NATIONAL ENERGY TECHNOLOGY LABORATORY

Impact of Drought on U.S. Steam Electric Power Plant Cooling Water Intakes and Related Water Resource Management Issues

April 2009

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Colorado River Commission of Nevada
Columbia River Gorge Commission
Delaware River Basin Commission
Edison Electric Institute
Electric Power Research Institute
Great Lakes Basin Compact
Interstate Commission on the Potomac River Basin
Interstate Council on Water Policy
Northwest Power and Conservation Council
Ohio River Valley Water Sanitation Commission
Susquehanna River Basin Commission
Tennessee Valley Authority
Upper Colorado River Commission
Utility Water Act Group
Washington State Conservation Commission
Western States Water Council

Chapter 1 – Introduction

Extent of the Problem

This report was funded by the U.S. Department of Energy's (DOE's) National Energy Technology Laboratory (NETL) Existing Plants Research Program, which has an energy-water research effort that focuses on water use at power plants. This study complements their overall research effort by evaluating water availability at power plants under drought conditions.

According to the National Drought Policy Commission, which was established in July 1998 when the 105th Congress enacted the National Drought Policy Act (Public Law 105-199), drought will occur at some time every year in the United States and can and does extend over long periods of time and across large geographical areas (NDPC 2000). Drought can also be more localized in nature, affecting smaller areas over shorter periods of time. Examination of the U.S. Drought Monitor archive, a program funded by several federal agencies and operated by the University of Nebraska-Lincoln (http://drought.unl.edu/DM/MONITOR.HTML), confirms this. Examination of historical records within the archives of the Drought Monitor reveals that there really is no time when some area within the United States is not experiencing at least some level of drought. Figure 1 shows the drought conditions across the United States as of January 6, 2008.

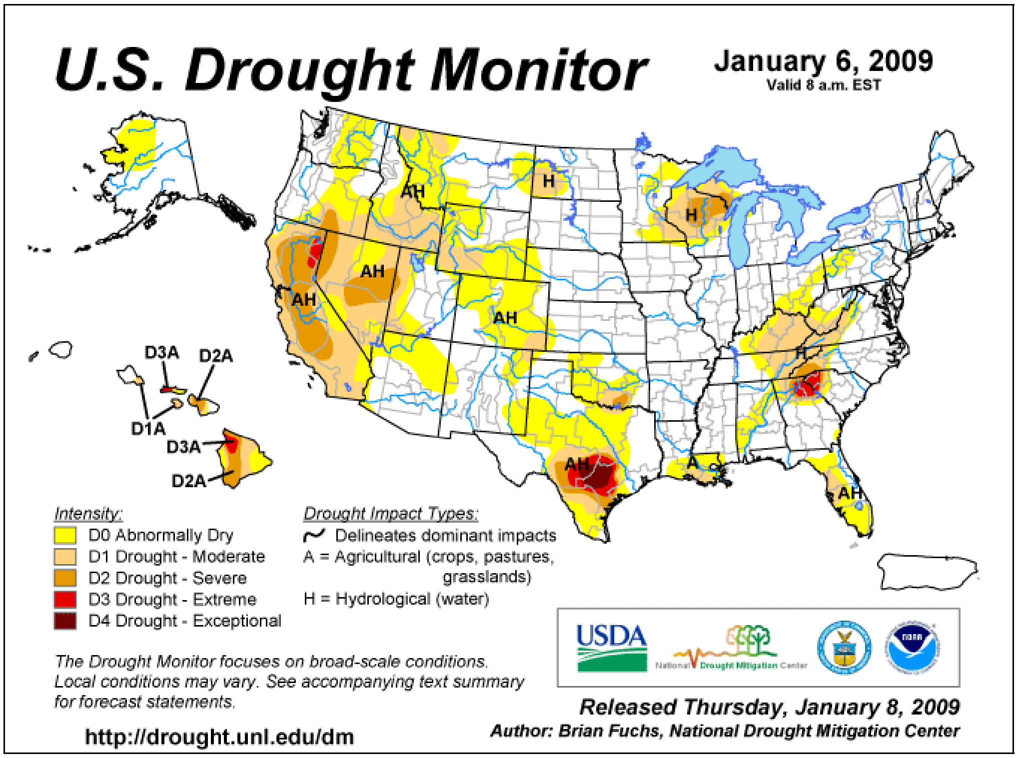


Figure 1 – Recent National Report from the U.S. Drought Monitor (Source: http://drought.unl.edu/DM/MONITOR.HTML)

