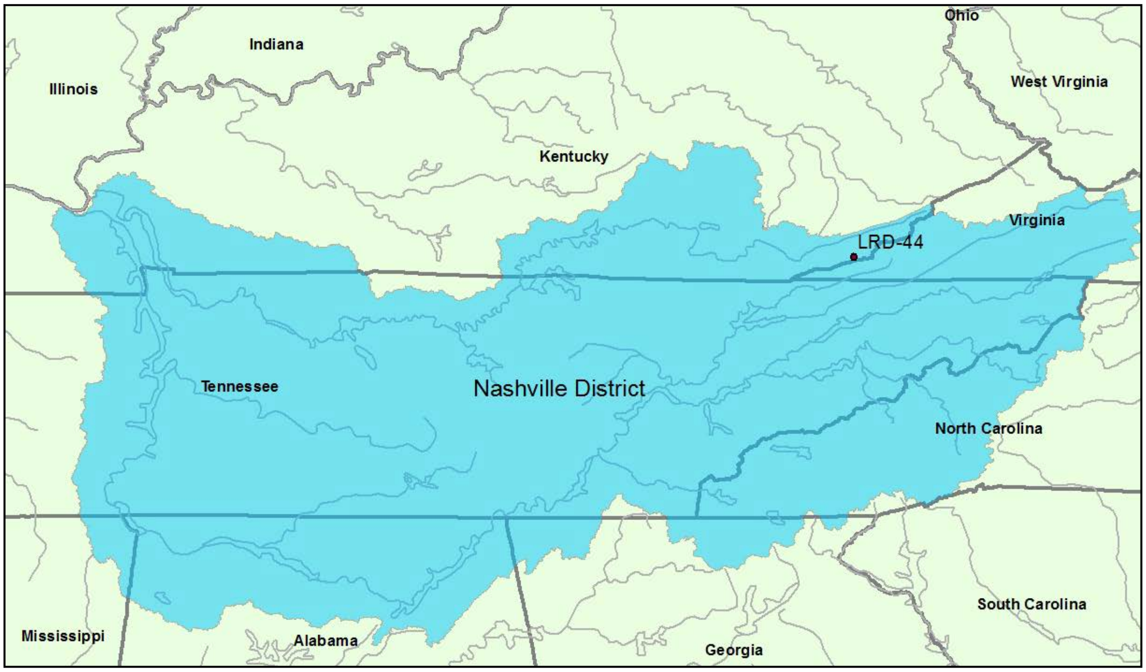
Table 17. Louisville District Economic Feasibility

LRL FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
BARREN RIVER LAKE DAM	LRD-6	< 1	1.03	0.04	12.39	1.08	0.05	3.91	1.21	0.06
BROOKVILLE LAKE DAM	LRD-12	< 1	1.62	0.09	11.33	1.15	0.05	2.16	1.70	0.09
BUCKHORN LAKE DAM	LRD-13	< 1	1.01	0.04	1.09	1.02	0.04	< 1	1.06	0.04
CAESAR CREEK LAKE DAM and Saddle Dams #1 and #4	LRD-15	< 1	1.19	0.05	2.87	1.00	0.04	< 1	1.19	0.05
CAGLES MILL LAKE DAM	LRD-16	< 1	1.21	0.06	3.11	1.03	0.04	< 1	1.32	0.06
CAVE RUN LAKE DAM	LRD-17	< 1	1.17	0.05	5.69	1.06	0.04	1.85	1.23	0.06
CECIL M HARDEN LAKE DAM	LRD-18	< 1	1.21	0.06	1.01	1.10	0.05	< 1	1.22	0.06
GREEN RIVER LAKE DAM	LRD-34	1.37	1.06	0.04	4.00	1.05	0.04	2.18	1.07	0.04
GREEN RIVER LOCK & DAM 1	LRD-35	NF	NF	NF	NF	NF	NF	NF	NF	NF
GREEN RIVER LOCK & DAM 2	LRD-36	NF	NF	NF	NF	NF	NF	NF	NF	NF
GREEN RIVER LOCK & DAM 3	LRD-37	NF	NF	NF	NF	NF	NF	NF	NF	NF
GREEN RIVER LOCK & DAM 5	LRD-38	1.28	1.12	0.05	3.33	1.06	0.04	1.85	1.12	0.05
GREEN RIVER LOCK & DAM 6	LRD-39	NF	NF	NF	NF	NF	NF	NF	NF	NF
J. EDWARD ROUSH LAKE DAM	LRD-41	< 1	1.35	0.07	1.15	1.08	0.05	< 1	1.36	0.07
JOHN T. MYERS LOCKS & DAM	LRD-42	23.55	3.06	0.17	115.25	1.92	0.10	35.77	3.16	0.17
MISSISSINEWA LAKE DAM	LRD-46	< 1	1.46	0.07	5.59	1.18	0.05	1.09	1.52	0.08
MONROE LAKE DAM	LRD-49	< 1	1.41	0.07	4.31	1.12	0.05	< 1	1.41	0.07
NEWBURGH LOCKS & DAM	LRD-53	15.18	2.02	0.11	97.22	1.06	0.04	21.90	2.02	0.11
NOLIN LAKE DAM	LRD-54	< 1	1.08	0.05	7.70	1.01	0.04	1.81	1.22	0.06
PATOKA LAKE DAM	LRD-60	< 1	1.15	0.05	1.45	1.02	0.04	< 1	1.21	0.06
ROUGH RIVER LAKE DAM	LRD-64	< 1	1.02	0.04	< 1	1.01	0.04	< 1	1.03	0.04
SALAMONIE LAKE DAM	LRD-65	< 1	1.17	0.05	4.15	1.07	0.04	1.13	1.30	0.06
TAYLORSVILLE LAKE DAM	LRD-69	NF	NF	NF	NF	NF	NF	NF	NF	NF
WILLIAM H. HARSHA LAKE DAM	LRD-73	< 1	1.41	0.07	3.43	1.03	0.04	< 1	1.41	0.07

7.1.3. Nashville District

Nashville District has only one dam under consideration in this study (Figure 12). Martins Fork Dam (LRD-44) has a potential capacity value of 1.7 MW, and annual average generation of about 2.4 GWh. These values then give a capacity factor of 0.16.

Figure 12. Nashville District Dams



Despite the power potential outlined in Table 18, when costs of development are taken into account, Martins Fork Dam proves infeasible for hydropower development (Table 19).

Table 18. Nashville District Power Potential

NASHVILLE DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
MARTINS FORK DAM	LRD-44	Full Data	1.70	2398.03	0.16	43.34	92.15	4.82

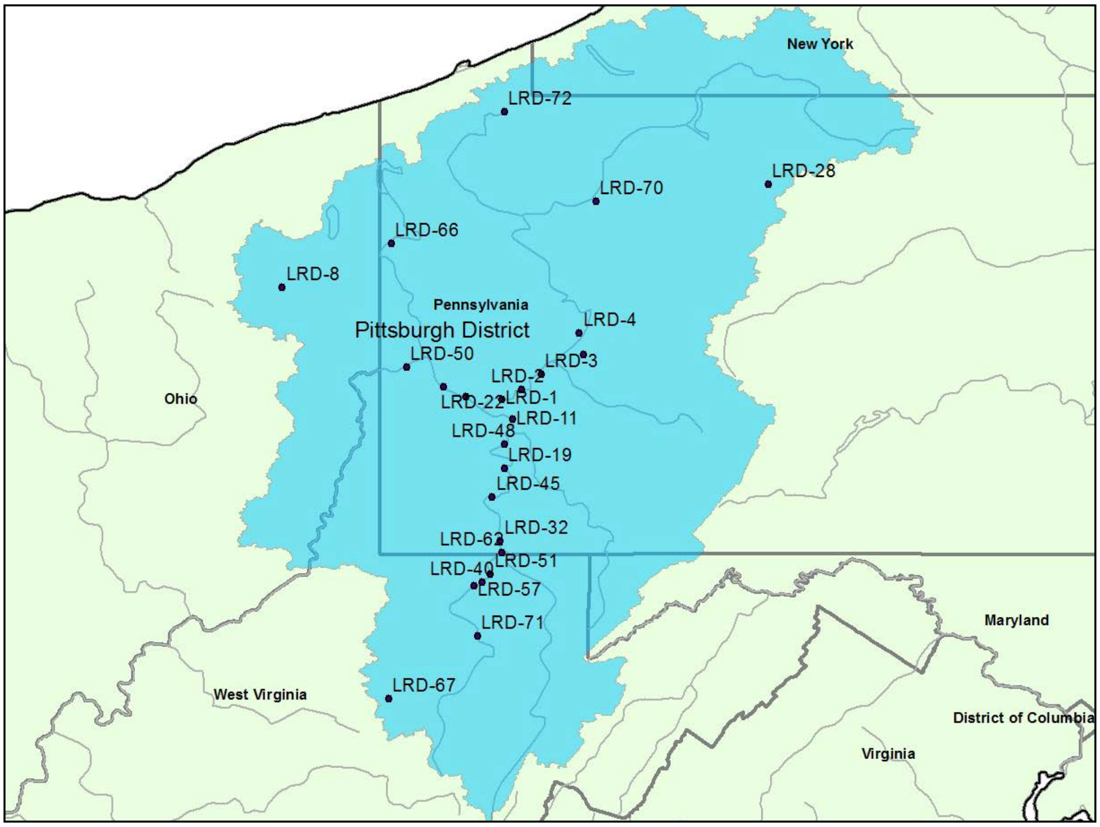
Table 19. Nashville District Economic Feasibility

LRN FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
MARTINS FORK DAM	LRD-44	NF	NF	NF	NF	NF	NF	NF	NF	NF

7.1.4. Pittsburgh District

Figure 13 shows a map of LRD along with the 24 dams considered in this study. These dams accounted for a total of about 904 MW of potential hydropower capacity. A little over half of this capacity is judged feasible by the economic model (about 520 MW).

Figure 13. Pittsburgh District Dams



As shown in Table 20, the highest potential capacity value belongs to Tygart Dam (LRD-71); it has estimated potential capacity of 111 MW. It also has average annual generation of about 156 GWh and a resulting capacity factor of 0.16. Development of hydropower at this site would eliminate about 313 million tons of CO_2 from equivalent thermal generation. Dashields Locks and Dam (LRD-22) also has significant potential capacity, about 106 MW. Corresponding average annual generation is about 204 GWh, which gives a capacity factor of 0.22.

The maximum feasible capacity at Tygart is about 48 MW, while the maximum feasible capacity at Dashields is about 30 MW, which represent about 43% and 28% of their potential capacity at the 1% level, respectively. Additionally, both Braddock Locks and Dam and Monongahela Locks and Dam are judged not feasible by the economic model (Table 21).

Table 20. Pittsburgh District Power Potential

PITTSBURGH DISTRICT								
NAME	**ID**	**DATA QUALITY**	**CAPACITY (MW)**	**GENERATION (MWh)**	**CAPACITY FACTOR**	**AVG. HEAD (Ft.)**	**AVG. FLOW (Cfs)**	**CO_2e AVOIDED (Millions of Tons)**
ALLEGHENY LOCK AND DAM 02	LRD-1	Full Data	59.13	81317.43	0.16	51.69	22802.71	146.28
ALLEGHENY LOCK AND DAM 03	LRD-2	Full Data	58.86	164608.94	0.32	13.38	22390.55	296.12
ALLEGHENY LOCK AND DAM 04	LRD-3	Full Data	40.29	96535.02	0.27	10.96	14974.04	173.66
ALLEGHENY LOCK AND DAM 07	LRD-4	Full Data	42.79	132253.59	0.35	13.55	18640.17	237.91
BERLIN DAM	LRD-8	Full Data	8.11	12306.62	0.17	62.29	324.03	24.65
BRADDOCK LOCKS AND DAM	LRD-11	Full Data	18.15	14440.51	0.09	1.45	10000.61	25.98
CHARLEROI LOCKS AND DAM	LRD-19	Full Data	20.21	79205.48	0.45	15.99	10371.85	142.48
CROOKED CREEK DAM	LRD-21	Full Data	9.49	11352.15	0.14	43.22	380.84	20.42
DASHIELDS LOCKS AND DAM	LRD-22	Full Data	106.22	204005.07	0.22	10.00	34018.83	366.99
EAST BRANCH DAM	LRD-28	Full Data	6.26	12301.21	0.22	141.60	146.57	22.13
EMSWORTH LOCKS AND DAMS	LRD-30	Full Data	83.41	277185.28	0.38	16.64	33606.01	498.64
GRAYS LANDING LOCK AND DAM	LRD-32	Full Data	44.45	148232.51	0.38	15.90	15415.75	266.66
HILDEBRAND LOCK AND DAM	LRD-40	Full Data	38.61	214781.27	0.64	21.07	16169.08	430.25
MAXWELL LOCKS AND DAM	LRD-45	Full Data	37.98	117914.73	0.35	19.99	10735.72	212.12
MONONGAHELA LOCKS AND DAM 03	LRD-48	Full Data	21.22	42803.21	0.23	7.54	9395.91	77.00
MONTGOMERY LOCKS AND DAM	LRD-50	Full Data	79.00	373053.19	0.54	16.21	42564.61	671.09
MORGANTOWN LOCK AND DAM	LRD-51	Full Data	26.57	114870.55	0.49	17.32	10908.32	230.11
OPEKISKA LOCK AND DAM	LRD-57	Full Data	36.69	71812.85	0.22	27.92	4274.35	143.86
POINT MARION LOCK AND DAM	LRD-62	Full Data	3.97	18046.66	0.52	21.75	1361.19	32.46
SHENANGO DAM	LRD-66	Full Data	8.83	15754.33	0.20	30.55	906.61	28.34
STONEWALL JACKSON DAM,WV	LRD-67	Full Data	3.53	5099.24	0.16	57.20	148.15	10.21
TIONESTA DAM	LRD-70	Full Data	26.92	30123.25	0.13	45.69	913.93	54.19
TYGART DAM	LRD-71	Full Data	111.01	156462.64	0.16	127.30	2341.93	313.43
UNION CITY DAM	LRD-72	Full Data	12.31	16224.75	0.15	40.60	548.45	29.19

Table 21. Pittsburgh District Economic Feasibility

LRP FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
ALLEGHENY LOCK AND DAM 02	LRD-1	3.88	1.75	0.09	23.85	1.10	0.05	3.88	1.75	0.09
ALLEGHENY LOCK AND DAM 03	LRD-2	5.93	1.55	0.07	35.73	1.16	0.05	7.83	1.57	0.08
ALLEGHENY LOCK AND DAM 04	LRD-3	4.28	1.23	0.05	17.16	1.02	0.04	4.28	1.23	0.05
ALLEGHENY LOCK AND DAM 07	LRD-4	3.91	1.59	0.08	33.93	1.05	0.04	5.47	1.59	0.08
BERLIN DAM	LRD-8	< 1	1.67	0.09	3.53	1.07	0.04	< 1	1.69	0.09
BRADDOCK LOCKS AND DAM	LRD-11	NF	NF	NF	NF	NF	NF	NF	NF	NF
CHARLEROI LOCKS AND DAM	LRD-19	4.24	1.74	0.09	20.21	1.07	0.04	4.24	1.74	0.09
CROOKED CREEK DAM	LRD-21	< 1	1.33	0.06	1.28	1.13	0.05	< 1	1.34	0.06
DASHIELDS LOCKS AND DAM	LRD-22	5.38	1.32	0.06	30.43	1.13	0.05	8.45	1.35	0.06
EAST BRANCH DAM	LRD-28	< 1	1.56	0.08	3.40	1.07	0.04	< 1	1.61	0.08
EMSWORTH LOCKS AND DAMS	LRD-30	17.82	2.21	0.11	55.33	1.41	0.07	17.82	2.21	0.11
GRAYS LANDING LOCK AND DAM	LRD-32	2.53	2.19	0.11	27.76	1.41	0.07	3.59	2.21	0.11
HILDEBRAND LOCK AND DAM	LRD-40	22.49	2.54	0.14	38.61	1.95	0.10	22.49	2.54	0.14
MAXWELL LOCKS AND DAM	LRD-45	7.16	2.00	0.10	37.98	1.03	0.04	7.16	2.00	0.10
MONONGAHELA LOCKS AND DAM 03	LRD-48	NF	NF	NF	NF	NF	NF	NF	NF	NF
MONTGOMERY LOCKS AND DAM	LRD-50	33.07	2.39	0.12	79.00	1.43	0.07	33.07	2.39	0.12
MORGANTOWN LOCK AND DAM	LRD-51	10.63	2.15	0.12	26.57	1.32	0.06	10.63	2.15	0.12
OPEKISKA LOCK AND DAM	LRD-57	1.87	1.90	0.10	21.69	1.11	0.05	1.87	1.90	0.10
POINT MARION LOCK AND DAM	LRD-62	1.81	1.65	0.08	3.97	1.07	0.04	1.81	1.65	0.08
SHENANGO DAM	LRD-66	< 1	1.56	0.08	2.89	1.05	0.04	< 1	1.56	0.08
STONEWALL JACKSON DAM,WV	LRD-67	< 1	1.34	0.07	< 1	1.15	0.05	< 1	1.35	0.07
TIONESTA DAM	LRD-70	< 1	1.70	0.09	4.58	1.25	0.06	< 1	1.72	0.09
TYGART DAM	LRD-71	4.58	2.84	0.17	48.03	1.48	0.08	5.54	2.87	0.17
UNION CITY DAM	LRD-72	< 1	1.24	0.06	3.63	1.00	0.04	< 1	1.27	0.06

7.2. Mississippi Valley Division

Mississippi Valley Division (MVD) consists of six Districts, four of which were considered in this study. Taken together, these four Districts contain 50 dams for which potential power capacity is estimated. These 50 dams represent 1,568 MW of potential capacity between them. Total feasible capacity represents about 60% of this total or about 940 MW. Table 22 shows that 48 of the 50 dams considered have capacity estimates based on full data. The remaining two dams, Little River Closure and Pearl River Lock #1, have estimates based on ORNL data. Twenty-eight of the dams in MVD currently have pending FERC licenses.

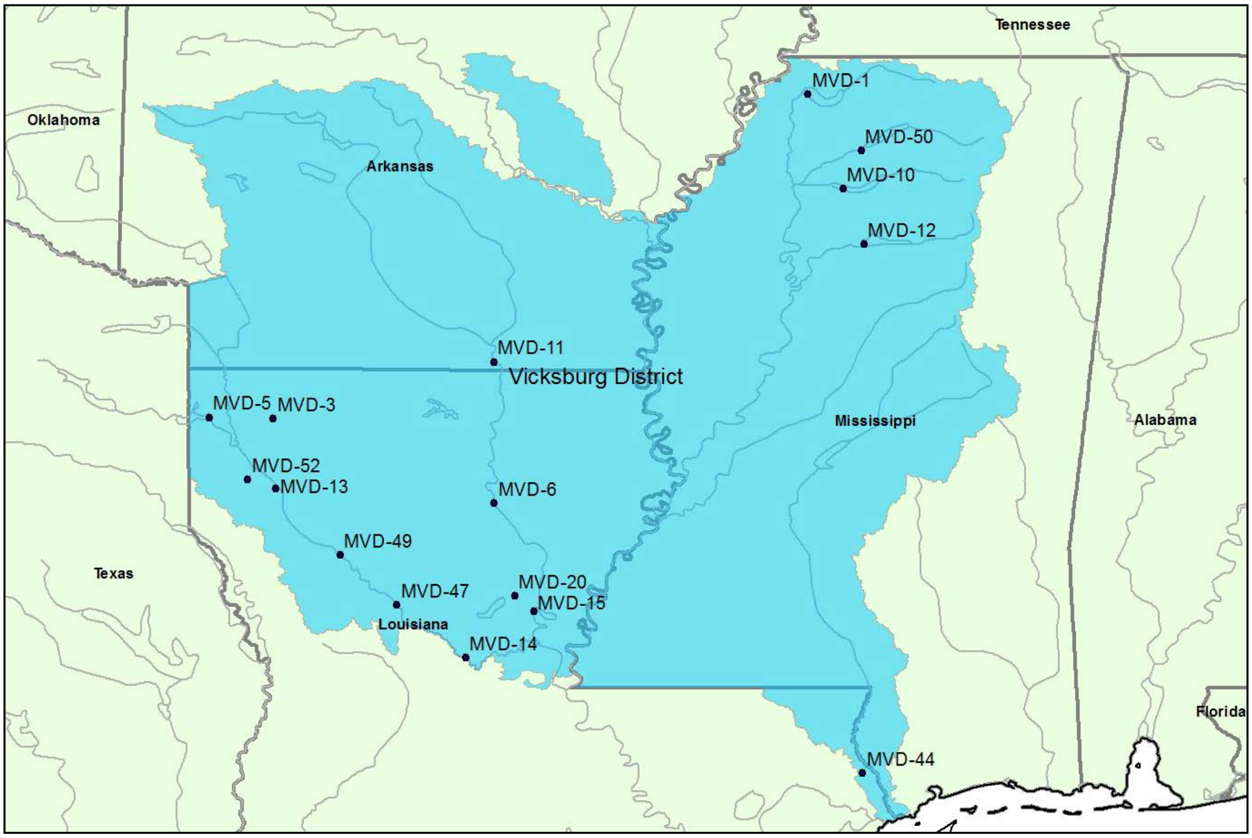
Table 22. Mississippi Valley Division Data Completeness and FERC Status

MISSISSIPPI VALLEY DIVISION				
ID	**NAME**	**CONFIDENCE**	**FERC STATUS**	**WATERWAY**
MVD-1	ARKABUTLA DAM	Full Data	P	COLDWATER RIVER
MVD-2	BALDHILL	Full Data	N	SHEYENNE RIVER
MVD-3	BAYOU BODCAU DAM	Full Data	N	BAYOU BODCAU
MVD-4	BRANDON ROAD LOCK & DAM	Full Data	P	DES PLAINES
MVD-5	CADDO DAM	Full Data	N	CYPRESS BAYOU
MVD-6	COLUMBIA LOCK & DAM	Full Data	P	OUACHITA RIVER
MVD-7	CORALVILLE DAM	Full Data	P	IOWA RIVER
MVD-8	DRESDEN ISLAND LOCK & DAM	Full Data	N	ILLINOIS RIVER
MVD-9	DUBUQUE NUMBER 11	Full Data	P	MISSISSIPPI
MVD-10	ENID DAM	Full Data	P	YOCONA RIVER
MVD-11	FELSENTHAL LOCK & DAM	Full Data	N	OUACHITA
MVD-12	GRENADA DAM	Full Data	P	YALOBUSHA RIVER
MVD-13	JOE D. WAGGONNER, JR. LOCK & DAM	Full Data	P	RED RIVER
MVD-14	JOHN OVERTON LOCK AND DAM	Full Data	P	RED RIVER
MVD-15	JONESVILLE LOCK & DAM	Full Data	N	BLACK RIVER
MVD-16	KASKASKIA LOCK & DAM	Full Data	N	KASKASKIA RIVER
MVD-17	LA GRANGE LOCK & DAM	Full Data	P	ILLINOIS RIVER
MVD-18	LAC QUI PARLE DAM	Full Data	N	MINNESOTA
MVD-19	LAKE SHELBYVILLE DAM	Full Data	N	KASKASKIA RIVER
MVD-21	LOCK & DAM #10	Full Data	P	MISSISSIPPI RIVER
MVD-22	LOCK & DAM #3	Full Data	N	MISSISSIPPI
MVD-23	LOCK & DAM #4	Full Data	P	MISSISSIPPI
MVD-24	LOCK & DAM #5A	Full Data	P	MISSISSIPPI
MVD-25	LOCK & DAM #6	Full Data	N	MISSISSIPPI RIVER
MVD-26	LOCK & DAM #7	Full Data	N	MISSISSIPPI
MVD-27	LOCK & DAM #8	Full Data	P	MISSISSIPPI RIVER
MVD-28	LOCK & DAM #9	Full Data	P	MISSISSIPPI RIVER
MVD-29	LOCK & DAM 24	Full Data	N	MISSISSIPPI RIVER
MVD-30	LOCK & DAM 25	Full Data	P	MISSISSIPPI RIVER
MVD-31	LOCK & DAM NO 5	Full Data	N	MISSISSIPPI
MVD-32	LOCK AND DAM 15	Full Data	P	MISSISSIPPI RIVER
MVD-33	LOCK AND DAM 18	Full Data	N	MISSISSIPPI RIVER
MVD-34	MELVIN PRICE LOCKS & DAM	Full Data	N	MISSISSIPPI RIVER
MVD-37	MISSISSIPPI RIVER DAM 14	Full Data	P	MISSISSIPPI RIVER
MVD-38	MISSISSIPPI RIVER DAM 16	Full Data	P	MISSISSIPPI RIVER
MVD-39	MISSISSIPPI RIVER DAM 17	Full Data	P	MISSISSIPPI RIVER
MVD-40	MISSISSIPPI RIVER DAM 20	Full Data	P	MISSISSIPPI RIVER
MVD-41	MISSISSIPPI RIVER DAM 21	Full Data	P	MISSISSIPPI RIVER
MVD-42	MISSISSIPPI RIVER DAM 22	Full Data	P	MISSISSIPPI RIVER
MVD-43	ORWELL RESERVOIR & DAM	Full Data	N	OTTER TAIL RIVER
MVD-45	PEORIA LOCK & DAM	Full Data	P	ILLINOIS RIVER
MVD-46	POKEGAMA LAKE DAM	Full Data	N	MISSISSIPPI
MVD-47	RED RIVER W.W. LOCK & DAM #3	Full Data	P	RED RIVER
MVD-49	RUSSELL B. LONG LOCK & DAM	Full Data	P	RED RIVER
MVD-50	SARDIS DAM	Full Data	P	TLE TALLAHATCHIE RI
MVD-51	SAYLORVILLE DAM	Full Data	P	DES MOINES RIVER
MVD-52	WALLACE LAKE DAM	Full Data	N	CYPRESS BAYOU
MVD-53	WINNIBIGOSHISH DAM	Full Data	N	MISSISSIPPI RIVER
MVD-20	LITTLE RIVER CLOSURE DAM	ORNL Data	N	LITTLE RIVER
MVD-44	PEARL RIVER LOCK #1 & SPILLWAY	ORNL Data	N	PEARL RIVER CANAL

7.2.1. Vicksburg District

Figure 14 shows a map of MVK along with the 16 dams considered in this study. These dams make up about 530 MW of potential capacity. About 415 MW, or about 78%, was determined to be feasible by the model.

Figure 14. Vicksburg District Dams



As shown in Table 23, Red River Lock and Dam 3 (MVD-47) has 130 MW of potential capacity, the highest in the District. It also has about 430 GWh of average annual generation, which gives it a capacity factor of 0.47. Both Joe D. Waggonner and John Overton Dams also have high potential capacity values, with estimates of 81 and 87 MW, respectively.

The economic feasibility results for MVK are shown in Table 24. The maximum feasible capacity for Red River Dam is also 103 MW. This gives a BCR of 1.41 and an IRR of 7%. Three projects are not feasible—Bayou Bodcau Dam, Felsenthal Lock and Dam, and Wallace Lake Dam. Little River Closure Dam and Pearl River Lock #1 have only maximum feasible capacity listed, and this is because they are the two dams in MVK whose results rely entirely on ORNL data. Thus, a feasibility range could not be calculated.

Table 23. Vicksburg District Power Potential

VICKSBURG DISTRICT								
NAME	**ID**	**DATA QUALITY**	**CAPACITY (MW)**	**GENERATION (MWh)**	**CAPACITY FACTOR**	**AVG. HEAD (Ft.)**	**AVG. FLOW (Cfs)**	**CO_2e AVOIDED (Millions of Tons)**
ARKABUTLA DAM	MVD-1	Full Data	19.41	36072.90	0.21	47.62	1271.65	45.48
BAYOU BODCAU DAM	MVD-3	Full Data	7.03	5033.32	0.08	5.61	689.59	6.35
CADDO DAM	MVD-5	Full Data	3.21	13903.03	0.49	19.83	2299.87	17.53
COLUMBIA LOCK & DAM	MVD-6	Full Data	20.03	60711.13	0.35	17.40	20164.84	76.54
ENID DAM	MVD-10	Full Data	12.65	28382.77	0.26	59.00	843.29	35.78
FELSENTHAL LOCK & DAM	MVD-11	Full Data	7.00	15402.82	0.25	11.80	7836.21	19.42
GRENADA DAM	MVD-12	Full Data	18.76	48172.97	0.29	51.67	1689.16	60.73
JOE D. WAGGONNER, JR. LOCK & DAM	MVD-13	Full Data	81.48	235621.65	0.33	24.69	23308.48	297.06
JOHN OVERTON LOCK AND DAM	MVD-14	Full Data	87.34	376501.63	0.49	23.46	40510.83	474.68
JONESVILLE LOCK & DAM	MVD-15	Full Data	45.35	54283.77	0.14	18.82	20164.84	68.44
RED RIVER W.W. LOCK & DAM #3	MVD-47	Full Data	103.40	429739.29	0.47	30.00	40510.83	541.80
RUSSELL B. LONG LOCK & DAM	MVD-49	Full Data	69.03	207561.05	0.34	24.82	22870.72	261.69
SARDIS DAM	MVD-50	Full Data	27.92	73250.94	0.30	57.82	2231.75	92.35
WALLACE LAKE DAM	MVD-52	Full Data	2.61	3343.67	0.15	11.16	459.45	4.22
LITTLE RIVER CLOSURE DAM	MVD-20	ORNL Data	21.06	67887.90	0.37	38.00	2831.18	85.59
PEARL RIVER LOCK #1 & SPILLWAY	MVD-44	ORNL Data	3.80	13930.46	0.42	11.00	2006.93	17.56

Table 24. Vicksburg District Economic Feasibility

MVK FEASIBILITY RESULTS		**MINIMUM**			**MAXIMUM**			**OPTIMAL**		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
ARKABUTLA DAM	MVD-1	< 1	1.43	0.08	9.98	1.01	0.04	2.04	1.50	0.08
BAYOU BODCAU DAM	MVD-3	NF	NF	NF	NF	NF	NF	NF	NF	NF
CADDO DAM	MVD-5	< 1	1.07	0.04	1.95	1.01	0.04	1.00	1.10	0.05
COLUMBIA LOCK & DAM	MVD-6	2.05	1.10	0.05	9.71	1.08	0.04	4.97	1.23	0.06
ENID DAM	MVD-10	< 1	1.03	0.04	7.99	1.11	0.05	3.05	1.43	0.08
FELSENTHAL LOCK & DAM	MVD-11	NF	NF	NF	NF	NF	NF	NF	NF	NF
GRENADA DAM	MVD-12	< 1	1.24	0.06	18.76	1.02	0.04	4.90	1.54	0.09
JOE D. WAGGONNER, JR. LOCK & DAM	MVD-13	8.86	2.00	0.11	63.10	1.13	0.05	8.86	2.00	0.11
JOHN OVERTON LOCK AND DAM	MVD-14	28.42	2.29	0.12	87.34	1.28	0.06	35.90	2.30	0.12
JONESVILLE LOCK & DAM	MVD-15	3.08	1.04	0.04	6.32	1.04	0.04	4.93	1.06	0.04
RED RIVER W.W. LOCK & DAM #3	MVD-47	30.51	2.60	0.14	103.40	1.41	0.07	30.51	2.60	0.14
RUSSELL B. LONG LOCK & DAM	MVD-49	8.83	2.00	0.11	53.37	1.14	0.05	8.83	2.00	0.11
SARDIS DAM	MVD-50	< 1	1.37	0.07	27.92	1.18	0.05	8.14	1.85	0.11
WALLACE LAKE DAM	MVD-52	NF	NF	NF	NF	NF	NF	NF	NF	NF
LITTLE RIVER CLOSURE DAM	MVD-20	--	--	--	21.06	1.10	0.05	--	--	--
PEARL RIVER LOCK #1 & SPILLWAY	MVD-44	--	--	--	3.80	0.57	Negative	--	--	--

7.2.2. St. Paul District

Figure 15 shows a map of MVP along with the 14 dams considered in this study. The total potential capacity for MVP is about 138 MW, of which only about 1.6 MW was determined to be feasible by the model.

Table 25 shows power potential results for the District. Lock and Dam No. 5 has the highest potential capacity with a relatively modest value of about 25 MW. It has average annual generation of about 101 GWh, which would result in a capacity factor of 0.47. This translates to about 220 million tons of CO_2 avoided. Both Pokegama Dam and Winnibigoshish Dam have potential capacity of less than 1 MW.

Figure 15. St. Paul District Dams

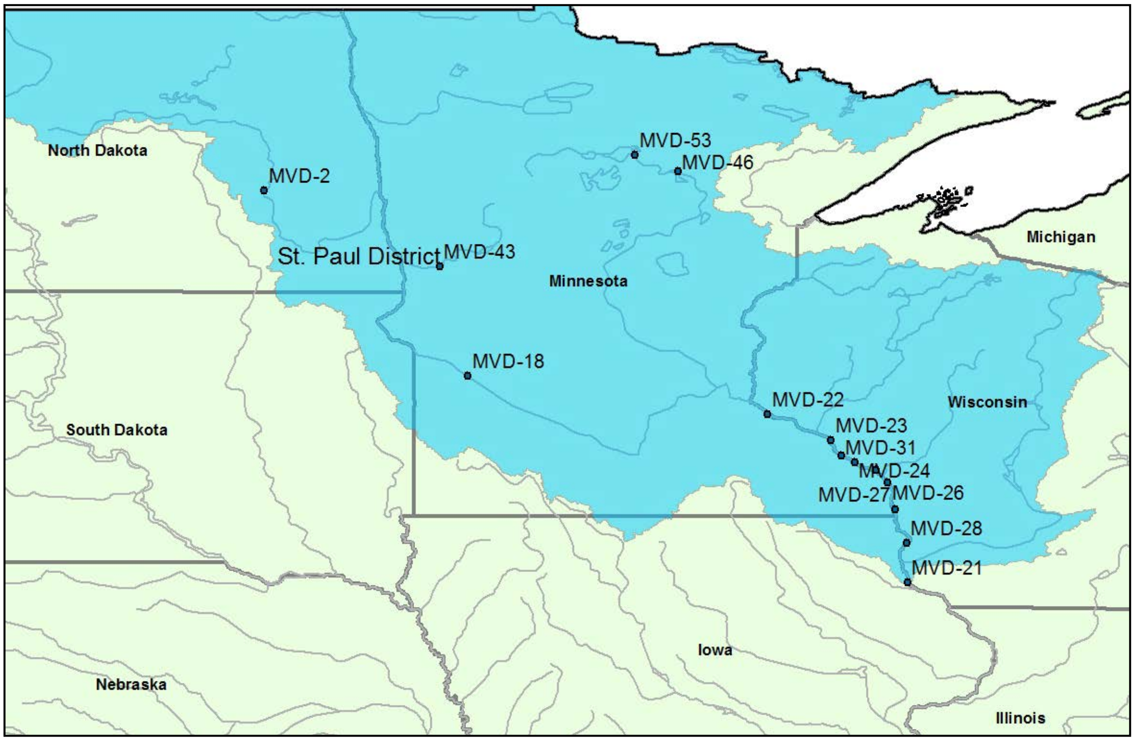


Table 25. St. Paul District Power Potential

ST. PAUL DISTRICT								
NAME	**ID**	**DATA QUALITY**	**CAPACITY (MW)**	**GENERATION (MWh)**	**CAPACITY FACTOR**	**AVG. HEAD (Ft.)**	**AVG. FLOW (Cfs)**	**CO_2e AVOIDED (Millions of Tons)**
BALDHILL	MVD-2	Full Data	10.66	9468.12	0.10	41.10	415.61	20.55
LAC QUI PARLE DAM	MVD-18	Full Data	4.00	6025.26	0.17	12.13	1451.61	13.08
LOCK & DAM #10	MVD-21	Full Data	14.96	70054.71	0.53	4.13	48445.96	152.07
LOCK & DAM #3	MVD-22	Full Data	5.68	26064.29	0.52	3.88	20415.59	56.58
LOCK & DAM #4	MVD-23	Full Data	14.73	58042.50	0.45	3.98	30706.45	125.99
LOCK & DAM #5A	MVD-24	Full Data	7.51	34459.29	0.52	2.87	32214.95	74.80
LOCK & DAM #6	MVD-25	Full Data	10.90	55484.84	0.58	4.24	33289.60	120.44
LOCK & DAM #7	MVD-26	Full Data	14.68	68097.08	0.53	4.12	34272.99	147.82
LOCK & DAM #8	MVD-27	Full Data	14.35	60583.99	0.48	3.51	37036.23	131.51
LOCK & DAM #9	MVD-28	Full Data	11.30	51007.20	0.52	3.78	39387.93	93.70
LOCK & DAM NO 5	MVD-31	Full Data	24.62	100969.74	0.47	5.87	32984.92	219.17
ORWELL RESERVOIR & DAM	MVD-43	Full Data	4.45	13924.53	0.36	31.79	706.77	30.23
POKEGAMA LAKE DAM	MVD-46	Full Data	< 1	--	--	4.72	1016.49	5.02
WINNIBIGOSHISH DAM	MVD-53	Full Data	< 1	--	--	13.44	494.33	6.90

The economic feasibility results shown in Table 26 are similar to what was discussed above—of all the power potential present in MVP, only 1.6 MW is feasible. Specifically, the only dam not judged infeasible by the economic model was Orwell Dam, which has a maximum feasible capacity of 1.6 MW, a BCR of 1.03 and a 4% IRR.

Table 26. St. Paul District Economic Feasibility

MVP FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
BALDHILL	MVD-2	NF	NF	NF	NF	NF	NF	NF	NF	NF
LAC QUI PARLE DAM	MVD-18	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM #10	MVD-21	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM #3	MVD-22	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM #4	MVD-23	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM #5A	MVD-24	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM #6	MVD-25	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM #7	MVD-26	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM #8	MVD-27	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM #9	MVD-28	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK & DAM NO 5	MVD-31	NF	NF	NF	NF	NF	NF	NF	NF	NF
ORWELL RESERVOIR & DAM	MVD-43	< 1	1.11	0.05	1.61	1.03	0.04	< 1	1.11	0.05
POKEGAMA LAKE DAM	MVD-46	NF	NF	NF	NF	NF	NF	NF	NF	NF
WINNIBIGOSHISH DAM	MVD-53	NF	NF	NF	NF	NF	NF	NF	NF	NF

7.2.3. Rock Island District

Figure 16 shows a map of MVR along with the 15 dams considered in this study. These dams represent a total potential capacity of about 608 MW. About 260 MW, or about 43%, was determined to be feasible by the model.

Figure 16. Rock Island District Dams

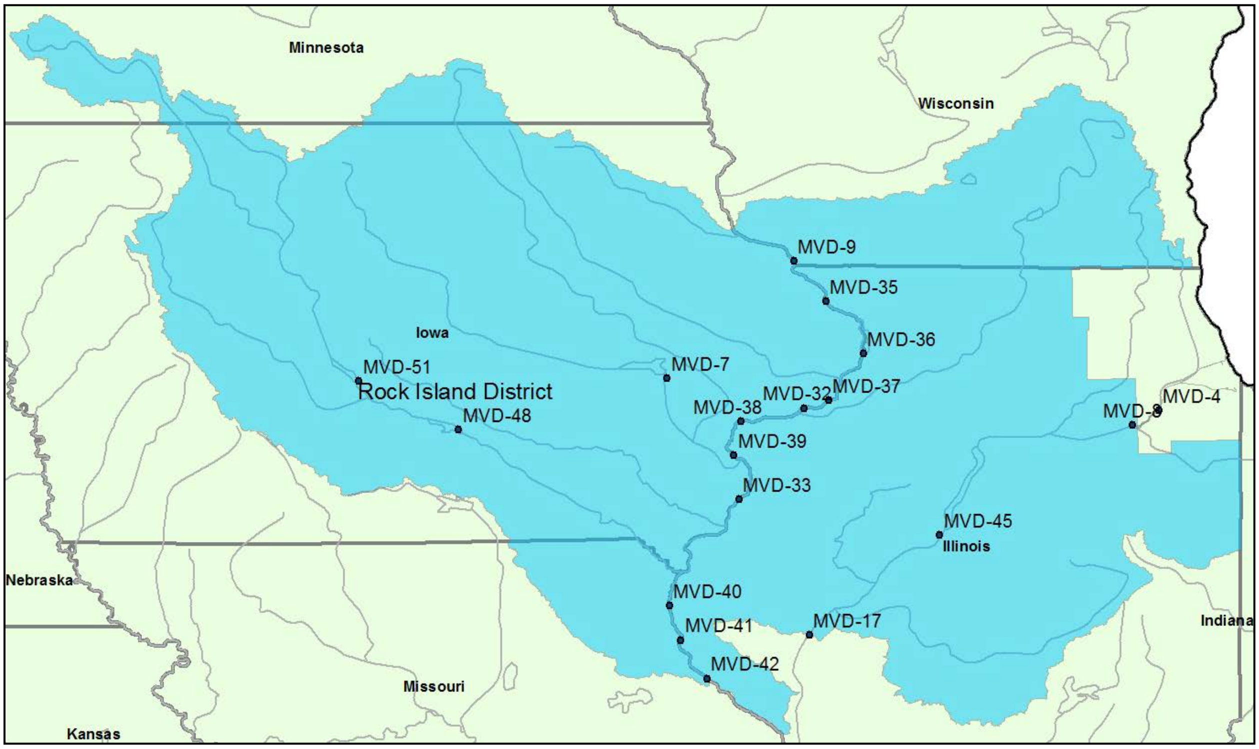


Table 27 shows that the largest potential power capacity value belongs to Saylorville Dam, with 111 MW. Saylorville has 125 GWh of average annual generation, which gives it a relatively low capacity factor of 0.13. Following Saylorville are Lock and Dam 18 and Lock and Dam 15, with potential capacities of 62 and 57 MW, respectively.

Table 28 shows that Saylorville's maximum feasible capacity is less than a quarter of its 1% estimate, at about 24 MW. Lock and Dam 15 has a maximum feasible capacity of 57 MW, the same as its 1% estimate, and a BCR of 1.06 with a 4% IRR. Despite its relatively high 1% capacity estimate in the power potential table, Lock and Dam 18 is judged not feasible by the economic model.

Table 27. Rock Island District Power Potential

ROCK ISLAND DISTRICT								
NAME	**ID**	**DATA QUALITY**	**CAPACITY (MW)**	**GENERATION (MWh)**	**CAPACITY FACTOR**	**AVG. HEAD (Ft.)**	**AVG. FLOW (Cfs)**	**CO_2e AVOIDED (Millions of Tons)**
BRANDON ROAD LOCK & DAM	MVD-4	Full Data	36.06	79686.70	0.25	34.06	3799.59	168.29
CORALVILLE DAM	MVD-7	Full Data	38.22	60651.07	0.18	35.27	2745.69	131.65
DRESDEN ISLAND LOCK & DAM	MVD-8	Full Data	25.82	92483.95	0.41	20.59	8983.91	195.32
DUBUQUE NUMBER 11	MVD-9	Full Data	37.90	206793.51	0.62	9.62	51451.54	448.88
LA GRANGE LOCK & DAM	MVD-17	Full Data	7.86	22771.35	0.33	6.66	26828.89	48.09
LOCK AND DAM 15	MVD-32	Full Data	57.32	338212.81	0.67	13.22	59405.51	734.15
LOCK AND DAM 18	MVD-33	Full Data	62.29	185438.98	0.34	7.08	79276.74	402.53
MISSISSIPPI RIVER DAM 14	MVD-37	Full Data	54.98	284227.31	0.59	10.24	56429.93	616.96
MISSISSIPPI RIVER DAM 16	MVD-38	Full Data	31.72	155341.75	0.56	7.27	67485.57	337.19
MISSISSIPPI RIVER DAM 17	MVD-39	Full Data	21.72	76259.16	0.40	4.56	69729.66	165.53
MISSISSIPPI RIVER DAM 20	MVD-40	Full Data	35.28	149645.73	0.48	6.43	92716.68	316.04
MISSISSIPPI RIVER DAM 21	MVD-41	Full Data	36.59	198984.36	0.62	7.68	95628.87	420.24
MISSISSIPPI RIVER DAM 22	MVD-42	Full Data	45.83	225307.10	0.56	7.71	104573.30	475.83
PEORIA LOCK & DAM	MVD-45	Full Data	6.15	18389.47	0.34	7.72	16497.03	38.84
SAYLORVILLE DAM	MVD-51	Full Data	110.59	125483.30	0.13	45.99	3908.17	272.38

Table 28. Rock Island District Economic Feasibility

MVR FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
BRANDON ROAD LOCK & DAM	MVD-4	4.91	1.81	0.10	17.09	1.22	0.06	4.91	1.81	0.10
CORALVILLE DAM	MVD-7	1.67	1.29	0.06	7.27	1.09	0.05	2.26	1.30	0.06
DRESDEN ISLAND LOCK & DAM	MVD-8	5.59	1.52	0.08	20.11	1.07	0.04	5.59	1.52	0.08
DUBUQUE NUMBER 11	MVD-9	17.62	1.16	0.05	30.11	1.03	0.04	17.62	1.16	0.05
LA GRANGE LOCK & DAM	MVD-17	NF	NF	NF	NF	NF	NF	NF	NF	NF
LOCK AND DAM 15	MVD-32	28.93	1.44	0.07	57.32	1.06	0.04	28.93	1.44	0.07
LOCK AND DAM 18	MVD-33	NF	NF	NF	NF	NF	NF	NF	NF	NF
MISSISSIPPI RIVER DAM 14	MVD-37	22.27	1.26	0.06	36.56	1.16	0.05	22.27	1.26	0.06
MISSISSIPPI RIVER DAM 16	MVD-38	NF	NF	NF	NF	NF	NF	NF	NF	NF
MISSISSIPPI RIVER DAM 17	MVD-39	NF	NF	NF	NF	NF	NF	NF	NF	NF
MISSISSIPPI RIVER DAM 20	MVD-40	NF	NF	NF	NF	NF	NF	NF	NF	NF
MISSISSIPPI RIVER DAM 21	MVD-41	12.73	1.15	0.05	30.56	1.02	0.04	12.73	1.15	0.05
MISSISSIPPI RIVER DAM 22	MVD-42	11.15	1.11	0.05	36.65	1.00	0.04	22.02	1.11	0.05
PEORIA LOCK & DAM	MVD-45	NF	NF	NF	NF	NF	NF	NF	NF	NF
SAYLORVILLE DAM	MVD-51	2.18	1.47	0.08	24.23	1.08	0.04	3.40	1.49	0.08

7.2.4. St. Louis District

Figure 17 shows a map of MVS along with the five dams considered in this study. These dams represent a total potential capacity of about 292 MW. About 263 MW, or about 90%, was determined to be feasible by the model.

Figure 17. St. Louis District Dams

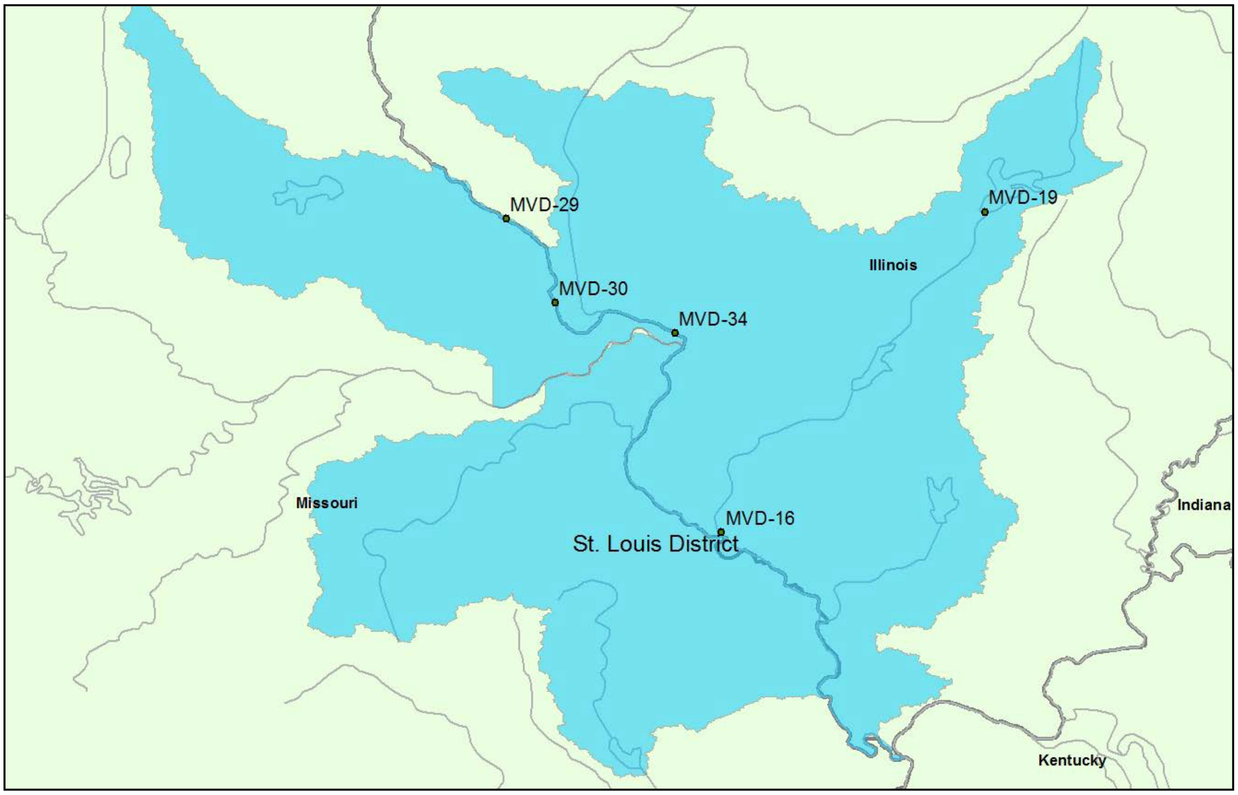


Table 29 shows that Melvin Price Dam has the highest potential capacity, with about 131 MW. It possesses about 632 GWh of average annual generation, which gives it a capacity factor of 0.55. These numbers indicate that CO_2 avoided would be around 1.3 billion tons.

Table 29. St. Louis District Power Potential

ST. LOUIS DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
KASKASKIA LOCK & DAM	MVD-16	Full Data	8.27	12760.54	0.18	14.91	3526.23	26.95
LAKE SHELBYVILLE DAM	MVD-19	Full Data	20.86	38315.87	0.21	63.21	1009.65	80.92
LOCK & DAM 24	MVD-29	Full Data	65.21	329211.76	0.58	11.91	97488.10	695.26
LOCK & DAM 25	MVD-30	Full Data	66.98	302672.50	0.52	11.84	97478.06	639.22
MELVIN PRICE LOCKS & DAM	MVD-34	Full Data	130.65	632103.54	0.55	17.52	115815.49	1334.94

The economic feasibility results in Table 30 show that the only non-feasible MVS dam is Kaskaskia, while the lowest maximum feasible capacity belongs to Lake Shelbyville, with 11.26 MW. Melvin Price has maximum feasible capacity equal to its 1% estimate, as does Lock and Dam 24, both of which contribute significantly to 90% of the potential capacity in MVS being feasible.

Table 30. St. Louis District Economic Feasibility

MVS FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
KASKASKIA LOCK & DAM	MVD-16	NF	NF	NF	NF	NF	NF	NF	NF	NF
LAKE SHELBYVILLE DAM	MVD-19	< 1	1.01	0.04	11.26	1.09	0.05	4.49	1.32	0.06
LOCK & DAM 24	MVD-29	14.33	1.31	0.06	65.21	1.00	0.04	32.21	1.34	0.06
LOCK & DAM 25	MVD-30	16.01	1.31	0.06	56.41	1.01	0.04	16.01	1.31	0.06
MELVIN PRICE LOCKS & DAM	MVD-34	46.80	1.65	0.08	130.65	1.13	0.05	62.70	1.67	0.08

7.3. North Atlantic Division

The North Atlantic Division (NAD) has about 288 MW of potential capacity spread across 21 dams in three of its Districts: Baltimore, New England, and Philadelphia. Only 22% of this potential capacity is feasible, about 63 MW. Table 31 shows that 16 of the 21 dams have estimates made with full data, while the remaining five are in the constant head category. Two dams in NAD have pending FERC licenses.

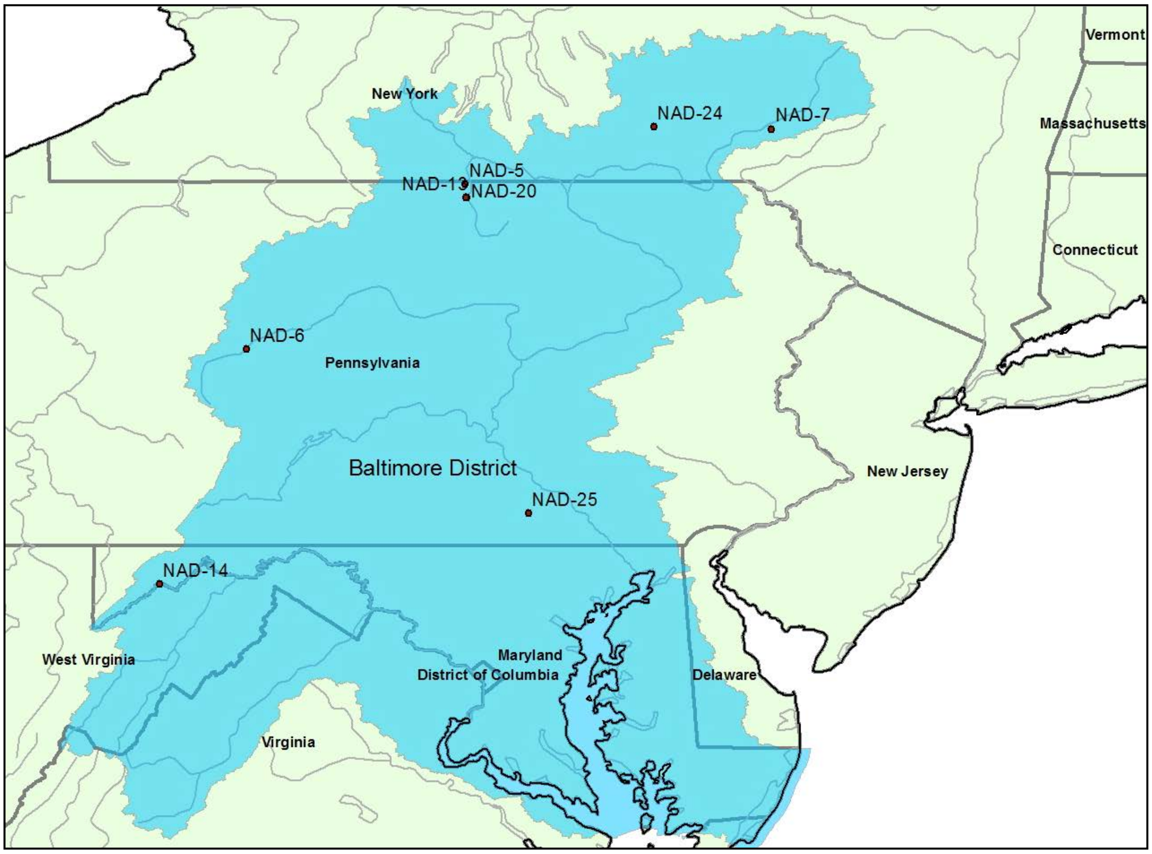
Table 31. North Atlantic Division Data Completeness and FERC Status

NORTH ATLANTIC DIVISION				
ID	NAME	CONFIDENCE	FERC STATUS	WATERWAY
NAD-2	BIRCH HILL DAM	Full Data	N	MILLERS RIVER
NAD-3	BLACKWATER DAM	Full Data	N	BLACKWATER RIVER
NAD-4	BLUE MARSH DAM	Full Data	N	TULPEHOCKEN CREEK
NAD-5	COWANESQUE DAM	Full Data	N	COWANESQUE RIVER
NAD-6	CURWENSVILLE DAM	Constant Head	N	WEST BRANCH SUSQUEHANNA RIVER
NAD-7	EAST SIDNEY DAM	Constant Head	N	OULEOUT CREEK
NAD-8	EVERETT DAM	Full Data	N	PISCATAQUQG RIVER
NAD-9	FRANCIS E WALTER DAM	Full Data	P	LEHIGH RIVER
NAD-10	FRANKLIN FALLS DAM	Full Data	P	PEMIGEWASSET RIVER
NAD-12	GENERAL EDGAR JADWIN	Full Data	N	DYBERRY CREEK
NAD-13	HAMMOND DAM	Constant Head	N	CROOKED CREEK
NAD-15	LITTLEVILLE DAM	Full Data	N	WESTFIELD RIVER
NAD-16	NORTH SPRINGFIELD DAM	Full Data	N	BLACK RIVER
NAD-17	PROMPTON DAM	Full Data	N	LACKAWAXEN RIVER
NAD-18	SURRY MOUNTAIN DAM	Full Data	N	ASHUELOT RIVER
NAD-19	THOMASTON DAM	Full Data	N	NAUGATUCK RIVER
NAD-20	TIOGA DAM	Full Data	N	TIOGA RIVER
NAD-22	WEST THOMPSON DAM	Full Data	N	QUINEBAUG RIVER
NAD-23	WESTVILLE DAM	Full Data	N	QUINEBAUG RIVER
NAD-24	WHITNEY POINT DAM	Constant Head	N	OTSELIC RIVER
NAD-25	YORK INDIAN ROCK DAM	Constant Head	N	CODORUS CREEK

7.3.1. Baltimore District

Figure 18 shows a map of NAB along with the seven dams considered in this study. These dams represent a total potential capacity of about 79 MW. About 14 MW, or about 18%, was determined to be feasible by the model.

Figure 18. Baltimore District Dams



As shown in Table 32, the 19 MW of potential capacity at Cowanesque is the highest in the District. To go with it, Cowanesque has about 16 GWh of average annual generation, which gives the capacity factor of 0.10. The remaining six dams are summarized in the table.

Table 32. Baltimore District Power Potential

BALTIMORE DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
COWANESQUE DAM	NAD-5	Full Data	19.39	16296.17	0.10	77.80	337.04	29.32
CURWENSVILLE DAM	NAD-6	Const. Head	12.09	14791.41	0.14	37.00	638.23	26.61
EAST SIDNEY DAM	NAD-7	Const. Head	7.16	7177.81	0.11	59.00	193.68	10.92
HAMMOND DAM	NAD-13	Const. Head	6.77	6026.34	0.10	84.00	117.12	10.84
TIOGA DAM	NAD-20	Full Data	15.87	15895.17	0.11	52.03	504.22	28.59
WHITNEY POINT DAM	NAD-24	Const. Head	15.39	20752.09	0.15	66.00	502.49	31.56
YORK INDIAN ROCK DAM	NAD-25	Const. Head	2.67	4225.91	0.18	66.00	104.16	7.60

In contrast to its 1% potential capacity value stated above, the maximum feasible capacity at Cowanesque is only 1.7 MW. Additionally, Table 33 shows that the project has a projected BCR of 1.1, and an IRR of 5%. The highest maximum feasible capacity estimate belongs to Whitney Point Dam, with about 6 MW. This is compared to about 15 MW for the same dam based on its 1% estimate.