During the summer and fall of 2007, a serious drought affected the southeastern United States. As shown in Figure 1, a part of this area of the country is still experiencing extreme drought. In 2007, river flows in the southeast decreased, and water levels in lakes and reservoirs dropped. In some cases, water levels were so low that power production at some power plants had to be stopped or reduced. The problem for power plants becomes acute when river, lake, or reservoir water levels fall near or below the level of the water intakes used for drawing water for cooling. A related problem occurs when the temperature of the surface water increases to the point where the water can no longer be used for cooling. In this case, the concern is with discharge of heated water used for cooling back into waterways that are just too warm to keep temperatures at levels required to meet state water quality standards. Permits issued under the Clean Water Act (CWA) National Pollutant Discharge Elimination System (NPDES) program limit power plants from discharging overly heated water. For example, the Tennessee Valley Authority (TVA) Gallatin Fossil Plant is not permitted to discharge water used for cooling back into the Cumberland River that is higher than 90ºF (WSMV Nashville 2007).

The southeast experienced particularly acute drought conditions in August 2007. As a result, nuclear and coal-fired plants within the TVA system were forced to shut down some reactors (e.g., the Browns Ferry facility in August 2007) and curtail operations at others. This problem has not been limited to the 2007 drought in the southeastern United States. A similar situation occurred in August 2006 along the Mississippi River (Exelon Quad Cities Illinois plant). Other plants in Illinois and some in Minnesota were also affected (Union of Concerned Scientists 2007). Given the current prolonged drought being experienced in the western United States (see also Figure 1), and also the scarcity of water resources in this region in general, many western utilities and power authorities are also beginning to examine the issue. The problem has also been experienced in Europe as well. During a serious drought in 2003, France was forced to reduce operations at many of its nuclear power plants (Union of Concerned Scientists 2007).

Meeting Cooling Water Demands in a Water-Constrained Environment

Situations of extreme drought, in addition to being associated with prolonged lower precipitation, are often accompanied by excessively high temperatures. Demand for power during these times, for example, for use in air conditioning, is very high. If power plants reduce or close down operations, electricity can usually be obtained from other generators through the grid; however, the cost of power in this situation will also increase. During the summer of 2007, TVA could not generate as much power as was needed, so additional electricity was purchased on the market, at higher cost than could be generated within the TVA system. These costs were passed on to consumers (WSMV Nashville 2007).

In addition to the utilities and power plants, there are a number of other competing users for water. Cities and municipalities draw water for use by the general population. For example, about 15 million people use water from the Delaware River Basin for household and industrial purposes. In addition to the Philadelphia, Pennsylvania, area, about seven million people from New York and northern New Jersey also rely on the Delaware River Basin for drinking water. New York City itself draws about half of its water from three of the large reservoirs located within the Delaware River Basin (DRBC 2007).

The Delaware River also is used for industrial water supply and irrigation. An additional concern, especially during drought conditions, is that enough water be maintained in water systems to support the local water system ecology. Recreational water use for boaters and fishermen has also entered into the equation, as has uses of the primary river systems in the United States for commercial navigation. One of the most long-standing disputes involving these issues has involved the Klamath River Basin in southern Oregon and northern California. The ongoing drought in this area has aggravated the problems of “too many users for too little water,” causing tensions between farmers, fishermen, and Indian tribes over water in the Klamath Basin of southern Oregon for a number of years. Many news stories and Internet articles can be found on this subject. The National Academies of Science National Research Council (NRC) has also published a number of reports on this subject (NRC 2008).

It is likely that in coming years competing water demands will increase across the United States. It is also possible, considering global warming, that climatic conditions will become warmer or at least more variable, thereby exacerbating future droughts and additional conflicts over competing uses. This is one of the primary themes outlined in a recent report of the Interstate Council of Water Policy (ICWP) (ICWP 2006), and in similar reports, such as one issued by the U.S. General Accounting Office (now the U.S. Government Accountability Office) (GAO) in 2003 (GAO 2003).

Purpose and Structure of the Report

While there are a number of competing demands on water uses, particularly during drought conditions, this report focuses solely on impacts to the U.S. steam electric power plant fleet. Included are both fossil-fuel and nuclear power plants. One plant examined also uses biomass as a fuel.