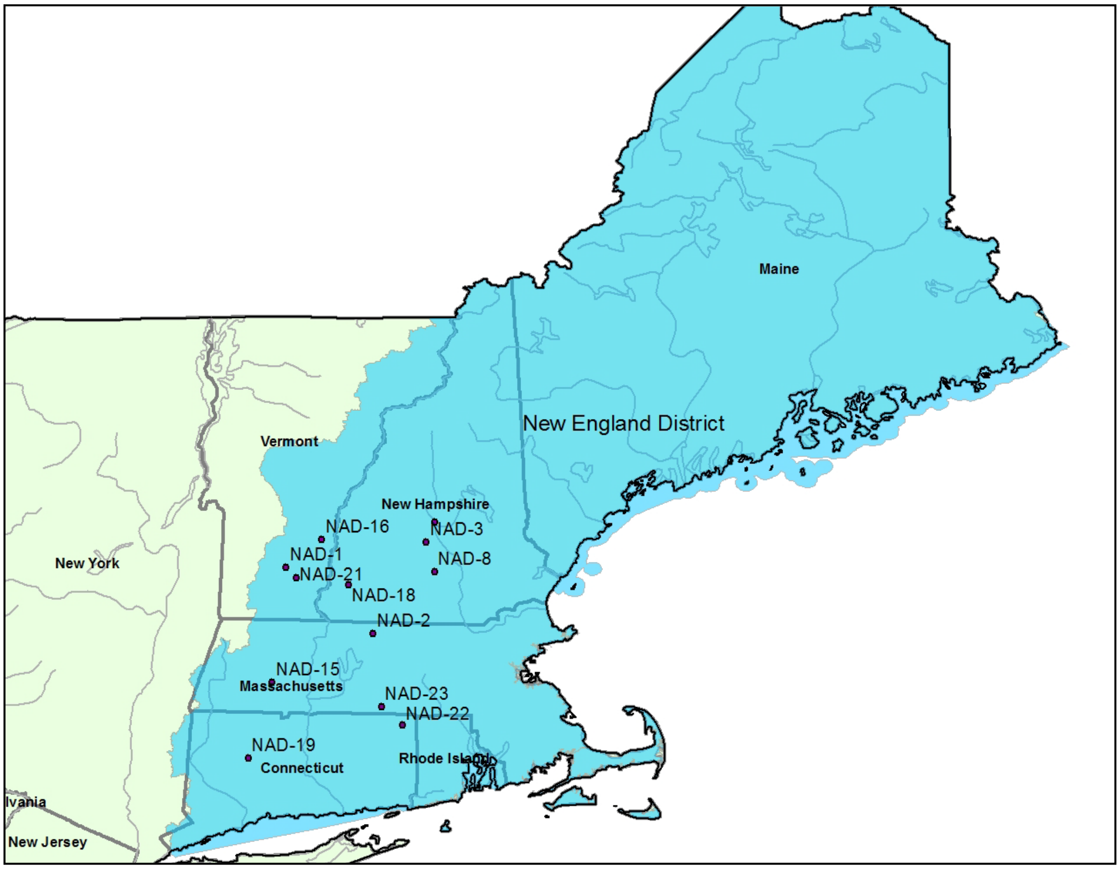
Table 33. Baltimore District Economic Feasibility

NAB FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
COWANESQUE DAM	NAD-5	< 1	1.07	0.04	1.66	1.10	0.05	< 1	1.19	0.05
CURWENSVILLE DAM	NAD-6	< 1	1.48	0.07	2.53	1.10	0.05	< 1	1.49	0.07
EAST SIDNEY DAM	NAD-7	< 1	1.22	0.06	1.22	1.07	0.04	< 1	1.28	0.06
HAMMOND DAM	NAD-13	NF	NF	NF	NF	NF	NF	NF	NF	NF
TIOGA DAM	NAD-20	< 1	1.31	0.06	2.76	1.16	0.05	< 1	1.43	0.07
WHITNEY POINT DAM	NAD-24	< 1	1.62	0.08	6.16	1.13	0.05	< 1	1.73	0.09
YORK INDIAN ROCK DAM	NAD-25	< 1	1.48	0.07	< 1	1.18	0.05	< 1	1.49	0.07

7.3.2. New England District

Figure 19 shows a map of NAE along with the 10 dams considered in this study. These dams represent a total potential capacity of about 128 MW. About 32 MW, or about 25%, was determined to be feasible.

Figure 19. New England District Dams



As shown in Table 34, the highest potential capacity is about 64 MW, belonging to Franklin Falls Dam. Its average annual generation is about 81 GWh, which allows for avoidance of 107 million tons of CO_2. The next highest potential capacity is a significant drop, to about 15 MW, belonging to Birch Hill Dam.

Table 34. New England District Power Potential

NEW ENGLAND DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
BIRCH HILL DAM	NAD-2	Full Data	15.22	24538.57	0.18	95.98	398.90	32.42
BLACKWATER DAM	NAD-3	Full Data	13.67	15954.88	0.13	84.66	279.72	21.08
EVERETT DAM	NAD-8	Full Data	5.88	2411.31	0.05	16.45	138.27	3.19
FRANKLIN FALLS DAM	NAD-10	Full Data	63.81	81317.43	0.15	51.69	2369.87	107.43
LITTLEVILLE DAM	NAD-15	Full Data	8.03	9319.82	0.13	116.98	124.92	12.31
NORTH SPRINGFIELD DAM	NAD-16	Full Data	6.67	4844.61	0.08	19.61	349.46	6.40
SURRY MOUNTAIN DAM	NAD-18	Full Data	3.06	2802.75	0.10	16.43	216.05	3.70
THOMASTON DAM	NAD-19	Full Data	7.44	5114.29	0.08	28.43	225.98	6.76
WEST THOMPSON DAM	NAD-22	Full Data	3.26	3551.90	0.12	16.76	340.39	4.69
WESTVILLE DAM	NAD-23	Full Data	1.42	1586.76	0.13	11.27	211.22	2.10

As shown on Table 35, the maximum feasible capacity for Franklin Falls is a little over a quarter of the 1% estimate, at about 21 MW. That capacity estimate has a corresponding BCR of 1.54, and an 8% IRR. Notice that 6 of the 10 NAE dams are not feasible.

Table 35. New England District Economic Feasibility

NAE FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
BIRCH HILL DAM	NAD-2	< 1	1.48	0.08	6.50	1.08	0.04	6.50	1.56	0.08
BLACKWATER DAM	NAD-3	< 1	1.28	0.06	2.81	1.06	0.04	< 1	1.33	0.06
EVERETT DAM	NAD-8	NF	NF	NF	NF	NF	NF	NF	NF	NF
FRANKLIN FALLS DAM	NAD-10	2.56	2.33	0.13	21.42	1.54	0.08	21.42	2.37	0.13
LITTLEVILLE DAM	NAD-15	< 1	1.17	0.05	1.54	1.02	0.04	< 1	1.24	0.06
NORTH SPRINGFIELD DAM	NAD-16	NF	NF	NF	NF	NF	NF	NF	NF	NF
SURRY MOUNTAIN DAM	NAD-18	NF	NF	NF	NF	NF	NF	NF	NF	NF
THOMASTON DAM	NAD-19	NF	NF	NF	NF	NF	NF	NF	NF	NF
WEST THOMPSON DAM	NAD-22	NF	NF	NF	NF	NF	NF	NF	NF	NF
WESTVILLE DAM	NAD-23	NF	NF	NF	NF	NF	NF	NF	NF	NF

7.3.3. Philadelphia District

Figure 20 shows a map of NAP along with the four dams considered in this study. These dams represent a total potential capacity of about 80 MW. About 17 MW, or about 21%, was determined to be feasible by the model.

Table 36 shows that the highest potential capacity value belongs to Francis Walter Dam, with 63 MW. It also has average annual generation of about 58 GW, leading to a capacity factor of 0.10. The next highest potential in NAP is nearly an order of magnitude smaller—Prompton Dam has about 8 MW of potential capacity. Table 37 shows that Francis E. Walter also has the highest maximum feasible capacity, at 13 MW. General Edgar Jadwin was the only dam to be not feasible.

Figure 20. Philadelphia District Dams

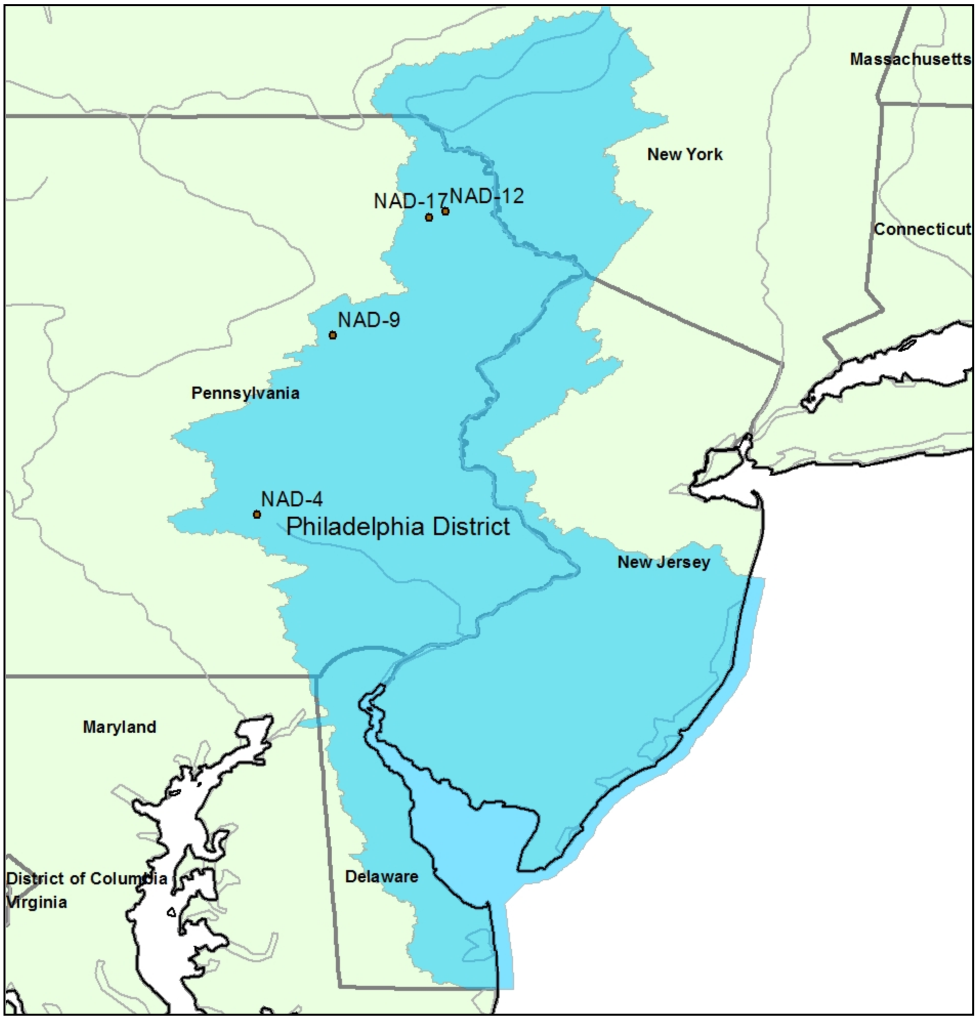


Table 36. Philadelphia District Power Potential

PHILADELPHIA DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
BLUE MARSH DAM	NAD-4	Full Data	7.37	11938.24	0.18	57.11	360.61	21.48
FRANCIS E WALTER DAM	NAD-9	Full Data	63.06	57732.55	0.10	148.69	733.34	103.86
GENERAL EDGAR JADWIN	NAD-12	Full Data	1.56	893.62	0.07	8.04	151.20	1.61
PROMPTON DAM	NAD-17	Full Data	8.29	9007.17	0.12	39.81	367.31	16.20

Table 37. Philadelphia District Economic Feasibility

NAP FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
BLUE MARSH DAM	NAD-4	< 1	1.90	0.10	2.46	1.29	0.06	< 1	1.93	0.10
FRANCIS E WALTER DAM	NAD-9	2.24	2.40	0.13	13.00	1.59	0.08	2.64	2.42	0.13
GENERAL EDGAR JADWIN	NAD-12	NF	NF	NF	NF	NF	NF	NF	NF	NF
PROMPTON DAM	NAD-17	< 1	1.39	0.07	1.45	1.04	0.04	< 1	1.41	0.07

7.4. Northwestern Division

Table 38 shows 12 Northwestern Division (NWD) dams with a total potential capacity of 349 MW. Only a relatively small portion of this, about 51 MW, was determined to be feasible by the economic model used in this study. Seven of the 12 dams have full data available, while the others fall into the constant head category. Five of the NWD dams have pending FERC licenses.

Table 38. Northwestern Division Data Completeness and FERC Status

NORTHWESTERN DIVISION				
ID	**NAME**	**CONFIDENCE**	**FERC STATUS**	**WATERWAY**
NWD-2	BLUE RIVER	Constant Head	P	BLUE RIVER
NWD-3	CHATFIELD DAM	Full Data	P	SOUTH PLATTE RIVER
NWD-4	COTTAGE GROVE	Constant Head	N	COAST FORK WILLAMETTE RIVER
NWD-6	FERN RIDGE	Constant Head	N	LONG TOM RIVER
NWD-7	HIRAM M. CHITTENDEN LOCKS & DAM	Constant Head	P	CEDAR RIVER, SAMMAMISH RIVER
NWD-8	HOWARD A HANSON DAM	Constant Head	N	GREEN
NWD-9	KANOPOLIS DAM	Full Data	N	SMOKY HILL RIVER
NWD-10	MELVERN DAM	Full Data	N	MARAIS DES CYGNES
NWD-11	MILFORD DAM	Full Data	P	REPUBLICAN RIVER
NWD-12	PERRY DAM	Full Data	N	DELAWARE RIVER
NWD-13	POMME DE TERRE DAM	Full Data	N	POMME DE TERRE RIVER
NWD-14	TUTTLE CREEK DAM	Full Data	P	BIG BLUE RIVER

7.4.1. Kansas City District

Figure 21 shows a map of NWK along with the six dams considered in this study. These dams represent a total potential capacity of about 228 MW. About 36 MW, or about 16%, was determined to be feasible by the model.

Table 39 shows that Tuttle Creek represents about half of the potential capacity available in NWK, with a value of about 111 MW, corresponding to about 105 GWh of average annual generation. As shown in Table 40, less than a third of this capacity is feasible. Table 40 also shows that both Kanopolis and Melvern dams are not feasible. Perry Dam has a capacity value less than 1 MW.

Figure 21. Kansas City District Dams

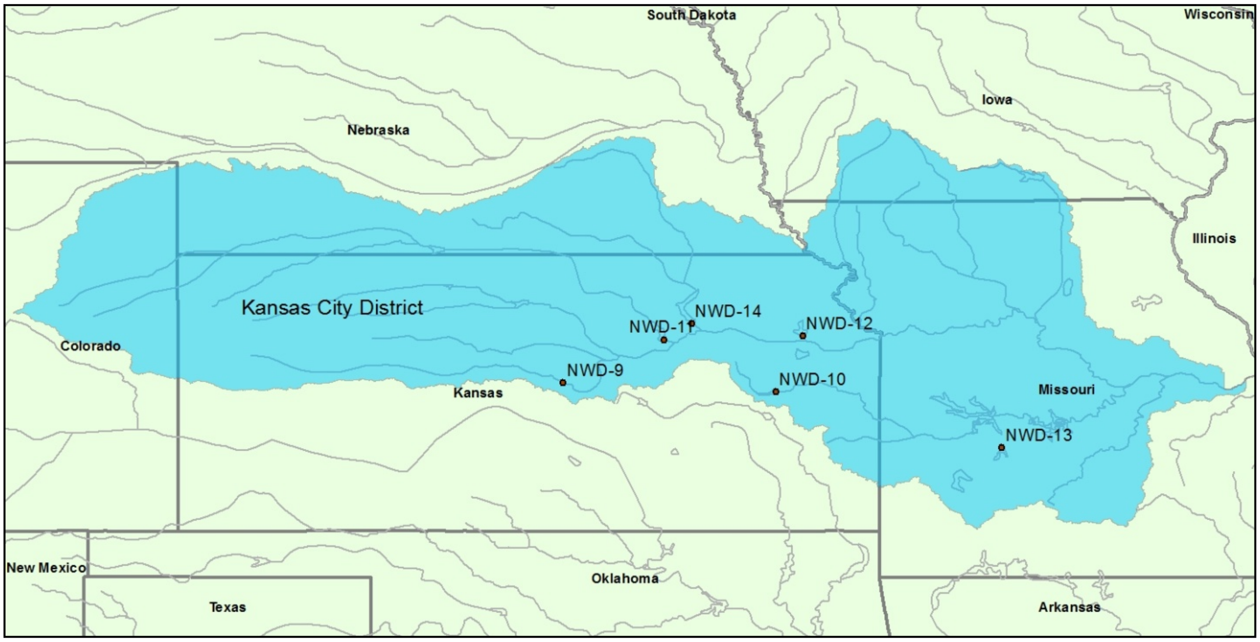


Table 39. Kansas City District Power Potential

KANSAS CITY DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
KANOPOLIS DAM	NWD-9	Full Data	12.88	7708.86	0.07	58.22	207.44	16.81
MELVERN DAM	NWD-10	Full Data	11.87	10016.81	0.10	80.91	204.99	21.84
MILFORD DAM	NWD-11	Full Data	40.78	34492.40	0.10	74.12	803.18	75.20
PERRY DAM	NWD-12	Full Data	28.48	19813.21	0.08	47.16	673.37	43.20
POMME DE TERRE DAM	NWD-13	Full Data	22.80	33636.21	0.17	89.76	595.64	71.04
TUTTLE CREEK DAM	NWD-14	Full Data	111.28	104836.42	0.11	66.83	2422.17	228.58

Table 40. Kansas City District Economic Feasibility

NWK FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
KANOPOLIS DAM	NWD-9	NF	NF	NF	NF	NF	NF	NF	NF	NF
MELVERN DAM	NWD-10	NF	NF	NF	NF	NF	NF	NF	NF	NF
MILFORD DAM	NWD-11	1.02	1.06	0.04	3.07	1.01	0.04	1.30	1.07	0.04
PERRY DAM	NWD-12	< 1	1.02	0.04	< 1	1.01	0.04	< 1	1.02	0.04
POMME DE TERRE DAM	NWD-13	< 1	1.08	0.04	1.91	1.01	0.04	< 1	1.11	0.05
TUTTLE CREEK DAM	NWD-14	1.89	1.90	0.11	30.73	1.22	0.06	3.43	1.96	0.12

7.4.2. Omaha District

The only NWO dam considered in this study was Chatfield Dam (Figure 22). It has about 4.5 MW of potential capacity and average annual generation of about 4.5 GWh (Table 41). This gives a capacity factor of 0.11. This development would avoid approximately 7 million tons of CO_2. As seen in Table 42, Chatfield Dam was determined to be not feasible by the model.

Figure 22. Omaha District Dams

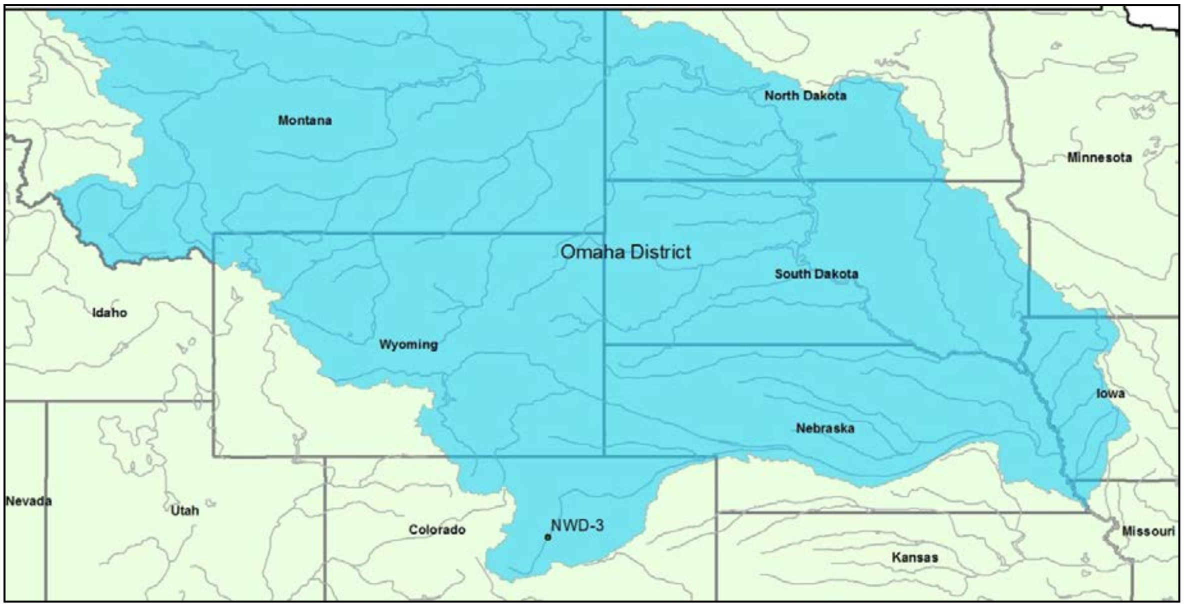


Table 41. Omaha District Power Potential

OMAHA DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
CHATFIELD DAM	NWD-3	Full Data	4.53	4538.10	0.11	55.99	138.19	7.37

Table 42. Omaha District Economic Feasibility

NWO FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
CHATFIELD DAM	NWD-3	NF	NF	NF	NF	NF	NF	NF	NF	NF

7.4.3. Portland District

Figure 23 shows a map of NWP along with the three dams considered in this study. These dams represent a total potential capacity of about 39 MW (Table 43). The highest capacity value in the table was for Blue River Dam, about 20 MW. It has average annual generation of about 33 GWh, which gives a capacity factor of 0.18. However, as shown in Table 44, none of the potential capacity at the three dams was determined to be feasible by the model.

Figure 23. Portland District Dams

Table 43. Portland District Power Potential

PORTLAND DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
BLUE RIVER	NWD-2	Const. Head	20.63	32565.26	0.18	115.00	451.54	43.65
COTTAGE GROVE	NWD-4	Const. Head	8.41	12048.79	0.27	76.00	256.74	16.15
FERN RIDGE	NWD-6	Const. Head	10.08	11832.67	0.21	40.00	472.97	15.86

Table 44. Portland District Economic Feasibility

NWP FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
BLUE RIVER	NWD-2	NF	NF	NF	NF	NF	NF	NF	NF	NF
COTTAGE GROVE	NWD-4	NF	NF	NF	NF	NF	NF	NF	NF	NF
FERN RIDGE	NWD-6	NF	NF	NF	NF	NF	NF	NF	NF	NF

7.4.4. Seattle District

Figure 24 shows a map of NWS and its two dams, Hiram Chittenden Dam and Howard A. Hanson Dam, considered in this study. Combined, the two dams account for 77 MW of potential capacity (Table 45). Only the potential capacity at Howard Hanson Dam (about 66 MW) was determined to be feasible by the model (Table 46). The dam has 96 GWh of average annual generation, with a capacity factor of 0.17.

Figure 24. Seattle District Dams

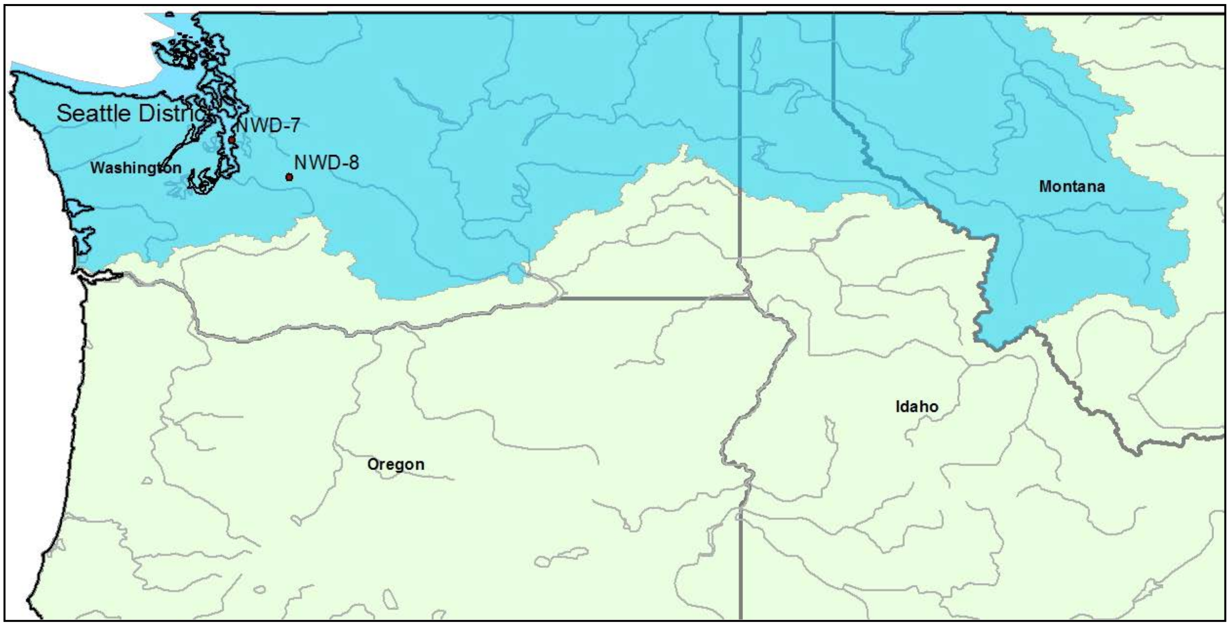


Table 45 - Seattle District Power Potential

SEATTLE DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
HIRAM M. CHITTENDEN LOCKS & DAM	NWD-7	Const. Head	11.43	16755.29	0.17	25.00	1083.40	22.46
HOWARD A HANSON DAM	NWD-8	Const. Head	65.58	95576.38	0.17	149.00	1025.96	128.12

Table 46. Seattle District Economic Feasibility

NWS FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
HIRAM M. CHITTENDEN LOCKS & DAM	NWD-7	NF	NF	NF	NF	NF	NF	NF	NF	NF
HOWARD A HANSON DAM	NWD-8	3.67	1.37	0.07	14.92	1.16	0.05	5.40	1.41	0.07

7.5. South Atlantic Division

South Atlantic Division (SAD) contains 18 dams of interest to this study, across three of its Districts—Jacksonville, Mobile, and Wilmington. These dams represent about 672 MW, with about 325 MW determined to be feasible by the model. The majority of this capacity is located in Mobile District. Table 47 shows a summary of current FERC license status and data quality for SAD. Six of the SAD dams have full data available. One dam is categorized as constant head, and the remaining 11 rely on ORNL data for capacity estimates. Five SAD dams have FERC permits pending.

Table 47. South Atlantic Division Data Completeness and FERC Status

SOUTH ATLANTIC DIVISION				
ID	**NAME**	**CONFIDENCE**	**FERC STATUS**	**WATERWAY**
SAD-1	A.I.SELDEN	Constant Head	P	BLACK WARRIOR RIVER
SAD-2	ABERDEEN LK/DM (TENN-TOM, AL & MS)	Full Data	P	TOMBIGBEE
SAD-5	CLAIBORNE LOCK AND DAM	Full Data	N	ALABAMA RIVER
SAD-6	COFFEEVILLE LOCK AND DAM	Full Data	P	TOMBIGBEE RIVER
SAD-7	DEMOPOLIS LOCK AND DAM	Full Data	P	TOMBIGBEE RIVER
SAD-10	GEORGE W ANDREWS LOCK AND DAM	Full Data	P	CHATTAHOOCHEE RIVER
SAD-13	JOHN C. STENNIS	Full Data	N	TOMBIGBEE RIVER
SAD-3	AMORY	ORNL Data	N	TOMBIGBEE RIVER
SAD-8	FULTON	ORNL Data	N	TOMBIGBEE RIVER
SAD-9	G.V. MONTGOMERY	ORNL Data	N	TOMBIGBEE RIVER
SAD-11	GLOVER WILKINS	ORNL Data	N	TOMBIGBEE RIVER
SAD-12	JAMIE L WHITTEN LOCK AND DAM	ORNL Data	N	TOMBIGBEE RIVER
SAD-14	JOHN RANKIN	ORNL Data	N	TOMBIGBEE RIVER
SAD-20	WILLIAM BACON OLIVER REPLACEMENT	ORNL Data	N	BLACK WARRIER
SAD-15	LOCK AND DAM #1	ORNL Data	N	CAPE FEAR RIVER
SAD-16	LOCK AND DAM #2	ORNL Data	N	CAPE FEAR RIVER
SAD-18	STRUCTURE 78	ORNL Data	N	CALOOSAHATCHEE RIVER (C-43)
SAD-19	STRUCTURE 80	ORNL Data	N	ST LUCIE CANAL
SAD-21	WILLIAM O. HUSKE LOCK & DAM	ORNL Data	N	CAPE FEAR RIVER

7.5.1. Jacksonville District

Figure 25 shows a map of SAJ along with the two dams considered in this study. These dams represent a total potential capacity of about 13 MW. Table 48 shows that Structure 80 has about 11 MW of potential capacity, and about 39 GWh of average annual generation, giving a capacity factor of 0.40. Structure 78 has a potential capacity of about 2 MW, with average annual generation of about 7 GWh, giving a capacity factor of 0.40. None of this potential capacity was found to be feasible (Table 49).

Figure 25. Jacksonville District Dams

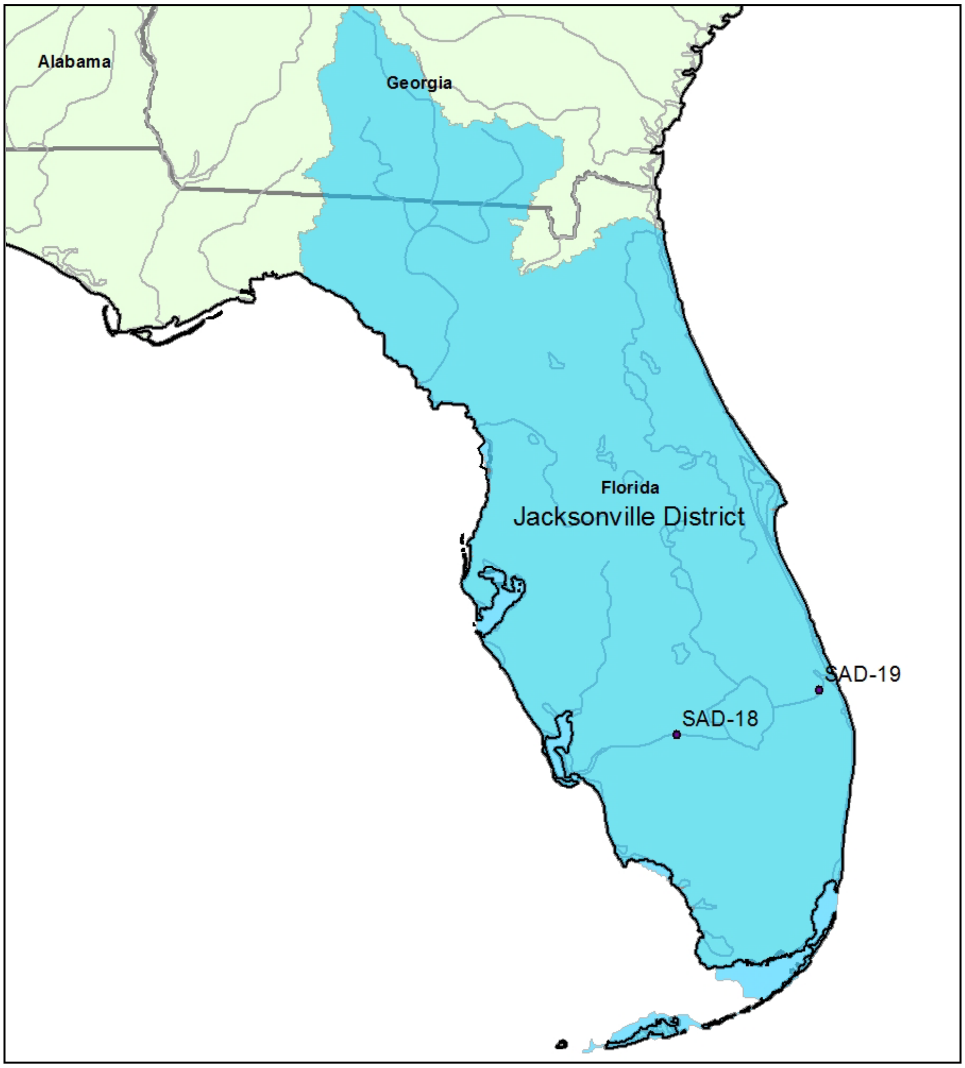


Table 48. Jacksonville District Power Potential

JACKSONVILLE DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
STRUCTURE 78	SAD-18	ORNL Data	1.92	6748.44	0.40	30.00	356.49	9.17
STRUCTURE 80	SAD-19	ORNL Data	11.04	38910.79	0.40	13.00	4743.36	52.87

Table 49. Jacksonville District Economic Feasibility

SAJ FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
STRUCTURE 78	SAD-18	--	--	--	NF	NF	NF	--	--	--
STRUCTURE 80	SAD-19	--	--	--	NF	NF	NF	--	--	--

7.5.2. Mobile District

Figure 26 shows a map of SAM along with the 14 dams considered in this study. These dams represent a total potential capacity of about 641 MW. About 325 MW, or about 51%, was determined to be feasible by the model. Table 50 shows that the greatest contributor of potential capacity was A.I. Selden Dam at about 165 MW and about 237 GWh of potential generation. The next highest contributor was Demopolis with a potential capacity of about 146 MW and about 307 GWh of potential generation. The economic feasibility results are shown in Table 51. Fulton, G.V. Montgomery, Glover Wilkins, and John Rankin were all determined to be not feasible by the model. Demopolis has the highest feasible capacity at about 91 MW, with a BCR of 1.13 and an IRR 5%.

Figure 26. Mobile District Dams

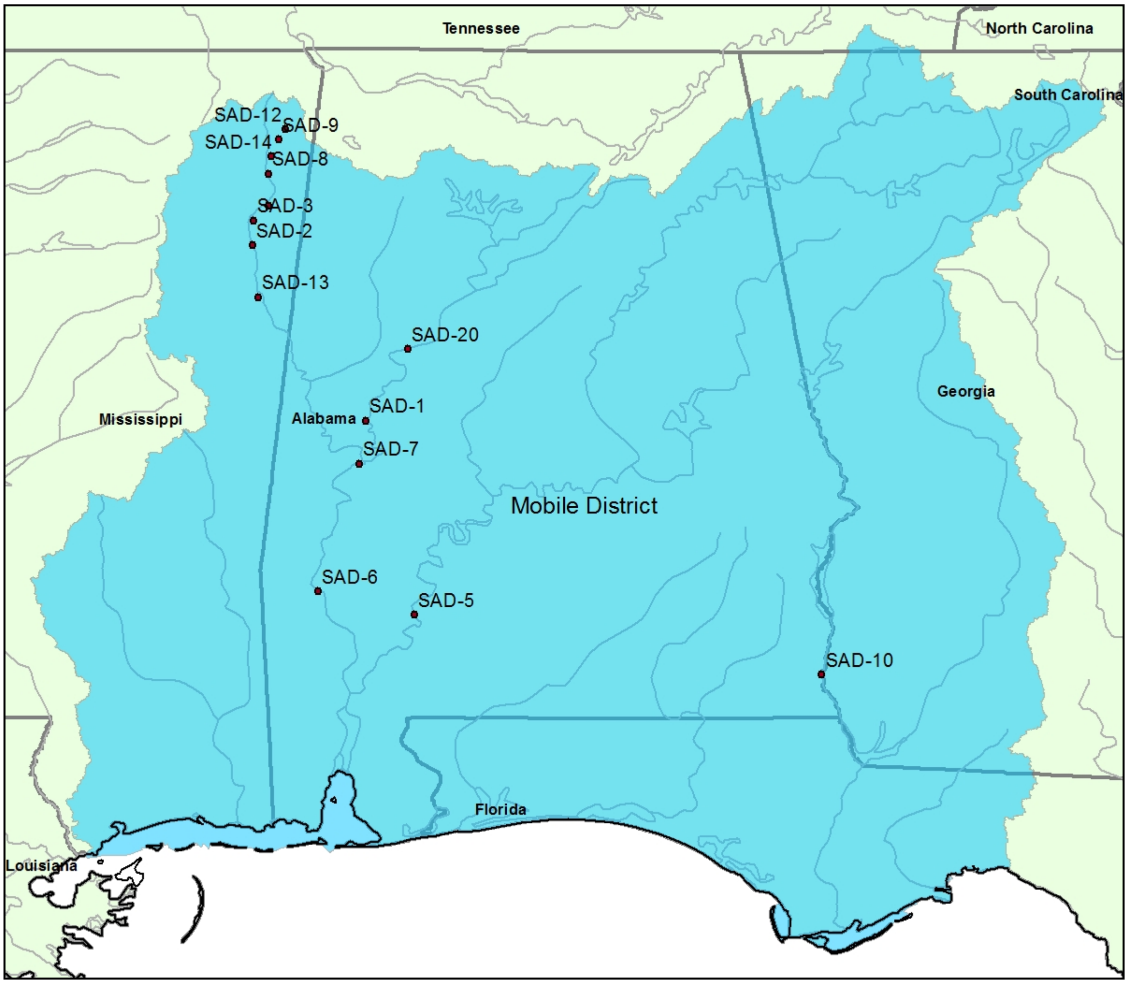


Table 50. Mobile District Power Potential

MOBILE DISTRICT								
NAME	**ID**	**DATA QUALITY**	**CAPACITY (MW)**	**GENERATION (MWh)**	**CAPACITY FACTOR**	**AVG. HEAD (Ft.)**	**AVG. FLOW (Cfs)**	**CO$_2$e AVOIDED (Millions of Tons)**
A.I.SELDEN	SAD-1	Const. Head	164.81	237376.00	0.16	22.00	17259.82	405.00
ABERDEEN LK/DM (TENN-TOM, AL & MS)	SAD-2	Full Data	34.27	50959.62	0.17	27.05	3291.40	64.25
CLAIBORNE LOCK AND DAM	SAD-5	Full Data	63.93	200077.37	0.36	27.20	27478.56	341.36
COFFEEVILLE LOCK AND DAM	SAD-6	Full Data	103.40	226553.79	0.25	30.83	25603.72	386.53
DEMOPOLIS LOCK AND DAM	SAD-7	Full Data	146.42	307377.13	0.24	40.41	20503.77	524.43
GEORGE W ANDREWS LOCK AND DAM	SAD-10	Full Data	27.71	113306.36	0.47	24.74	10201.20	193.32
JOHN C. STENNIS	SAD-13	Full Data	55.21	129914.10	0.27	26.59	9923.00	163.79
AMORY	SAD-3	ORNL Data	7.70	34434.94	0.51	30.00	1819.02	43.41
FULTON	SAD-8	ORNL Data	3.20	14324.49	0.51	25.00	908.03	18.06
G.V. MONTGOMERY	SAD-9	ORNL Data	< 1	--	--	30.00	206.23	4.92
GLOVER WILKINS	SAD-11	ORNL Data	2.21	9905.48	0.51	25.00	627.91	12.49
JAMIE L WHITTEN LOCK AND DAM	SAD-12	ORNL Data	1.19	5332.19	0.51	84.00	100.60	6.72
JOHN RANKIN	SAD-14	ORNL Data	2.38	10645.06	0.51	30.00	562.32	13.42
WILLIAM BACON OLIVER REPLACEMENT	SAD-20	ORNL Data	28.29	126496.68	0.51	28.00	7159.46	215.82

Table 51. Mobile District Economic Feasibility

SAM FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
A.I.SELDEN	SAD-1	8.32	1.72	0.09	41.36	1.14	0.05	12.03	1.72	0.09
ABERDEEN LK/DM (TENN-TOM, AL & MS)	SAD-2	1.03	1.50	0.08	8.24	1.03	0.04	1.03	1.50	0.08
CLAIBORNE LOCK AND DAM	SAD-5	13.08	2.07	0.12	38.05	1.61	0.09	16.89	2.07	0.12
COFFEEVILLE LOCK AND DAM	SAD-6	10.26	2.09	0.12	49.94	1.32	0.06	14.51	2.09	0.12
DEMOPOLIS LOCK AND DAM	SAD-7	6.66	2.10	0.12	90.71	1.13	0.05	9.51	2.12	0.13
GEORGE W ANDREWS LOCK AND DAM	SAD-10	4.99	2.19	0.13	27.71	1.19	0.05	4.99	2.19	0.13
JOHN C. STENNIS	SAD-13	2.33	1.91	0.11	31.31	1.12	0.05	3.03	1.91	0.11
AMORY	SAD-3	--	--	--	7.70	1.10	0.05	--	--	--
FULTON	SAD-8	--	--	--	NF	NF	NF	--	--	--
G.V. MONTGOMERY	SAD-9	--	--	--	NF	NF	NF	--	--	--
GLOVER WILKINS	SAD-11	--	--	--	NF	NF	NF	--	--	--
JAMIE L WHITTEN LOCK AND DAM	SAD-12	--	--	--	1.19	1.08	0.05	--	--	--
JOHN RANKIN	SAD-14	--	--	--	NF	NF	NF	--	--	--
WILLIAM BACON OLIVER REPLACEMENT	SAD-20	--	--	--	28.29	1.37	0.07	--	--	--

7.5.3. Wilmington District

Figure 27 shows a map of SAW along with the three dams considered in this study. These dams represent a total potential capacity of about 18 MW. All three dams had similar potential capacity values (Table 52). However, none of this capacity was found to be feasible (Table 53).

Figure 27. Wilmington District Dams

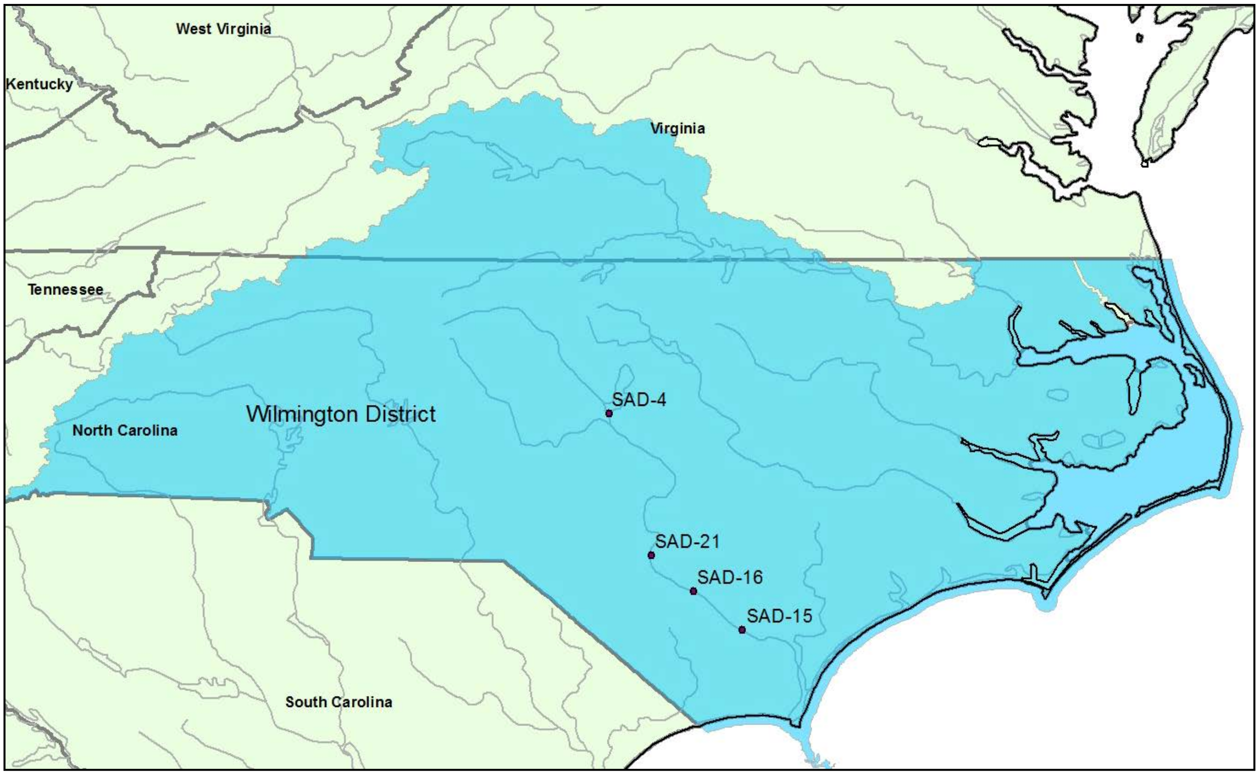


Table 52. Wilmington District Power Potentials

WILMINGTON DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
LOCK AND DAM #1	SAD-15	ORNL Data	7.21	38933.54	0.62	11.00	5609.06	69.72
LOCK AND DAM #2	SAD-16	ORNL Data	5.61	30313.11	0.62	9.00	5337.61	54.28
WILLIAM O. HUSKE LOCK & DAM	SAD-21	ORNL Data	5.41	29242.12	0.62	9.00	5149.03	52.36

Table 53. Wilmington District Economic Feasibility

SAW FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
LOCK AND DAM #1	SAD-15	--	--	--	NF	NF	NF	--	--	--
LOCK AND DAM #2	SAD-16	--	--	--	NF	NF	NF	--	--	--
WILLIAM O. HUSKE LOCK & DAM	SAD-21	--	--	--	NF	NF	NF	--	--	--

7.6. South Pacific Division

South Pacific Division (SPD) contains 11 dams, with total potential capacity of about 116 MW. About 113 MW (97%) of this capacity was found to be feasible. All 11 SPD plants rely solely on ORNL data for the computation of their results. This means that no feasibility range is calculated, a single feasible capacity is reported. In addition to data quality, Table 54 shows that two of the dams, John Martin Dam and Reservoir and Trinidad Dam, currently have pending FERC licenses.

Table 54. South Pacific Division Summary of Data Completeness and FERC Status

SOUTH PACIFIC DIVISION				
ID	**NAME**	**CONFIDENCE**	**FERC STATUS**	**WATERWAY**
SPD-1	ALAMO DAM	ORNL Data	N	BILL WILLIAMS RIVER
SPD-2	BUCHANAN DAM	ORNL Data	N	CHOWCHILLA RIVER
SPD-3	COCHITI LAKE	ORNL Data	N	RIO GRANDE & SANTA FE
SPD-4	CONCHAS DAM	ORNL Data	N	CANADIAN RIVER/CONCHAS RIVER
SPD-5	HIDDEN DAM	ORNL Data	N	FRESNO RIVER
SPD-6	JEMEZ CANYON DAM	ORNL Data	N	JEMEZ RIVER
SPD-7	JOHN MARTIN DAM & RESERVOIR	ORNL Data	P	ARKANSAS
SPD-8	NORTH FORK DAM	ORNL Data	N	NORTH FORK AMERICAN RIVER
SPD-9	PAINTED ROCK DAM	ORNL Data	N	GILA RIVER
SPD-10	SANTA ROSA DAM	ORNL Data	N	PECOS RIVER
SPD-11	TRINIDAD	ORNL Data	P	PURGATOIRE RIVER

7.6.1. Albuquerque District

Figure 28 shows a map of SPA along with the six dams considered in this study. These dams represent a total potential capacity of about 99 MW, which accounts for the majority of the total potential capacity for SWD. All of this potential capacity was determined to be feasible by the model.

Table 55 shows that the majority of the potential capacity is accounted for by John Martin Dam at about 72 MW. The next highest potential capacity is significantly lower, about 12 MW at Cochiti Lake.

Table 56 shows feasible capacity numbers for SPA dams. As noted above, all of the capacity was found to be feasible, and since ORNL data is used throughout, the feasible capacity numbers are the same as the 1% estimates show in Table 55. Note that while the highest potential capacity belongs to John Martin Dam, it only has a BCR of 1.13. The highest BCR belongs to Santa Rosa Dam, which has feasible potential capacity of about 5 MW, a BCR of 2.42, and an IRR of 15%.

Figure 28. Albuquerque District Dams

Table 55. Albuquerque District Power Potential

ALBUQUERQUE DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
COCHITI LAKE	SPD-3	ORNL Data	11.66	45965.13	0.45	108.00	674.47	55.37
CONCHAS DAM	SPD-4	ORNL Data	6.46	17524.35	0.31	51.00	544.54	21.11
JEMEZ CANYON DAM	SPD-6	ORNL Data	< 1	--	--	87.00	60.73	4.02
JOHN MARTIN DAM & RESERVOIR	SPD-7	ORNL Data	72.25	247411.56	0.39	78.00	5026.72	401.90
SANTA ROSA DAM	SPD-10	ORNL Data	3.61	19781.04	0.63	160.00	195.92	23.83
TRINIDAD	SPD-11	ORNL Data	4.99	17097.02	0.39	195.00	138.95	27.77

Table 56. Albuquerque District Economic Feasibility

SPA FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
COCHITI LAKE	SPD-3	--	--	--	11.66	1.97	0.11	--	--	--
CONCHAS DAM	SPD-4	--	--	--	6.46	1.00	0.04	--	--	--
JEMEZ CANYON DAM	SPD-6	--	--	--	< 1	1.13	0.05	--	--	--
JOHN MARTIN DAM & RESERVOIR	SPD-7	--	--	--	72.25	1.91	0.10	--	--	--
SANTA ROSA DAM	SPD-10	--	--	--	3.61	2.42	0.15	--	--	--
TRINIDAD	SPD-11	--	--	--	4.99	1.47	0.08	--	--	--

7.6.2. Sacramento District

The three dams from SPK considered in this study represent a total potential capacity of about 10 MW (Figure 29). Table 57 shows that the potential capacity was spread fairly evenly among Buchanan Dam, with about 3 MW, Hidden Dam with about 2 MW, and North Fork with about 4 MW. All of this capacity was found to be feasible (Table 58). The highest BCR was 2.21 for North Fork Dam.

Figure 29. Sacramento District Dams

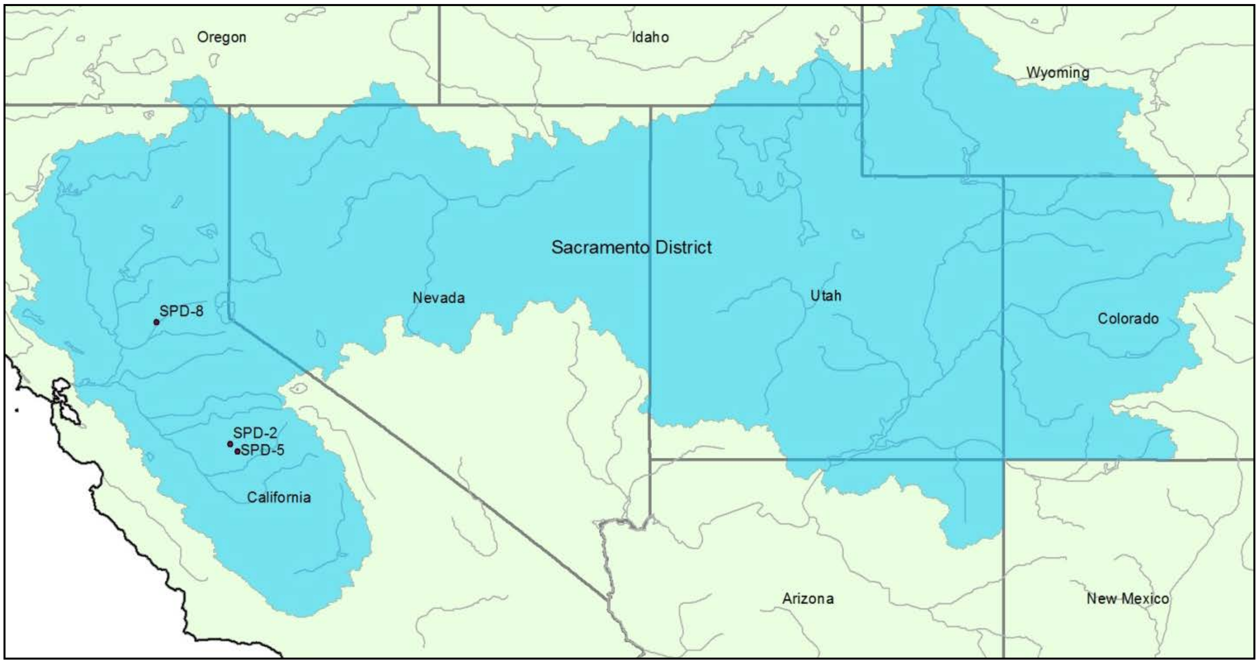


Table 57. Sacramento District Power Potential

SACRAMENTO DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
BUCHANAN DAM	SPD-2	ORNL Data	2.98	11257.59	0.43	192.00	92.92	12.22
HIDDEN DAM	SPD-5	ORNL Data	2.48	9350.40	0.43	83.00	178.53	10.15
NORTH FORK DAM	SPD-8	ORNL Data	4.12	23101.24	0.64	108.00	338.98	25.08

Table 58. Sacramento District Economic Feasibility

SPK FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
BUCHANAN DAM	SPD-2	--	--	--	2.98	1.68	0.10	--	--	--
HIDDEN DAM	SPD-5	--	--	--	2.48	1.29	0.06	--	--	--
NORTH FORK DAM	SPD-8	--	--	--	4.12	2.21	0.13	--	--	--

7.6.3. Los Angeles District

The two dams from SPL considered in this study represent a total potential capacity of about 8 MW (Figure 30). Each dam has a potential capacity of about 4 MW (Table 59). Table 60 shows that only Alamo Dam was feasible based on a BCR of 1.22; since ORNL data was used, the feasible capacity was about 4 MW.

Figure 30. Los Angeles District Dams

Table 59. Los Angeles District Power Potential

LOS ANGELES DISTRICT								
NAME	**ID**	**DATA QUALITY**	**CAPACITY (MW)**	**GENERATION (MWh)**	**CAPACITY FACTOR**	**AVG. HEAD (Ft.)**	**AVG. FLOW (Cfs)**	**CO_2e AVOIDED (Millions of Tons)**
ALAMO DAM	SPD-1	ORNL Data	4.16	11396.00	0.31	185.00	97.62	13.73
PAINTED ROCK DAM	SPD-9	ORNL Data	3.59	6880.90	0.22	142.00	76.79	8.29

Table 60. Los Angeles District Economic Feasibility

SPL FEASIBILITY RESULTS		**MINIMUM**			**MAXIMUM**			**OPTIMAL**		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
ALAMO DAM	SPD-1	--	--	--	4.16	1.22	0.06	--	--	--
PAINTED ROCK DAM	SPD-9	--	--	--	NF	NF	NF	--	--	--

7.7. Southwestern Division

Southwestern Division (SWD) contains 39 dams spread across three Districts, accounting for about 1,302 MW of potential capacity, of which about one third is feasible. As shown in Table 61, the results for all but three of the 39 dams were calculated with full data. The other three dams fall into the constant head category. Six of the dams have pending FERC licenses.

Table 61. Southwestern Division Data Completeness and FERC Status

SOUTHWESTERN DIVISION				
ID	**NAME**	**CONFIDENCE**	**FERC STATUS**	**WATERWAY**
SWD-1	BARDWELL LAKE	Full Data	N	WAXAHACHIE CREEK
SWD-2	BELTON LAKE	Full Data	N	LEON RIVER
SWD-3	BENBROOK LAKE	Full Data	N	CLEAR FORK OF TRINITY RIVER
SWD-4	BLUE MOUNTAIN	Full Data	N	PETIT JEAN
SWD-5	CANTON LAKE	Constant Head	N	NORTH CANADIAN RIVER
SWD-6	CHOUTEAU LOCK AND DAM	Full Data	N	VERDIGRIS RIVER
SWD-7	CLEARWATER DAM	Full Data	N	BLACK
SWD-8	COL CHARLES D. MAYNARD LOCK AND DAM	Full Data	N	ARKANSAS
SWD-9	COPAN LAKE	Full Data	N	LITTLE CANEY
SWD-10	DAVID D. TERRY LOCK & DAM	Full Data	P	ARKANSAS
SWD-11	DEQUEEN	Full Data	N	ROLLING FORK
SWD-12	EMMETT SANDERS LOCK & DAM	Full Data	N	ARKANSAS
SWD-13	FALL RIVER LAKE	Full Data	N	FALL RIVER
SWD-14	FERRELLS BRIDGE DAM	Full Data	N	CYPRESS CREEK
SWD-15	GILLHAM	Full Data	N	COSSATOT
SWD-16	GRANGER DAM AND LAKE	Full Data	N	SAN GABRIEL RIVER
SWD-17	GRAPEVINE LAKE	Full Data	N	DENTON CREEK
SWD-18	GREAT SALT PLAINS LAKE	Full Data	N	SALT FORK OF ARKANSAS RIVER
SWD-19	HULAH LAKE	Full Data	N	CANEY RIVER
SWD-20	JOE HARDIN LOCK & DAM	Full Data	P	ARKANSAS
SWD-21	JOE POOL LAKE	Full Data	N	MOUNTAIN CREEK
SWD-22	JOHN REDMOND LAKE	Full Data	N	GRAND NEOSHO RIVER
SWD-23	LAVON LAKE	Full Data	N	EAST FORK OF TRINITY RIVER
SWD-24	MILLWOOD DAM	Full Data	P	LITTLE
SWD-25	MONTGOMERY POINT LOCK & DAM	Constant Head	P	WHITE
SWD-26	NAVARRO MILLS LAKE	Full Data	N	RICHLAND CREEK
SWD-27	NEWT GRAHAM LOCK AND DAM	Full Data	N	VERDIGRIS RIVER
SWD-28	NIMROD	Full Data	N	FOURCHE LA FAVE
SWD-29	NORTH SAN GABRIEL DAM	Full Data	N	NORTH FORK SAN GABRIEL RIVER
SWD-30	OOLOGAH LAKE	Full Data	P	VERDIGRIS RIVER
SWD-32	PROCTOR LAKE	Full Data	N	LEON RIVER
SWD-33	SKIATOOK LAKE	Full Data	N	HOMINY CREEK
SWD-34	STILLHOUSE-HOLLOW DAM	Full Data	N	LAMPASAS RIVER
SWD-35	TOAD SUCK FERRY LOCK & DAM	Full Data	N	ARKANSAS
SWD-36	TORONTO LAKE	Full Data	N	VERDIGRIS RIVER
SWD-37	W.D.MAYO LOCK AND DAM	Full Data	N	ARKANSAS RIVER
SWD-38	WACO LAKE	Full Data	N	BOSQUE RIVER
SWD-39	WISTER LAKE	Constant Head	N	POTEAU RIVER
SWD-40	WRIGHT PATMAN DAM AND LAKE	Full Data	P	SULPHUR RIVER

7.7.1. Fort Worth District

Figure 31 shows a map of SWF along with the 14 dams considered in this study. These dams represent about 207 MW of potential capacity, estimated at the 1% level. However, none of this capacity was found to be feasible by the model.