The purpose of this project is to estimate the impact on generation capacity of a drop in water level at U.S. steam electric power plants due to climatic or other conditions. While, as indicated above, the temperature of the water can impact decisions to halt or curtail power plant operations, this report specifically examines impacts as a result of a drop in water levels below power plant submerged cooling water intakes. Impacts due to the combined effects of excessive temperatures of the returned cooling water and elevated temperatures of receiving waters (due to high ambient temperatures associated with drought) may be examined in a subsequent study.

For this study, the sources of cooling water used by the U.S. steam electric power plant fleet were examined. This effort entailed development of a database of power plants and cooling water intake locations and depths for those plants that use surface water as a source of cooling water. Development of the database and its general characteristics are described in Chapter 2 of this report. Examination of the database gives an indication of how low water levels can drop before cooling water intakes cease to function. Water level drops are evaluated against a number of different power plant characteristics, such as the nature of the water source (river vs. lake or reservoir) and type of plant (nuclear vs. fossil fuel). This is accomplished in Chapter 3.

In Chapter 4, the nature of any compacts or agreements that give priority to users (i.e., which users must stop withdrawing water first) is examined. This is examined on a regional or watershed basis, specifically for western water rights, and also as a function of federal and state water management programs.

Chapter 5 presents the findings and conclusions of this study.

In addition to the above, a related intent of this study is to conduct preliminary modeling of how lowered surface water levels could affect generating capacity and other factors at different regional power plants. If utility managers are forced to take some units out of service or reduce plant outputs, the fuel mix at the remaining plants and the resulting carbon dioxide emissions may change. Electricity costs and other factors may also be impacted. Argonne has conducted some modeling based on the information presented in the database described in Chapter 2 of this report. A separate report of the modeling effort has been prepared (Poch et al. 2009). In addition to the U.S. steam electric power plant fleet, this modeling also includes an evaluation of power production of hydroelectric facilities. The focus of this modeling is on those power plants located in the western United States.

Chapter 2 – Database of Power Plants and Cooling Water Intakes

In order to conduct the above analyses, one of the most important pieces of information that was needed was identification of the various plants nationwide that make up the U.S. steam electric power plant fleet, including both those that use fossil fuels and those that employ nuclear power. Many other data inputs were also critical data to the analysis. The key data needed were as follows:

- Plant name
- Plant state
- Plant location (latitude/longitude)
- Utility name
- Nameplate rating (e.g., generating capacity, preferably in megawatts)
- Plant status (e.g., operating, out-of-service, standby)
- Fuel type (e.g., coal, oil, natural gas, biomass, nuclear)
- Cooling identification (intake)
- Cooling type (e.g., once through, closed cycle, combination)
- Rate of withdrawal (from the cooling intake)
- Rate of discharge (to the receiving water body)
- Rate of consumption (water used during the process)
- Cooling water source (e.g., river, reservoir)
- Intake depth below surface (from normal flow or pool)
- Intake distance from shoreline (at normal flow or pool)
- Intake rate (at 100% generation)

Data Sources

The Department of Energy's (DOE) Energy Information Administration (EIA) is one source of much of this information. EIA has been collecting the type of information referred to above annually since 1949 and accumulating it in a database commonly referred to as "the 767 database." The EIA-767 form was used by the EIA to collect the information annually through 2005 from all U.S. plants with a total existing or planned organic-fueled or combustible renewable steam-electric unit that has a generator nameplate rating of 10 megawatts or larger (EIA 2005a). The EIA-767 form was replaced in 2007 by two new forms (EIA-860 and EIA-923).

At the time this report was prepared, the most recent year of available EIA data was 2005; this was used to develop the project database. The 2005 EIA-767 form does not include information on nuclear plants. The last year in which that form contained nuclear plant data was 2000. Therefore, for the nuclear plants, data were obtained from the 2000 EIA-767 form data collection effort (EIA 2000).

The EIA-767 data are used for economic analyses conducted by DOE. The data collected on this form are used to monitor the current status and trends in the electric power industry and to evaluate the future of the industry. The data are also used in preparing the *Electric Power Annual* (EIA, prepared annually) and the *Annual Energy Review* (EIA, prepared annually).

Following data analysis and filtering (see below), the EIA data were provided to the Edison Electric Institute, the Electric Power Research Institute, and the Utility Water Act Group in an attempt to identify any errors and to update the information. Several adjustments were made to the database as a result of the above contacts. In addition, as part of the effort to examine legal issues and agreements affecting water availability during droughts (Chapter 4), a number of different types of water authorities (compacts, commissions, councils, and state programs) representing different regions and watersheds nationwide were contacted for information. Several of these contacts led to additional refinement of the database. For example, in one case, a power plant that had been decommissioned between 2005 and the present was removed from further consideration.