Figure 31. Fort Worth District Dams

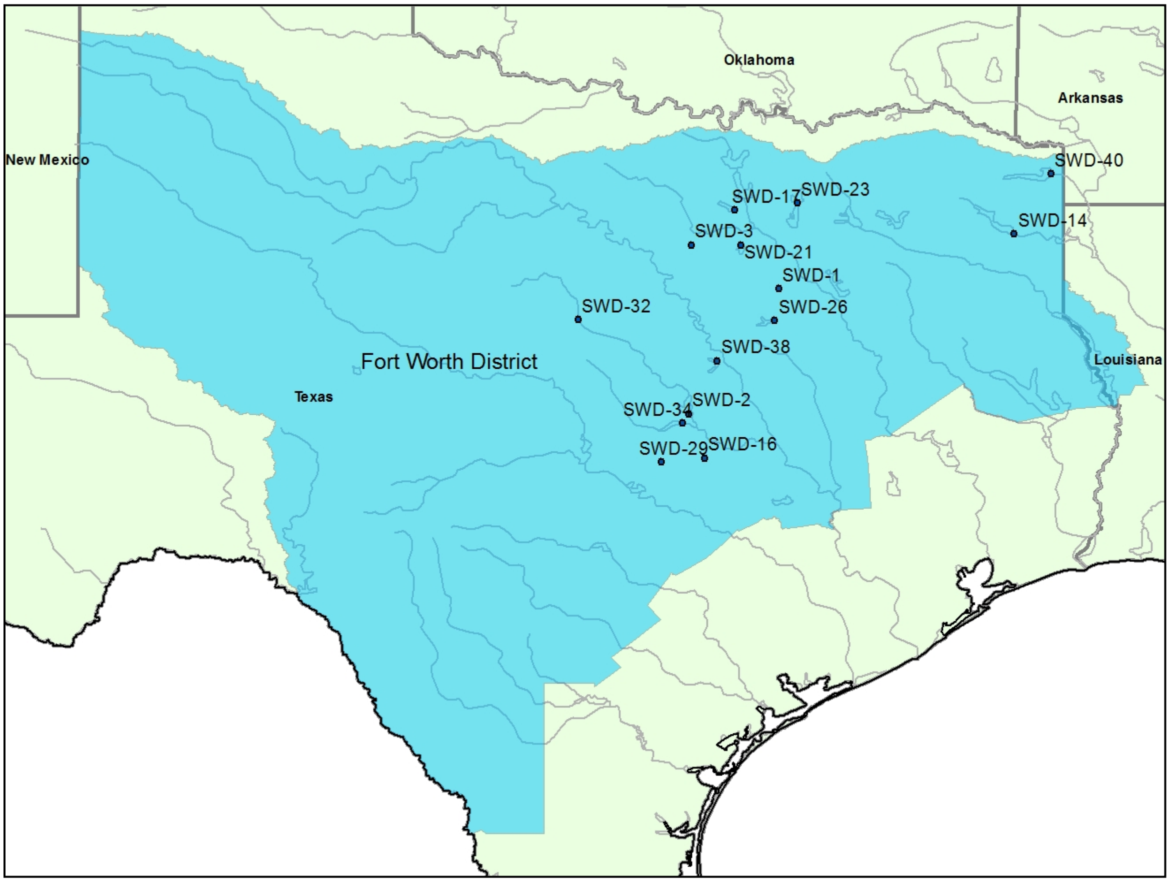


Table 62 shows capacity estimates at the 1% level, absent any concerns about feasibility. The highest potential capacity belongs to Waco Lake, with about 50 MW of potential and about 22 GWh of average annual generation. The lowest potential capacity belongs to Navarro Mills Lake, which has about 2 MW of potential capacity.

Table 63 shows the economic feasibility results for SWF. Eleven of the 14 SWF dams were found to be not feasible. The remaining three dams, Belton Lake, Ferrell's Bridge, and Grapevine Lake, while possessing BCRs greater than one, all have capacity values below 1 MW. This is too low to be reliably estimated by the current model, so these dams are regarded as having no feasible capacity.

Table 62. Fort Worth District Power Potential

FORT WORTH DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
BARDWELL LAKE	SWD-1	Full Data	4.44	2306.23	0.06	43.76	98.42	2.59
BELTON LAKE	SWD-2	Full Data	29.57	21427.73	0.08	87.59	609.87	24.02
BENBROOK LAKE	SWD-3	Full Data	5.23	2671.74	0.06	83.04	76.83	3.00
FERRELLS BRIDGE DAM	SWD-14	Full Data	9.27	11896.38	0.15	42.38	520.37	13.34
GRANGER DAM AND LAKE	SWD-16	Full Data	10.71	10698.75	0.11	68.99	264.91	11.99
GRAPEVINE LAKE	SWD-17	Full Data	5.23	5084.27	0.11	45.31	206.39	5.70
JOE POOL LAKE	SWD-21	Full Data	5.44	3713.47	0.08	64.47	100.74	4.16
LAVON LAKE	SWD-23	Full Data	13.28	5324.43	0.05	46.66	276.98	5.97
NAVARRO MILLS LAKE	SWD-26	Full Data	2.27	1244.45	0.06	37.31	128.07	1.40
NORTH SAN GABRIEL DAM	SWD-29	Full Data	4.85	3116.18	0.07	82.28	53.83	3.49
PROCTOR LAKE	SWD-32	Full Data	4.80	1624.77	0.04	42.63	77.79	1.82
STILLHOUSE-HOLLOW DAM	SWD-34	Full Data	37.48	27441.12	0.08	122.25	342.28	30.76
WACO LAKE	SWD-38	Full Data	49.74	22238.05	0.05	78.82	453.70	24.93
WRIGHT PATMAN DAM AND LAKE	SWD-40	Full Data	25.06	26066.35	0.12	10.75	2296.26	29.22

Table 63, Fort Worth District Economic Feasibility

SWF FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
BARDWELL LAKE	SWD-1	NF	NF	NF	NF	NF	NF	NF	NF	NF
BELTON LAKE	SWD-2	< 1	1.02	0.04	< 1	1.01	0.04	< 1	1.02	0.04
BENBROOK LAKE	SWD-3	NF	NF	NF	NF	NF	NF	NF	NF	NF
FERRELLS BRIDGE DAM	SWD-14	< 1	1.03	0.04	< 1	1.01	0.04	< 1	1.03	0.04
GRANGER DAM AND LAKE	SWD-16	NF	NF	NF	NF	NF	NF	NF	NF	NF
GRAPEVINE LAKE	SWD-17	< 1	1.21	0.05	< 1	1.12	0.05	< 1	1.22	0.05
JOE POOL LAKE	SWD-21	NF	NF	NF	NF	NF	NF	NF	NF	NF
LAVON LAKE	SWD-23	NF	NF	NF	NF	NF	NF	NF	NF	NF
NAVARRO MILLS LAKE	SWD-26	NF	NF	NF	NF	NF	NF	NF	NF	NF
NORTH SAN GABRIEL DAM	SWD-29	NF	NF	NF	NF	NF	NF	NF	NF	NF
PROCTOR LAKE	SWD-32	NF	NF	NF	NF	NF	NF	NF	NF	NF
STILLHOUSE-HOLLOW DAM	SWD-34	NF	NF	NF	NF	NF	NF	NF	NF	NF
WACO LAKE	SWD-38	NF	NF	NF	NF	NF	NF	NF	NF	NF
WRIGHT PATMAN DAM AND LAKE	SWD-40	NF	NF	NF	NF	NF	NF	NF	NF	NF

7.7.2. Little Rock District

Figure 32 shows a map of SWL along with the 12 dams considered in this study. These dams represent about 714 MW of potential capacity, of which 365 MW (about 50%) was found to be feasible. Table 66 shows that Montgomery Point Lock and Dam had the highest potential capacity with about 228 MW. It had the potential for about 383 GWh of generation, which gives it a capacity factor of 0.19.

Table 67 shows the economic feasibility results for SWL. Blue Mountain Dam, Dequeen Dam, and Nimrod Dam were found not to be feasible. At both the maximum and optimal parts of the range, Gillham Dam has BCR equal to 1, but possesses less than 1 MW of feasible capacity. Montgomery Point, while significantly smaller than its 1% estimate, still has about 92 MW of feasible capacity.

Figure 32. Little Rock District Dams

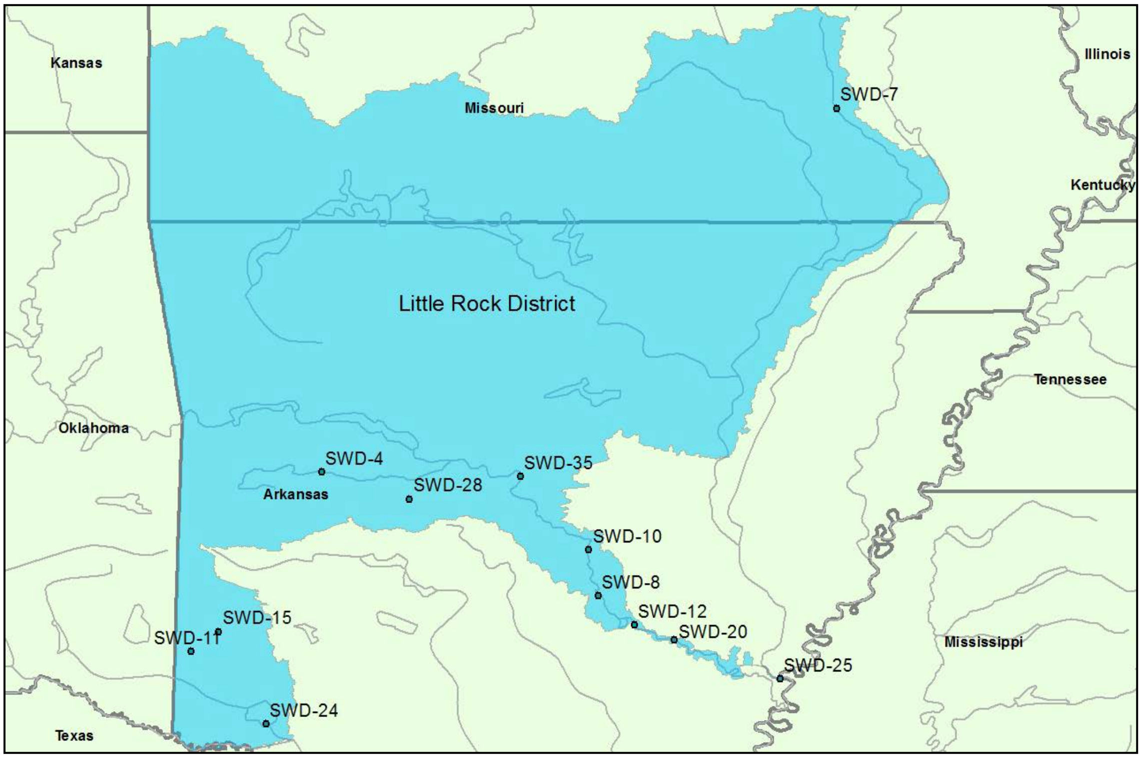


Table 64. Little Rock District Power Potential

LITTLE ROCK DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
BLUE MOUNTAIN	SWD-4	Full Data	8.64	10499.72	0.14	26.31	541.08	13.24
CLEARWATER DAM	SWD-7	Full Data	28.03	33900.19	0.14	45.15	974.42	71.59
COL CHARLES D. MAYNARD LOCK AND DAM	SWD-8	Full Data	95.51	289587.56	0.35	17.11	44163.91	365.10
DAVID D. TERRY LOCK & DAM	SWD-10	Full Data	83.46	279707.16	0.38	17.74	43973.18	352.64
DEQUEEN	SWD-11	Full Data	10.72	10139.10	0.11	72.39	216.86	12.78
EMMETT SANDERS LOCK & DAM	SWD-12	Full Data	67.90	213392.41	0.36	13.68	45024.49	269.04
GILLHAM	SWD-15	Full Data	19.27	22171.34	0.13	75.90	433.95	27.95
JOE HARDIN LOCK & DAM	SWD-20	Full Data	89.03	227308.24	0.29	18.82	45495.74	286.58
MILLWOOD DAM	SWD-24	Full Data	23.30	51364.52	0.25	32.30	4329.54	64.76
MONTGOMERY POINT LOCK & DAM	SWD-25	Const. Head	227.61	383177.04	0.19	20.00	30913.63	483.10
NIMROD	SWD-28	Const. Head	20.05	22742.04	0.13	37.49	905.98	28.67
TOAD SUCK FERRY LOCK & DAM	SWD-35	Const. Head	40.10	139406.63	0.40	14.81	41680.74	175.76

Table 65. Little Rock District Economic Feasibility

SWL FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	**ID**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**	**CAPACITY**	**BCR**	**IRR**
BLUE MOUNTAIN	SWD-4	NF	NF	NF	NF	NF	NF	NF	NF	NF
CLEARWATER DAM	SWD-7	< 1	1.51	0.08	2.59	1.22	0.06	< 1	1.51	0.08
COL CHARLES D. MAYNARD LOCK AND DAM	SWD-8	8.58	1.60	0.08	69.05	1.09	0.04	69.05	1.63	0.08
DAVID D. TERRY LOCK & DAM	SWD-10	8.52	1.64	0.08	63.68	1.16	0.05	63.68	1.66	0.09
DEQUEEN	SWD-11	NF	NF	NF	NF	NF	NF	NF	NF	NF
EMMETT SANDERS LOCK & DAM	SWD-12	6.81	1.40	0.07	44.37	1.01	0.04	44.37	1.42	0.07
GILLHAM	SWD-15	< 1	1.00	0.04	< 1	1.00	0.04	< 1	1.00	0.04
JOE HARDIN LOCK & DAM	SWD-20	8.72	1.67	0.09	49.79	1.16	0.05	49.79	1.70	0.09
MILLWOOD DAM	SWD-24	< 1	1.36	0.07	12.45	1.02	0.04	12.45	1.39	0.07
MONTGOMERY POINT LOCK & DAM	SWD-25	16.21	2.05	0.11	91.59	1.05	0.04	91.59	2.05	0.11
NIMROD	SWD-28	NF	NF	NF	NF	NF	NF	NF	NF	NF
TOAD SUCK FERRY LOCK & DAM	SWD-35	5.69	1.38	0.07	31.35	1.08	0.04	31.35	1.40	0.07

7.7.3. Tulsa District

Figure 33 shows a map of SWT along with the 13 dams considered in this study. These dams represent about 381 MW of potential capacity, of which 64 MW (about 17%) was found to be feasible. Table 66 shows that Oologah Lake has the highest potential capacity, with about 119 MW and potential average annual generation of about 140 GWh. The next highest potential capacity was 56 MW at W.D. Mayo Lock and Dam, with potential generation of about 183 MW, which is higher than that of Oologah. W.D. Mayo also allows for more CO2 avoided, 254 million tons to Oologah's 193 million tons.

Figure 33. Tulsa District Dams

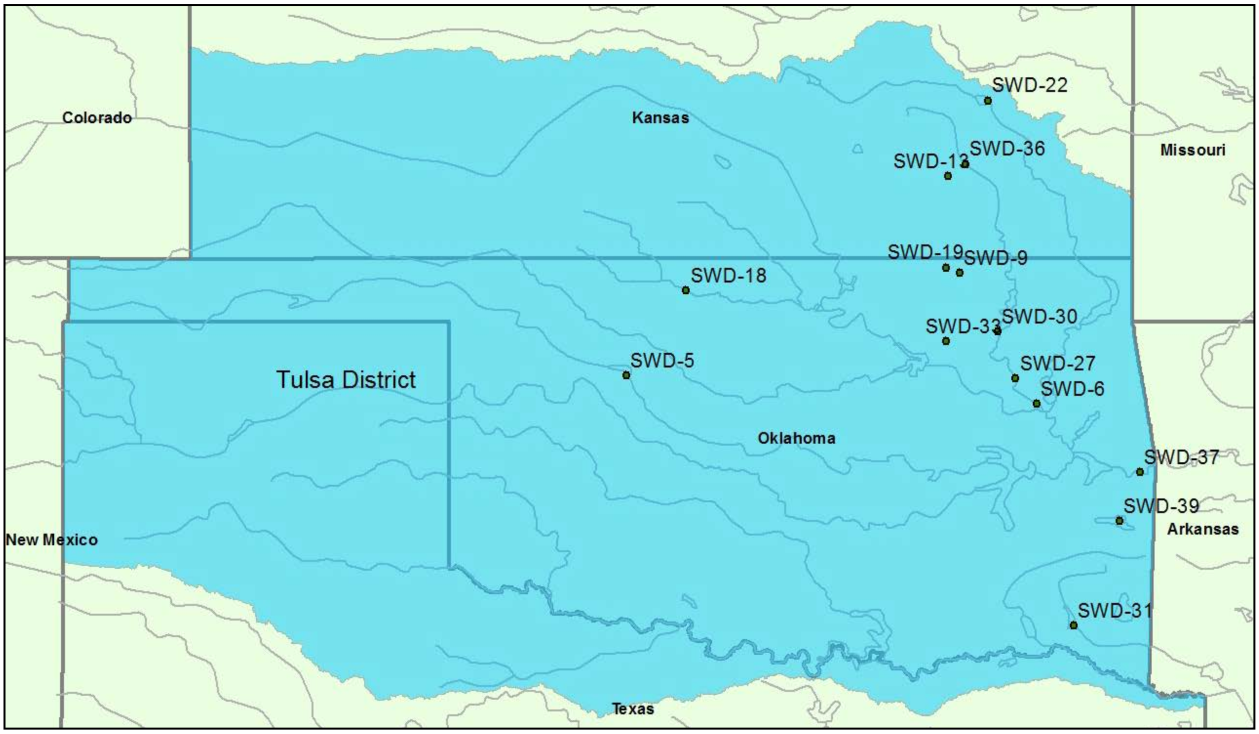


Table 66. Tulsa District Power Potential

TULSA DISTRICT								
NAME	ID	DATA QUALITY	CAPACITY (MW)	GENERATION (MWh)	CAPACITY FACTOR	AVG. HEAD (Ft.)	AVG. FLOW (Cfs)	CO_2e AVOIDED (Millions of Tons)
CANTON LAKE	SWD-5	Const. Head	4.24	5325.77	0.14	66.00	128.46	7.37
CHOUTEAU LOCK AND DAM	SWD-6	Full Data	9.61	31237.67	0.37	18.50	6232.63	43.21
COPAN LAKE	SWD-9	Full Data	9.19	7707.02	0.10	33.00	340.25	10.66
FALL RIVER LAKE	SWD-13	Full Data	17.74	14551.39	0.09	41.46	478.62	31.73
GREAT SALT PLAINS LAKE	SWD-18	Full Data	11.19	8834.54	0.09	26.40	540.36	12.22
HULAH LAKE	SWD-19	Full Data	12.64	12443.45	0.11	31.90	547.54	17.21
JOHN REDMOND LAKE	SWD-22	Full Data	31.73	31105.36	0.11	32.37	1398.48	67.82
NEWT GRAHAM LOCK AND DAM	SWD-27	Full Data	27.11	58108.56	0.24	20.94	5847.09	80.38
OOLOGAH LAKE	SWD-30	Full Data	119.30	139773.86	0.13	76.80	3222.06	193.35
SKIATOOK LAKE	SWD-33	Full Data	13.10	9537.70	0.08	100.75	158.81	13.19
TORONTO LAKE	SWD-36	Full Data	18.02	13694.40	0.09	34.13	552.84	29.86
W.D.MAYO LOCK AND DAM	SWD-37	Full Data	55.85	183285.07	0.37	20.44	30416.21	253.54
WISTER LAKE	SWD-39	Const. Head	50.96	62159.72	0.14	95.00	1047.57	85.99

Table 67 shows that all but three of the SWF dams are not feasible for hydropower development. Only Newt Graham Lock and Dam, Oologah Lake, and W.D. Mayo Lock and Dam were found to be feasible. Oologay has a maximum feasible capacity of 34 MW and Oologah has a maximum feasible capacity of 30 MW. While remaining feasible based on BCR, Newt Graham has feasible capacity less than 1 MW at minimum, maximum and feasible levels.

Table 67. Tulsa District Economic Feasibility

SWT FEASIBILITY RESULTS		MINIMUM			MAXIMUM			OPTIMAL		
NAME	ID	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR	CAPACITY	BCR	IRR
CANTON LAKE	SWD-5	NF	NF	NF	NF	NF	NF	NF	NF	NF
CHOUTEAU LOCK AND DAM	SWD-6	NF	NF	NF	NF	NF	NF	NF	NF	NF
COPAN LAKE	SWD-9	NF	NF	NF	NF	NF	NF	NF	NF	NF
FALL RIVER LAKE	SWD-13	NF	NF	NF	NF	NF	NF	NF	NF	NF
GREAT SALT PLAINS LAKE	SWD-18	NF	NF	NF	NF	NF	NF	NF	NF	NF
HULAH LAKE	SWD-19	NF	NF	NF	NF	NF	NF	NF	NF	NF
JOHN REDMOND LAKE	SWD-22	NF	NF	NF	NF	NF	NF	NF	NF	NF
NEWT GRAHAM LOCK AND DAM	SWD-27	< 1	1.01	0.04	< 1	1.01	0.04	< 1	1.01	0.04
OOLOGAH LAKE	SWD-30	9.45	1.11	0.05	30.08	1.15	0.05	21.33	1.18	0.05
SKIATOOK LAKE	SWD-33	NF	NF	NF	NF	NF	NF	NF	NF	NF
TORONTO LAKE	SWD-36	NF	NF	NF	NF	NF	NF	NF	NF	NF
W.D.MAYO LOCK AND DAM	SWD-37	10.36	1.07	0.04	34.31	1.11	0.05	19.28	1.18	0.05
WISTER LAKE	SWD-39	NF	NF	NF	NF	NF	NF	NF	NF	NF

8. CONCLUSION

This study considered non-powered USACE sites that an ORNL 2012 study identified as having 1 MW or more of potential hydropower capacity. For this study, USACE Division and District offices were contacted to supply daily hydrological information (flow and head) to establish more realistic power capability estimates. An economic analysis was also performed to determine the economic feasibility of developing the potential power capacity. This section summarizes the results of the analysis and further describes some of the limitations of the study.

8.1. Summary of Results

For this analysis, potential capacity values for a site are determined from the power duration curve. Potential capacity is defined as the capacity associated with a 1% exceedance on the power duration curve. The feasible capacity is the maximum capacity considered for a site that has a BCR greater than 1.0. Table 68 lists the sums of potential and feasible capacity by USACE Division. The LRD and MVD have the most potential and feasible capacity to be added at non-powered USACE sites.

For all sites, there were approximately 6,256 MW of potential energy, with about 2,818 MW estimated as feasible under the study's economic assumptions. The percentage of potential capacity assumed feasible varied across USACE Divisions and ranged from about 15% in NWD to almost 97% in SPD.

Table 68. Potential and Maximum Feasible Capacity Estimates for Non-powered USACE Sites

Division	Number of Plants	Potential Capacity (MW)	Feasible Capacity (MW)	Percent of Potential Capacity Assumed Feasible
LRD	71	1961.50	898.16	46%
MVD	50	1568.22	939.75	60%
NAD	21	288.07	63.49	22%
NWD	12	348.74	50.63	15%
SAD	19	671.92	324.51	48%
SPD	11	116.29	112.71	97%
SWD	39	1301.67	429.27	33%
USACE Total	223	6256.43	2818.54	45%

Of particular interest is the FERC permit status of the sites identified as having feasible capacity potential. Table 69 shows the FERC permit status of non-powered USACE sites identified as having feasible capacity potential. Of the 146 sites identified as having feasible capacity potential, 72 have no preliminary or pending permits. However, the remaining 74 sites with pending or preliminary permits account for about 75% of 2,818 MW of potential feasible capacity (Figure 34).

Table 69. FERC Status of Non-powered USACE Sites with Feasible Capacity

Division	Plants with Feasible Capacity		No FERC Permits		With at Least a Pending FERC Permit	
	Number	Capacity	Number	Capacity (MW)	Number	Capacity (MW)
LRD	50	898.17	16	76.94	34	821.23
MVD	27	939.75	9	261.97	18	677.78
NAD	18	63.50	16	29.07	2	34.42
NWD	6	50.64	4	16.83	2	33.80
SAD	15	324.51	8	106.54	7	217.97
SPD	18	112.71	14	35.47	4	77.24
SWD	12	429.27	5	181.68	7	247.59
USACE	146	2818.54	72	708.50	74	2110.04

Figure 34. FERC Status of Estimated Feasible New Hydropower Capacity

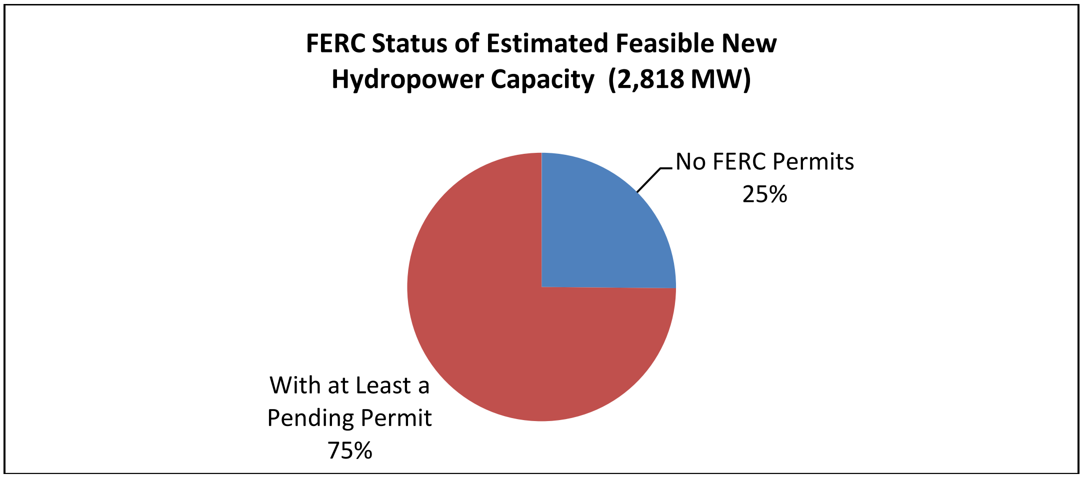


Table 70 lists the top 20 non-powered USACE sites identified as having feasible potential and no existing preliminary or pending FERC permits, ranked by BCR. Cumulatively, these top 20 sites account for 350 MW of potential feasible capacity, which is about half of the potential feasible capacity available at all 72 sites without any FERC permits. Eight of these 20 sites have a potential feasible capacity greater than 10 MW. In terms of feasible capacity, Melvin Price Lock and Dam has the greatest potential feasibility capacity at 130 MW.

Table 70. Top 20 Non-powered USACE Sites with Feasible Hydropower Potential Ranked by BCR

Ranking	Plant	Plant_ID	Division	District	Data Confidence	Feasible Capacity (MW)	Estimated BCR
1	Santa Rosa Dam	SPD-10	SPD	SPA	ORNL Data	3.61	2.42
2	North Fork Dam	SPD-8	SPD	SPK	ORNL Data	4.12	2.21
3	Cochiti Lake	SPD-3	SPD	SPA	ORNL Data	11.66	1.97
4	Bluestone Dam	LRD-9	LRD	LRH	Full Data	31.09	1.69
5	Buchanan Dam	SPD-2	SPD	SPK	ORNL Data	2.98	1.68
6	Claiborne Lock and Dam	SAD-5	SAD	SAM	Full Data	38.05	1.61
7	William Bacon Oliver Replacement	SAD-20	SAD	SAM	ORNL Data	28.29	1.37
8	Bolivar Dam	LRD-10	LRD	LRH	Constant Head	8.98	1.32
9	Hidden Dam	SPD-5	SPD	SPK	ORNL Data	2.48	1.29
10	Blue Marsh Dam	NAD-4	NAD	NAP	Full Data	2.46	1.29
11	Alamo Dam	SPD-1	SPD	SPL	ORNL Data	4.16	1.22
12	Clearwater Dam	SWD-7	SWD	SWL	Full Data	2.59	1.22
13	Tioga Dam	NAD-20	NAD	NAB	Full Data	2.76	1.16
14	Howard A Hanson Dam	NWD-8	NWD	NWS	Constant Head	14.92	1.16
15	Brookville Lake Dam	LRD-12	LRD	LRL	Full Data	11.33	1.15
16	Whitney Point Dam	NAD-24	NAD	NAB	Constant Head	6.16	1.13
17	Melvin Price Locks and Dam	MVD-34	MVD	MVS	Full Data	130.65	1.13
18	Paint Creek Dam	LRD-58	LRD	LRH	Full Data	3.09	1.13
19	John C. Stennis	SAD-13	SAD	SAM	Full Data	31.31	1.12
20	Amory	SAD-3	SAD	SAM	ORNL Data	7.70	1.10

8.2. Sensitivity to Long-term Energy Forecasts

A sensitivity analysis was performed for this study on the maximum feasible capacity to the uncertainty surrounding the long-term energy forecasts. This analysis compared the maximum feasible capacity for expected low- and high-energy values to the expected baseline scenario.