Data Analysis and Filtering

The data collected through EIA's 767 form are maintained in a series of database files that focus on specific data elements, such as general plant information, boiler generator, and boiler cooling intakes. Each file is organized differently, but the common identifier in each file is a utility and plant code. These codes were used to extract needed data elements from each file and then combine them all into a project database, created using Microsoft Excel®, containing all of the data elements needed for this study.

Many of the power plants employ multiple boilers and multiple cooling water intakes. Typically, there is an intake for each boiler. The project database included a separate row for each boiler and for each cooling intake, which then needed to be combined so that each cooling water intake was paired with the correct boiler. This data compilation was conducted for every power plant included in the 767 system, including both the fossil fuel/biomass systems (2005) and the nuclear systems (2000). The resulting project database therefore often included multiple entries for each power plant. Including multiple boilers and cooling intakes for each power plant, the initial project database included 1,338 entries (rows).

In order to make the database more representative and useful for the purpose of the study, it was necessary to apply several types of filtering to remove incomplete or non-applicable data. For example, in the process of extracting the needed information from each file and creating the project database, it became apparent that each utility, and sometimes each power plant within each utility, entered information into the EIA data submittal differently. Interpretation of the entered data was frequently necessary. In many cases, data were missing, and, in some cases, it was difficult to determine an exact match between cooling intakes and the boiler. Where the validity of the data entry was in question, we chose to exclude the power plant (or, in some cases, just one or more cooling intake/boiler from the power plant) from further analysis.

In addition, the project database was further refined by removing those plants that draw cooling water from non-surface water supplies (e.g., wastewater systems, ground water), since the focus of the study was on drought and surface waters. Although droughts can affect ground water elevation levels, we were not able to take that into account; therefore, the project database was limited to just those plants that withdraw surface waters for cooling. In addition, the database was further refined by removing those plants that draw their cooling water from tidal zones (saline water). During drought, the levels of tidal waters are unaffected or minimally affected. In addition, considering the affects of global warming, melting of glaciers and ice caps will likely result in an increase of water level. The increase in water level in tidal areas associated with global warming presents a different type of problem for power plants located in coastal areas; however, this issue is not further evaluated in this report.

Finally, the most critical data needed for the study were the depths of the submerged water intakes. If this data was missing for a particular intake, the database was further revised by removing the intake (and sometimes an entire power plant).

Database Description

After the filtering described above, the final project database, still containing individual data for each intake/boiler combination, was reduced to a total of 829 entries (rows). After combining intake/boiler information from each power plant into one data entry (row) for each power plant in the project database, the database covered 423 power plants. Figure 2 shows the approximate location of each power plant using latitude/longitude information and a geographic information system (GIS) program.