As described in Section 4, the projected annual generation electricity costs to the year 2040 for 22 EMM supply regions was provided by the EIA's 2013 Annual Energy Outlook (early release). Based on these EMM estimates, the lowest and highest energy values for each state over the years 2015-2040 were used to represent best and worst case scenarios, respectively.

Figure 35 depicts the high (best) and low (worst) projected energy values from 2015-2040 for the State of Washington. The year with the lowest energy values can be derived from the plotted line that is at the bottom of the graph. In contrast, the year with the highest energy values can be derived from the top line plotted in the graph.

Figure 35. Best and Worst Case Energy Prices for the State of Washington

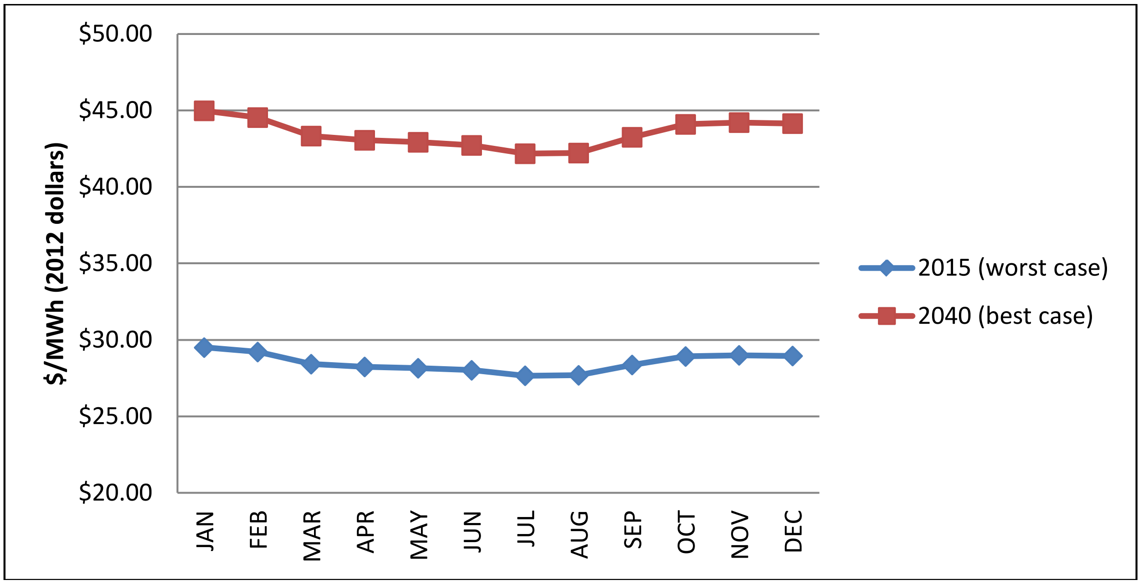


Table 71 shows the comparison of maximum feasibility for scenarios that address the uncertainty of future electricity prices. According to the analysis, the worst-case scenario (uses the lowest electricity prices) decreased the potential feasible capacity by about 584 MW, a 25% decrease in feasible capacity for the sites considered with the lowest projected electricity prices. In contrast, the best-case scenario (uses the highest electricity prices) increased the potential feasibility by about 350 MW, a 12% increase in feasible capacity for the sites considered with the highest projected electricity prices.

Table 71. Potential Feasible Capacity Under Best and Worst Long-term Energy Price Forecasts

Maximum Capacity Values (MW) with Different Electricity Prices			
Division	**Baseline**	**Worst Case Scenario Lowest Projected Prices**	**Best Case Scenario Highest Projected Prices**
LRD	898.16	653.84	964.42
MVD	939.75	747.96	1024.31
NAD	63.49	43.53	106.59
NWD	50.63	43.44	63.31
SAD	324.51	290.7	326.42
SPD	112.71	102.09	112.71
SWD	429.27	352.63	567.75
USACE Total	2,818.54	2,234.18	3,165.52

8.3. Limitations of Analysis

This study assessed the potential and economic feasibility of adding hydroelectric power to non-powered USACE projects over a 50-year period of analysis. There were a number of limitations to the analysis, as discussed below, because of the large number of projects considered and the uncertainty surrounding economic estimates over the 50-year period of analysis.

1. Incomplete hydrological data. Although significant effort was made to collect hydrological data for each site, in some instances sufficient data was not available. In these cases, static head and flow values were used, which may over- or under-estimate hydropower potential. In addition, even sites with complete data may require longer period of records than the ones used in this analysis to better quantify the annual hydrologic variability.

2. Site-specific restrictions. The analysis did not go into site-specific characteristics that may restrict hydropower development. These restrictions could include environmental, water quality, and other developmental restrictions.

3. Hydropower component attributes assumptions. Hydropower components attributes, such as turbine types and generator speeds, were assumed using very general guidelines based on a site's head and flow characteristics. Correctly identifying these attributes for a specific site may add significant cost, especially for sites with extremely low hydraulic heads.

4. Cost estimates. The cost estimates were based on an INEEL 2003 study that developed parametric equations for cost based on general site attributes such as flow and head. Although these cost equations were indexed to 2012 dollars, important economic considerations, such as an increase or decrease in hydropower production, were not taken into consideration by the index. In addition, the cost parameterizations may not sufficiently address different site-specific needs, especially in low head situations.

5. Energy value estimates. The energy value estimates were based on generation cost estimates for large geographic regions as defined by the Energy Information Administration. There are considerable uncertainties surrounding cost estimates that are projected over a long time period and a large geographic region.

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APPENDICES

Appendix A: FERC Coordinators by USACE Districts

District Name	District	Primary POC	Phone
Alaska	POA	Steve Boardman	907-753-5799
Albuqueque	SPA	Don Gallegos	505 342 3382
Baltimore	NAB	Ray Smith	410-962-4507
Buffalo	LRB	Keith Koralewski	716 879 4358
Charleston	SAC	Brian Wells	843-329-8049
Chicago	LRC	Tzuoh-ying Su	312 846 5510
Detriot	LRE	Eric Tauriainen	313-226-4886
Ft Worth	SWF	Terry Bachim	817-886-1606
Galveston	SWG	Jayson Hudson	409-766-3108
Honolulu	POH	Derek Chow	808-438-7009
Huntington	LRH	David Frantz	304 399 5849
Jacksonville	SAJ	N/A	
Kansas City	NWK	Ed Parker	816-389-3145
Little Rock	SWL	Lee Beverly	501-324-5842 Ext 1067
Los Angeles	SPL	Mike Vahabzadeh-Hagh	213-452-3613
Louisville	LRL	Ken Lamkin	502 315-6458
Memphis	MVM	Darian Chasteen	901-544-3218
Mobile	SAM	Randall Harvey	251-690-2730
Nashville	LRN	Jay Sadler	615 736 7664
New England	NAE	Bruce Williams	978-318-8168
New Orleans	MVN	Brenda Archer	504-862-2046
New York	NAN	William Petronis	518-273-0870
Norfolk	NAO	Mark Hudgins	757-201-7107
Omaha	NWO	Mike Swenson	402-996-3860
Philadelphia	NAP	Christine Lewis-Coker	215-656-6679
Pittsburgh	LRP	Jeff Benedict	412 395 7202
Portland	NWP	Pat Duyck	503-808-4739
Rock Island	MVR	Jim Bartek	309 794 5599
Sacramento	SPK	Rachael Hersh-Burdick	916-557-7009
San Francisco	SPN	Mike Dillabough	415-503-6770
Savannah	SAS	Stan Simpson	912-652-5501
Seattle	NWS	Larry Schick	206-764-6878
St. Louis	MVS	Matthew Rector	314-331-8540
St. Paul	MVP	Nanette Bischoff	651 290-5426
Tulsa	SWT	Scott Henderson	918 669 7509
Vicksburg	MVK	Andrew Tomlinson	601-631-7474
Walla Walla	NWW	Mike Francis	509-527-7288
Wilmington	SAW	Tony Young	910-251-4455

Appendix B: Electric Market Module and eGrid Regions by State

State		Electric Market Module (EMM) Region	eGRID Region
Alabama	AL	SERC Reliability Corporation/ Southeast (SRSE)	SERC South
Arkansas	AR	SERC Reliability Corporation/ delta (SRDA)	SERC Mississippi Valley
Arizona	AZ	WECC Southwest(AZNM)	WECC Southwest
California	CA	WECC California (CAMX)	WECC California
Colorado	CO	WECC/Rockies (RMPA)	WECC Rockies
Connecticut	CT	Northeast Power Coordinating Council (NEWE)	NPCC New England
Delaware	DE	Reliability First Corporation /East (RFCE)	RFC East
Florida	FL	Florida Reliability Coordinating Council (FRCC)	FRCC All
Georgia	GA	SERC Reliability Corporation/ Southeast (SRSE)	SERC South
Iowa	IA	Midwest Reliability Organization West (MROW)	MRO West
Idaho	ID	WECC Northwest Power Pool (NWPP)	WECC Northwest
Illinois	IL	SERC Reliability Corporation/ Gateway (SRGW)	SERC Midwest
Indiana	IN	Reliability First Corporation/West(RFCW)	RFC West
Kansas	KS	Southwest Power Pool Regional Entity North (SPNO)	SPP North
Kentucky	KY	SRCE Reliabiltiy Corporation/central (SRCE)	SERC Tennessee Valley
Louisiana	LA	SERC Reliability Corporation/ delta (SRDA)	SERC Mississippi Valley
Massachusetts	MA	Northeast Power Coordinating Council (NEWE)	NPCC New England
Maryland	MD	Reliability First Corporation /East (RFCE)	RFC East
Maine	ME	Northeast Power Coordinating Council (NEWE)	NPCC New England
Michigan	MI	Reliability First Corporation /Michigan (RFCM)	RFC Michigan
Minnesota	MN	Midwest Reliability Organization West (MROW)	MRO West
Missouri	MO	SERC Reliability Corporation/ Gateway (SRGW)	SERC Midwest
Mississippi	MS	SERC Reliability Corporation/ Southeast (SRSE)	SERC Mississippi Valley
Montana	MT	WECC Northwest Power Pool (NWPP)	WECC Northwest
North Carolina	NC	SERC Reliability Corporation/ Virgina-Carolina (SRVC)	SERC Virginia/Carolina
North Dakota	ND	Midwest Reliability Organization West (MROW)	MRO West
Nebraska	NE	Midwest Reliability Organization West (MROW)	MRO West
New Hampshire	NH	Northeast Power Coordinating Council (NEWE)	NPCC New England
New Jersey	NJ	Reliability First Corporation /East (RFCE)	RFC East
New Mexico	NM	WECC Southwest(AZNM)	WECC Southwest
Nevada	NV	WECC Northwest Power Pool (NWPP)	WECC Northwest
New York	NY	Northeast Power Coordinating Council /Upstate (NYUP)	NPCC Upstate NY
Ohio	OH	Reliability First Corporation/West(RFCW)	RFC West
Oklahoma	OK	Southwest Power Pool Regional Entity/South(SPSO)	SPP South
Oregon	OR	WECC Northwest Power Pool (NWPP)	WECC Northwest
Pennsylvania	PA	Reliability First Corporation /East (RFCE)	RFC East
Rhode Island	RI	Northeast Power Coordinating Council (NEWE)	NPCC New England
South Carolina	SC	SERC Reliability Corporation/ Virgina-Carolina (SRVC)	SERC Virginia/Carolina
South Dakota	SD	Midwest Reliability Organization West (MROW)	MRO West
Tennessee	TN	SRCE Reliabiltiy Corporation/central (SRCE)	SERC Tennessee Valley
Texas	TX	Texas Reliability Enitity (ERCT)	ERCOT All
Utah	UT	WECC Northwest Power Pool (NWPP)	WECC Northwest
Virginia	VA	SERC Reliability Corporation/ Virgina-Carolina (SRVC)	SERC Virginia/Carolina
Vermont	VT	Northeast Power Coordinating Council (NEWE)	NPCC New England
Washington	WA	WECC Northwest Power Pool (NWPP)	WECC Northwest
Wisconsin	WI	Midwest Reliability Organization East (MROE)	MRO East
West Virginia	WV	Reliability First Corporation/West(RFCW)	RFC West
Wyoming	WY	WECC Northwest Power Pool (NWPP)	WECC Northwest

Appendix C: Energy Information Administration Price Forecasts

EMM Region	RFCE	NEWE	NYUP	SRGW	RFCW	RFCM	MORE	MROW	SPNO	SRSE	FRCC	SRCE	SPSO	ERCT	AZNM	NWPP	RMPA	CAMX	SRVC	SRDA
2015	$51.95	$49.74	$48.75	$40.96	$62.91	$56.07	$52.11	$44.96	$59.89	$56.89	$69.08	$49.70	$37.47	$36.32	$60.30	$27.94	$46.67	$56.06	$63.49	$55.14
2016	$52.94	$51.40	$53.62	$43.70	$64.44	$58.36	$53.62	$46.61	$61.59	$58.31	$70.03	$51.41	$40.61	$38.56	$61.74	$29.72	$47.65	$56.78	$64.36	$56.61
2017	$52.40	$53.24	$55.24	$46.56	$66.80	$60.82	$55.38	$47.68	$61.66	$59.90	$69.83	$51.24	$42.59	$41.01	$63.10	$30.99	$48.03	$57.80	$64.31	$56.65
2018	$54.03	$53.58	$57.38	$47.31	$67.81	$60.66	$54.93	$47.07	$60.63	$60.60	$69.36	$50.82	$42.54	$42.37	$63.23	$32.70	$48.66	$58.22	$64.91	$55.34
2019	$54.13	$54.81	$58.64	$47.94	$67.46	$60.47	$54.38	$46.58	$59.25	$59.71	$68.56	$50.51	$43.07	$42.81	$63.39	$31.57	$49.45	$58.93	$64.88	$54.94
2020	$57.31	$54.14	$59.45	$48.13	$66.47	$59.98	$54.06	$45.82	$58.25	$59.00	$67.79	$50.26	$43.40	$44.02	$61.62	$30.28	$50.97	$64.11	$64.73	$54.86
2021	$58.31	$59.42	$55.59	$48.40	$67.31	$59.60	$53.90	$45.37	$57.45	$58.61	$67.29	$50.03	$43.93	$47.56	$61.31	$29.03	$51.49	$68.24	$63.94	$54.78
2022	$59.56	$58.91	$57.88	$49.00	$67.70	$59.51	$53.59	$45.29	$56.74	$58.06	$67.34	$49.64	$44.66	$51.63	$62.89	$29.53	$51.91	$66.13	$63.15	$55.46
2023	$61.92	$64.62	$59.02	$49.93	$68.60	$59.74	$53.44	$45.51	$56.84	$57.72	$67.86	$49.33	$45.89	$49.76	$64.28	$30.73	$52.72	$66.11	$62.86	$55.97
2024	$63.02	$63.77	$61.09	$50.79	$69.17	$60.14	$53.32	$45.86	$56.84	$57.46	$68.13	$49.04	$46.83	$50.66	$65.74	$30.97	$53.45	$65.70	$62.65	$56.72
2025	$64.11	$62.97	$62.20	$51.30	$69.31	$60.48	$53.14	$45.98	$56.91	$57.14	$68.29	$49.50	$47.42	$49.48	$65.14	$29.82	$54.58	$68.90	$62.38	$58.72
2026	$65.55	$60.25	$63.52	$52.12	$69.55	$60.22	$52.96	$46.06	$56.18	$56.98	$68.52	$49.66	$48.25	$50.82	$65.29	$30.06	$55.40	$71.40	$62.32	$60.87
2027	$66.75	$68.46	$65.02	$52.41	$69.61	$60.49	$52.87	$46.19	$55.86	$57.02	$68.85	$49.86	$49.18	$53.61	$66.81	$31.66	$55.87	$68.22	$61.75	$58.32
2028	$67.24	$68.13	$68.25	$52.70	$69.63	$60.71	$52.78	$46.33	$55.57	$56.72	$69.19	$50.09	$50.66	$56.28	$67.61	$32.49	$56.41	$65.65	$61.60	$58.92
2029	$68.21	$69.82	$66.42	$53.30	$69.97	$60.69	$52.81	$46.47	$56.18	$56.83	$69.61	$50.02	$51.45	$58.73	$68.35	$32.95	$57.15	$65.43	$61.50	$59.37
2030	$69.02	$70.97	$69.05	$54.00	$70.20	$60.23	$52.90	$46.64	$56.40	$56.69	$70.06	$50.03	$51.53	$59.30	$69.06	$33.51	$57.90	$65.66	$61.33	$59.27
2031	$70.35	$71.80	$68.43	$54.81	$70.52	$60.35	$52.99	$46.91	$56.26	$56.12	$70.67	$50.23	$52.40	$60.00	$69.74	$33.85	$58.62	$65.84	$61.41	$59.49
2032	$70.99	$72.66	$69.45	$55.11	$70.95	$60.55	$53.24	$47.79	$56.30	$55.98	$71.70	$50.24	$53.25	$61.02	$70.57	$34.31	$59.40	$66.42	$61.38	$59.74
2033	$71.64	$74.35	$78.85	$55.46	$71.52	$61.13	$53.50	$48.03	$56.64	$56.25	$72.85	$50.43	$54.37	$61.41	$71.04	$34.61	$60.74	$67.31	$61.65	$59.99
2034	$72.51	$64.22	$78.68	$56.34	$72.49	$61.95	$53.81	$48.16	$56.62	$56.77	$74.62	$51.19	$54.78	$63.93	$71.56	$35.10	$62.07	$68.68	$62.26	$61.50
2035	$74.16	$66.43	$79.95	$57.46	$73.57	$62.67	$54.32	$48.68	$58.45	$57.58	$76.49	$51.79	$56.38	$64.92	$73.22	$36.12	$63.18	$70.43	$63.26	$64.16
2036	$77.01	$72.79	$83.35	$58.78	$75.35	$63.42	$55.04	$49.34	$60.97	$58.16	$78.55	$52.09	$58.94	$68.12	$75.43	$37.08	$63.73	$72.19	$64.08	$64.27
2037	$79.83	$72.51	$78.41	$59.70	$77.00	$63.89	$55.51	$49.99	$62.42	$58.69	$80.83	$52.64	$61.28	$71.18	$76.65	$38.45	$64.76	$73.92	$64.75	$65.41
2038	$81.50	$71.80	$80.34	$60.53	$78.26	$64.91	$56.03	$50.35	$63.03	$59.44	$83.21	$53.26	$63.17	$73.45	$77.60	$40.03	$66.25	$75.68	$65.53	$66.97
2039	$83.61	$78.69	$91.14	$61.74	$79.62	$65.96	$56.62	$50.45	$62.16	$60.08	$84.92	$53.94	$65.30	$75.97	$79.14	$40.91	$69.29	$76.99	$66.17	$68.00
2040	$84.84	$74.07	$88.47	$62.81	$80.44	$67.19	$56.71	$50.70	$61.51	$60.73	$86.58	$54.59	$65.83	$76.52	$80.66	$42.60	$71.50	$78.20	$66.55	$68.93

The 2013 Annual Energy Outlook (early release) by the Energy Information Administration (EIA) provides projected annual end-use electricity costs to the year 2040 for 22 electric market module (EMM) supply regions using the National Energy Modeling System (NEMS) EMM. The projected annual end-use electricity costs are further broken down into generation, transmission, and distribution for each of the supply regions. For this study, long-term energy values will be based on the projected generation category of the end use price. This table displays the projected generating costs for each supply region used in this study.

Appendix D: State Energy Price Shaping Factors

State	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
AK	0.989	0.995	0.995	0.994	1.007	1.038	1.011	1.019	0.998	0.995	0.972	0.986
AL	1.003	0.986	1.006	1.037	1.072	1.065	1.066	0.973	0.946	0.930	0.951	0.964
AR	0.977	0.970	0.984	1.042	1.067	1.077	1.061	0.983	0.962	0.965	0.958	0.952
AZ	0.923	0.929	1.023	1.069	1.106	1.115	1.093	1.060	0.958	0.917	0.910	0.898
CA	0.934	0.961	1.007	1.105	1.118	1.107	1.083	0.974	0.918	0.924	0.928	0.942
CO	0.963	0.994	1.003	1.070	1.084	1.084	1.044	0.993	0.982	0.933	0.936	0.915
CT	0.991	1.001	1.007	0.992	1.008	1.001	1.002	1.007	1.000	0.985	0.996	1.010
DC	0.969	0.967	0.998	1.012	1.015	1.021	1.017	0.989	1.015	1.009	0.999	0.988
DE	0.994	0.984	0.990	1.009	1.021	1.028	1.029	1.009	0.992	0.984	0.979	0.980
FL	1.006	1.015	1.012	1.015	1.017	1.007	1.001	0.991	0.987	0.997	0.998	0.953
GA	0.963	0.948	0.977	1.042	1.097	1.105	1.087	0.976	0.950	0.955	0.953	0.948
HI	1.006	1.039	1.057	1.058	1.049	1.020	1.009	0.976	0.948	0.944	0.948	0.946
IA	0.970	0.925	0.963	1.050	1.150	1.164	1.048	0.971	0.961	0.953	0.920	0.926
ID	1.015	1.006	0.997	0.985	1.045	1.057	1.052	0.963	0.966	0.975	0.969	0.970
IL	0.954	0.995	0.997	1.012	1.035	1.045	1.030	1.005	0.986	0.994	0.984	0.964
IN	1.001	1.012	1.016	1.019	1.025	1.027	1.006	0.992	0.991	0.971	0.975	0.965
KS	0.959	0.965	0.989	1.033	1.085	1.099	1.071	1.001	0.975	0.968	0.946	0.909
KY	0.990	0.982	0.987	1.029	1.081	1.080	1.052	0.988	0.950	0.940	0.969	0.954
LA	0.936	0.949	1.031	1.045	1.051	1.041	0.980	0.997	0.992	1.021	0.985	0.972
MA	0.993	0.967	0.986	1.030	1.022	1.012	1.032	0.997	0.975	0.996	0.990	1.001
MD	0.976	0.958	0.992	1.019	1.028	1.039	1.025	0.988	0.985	0.992	1.004	0.993
ME	1.024	0.996	0.974	0.972	1.001	0.999	0.972	0.973	0.972	1.008	1.044	1.065
MI	1.010	0.972	0.985	1.010	1.070	1.079	1.038	0.999	0.958	0.956	0.960	0.962
MN	0.979	0.968	0.979	1.021	1.075	1.085	1.051	0.978	0.960	0.972	0.969	0.962
MO	0.914	0.925	0.953	1.058	1.191	1.197	1.169	1.042	0.917	0.897	0.877	0.860
MS	0.987	0.987	0.992	1.030	1.045	1.047	1.027	0.995	0.979	0.975	0.972	0.964
MT	0.999	0.992	1.008	1.034	1.029	1.020	0.988	0.996	0.977	0.992	0.985	0.981
NC	0.990	0.974	1.019	1.044	1.039	1.055	1.001	0.971	0.971	0.984	0.984	0.969
ND	0.967	0.993	1.016	1.069	1.067	1.067	1.066	1.000	0.973	0.941	0.946	0.893
NE	0.929	0.936	0.985	1.095	1.118	1.137	1.078	0.975	0.956	0.978	0.923	0.889
NH	1.003	1.000	1.000	0.997	1.000	1.007	1.008	1.001	1.001	0.993	0.990	1.000
NJ	0.957	0.953	0.953	1.038	1.083	1.102	1.072	0.982	0.953	0.952	0.973	0.982
NM	0.950	0.939	1.019	1.046	1.118	1.094	1.055	0.961	0.938	0.964	0.973	0.943
NV	0.937	0.872	0.989	1.090	1.096	1.128	1.041	0.968	0.965	0.970	0.978	0.966
NY	0.954	0.947	0.996	1.058	1.080	1.103	1.062	0.984	0.951	0.939	0.959	0.967
OH	0.994	0.996	0.996	1.017	1.050	1.060	1.032	0.995	0.974	0.967	0.961	0.959
OK	0.912	0.942	1.026	1.098	1.111	1.101	1.065	0.986	0.958	0.930	0.958	0.913
OR	1.011	1.021	1.008	0.995	0.987	0.995	0.984	0.991	0.996	1.000	1.012	1.000
PA	0.988	0.988	0.988	1.002	1.033	1.035	1.021	0.991	0.990	0.985	1.000	0.978
RI	1.018	0.986	0.947	1.009	1.000	0.973	1.013	1.017	0.966	1.009	1.033	1.030
SC	1.008	1.004	0.989	1.031	1.053	1.052	1.036	0.975	0.951	0.949	0.975	0.977
SD	0.976	0.989	1.024	1.047	1.042	1.052	1.037	1.010	0.974	0.959	0.952	0.939
TN	1.026	1.013	1.033	1.027	1.026	1.033	1.021	0.981	0.970	0.962	0.950	0.958
TX	0.971	0.952	0.983	1.020	1.049	1.048	1.043	0.987	0.976	0.982	0.997	0.994
UT	0.938	0.934	1.026	1.077	1.086	1.103	1.091	1.003	0.956	0.934	0.927	0.922
VA	1.011	1.002	0.998	1.021	1.048	1.049	1.014	0.981	0.963	0.969	0.975	0.969
VT	1.014	1.014	1.012	0.994	0.998	0.999	1.000	0.997	0.993	1.000	0.994	0.984
WA	1.035	1.025	0.997	0.990	0.987	0.983	0.970	0.971	0.995	1.014	1.017	1.016
WI	0.984	0.994	0.986	1.023	1.033	1.044	1.032	0.983	0.979	0.973	0.985	0.984
WV	1.026	1.037	1.010	1.004	1.018	1.007	0.977	0.993	0.977	0.989	0.987	0.973
WY	0.999	1.004	1.034	1.022	1.014	1.022	0.997	0.998	0.981	0.993	0.980	0.955

Appendix E: Comparison of Estimated Site Attributes Between Oak Ridge National Laboratory and USACE Studies

This appendix compares the estimated site attributes of the 2012 Oak Ridge National Laboratory (ORNL) study, *An Assessment of Energy Potential at Non-Powered Dams in the United States*, and the current USACE hydropower resource assessment study. The goal of this comparison is to quantify the difference in the estimation of site attributes between the ORNL study, which used limited data, and this study, which uses more detailed hydrologic data. In this regard, the comparison is limited to the 182 sites where at least 3 years of daily flow and head data were available. This appendix considers three site attributes: estimated potential capacity, design head, and average annual flow.

Table E-1 shows the comparison of the estimated potential capacity between the ORNL and USACE studies by USACE Division. Across all Divisions, the USACE estimates of potential capacity range between 50% and 400% of the ORNL estimate. Overall, average potential capacity at the USACE sites is approximately 87% of the ORNL average. However, in terms of feasible potential, the USACE estimates are about 39% of the ORNL estimate.

Table E-1. Comparison Between USACE and ORNL Estimated Potential and Feasible Capacity

Division	ORNL Estimated Capacity (MW)	USACE Estimated Potential Capacity (based on 1% exceedance)		USACE Estimated Feasible Capacity	
		Capacity (MW)	Ratio USACE/ORNL	Capacity (MW)	Ratio USACE/ORNL
LRD	1,769.91	1,980.55	1.12	901.02	0.51
MVD	2,642.48	1,798.83	0.68	1,003.14	0.38
NAD	90.40	350.95	3.88	110.42	1.22
NWD	58.15	232.62	4.00	35.80	0.62
SAD	832.48	430.94	0.52	245.97	0.30
SWD	1,300.55	1,018.86	0.78	339.54	0.26
USACE Total	6,693.97	5,812.75	0.87	2,635.91	0.39

Tables E-2 and E-3 show a comparison of estimated design head and average annual flow between the two studies. As discussed in Section 5 of the main report, the USACE estimated design head corresponds to a 30% exceedance on the head duration curve. In this comparison, the USACE estimated design head is always less than the ORNL study head, varying from 64% to nearly 100% of the ORNL estimate. On the hand, the USACE estimated average annual flow is almost always greater than the ORNL estimates, varying from about 97% to almost 170%.