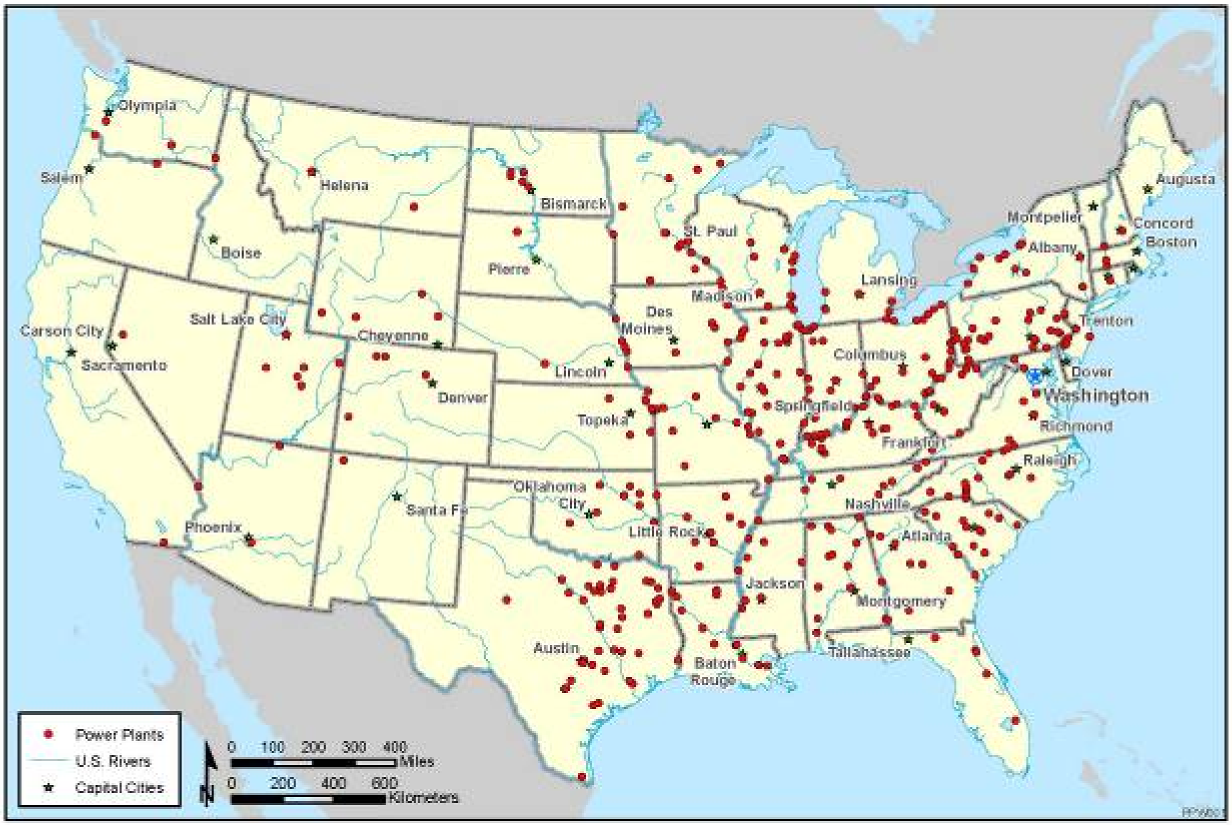


Figure 2 – Distribution of Power Plants Included in Project Database Nationwide

Overall, the database consists of the following:

- 423 total power plants
- Power plants in 44 states
- 293 power plants that draw cooling water from rivers (including creeks and canals)
- 130 power plants that draw cooling water from lakes or reservoirs (includes some cooling ponds)
- 257 coal-fired power plants
- 105 natural gas-fired power plants
- 46 nuclear power plants
- 9 fuel oil-fired power plants
- 1 combination fuel oil/natural gas power plant
- 1 biomass power plant
- 4 power plants where the fuel was unspecified

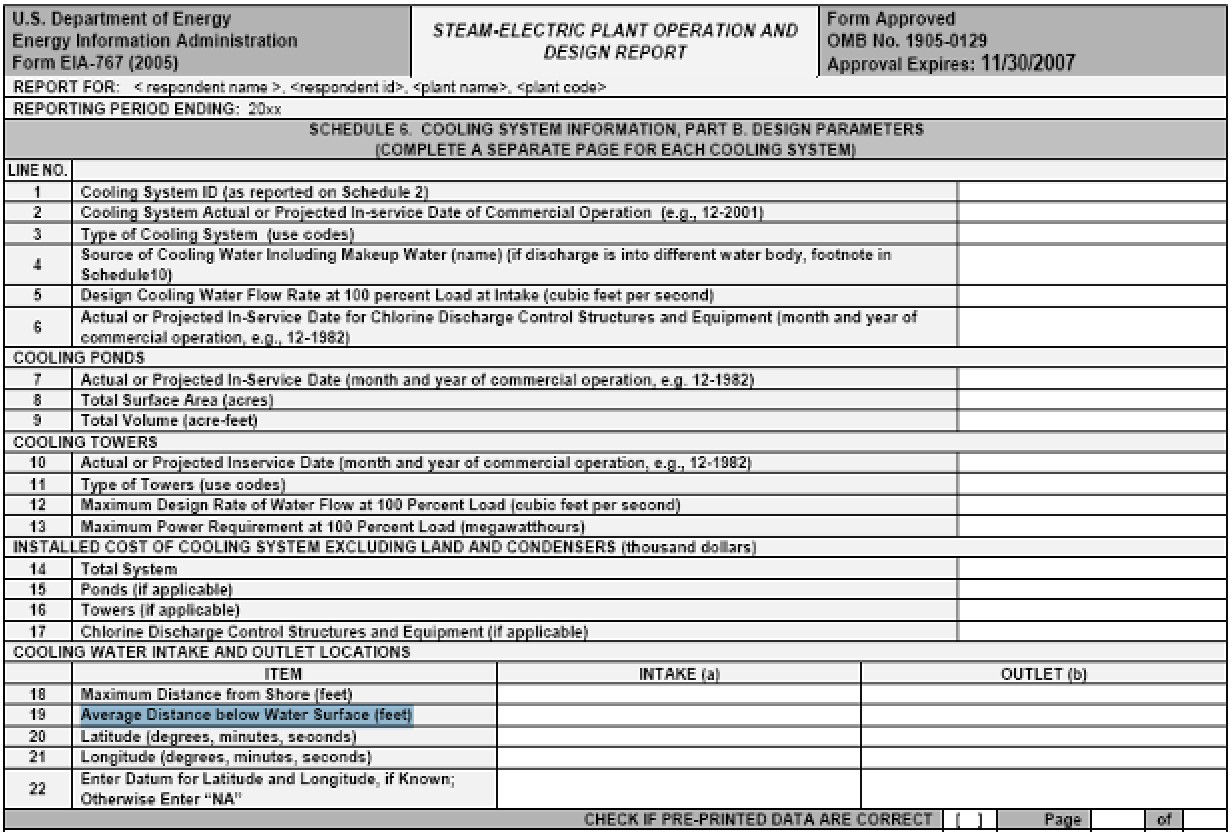
The resulting database of the 423 power plants, showing selected fields, is presented as Appendix A to this report. Appendix B provides a list of power plants filtered out, showing the reason for excluding each power plant. In total, 193 plants were removed.