Table E-2. Comparison between USACE and ORNL Design Head

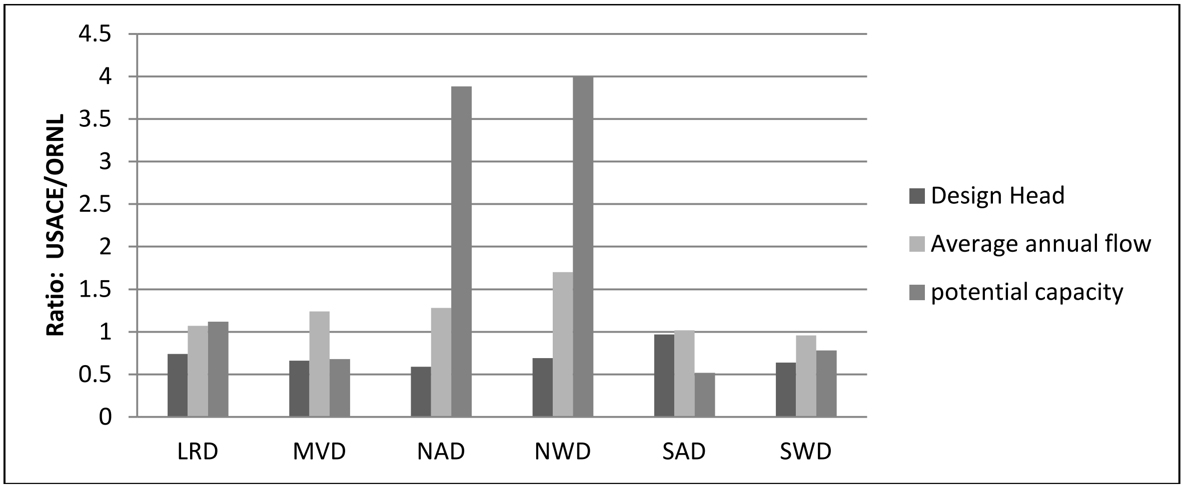
Division	USACE Average Estimated Design Head (ft)	ORNL Average Estimated Head (ft)	Difference (ORNL-USACE) (ft)	Ratio USACE (ft)/ORNL (ft)
LRD	48.45	65.56	17.11	0.74
MVD	18.47	28.19	9.71	0.66
NAD	52.61	88.94	36.33	0.59
NWD	67.57	97.29	29.72	0.69
SAD	29.47	30.50	1.03	0.97
SWD	46.24	72.44	26.21	0.64

Table E-3. Comparison Between USACE and ORNL Average Annual Flow Values

Division	USACE Average Annual Flow (cfs)	ORNL Estimated Average Annual Flow (cfs)	Difference (ORNL-USACE) (cfs)	Ratio USACE (cfs)/ORNL (cfs)
LRD	9236.48	8651.19	-585.29	1.07
MVD	32343.12	26138.74	-6204.38	1.24
NAD	444.28	346.17	-98.11	1.28
NWD	720.71	423.18	-297.53	1.70
SAD	16166.94	15791.95	-374.99	1.02
SWD	7860.59	8184.46	323.87	0.96

Figure E-1 shows a graphical comparison between the two studies. An interesting relationship seen in this graph is that SAD had the most similar head and flow relationships between the two studies, while also having the smallest ratio between the two studies when comparing potential capacity. This may illustrate the significance of the head and flow relationship and the monthly hydrological variability.

Figure E-1. Comparison Between USACE and ORNL Studies



Appendix F: Sensitivity Analysis Methodology in Estimating Site Attributes

Different methods were employed to calculate results depending on the completeness and quality of the data available. This appendix outlines and compares the different methodologies. Southwestern Division (SWD) serves as the basis for comparison because the data collected for SWD was of uniformly high quality, which allowed the full model methodology to be employed in its entirety.

Oak Ridge National Laboratory (ORNL) Data Estimate

The first comparison is between the full data complete model results and the results obtained from the ORNL data estimate. Methodology for both of these approaches can be found in Section 3. The data estimate is applied in the situation where no further data is available beyond the constant head value and average monthly flow values obtained by the Department of Energy. In this case, the single capacity value that results from the "ORNL Data" estimate is compared to both the maximum feasible capacity from the "full data estimate" and the capacity associated with the 1% cutoff of the power duration curve in the full data estimate. Table F-1 shows the results.

Table F-1. Capacity Comparison for Full Data vs. ORNL Data

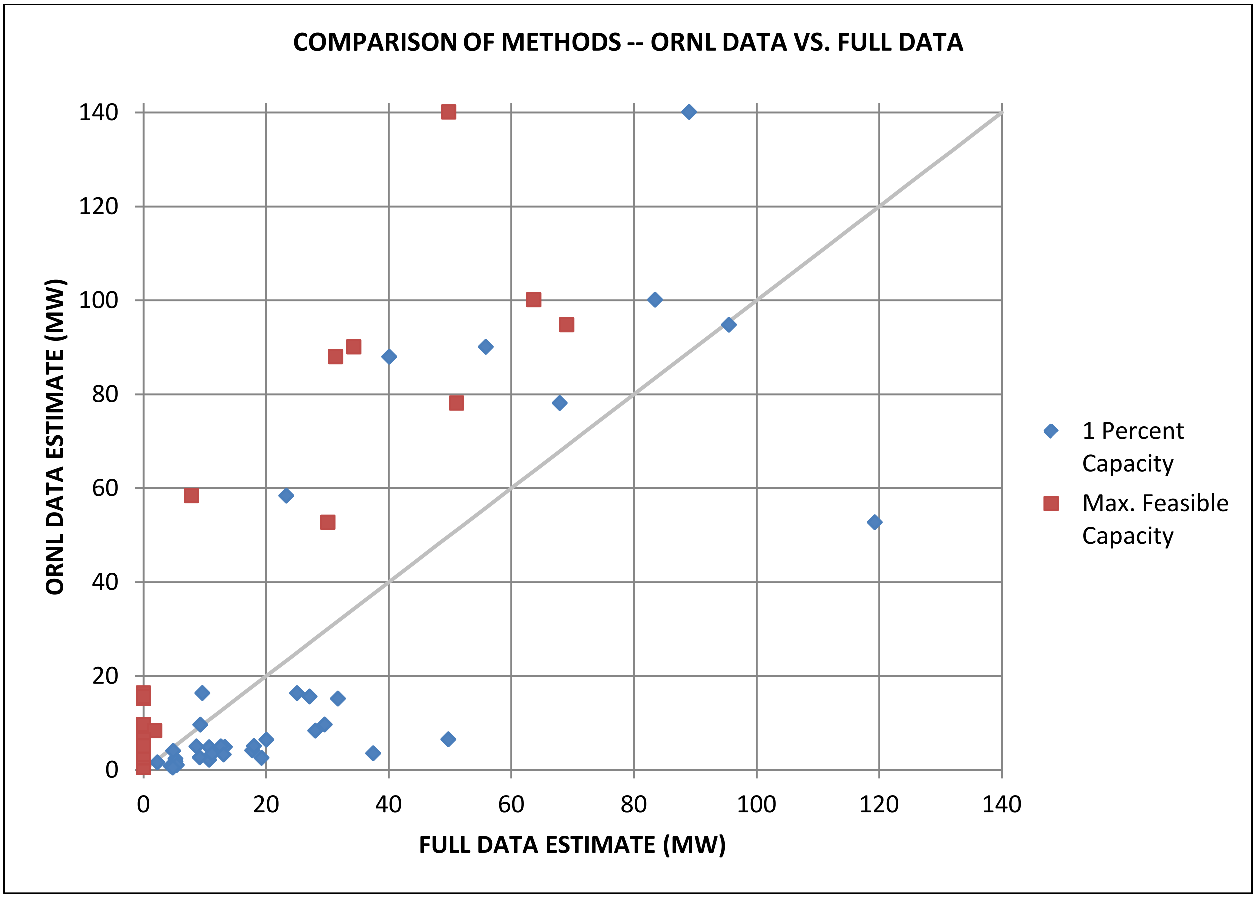
FULL DATA ESTIMATE	ORNL Data	COMPARISON		FUL DATA ESTIMATE	ORNL Data	COMPARISON
MAX 1% CAPACITY (MW)	MAX CAPACITY (MW)	% DIFF.	DAM NAME	MAX FEASIBLE CAPACITY (MW)	MAX CAPACITY (MW)	% DIFF.
4.440	0.882	-80.14%	Bardwell Lake	0.000	0.882	--
29.573	9.709	-67.17%	Belton Lake	0.000	9.709	--
5.226	2.407	-53.94%	Benbrook Lake	0.000	2.407	--
10.715	2.208	-79.39%	Granger Dam And Lake	0.000	2.208	--
5.228	1.809	-65.41%	Grapevine Lake	0.000	1.809	--
5.440	1.096	-79.85%	Joe Pool Lake	0.000	1.096	--
13.284	4.947	-62.76%	Lavon Lake	0.000	4.947	--
2.266	1.646	-27.33%	Navarro Mills Lake	0.000	1.646	--
4.855	4.122	-15.09%	North Fork Dam	0.000	4.122	--
25.059	16.383	-34.62%	Wright Patman Dam And Lake	0.000	16.383	--
9.273	9.678	4.36%	Ferrells Bridge Dam	0.000	9.678	--
4.799	0.548	-88.57%	Proctor Lake	0.000	0.548	--
37.476	3.573	-90.46%	Stillhouse-Hollow Dam	0.000	3.573	--
49.740	6.559	-86.81%	Waco Lake	0.000	6.559	--
8.642	5.049	-41.57%	Blue Mountain	0.000	5.049	--
28.032	8.407	-70.01%	Clearwater Dam	1.837	8.407	357.61%
83.460	100.181	20.04%	David D. Terry Lock & Dam	63.675	100.181	57.33%
10.716	4.865	-54.60%	DeQueen	0.000	4.865	--
67.905	78.173	15.12%	Emmett Sanders Lock & Dam	51.085	78.173	53.03%
19.267	2.609	-86.46%	Gillham	0.000	2.609	--
89.027	140.159	57.43%	Joe Hardin Lock & Dam	49.793	140.159	181.48%
95.513	94.850	-0.69%	Col Charles D. Maynard Lock And Dam	69.048	94.850	37.37%
23.303	58.446	150.81%	Millwood Dam	7.844	58.446	645.08%
20.053	6.472	-67.73%	Nimrod	0.000	6.472	--
40.097	88.038	119.56%	Toad Suck Ferry Lock & Dam	31.352	88.038	180.80%
9.614	16.411	70.69%	Chouteau Lock And Dam	0.000	16.411	--
9.187	2.710	-70.51%	Copan Lake	0.000	2.710	--
17.745	4.192	-76.37%	Fall River Lake	0.000	4.192	--
11.193	3.496	-68.77%	Great Salt Plains Lake	0.000	3.496	--
12.637	5.048	-60.05%	Hulah Lake	0.000	5.048	--
31.727	15.233	-51.99%	John Redmond Lake	0.000	15.233	--
27.107	15.674	-42.18%	Newt Graham Lock And Dam	0.000	15.674	--
119.299	52.776	-55.76%	Oologah Lake	30.082	52.776	75.44%
13.097	3.326	-74.60%	Skiatook Lake	0.000	3.326	--
18.023	5.143	-71.46%	Toronto Lake	0.000	5.143	--
55.847	90.140	61.41%	W.D.Mayo Lock And Dam	34.311	90.140	162.72%

The left side of Table F-1 compares the 1% capacity from the full data estimate and the single capacity value from the ORNL data estimate. Of the 36 ORNL data estimates, 28 are below those of the full model and they fall below the full data estimates by an average of about 10 megawatts (MW). The right side of Table F-1 compares the maximum feasible capacity calculated by the full model, with full data, to the (maximum) capacity value calculated in the ORNL data estimate. For all 36 of the dams in SWD, the capacity value given by the ORNL data estimate overstates potential capacity. In particular, 75% of the dams in SWD (27 of 36) are judged not feasible by the full model (indicated by a maximum feasible capacity value of zero; see the *Methodology* section in the main report for more information). Only two of the corresponding ORNL data estimates come in with capacity values less than one.

This overestimation is unsurprising, given that the maximum feasible capacity estimate taken from the full model represents the maximum capacity that can be achieved satisfying the constraint that the benefit-cost ratio of the project is still one.

Figure F-1 shows a graphical representation of the comparisons from Table F-1. The full data estimates are shown on the x-axis, while the estimates based on ORNL data are shown on the y-axis. In addition, the line with equation y = x is plotted. All the points above this line are those for which the ORNL data estimate is greater than the full data estimate, and all those points below this line show the dams for which the ORNL data estimate is smaller than the full data estimate.

Figure F-1. Plot of Capacity Estimates for Full Data vs. ORNL Data



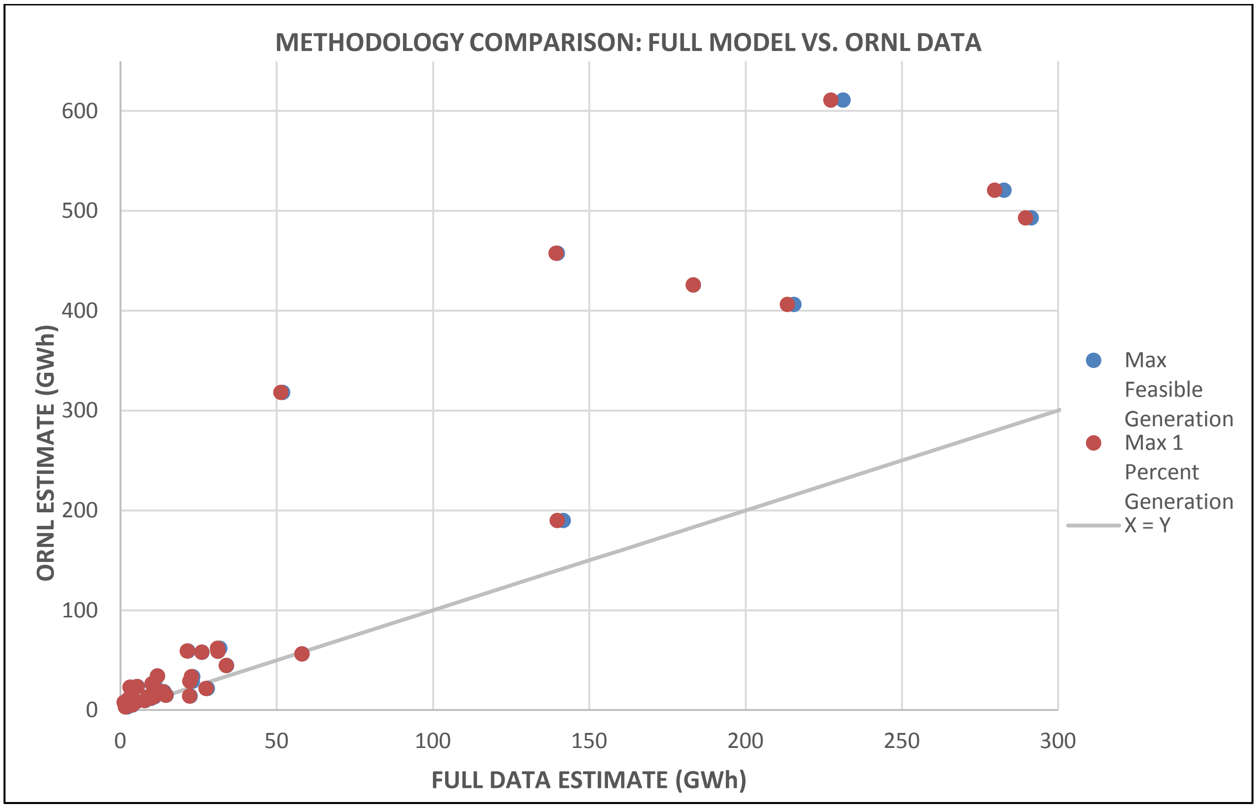
The generation estimates obtained from full data estimates to those obtained in ORNL data estimates also were compared. Table F-2 shows average annual generation comparisons. The left side of the table shows the comparison between the ORNL data estimate and the full data estimate, taken from the maximum capacity numbers. Note that all but three of the dams in question show an increase in average annual generation from the full data estimate to the ORNL data estimate, but that in Table F-1 all but eight dams show a decrease in capacity between the two estimates. This is because the capacity value which is reported for the ORNL data method is the maximum of the 12 monthly capacity values; when generation is calculated, monthly capacity values are used and the capacity values produced in the ORNL estimate are somewhat smaller than the monthly capacity values from the full data estimate.

Table F-2. Generation Comparison for Full Data vs. ORNL Data

FULL DATA ESTIMATE	ORNL Data ESTIMATE	COMPARISON		FULL DATA ESTIMATE	ORNL Data ESTIMATE	COMPARISON
ANN. GEN. MAX	**ANN. GEN.**	**% DIFF**	**DAM NAME**	**ANN. GEN. 1% MAX**	**ANN. GEN.**	**% DIFF**
2362.41	4228.19	78.98%	Bardwell Lake	2306.23	4228.19	83.34%
21645.19	59345.61	174.17%	Belton Lake	21427.73	59345.61	176.96%
2871.61	11541.52	301.92%	Benbrook Lake	2671.74	11541.52	331.99%
10909.14	13495.63	23.71%	Granger Dam And Lake	10698.75	13495.63	26.14%
5151.72	8672.61	68.34%	Grapevine Lake	5084.27	8672.61	70.58%
3878.14	5256.90	35.55%	Joe Pool Lake	3713.47	5256.90	41.56%
5473.47	23720.19	333.37%	Lavon Lake	5324.43	23720.19	345.50%
1271.82	7894.56	520.73%	Navarro Mills Lake	1244.45	7894.56	534.38%
3292.71	23101.24	601.59%	North Fork Dam	3116.18	23101.24	641.33%
26152.49	58152.11	122.36%	Wright Patman Dam And Lake	26066.35	58152.11	123.09%
11911.04	34352.43	188.41%	Ferrells Bridge Dam	11896.38	34352.43	188.76%
2256.77	3351.85	48.52%	Proctor Lake	1624.77	3351.85	106.30%
27853.81	21841.21	-21.59%	Stillhouse-Hollow Dam	27441.12	21841.21	-20.41%
23016.06	29097.57	26.42%	Waco Lake	22238.05	29097.57	30.85%
10981.79	26252.86	139.06%	Blue Mountain	10499.72	26252.86	150.03%
34006.77	44842.78	31.86%	Clearwater Dam	33900.19	44842.78	32.28%
282700.30	520853.26	84.24%	David D. Terry Lock & Dam	279707.16	520853.26	86.21%
10212.28	26497.35	159.47%	DeQueen	10139.10	26497.35	161.34%
215494.50	406432.34	88.60%	Emmett Sanders Lock & Dam	213392.41	406432.34	90.46%
22354.62	14210.90	-36.43%	Gillham	22171.34	14210.90	-35.90%
231213.62	611082.85	164.29%	Joe Hardin Lock & Dam	227308.24	611082.85	168.83%
291409.22	493138.33	69.23%	Col Charles D. Maynard Lock And Dam	289587.56	493138.33	70.29%
51938.93	318357.93	512.95%	Millwood Dam	51364.52	318357.93	519.80%
23182.17	33648.80	45.15%	Nimrod	22742.04	33648.80	47.96%
139823.15	457719.66	227.36%	Toad Suck Ferry Lock & Dam	139406.63	457719.66	228.33%
31248.29	59101.75	89.14%	Chouteau Lock And Dam	31237.67	59101.75	89.20%
7959.25	9758.66	22.61%	Copan Lake	7707.02	9758.66	26.62%
14675.55	15098.58	2.88%	Fall River Lake	14551.39	15098.58	3.76%
9189.59	13467.43	46.55%	Great Salt Plains Lake	8834.54	13467.43	52.44%
12864.88	18180.04	41.32%	Hulah Lake	12443.45	18180.04	46.10%
31829.11	62087.80	95.07%	John Redmond Lake	31105.36	62087.80	99.60%
58149.20	56448.43	-2.92%	Newt Graham Lock And Dam	58108.56	56448.43	-2.86%
141707.39	190067.49	34.13%	Oologah Lake	139773.86	190067.49	35.98%
9849.18	11979.67	21.63%	Skiatook Lake	9537.70	11979.67	25.60%
13980.82	18521.59	32.48%	Toronto Lake	13694.40	18521.59	35.25%
183325.11	425968.54	132.36%	W.D.Mayo Lock And Dam	183285.07	425968.54	132.41%

The right side of Table F-2 shows the average annual generation at 99% of maximum produced by the full data estimate and the average annual generation estimate from the ORNL data estimate, which is the same as that shown on the left side of the table. The percentage change looks similar to that from the left side of the table, only slightly higher. This is because the full data estimate generation here is taken from point slightly lower on the power duration curve, while the ORNL data estimate is the same.

Figure F-2. Plot of Generation Estimates for Full Data vs. ORNL Data



Constant Head Estimate

In this section, the full data estimates are compared to those obtained by running the full model on restricted data. For the constant head estimate, daily flow data is utilized but a constant head value is assumed. This represents an intermediate step between the ORNL data estimate and the full data estimate. Table F-3 shows a comparison similar to that shown in the previous section. Unlike the ORNL data estimate, the constant head estimate produces both a 1% capacity and a maximum feasible capacity, allowing for a more appropriate comparison to be made.

The right side of Table F-3 shows comparison between 1% capacity as calculated by the full model and 1% capacity given by the constant head estimate. Except Clearwater Dam and Gillham, there is a consistent overestimate in the constant head case—by an average of 145%. The upward bias of the constant head estimate is expected. Since higher flow values correspond to lower head values, the use of a constant head value alongside daily flow will overstate power during any periods of higher flow.

The left side of Table F-3 compares the maximum feasible capacity comparison between the two methods. As noted above in regards to Table F-1, zero capacity is listed for all estimates coming in below 1 MW, owing to lack of resolution in the model. As noted above, unlike the no data estimate, the constant head estimate involves a feasibility constraint, as in the full model, which leads to a zero being assigned to all capacity values below 1 MW.

Table F-3. Capacity Comparison for Full Data vs. Constant Head Data

FULL DATA ESTIMATE	CONSTANT HEAD ESTIMATE	% CHANGE		FULL DATA ESTIMATE	CONSTANT HEAD ESTIMATE	% CHANGE
MAX FEASIBLE CAP (MW)	**MAX FEASIBLE CAP (MW)**	**MAX CAP -- %Δ**	**DAM NAME**	**MAX 1% CAP (MW)**	**MAX 1% CAP (MW)**	**MAX 1% CAP -- %Δ**
0.000	0.000	--	Bardwell Lake	4.440	9.231	107.92%
0.000	0.000	--	Belton Lake	29.573	47.618	61.02%
0.000	0.000	--	Benbrook Lake	5.226	13.086	150.40%
0.000	0.000	--	Granger Dam And Lake	10.715	16.663	55.51%
0.000	0.000	--	Grapevine Lake	5.228	11.989	129.32%
0.000	0.000	--	Joe Pool Lake	5.440	9.363	72.13%
0.000	0.000	--	Lavon Lake	13.284	31.736	138.90%
0.000	0.000	--	Navarro Mills Lake	2.266	10.084	345.08%
0.000	0.000	--	North Fork Dam	4.855	5.158	6.25%
0.000	0.000	--	Wright Patman Dam And Lake	25.059	30.574	22.01%
0.000	0.000	--	Ferrells Bridge Dam	9.273	19.222	107.28%
0.000	0.000	--	Proctor Lake	4.799	9.248	92.71%
0.000	0.000	--	Stillhouse-Hollow Dam	37.476	39.262	4.77%
0.000	0.000	--	Waco Lake	49.740	56.982	14.56%
0.000	0.000	--	Blue Mountain	8.642	17.755	105.44%
1.837	4.709	156.31%	Clearwater Dam	28.032	21.443	-23.50%
63.675	97.246	52.72%	David D. Terry Lock & Dam	83.460	278.771	234.02%
0.000	0.000	--	DeQueen	10.716	18.644	73.99%
51.085	76.644	50.03%	Emmett Sanders Lock & Dam	67.905	221.864	226.73%
0.000	0.000	--	Gillham	19.267	9.616	-50.09%
49.793	110.642	122.20%	Joe Hardin Lock & Dam	89.027	316.949	256.01%
69.048	91.843	33.01%	Col Charles D. Maynard Lock And Dam	95.513	263.284	175.65%
7.844	71.274	808.61%	Millwood Dam	23.303	169.201	626.10%
0.000	0.000	--	Nimrod	20.053	29.296	46.09%
31.352	80.961	158.23%	Toad Suck Ferry Lock & Dam	40.097	237.543	492.43%
0.000	0.000	--	Chouteau Lock And Dam	9.614	54.441	466.25%
0.000	0.000	--	Copan Lake	9.187	14.691	59.91%
0.000	0.000	--	Fall River Lake	17.745	26.186	47.57%
0.000	0.000	--	Great Salt Plains Lake	11.193	22.449	100.56%
0.000	0.000	--	Hulah Lake	12.637	24.482	93.74%
0.000	0.000	--	John Redmond Lake	31.727	63.874	101.32%
0.000	0.000	--	Newt Graham Lock And Dam	27.107	55.757	105.69%
30.082	36.191	20.31%	Oologah Lake	119.299	157.661	32.16%
0.000	0.000	--	Skiatook Lake	13.097	14.129	7.88%
0.000	0.000	--	Toronto Lake	18.023	32.681	81.33%
34.311	75.207	119.20%	W.D.Mayo Lock And Dam	55.847	226.218	305.07%

The left side of Table F-4 shows a comparison of maximum average annual generation for the full data estimate and the constant head estimate. The constant head estimate is on average 105% larger than the full data estimate. The right side of Table F-4 compares the results of the two methods for average annual generation calculated at the 99% of maximum point on the power duration curve. In this case, the constant head method is an average of 106% larger than the full data method. These increases have the same explanation as the increased capacity values noted above. Typically, with real data, an increase in flow will correspond to a decrease in head, and vice versa. Hence, when constant head data is used in conjunction with actual observed flow data, power and generation values will be artificially inflated, since the head value does not decrease in the presence of a higher flow value.

Table F-4. Generation Comparison for Full Data vs. Constant Head Data

FULL DATA ESTIMATE	CONSTANT HEAD ESTIMATE	COMPARISON		FULL DATA ESTIMATE	CONSTANT HEAD ESTIMATE	COMPARISON
ANN. GEN. MAX	**ANN. GEN.**	**% DIFF**	**DAM NAME**	**ANN. GEN. 1% MAX**	**ANN. GEN.**	**% DIFF**
2362.41	4823.72	104.19%	Bardwell Lake	2306.23	4770.87	106.87%
21645.19	44960.49	107.72%	Belton Lake	21427.73	44860.09	109.36%
2871.61	5984.31	108.40%	Benbrook Lake	2671.74	5639.72	111.09%
10909.14	15185.30	39.20%	Granger Dam And Lake	10698.75	14933.58	39.58%
5151.72	12351.63	139.76%	Grapevine Lake	5084.27	12280.99	141.55%
3878.14	6503.65	67.70%	Joe Pool Lake	3713.47	6222.46	67.56%
5473.47	13231.86	141.75%	Lavon Lake	5324.43	12990.44	143.98%
1271.82	6209.82	388.26%	Navarro Mills Lake	1244.45	6171.30	395.91%
3292.71	3646.08	10.73%	North Fork Dam	3116.18	3439.83	10.39%
26152.49	57828.20	121.12%	Wright Patman Dam And Lake	26066.35	57772.95	121.64%
11911.04	29480.37	147.50%	Ferrells Bridge Dam	11896.38	29466.75	147.70%
2256.77	4015.68	77.94%	Proctor Lake	1624.77	3208.45	97.47%
27853.81	31165.88	11.89%	Stillhouse-Hollow Dam	27441.12	30726.69	11.97%
23016.06	27365.44	18.90%	Waco Lake	22238.05	26600.70	19.62%
10981.79	27532.25	150.71%	Blue Mountain	10499.72	26989.25	157.05%
34006.77	47292.53	39.07%	Clearwater Dam	33900.19	47263.67	39.42%
282700.30	499574.43	76.72%	David D. Terry Lock & Dam	279707.16	496525.34	77.52%
10212.28	19768.43	93.58%	DeQueen	10139.10	19729.54	94.59%
215494.50	397847.57	84.62%	Emmett Sanders Lock & Dam	213392.41	395213.17	85.20%
22354.62	13110.31	-41.35%	Gillham	22171.34	13088.30	-40.97%
231213.62	574300.62	148.39%	Joe Hardin Lock & Dam	227308.24	569975.74	150.75%
291409.22	473848.91	62.61%	Col Charles D. Maynard Lock And Dam	289587.56	470864.17	62.60%
51938.93	201761.44	288.46%	Millwood Dam	51364.52	198780.34	287.00%
23182.17	39759.95	71.51%	Nimrod	22742.04	39442.54	73.43%
139823.15	421070.21	201.14%	Toad Suck Ferry Lock & Dam	139406.63	418076.62	199.90%
31248.29	82704.89	164.67%	Chouteau Lock And Dam	31237.67	81311.04	160.30%
7959.25	14423.15	81.21%	Copan Lake	7707.02	14135.30	83.41%
14675.55	26634.92	81.49%	Fall River Lake	14551.39	26569.68	82.59%
9189.59	19094.29	107.78%	Great Salt Plains Lake	8834.54	18427.20	108.58%
12864.88	29766.89	131.38%	Hulah Lake	12443.45	29095.18	133.82%
31829.11	70663.57	122.01%	John Redmond Lake	31105.36	70042.61	125.18%
58149.20	77585.33	33.42%	Newt Graham Lock And Dam	58108.56	76268.72	31.25%
141707.39	175149.30	23.60%	Oologah Lake	139773.86	173425.54	24.08%
9849.18	10461.48	6.22%	Skiatook Lake	9537.70	10102.37	5.92%
13980.82	29315.06	109.68%	Toronto Lake	13694.40	29017.55	111.89%
183325.11	403590.46	120.15%	W.D.Mayo Lock And Dam	183285.07	399063.90	117.73%

Figures F-3 and F-4 show the graphical comparison of the capacity and generation estimates, respectively. They are analogous to Figures F-1 and F-2.

Figure F-3. Plot of Capacity Estimates for Full Data vs. Constant Head Data

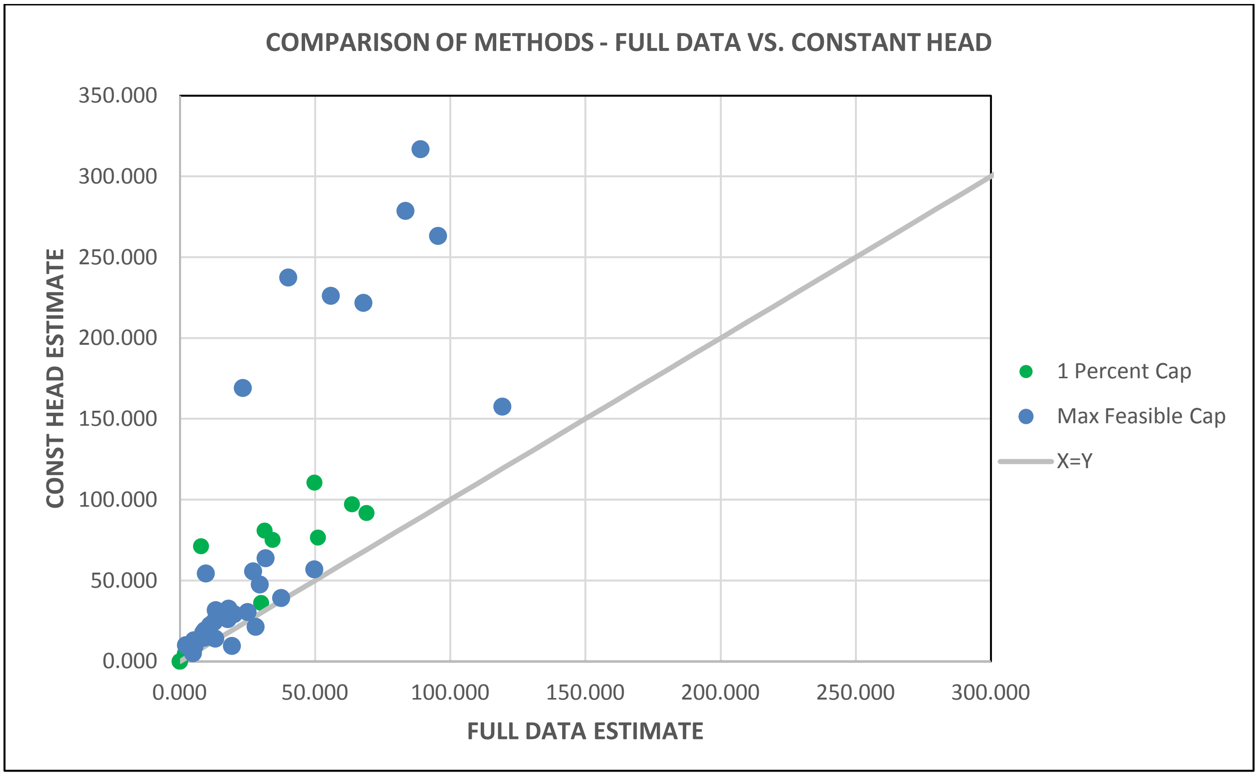
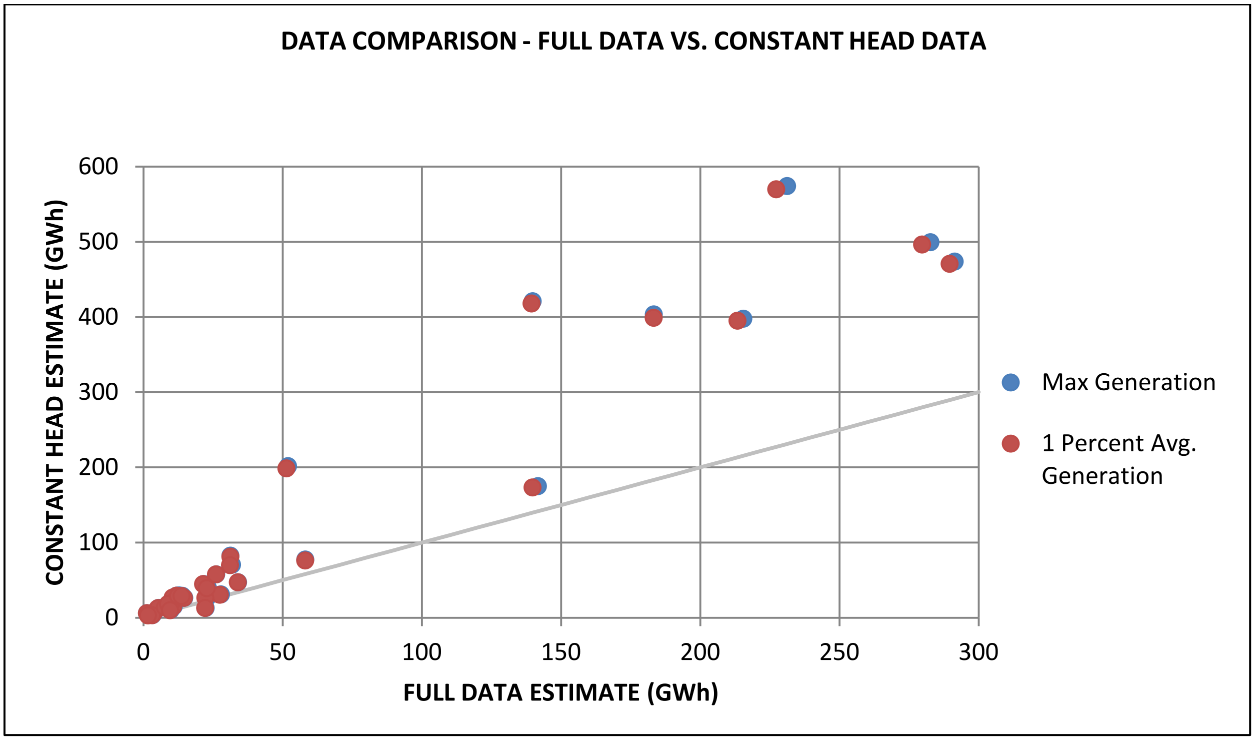


Figure F-4. Plot of Generation Estimates for Full Data vs. Constant Head Data



Appendix G: Estimated Benefits of Federal Renewable Energy Credit

The two primary federal renewable energy incentives are the Production Tax Credit (PTC) and the Investment Tax Credit (ITC). The ITC and PTC are both per-kilowatt-hour tax credits for eligible energy sources. In general, the ITC and PTC equal 30% of eligible costs. While these two programs are uniquely different, The American Recovery and Reinvestment Act of 2009 allows facilities that qualify for the PTC to take the ITC instead. In addition, in January 2013, the American Taxpayer Relief Act of 2013 revised the language governing the eligibility of PTC-eligible facilities to claim the ITC.

Renewable energy facilities that qualify for the PTC also have the option to take an equivalent cash grant from the U.S. Department of Treasury. It should be noted that in order to be eligible for the PTC, eligible facilities must begin construction by December 31, 2013. In contrast, the ITC is available for eligible systems placed in service on or before December 31, 2016. However, hydroelectric eligibility for the ITC ends at the same time as the PTC.

This appendix demonstrates the contribution of the federal renewable energy credits in regards to the benefit-cost ratio (BCR), internal rate of return (IRR), and carbon emissions. The goal of this analysis is to catalogue the impacts of the federal renewable incentives and to understand the ramifications of the termination of these tax credits. For the purposes of this analysis, the federal renewable energy incentive reported by the Database of State Incentives for Renewables & Efficiency (DSIRE) was used. The amount given by the database is 1.1¢ per kilowatt hour (kWh) for qualified hydroelectric or equivalently, $11.00 per megawatt hour (MWh). This analysis was performed on only the 197 sites that had at least 3 years of daily flow data. The 27 sites with no additional data were not included.

The table below shows the comparison of maximum feasibility and total equivalent carbon dioxide (CDE) avoided for a scenario including federal renewable benefits and a scenario not including them. According to this analysis, the federal benefit increases the potential feasible capacity by about 180 MW or approximately a 6.3% increase in feasible capacity for the sites considered when compared to the no federal benefit scenario. This capacity increase results in an addition estimated 0.64 billion pounds of avoided CDE.

	With Federal Benefits		Without Federal Benefits		Difference (with-without)	
Division	**Total Maximum Feasible Capacity (MW)**	**Total CDE Avoided (billion lbs.)**	**Total Maximum Feasible Capacity (MW)**	**Total CDE Avoided (billion lbs.)**	**Total Maximum Feasible Capacity (MW)**	**Total CDE Avoided (billion lbs.)**
LRD	955.33	7.51	898.16	7.35	57.16	0.16
MVD	987.33	8.22	939.75	7.93	51.37	0.28
NAD	66.05	0.34	63.49	0.34	2.56	0.01
NWD	62.39	0.36	50.63	0.31	11.75	0.05
SAD	374.24	2.25	324.51	2.14	49.73	0.12
SPD	112.71	0.59	112.71	0.59	0.00	0.00
SWD	434.19	2.28	429.27	2.25	4.92	0.03
Total	**2992.24**	**21.55**	**2818.54**	**20.91**	**177.49**	**0.64**

Appendix H: National Inventory of Dams (NID) Identification Numbers

ID	Plant	State	District	Division	NID ID #
LRD-1	ALLEGHENY LOCK AND DAM 02	PA	LRP	LRD	PA00112
LRD-10	BOLIVAR DAM	OH	LRH	LRD	OH00004
LRD-11	BRADDOCK LOCKS AND DAM	PA	LRP	LRD	PA00120
LRD-12	BROOKVILLE LAKE DAM	IN	LRL	LRD	IN03017
LRD-13	BUCKHORN LAKE DAM	KY	LRL	LRD	KY03027
LRD-14	BURNSVILLE LAKE DAM	WV	LRH	LRD	WV00707
LRD-15	CAESAR CREEK LAKE DAM and Saddle Dams #1 and #4	OH	LRL	LRD	OH00927
LRD-16	CAGLES MILL LAKE DAM	IN	LRL	LRD	IN03002
LRD-17	CAVE RUN LAKE DAM	KY	LRL	LRD	KY03055
LRD-18	CECIL M HARDEN LAKE DAM	IN	LRL	LRD	IN03003
LRD-19	CHARLEROI LOCKS AND DAM	PA	LRP	LRD	PA00122
LRD-2	ALLEGHENY LOCK AND DAM 03	PA	LRP	LRD	PA00113
LRD-20	CHARLES MILL DAM	OH	LRH	LRD	OH00020
LRD-21	CROOKED CREEK DAM	PA	LRP	LRD	PA00102
LRD-22	DASHIELDS LOCKS AND DAM	PA	LRP	LRD	PA00127
LRD-23	DEER CREEK DAM	OH	LRH	LRD	OH00008
LRD-24	DELAWARE DAM	OH	LRH	LRD	OH00015
LRD-25	DEWEY DAM	KY	LRH	LRD	KY03029
LRD-26	DILLON DAM	OH	LRH	LRD	OH00007
LRD-27	DOVER DAM	OH	LRH	LRD	OH00003
LRD-28	EAST BRANCH DAM	PA	LRP	LRD	PA00104
LRD-29	EAST LYNN DAM	WV	LRH	LRD	WV09901
LRD-3	ALLEGHENY LOCK AND DAM 04	PA	LRP	LRD	PA00114
LRD-30	EMSWORTH LOCKS AND DAMS	PA	LRP	LRD	PA00126
LRD-31	FISHTRAP DAM	KY	LRH	LRD	KY03028
LRD-32	GRAYS LANDING LOCK AND DAM	PA	LRP	LRD	PA00124
LRD-33	GRAYSON DAM	KY	LRH	LRD	KY03030
LRD-34	GREEN RIVER LAKE DAM	KY	LRL	LRD	KY03007
LRD-35	GREEN RIVER LOCK & DAM 1	KY	LRL	LRD	KY03002
LRD-36	GREEN RIVER LOCK & DAM 2	KY	LRL	LRD	KY03003
LRD-37	GREEN RIVER LOCK & DAM 3	KY	LRL	LRD	KY03004
LRD-38	GREEN RIVER LOCK & DAM 5	KY	LRL	LRD	KY03005
LRD-39	GREEN RIVER LOCK & DAM 6	KY	LRL	LRD	KY03006
LRD-4	ALLEGHENY LOCK AND DAM 07	PA	LRP	LRD	PA00117
LRD-40	HILDEBRAND LOCK AND DAM	WV	LRP	LRD	WV06107
LRD-41	J. EDWARD ROUSH LAKE DAM	IN	LRL	LRD	IN03006
LRD-42	JOHN T. MYERS LOCKS & DAM	IN	LRL	LRD	KY03060
LRD-43	JOHN W FLANNAGAN DAM	VA	LRH	LRD	VA05101
LRD-44	MARTINS FORK DAM	KY	LRN	LRD	KY03061
LRD-45	MAXWELL LOCKS AND DAM	PA	LRP	LRD	PA00123
LRD-46	MISSISSINEWA LAKE DAM	IN	LRL	LRD	IN03004
LRD-47	MOHICANVILLE DAM	OH	LRH	LRD	OH00019
LRD-48	MONONGAHELA LOCKS AND DAM 03	PA	LRP	LRD	PA00121
LRD-49	MONROE LAKE DAM	IN	LRL	LRD	IN03001
LRD-5	ALUM CREEK DAM	OH	LRH	LRD	OH00931

ID	Plant	State	District	Division	NID ID #
LRD-50	MONTGOMERY LOCKS AND DAM	PA	LRP	LRD	PA00128
LRD-51	MORGANTOWN LOCK AND DAM	WV	LRP	LRD	WV06106
LRD-53	NEWBURGH LOCKS & DAM	IN	LRL	LRD	KY03059
LRD-54	NOLIN LAKE DAM	KY	LRL	LRD	KY03011
LRD-57	OPEKISKA LOCK AND DAM	WV	LRP	LRD	WV06108
LRD-58	PAINT CREEK DAM	OH	LRH	LRD	OH00017
LRD-59	PAINTSVILLE DAM	KY	LRH	LRD	KY82202
LRD-6	BARREN RIVER LAKE DAM	KY	LRL	LRD	KY03009
LRD-60	PATOKA LAKE DAM	IN	LRL	LRD	IN03018
LRD-61	PLEASANT HILL DAM	OH	LRH	LRD	OH00001
LRD-62	POINT MARION LOCK AND DAM	PA	LRP	LRD	PA00125
LRD-63	R D BAILEY DAM	WV	LRH	LRD	WV10924
LRD-64	ROUGH RIVER LAKE DAM	KY	LRL	LRD	KY03012
LRD-65	SALAMONIE LAKE DAM	IN	LRL	LRD	IN03005
LRD-66	SHENANGO DAM	PA	LRP	LRD	PA00111
LRD-67	STONEWALL JACKSON DAM,WV	WV	LRP	LRD	WV00049
LRD-68	SUTTON DAM	WV	LRH	LRD	WV00701
LRD-69	TAYLORSVILLE LAKE DAM	KY	LRL	LRD	KY03051
LRD-7	BEACH CITY DAM	OH	LRH	LRD	OH00005
LRD-70	TIONESTA DAM	PA	LRP	LRD	PA00110
LRD-71	TYGART DAM	WV	LRP	LRD	WV09101
LRD-72	UNION CITY DAM	PA	LRP	LRD	PA00103
LRD-73	WILLIAM H. HARSHA LAKE DAM	OH	LRL	LRD	OH00929
LRD-74	WILLS CREEK DAM	OH	LRH	LRD	OH00002
LRD-75	YATESVILLE DAM	KY	LRH	LRD	KY82201
LRD-8	BERLIN DAM	OH	LRP	LRD	OH00032
LRD-9	BLUESTONE DAM	WV	LRH	LRD	WV08902
MVD-1	ARKABUTLA DAM	MS	MVK	MVD	MS01496
MVD-10	ENID DAM	MS	MVK	MVD	MS01495
MVD-11	FELSENTHAL LOCK & DAM	AR	MVK	MVD	AR01514
MVD-12	GRENADA DAM	MS	MVK	MVD	MS01494
MVD-13	JOE D. WAGGONNER, JR. LOCK & DAM	LA	MVK	MVD	LA00580
MVD-14	JOHN OVERTON LOCK AND DAM	LA	MVK	MVD	LA00581
MVD-15	JONESVILLE LOCK & DAM	LA	MVK	MVD	LA00175
MVD-16	KASKASKIA LOCK & DAM	IL	MVS	MVD	IL00115
MVD-17	LA GRANGE LOCK & DAM	IL	MVR	MVD	IL01015
MVD-18	LAC QUI PARLE DAM	MN	MVP	MVD	MN00580
MVD-19	LAKE SHELBYVILLE DAM	IL	MVS	MVD	IL00118
MVD-2	BALDHILL	ND	MVP	MVD	ND00309
MVD-20	LITTLE RIVER CLOSURE DAM	**LA**	MVK	MVD	LA00174
MVD-21	LOCK & DAM #10	IA	MVP	MVD	WI10500
MVD-22	LOCK & DAM #3	MN	MVP	MVD	MN00595
MVD-23	LOCK & DAM #4	MN	MVP	MVD	WI00727
MVD-24	LOCK & DAM #5A	MN	MVP	MVD	MN00588
MVD-25	LOCK & DAM #6	MN	MVP	MVD	WI00802

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MVD-26	LOCK & DAM #7	MN	MVP	MVD	MN00587
MVD-27	LOCK & DAM #8	MN	MVP	MVD	WI00803
MVD-28	LOCK & DAM #9	WI	MVP	MVD	WI00733
MVD-29	LOCK & DAM 24	IL	MVS	MVD	MO10300
MVD-3	BAYOU BODCAU DAM	LA	MVK	MVD	LA00179
MVD-30	LOCK & DAM 25	IL	MVS	MVD	MO10301
MVD-31	LOCK & DAM NO 5	MN	MVP	MVD	WI00589
MVD-32	LOCK AND DAM 15	IA	MVR	MVD	IL50073
MVD-33	LOCK AND DAM 18	IA	MVR	MVD	IL50075
MVD-34	MELVIN PRICE LOCKS & DAM	IL	MVS	MVD	IL50077
MVD-37	MISSISSIPPI RIVER DAM 14	IA	MVR	MVD	IA00006
MVD-38	MISSISSIPPI RIVER DAM 16	IA	MVR	MVD	IA00008
MVD-39	MISSISSIPPI RIVER DAM 17	IA	MVR	MVD	IA00009
MVD-4	BRANDON ROAD LOCK & DAM	IL	MVR	MVD	IL00001
MVD-40	MISSISSIPPI RIVER DAM 20	IL	MVR	MVD	MO10303
MVD-41	MISSISSIPPI RIVER DAM 21	IL	MVR	MVD	MO10304
MVD-42	MISSISSIPPI RIVER DAM 22	IL	MVR	MVD	MO10305
MVD-43	ORWELL RESERVOIR & DAM	MN	MVP	MVD	MN00574
MVD-44	PEARL RIVER LOCK #1 & SPILLWAY	**LA**	MVK	MVD	LA00089
MVD-45	PEORIA LOCK & DAM	IL	MVR	MVD	IL01014
MVD-46	POKEGAMA LAKE DAM	MN	MVP	MVD	MN00584
MVD-47	RED RIVER W.W. LOCK & DAM #3	LA	MVK	MVD	LA00582
MVD-48	RED ROCK DAM	IA	MVR	MVD	IA00013
MVD-49	RUSSELL B. LONG LOCK & DAM	LA	MVK	MVD	LA00583
MVD-5	CADDO DAM	LA	MVK	MVD	LA00181
MVD-50	SARDIS DAM	MS	MVK	MVD	MS01493
MVD-51	SAYLORVILLE DAM	IA	MVR	MVD	IA00017
MVD-52	WALLACE LAKE DAM	LA	MVK	MVD	LA00180
MVD-53	WINNIBIGOSHISH DAM	MN	MVP	MVD	MN00586
MVD-6	COLUMBIA LOCK & DAM	LA	MVK	MVD	LA00177
MVD-7	CORALVILLE DAM	IA	MVR	MVD	IA00012
MVD-8	DRESDEN ISLAND LOCK & DAM	IL	MVR	MVD	IL00002
MVD-9	DUBUQUE NUMBER 11	IA	MVR	MVD	WI01249
NAD-1	BALL MOUNTAIN DAM	VT	NAE	NAD	VT00001
NAD-10	FRANKLIN FALLS DAM	NH	NAE	NAD	NH00003
NAD-11	GATHRIGHT DAM	VA	NAO	NAD	VA00501
NAD-12	GENERAL EDGAR JADWIN	PA	NAP	NAD	PA00009
NAD-13	HAMMOND DAM	PA	NAB	NAD	PA01133
NAD-14	JENNINGS RANDOLPH DAM	MD	NAB	NAD	MD00069
NAD-15	LITTLEVILLE DAM	MA	NAE	NAD	MA00968
NAD-16	NORTH SPRINGFIELD DAM	VT	NAE	NAD	VT00003
NAD-17	PROMPTON DAM	PA	NAP	NAD	PA00011
NAD-18	SURRY MOUNTAIN DAM	NH	NAE	NAD	NH00007
NAD-19	THOMASTON DAM	CT	NAE	NAD	CT00501
NAD-2	BIRCH HILL DAM	MA	NAE	NAD	MA00963

ID	Plant	State	District	Division	NID ID #
NAD-20	TIOGA DAM	PA	NAB	NAD	PA01132
NAD-21	TOWNSHEND DAM	VT	NAE	NAD	VT00004
NAD-22	WEST THOMPSON DAM	CT	NAE	NAD	CT00502
NAD-23	WESTVILLE DAM	MA	NAE	NAD	MA00972
NAD-24	WHITNEY POINT DAM	NY	NAB	NAD	NY01055
NAD-25	YORK INDIAN ROCK DAM	PA	NAB	NAD	PA00007
NAD-3	BLACKWATER DAM	NH	NAE	NAD	NH00001
NAD-4	BLUE MARSH DAM	PA	NAP	NAD	PA00921
NAD-5	COWANESQUE DAM	PA	NAB	NAD	PA01134
NAD-6	CURWENSVILLE DAM	PA	NAB	NAD	PA00003
NAD-7	EAST SIDNEY DAM	NY	NAB	NAD	NY01211
NAD-8	EVERETT DAM	NH	NAE	NAD	NH00002
NAD-9	FRANCIS E WALTER DAM	PA	NAP	NAD	PA00008
NWD-10	MELVERN DAM	KS	NWK	NWD	KS00007
NWD-11	MILFORD DAM	KS	NWK	NWD	KS00008
NWD-12	PERRY DAM	KS	NWK	NWD	KS00009
NWD-13	POMME DE TERRE DAM	MO	NWK	NWD	MO30201
NWD-14	TUTTLE CREEK DAM	KS	NWK	NWD	KS00012
NWD-2	BLUE RIVER	OR	NWP	NWD	OR00013
NWD-3	CHATFIELD DAM	CO	NWO	NWD	CO01281
NWD-4	COTTAGE GROVE	OR	NWP	NWD	OR00005
NWD-6	FERN RIDGE	OR	NWP	NWD	OR00016
NWD-7	HIRAM M. CHITTENDEN LOCKS & DAM	WA	NWS	NWD	WA00301
NWD-8	HOWARD A HANSON DAM	WA	NWS	NWD	WA00298
NWD-9	KANOPOLIS DAM	KS	NWK	NWD	KS00005
SAD-1	A.I.SELDEN	AL	SAM	SAD	AL01429
SAD-10	GEORGE W ANDREWS LOCK AND DAM	AL	SAM	SAD	AL01433
SAD-11	GLOVER WILKINS	**MS**	SAM	SAD	MS03059
SAD-12	JAMIE L WHITTEN LOCK AND DAM	**MS**	SAM	SAD	MS03605
SAD-13	JOHN C. STENNIS	MS	SAM	SAD	MS03056
SAD-14	JOHN RANKIN	**MS**	SAM	SAD	MS82201
SAD-15	LOCK AND DAM #1	**NC**	SAW	SAD	NC00182
SAD-16	LOCK AND DAM #2	**NC**	SAW	SAD	NC00205
SAD-18	STRUCTURE 78	**FL**	SAJ	SAD	FL00424
SAD-19	STRUCTURE 80	**FL**	SAJ	SAD	FL00425
SAD-2	ABERDEEN LK/DM (TENN-TOM, AL & MS)	MS	SAM	SAD	MS03057
SAD-20	WILLIAM BACON OLIVER REPLACEMENT	**AL**	SAM	SAD	AL01981
SAD-21	WILLIAM O. HUSKE LOCK & DAM	**NC**	SAW	SAD	NC00206
SAD-3	AMORY	**MS**	SAM	SAD	MS03058
SAD-4	B. EVERETT JORDAN DAM	**NC**	SAW	SAD	NC00173
SAD-5	CLAIBORNE LOCK AND DAM	AL	SAM	SAD	AL01436
SAD-6	COFFEEVILLE LOCK AND DAM	AL	SAM	SAD	AL01431
SAD-7	DEMOPOLIS LOCK AND DAM	AL	SAM	SAD	AL01430
SAD-8	FULTON	**MS**	SAM	SAD	MS03060
SAD-9	G.V. MONTGOMERY	**MS**	SAM	SAD	MS03604

ID	Plant	State	District	Division	NID ID #
SPD-1	ALAMO DAM	**AZ**	SPL	SPD	AZ82203
SPD-10	SANTA ROSA DAM	**NM**	SPA	SPD	NM00158
SPD-11	TRINIDAD	**CO**	SPA	SPD	CO00050
SPD-2	BUCHANAN DAM	**CA**	SPK	SPD	CA10243
SPD-3	COCHITI LAKE	**NM**	SPA	SPD	NM00404
SPD-4	CONCHAS DAM	**NM**	SPA	SPD	NM00006
SPD-5	HIDDEN DAM	**CA**	SPK	SPD	CA10244
SPD-6	JEMEZ CANYON DAM	**NM**	SPA	SPD	NM00003
SPD-7	JOHN MARTIN DAM & RESERVOIR	**CO**	SPA	SPD	CO01283
SPD-8	NORTH FORK DAM	**CA**	SPK	SPD	CA10110
SPD-9	PAINTED ROCK DAM	**AZ**	SPL	SPD	AZ10002
SWD-1	BARDWELL LAKE	TX	SWF	SWD	TX00001
SWD-10	DAVID D. TERRY LOCK & DAM	AR	SWL	SWD	AR00172
SWD-11	DEQUEEN	AR	SWL	SWD	AR01201
SWD-12	EMMETT SANDERS LOCK & DAM	AR	SWL	SWD	AR00167
SWD-13	FALL RIVER LAKE	KS	SWT	SWD	KS00003
SWD-14	FERRELLS BRIDGE DAM	TX	SWF	SWD	TX00020
SWD-15	GILLHAM	AR	SWL	SWD	AR01200
SWD-16	GRANGER DAM AND LAKE	TX	SWF	SWD	TX08005
SWD-17	GRAPEVINE LAKE	TX	SWF	SWD	TX00005
SWD-18	GREAT SALT PLAINS LAKE	OK	SWT	SWD	OK10319
SWD-19	HULAH LAKE	OK	SWT	SWD	OK10312
SWD-2	BELTON LAKE	TX	SWF	SWD	TX00002
SWD-20	JOE HARDIN LOCK & DAM	AR	SWL	SWD	AR00168
SWD-21	JOE POOL LAKE	TX	SWF	SWD	TX08007
SWD-22	JOHN REDMOND LAKE	KS	SWT	SWD	KS00004
SWD-23	LAVON LAKE	TX	SWF	SWD	TX00007
SWD-24	MILLWOOD DAM	AR	SWL	SWD	AR00536
SWD-25	MONTGOMERY POINT LOCK & DAM	AR	SWL	SWD	AR01545
SWD-26	NAVARRO MILLS LAKE	TX	SWF	SWD	TX00009
SWD-27	NEWT GRAHAM LOCK AND DAM	OK	SWT	SWD	OK10302
SWD-28	NIMROD	AR	SWL	SWD	AR00158
SWD-29	NORTH SAN GABRIEL DAM	TX	SWF	SWD	TX08006
SWD-3	BENBROOK LAKE	TX	SWF	SWD	TX00003
SWD-30	OOLOGAH LAKE	OK	SWT	SWD	OK10310
SWD-31	PINE CREEK LAKE	OK	SWT	SWD	OK10306
SWD-32	PROCTOR LAKE	TX	SWF	SWD	TX00010
SWD-33	SKIATOOK LAKE	OK	SWT	SWD	OK00037
SWD-34	STILLHOUSE-HOLLOW DAM	TX	SWF	SWD	TX00014
SWD-35	TOAD SUCK FERRY LOCK & DAM	AR	SWL	SWD	AR00170
SWD-36	TORONTO LAKE	KS	SWT	SWD	KS00011
SWD-37	W.D.MAYO LOCK AND DAM	OK	SWT	SWD	OK10305
SWD-38	WACO LAKE	TX	SWF	SWD	TX00016
SWD-39	WISTER LAKE	OK	SWT	SWD	OK10315
SWD-4	BLUE MOUNTAIN	AR	SWL	SWD	AR00157

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SWD-40	WRIGHT PATMAN DAM AND LAKE	TX	SWF	SWD	TX00021
SWD-5	CANTON LAKE	OK	SWT	SWD	OK10316
SWD-6	CHOUTEAU LOCK AND DAM	OK	SWT	SWD	OK10303
SWD-7	CLEARWATER DAM	MO	SWL	SWD	MO30203
SWD-8	COL CHARLES D. MAYNARD LOCK AND DAM	AR	SWL	SWD	AR00166
SWD-9	COPAN LAKE	OK	SWT	SWD	OK21489