Database Assumptions

As indicated above under "Data Sources," the 767 database was populated by individual utilities and power plants. Many times, data were entered differently by each utility and power plant, often requiring some interpretation. Also as indicated above, the project database created for the purpose of this study was provided to select industrial and utility associates for review, and in the process of doing this, a number of errors in the database were identified and corrected. On the positive side, few errors overall were found, and many of the errors dealt with utility and power plant names and owners. The most critical data for this analysis is the depth of the submerged intakes and distance from the shoreline, and there was only one instance where a power plant identified an error in intake depth.

One very important caveat to the data used in our project database is that we have no way to verify if the original data were entered correctly into the EIA-767 form. The EIA-767 form contains only minimal guidance for supplying data (see Figure 3 below, specifically line 19 on page 11 of the actual 2005 form — the only advice provided was to enter the data as feet). Overall, the separate instructions provided by EIA to those persons or companies completing the EIA-767 form were not particularly helpful for most of the cooling water data fields. For example, the only instructions given for the most relevant piece of data, the depth of the intake, are included in the following:

> *For lines 18 through 21, if the cooling system is a zero discharge type (RC, RF, RI, RN), do not complete column (b). The intake and the outlet are the points where the cooling system meets the source of cooling water found on line 4. For all longitude and latitude coordinates, please provide degrees, minutes, and seconds.*



U.S. Department of Energy
Energy Information Administration
Form EIA-767 (2005)

STEAM-ELECTRIC PLANT OPERATION AND DESIGN REPORT

Form Approved
OMB No. 1905-0129
Approval Expires: 11/30/2007

REPORT FOR: < respondent name >, <respondent id>, <plant name>, <plant code>

REPORTING PERIOD ENDING: 20xx

SCHEDULE 6. COOLING SYSTEM INFORMATION, PART B. DESIGN PARAMETERS
(COMPLETE A SEPARATE PAGE FOR EACH COOLING SYSTEM)

LINE NO.		
1	Cooling System ID (as reported on Schedule 2)	
2	Cooling System Actual or Projected In-service Date of Commercial Operation (e.g., 12-2001)	
3	Type of Cooling System (use codes)	
4	Source of Cooling Water Including Makeup Water (name) (if discharge is into different water body, footnote in Schedule10)	
5	Design Cooling Water Flow Rate at 100 percent Load at Intake (cubic feet per second)	
6	Actual or Projected In-Service Date for Chlorine Discharge Control Structures and Equipment (month and year of commercial operation, e.g., 12-1982)	
COOLING PONDS		
7	Actual or Projected In-Service Date (month and year of commercial operation, e.g. 12-1982)	
8	Total Surface Area (acres)	
9	Total Volume (acre-feet)	
COOLING TOWERS		
10	Actual or Projected Inservice Date (month and year of commercial operation, e.g., 12-1982)	
11	Type of Towers (use codes)	
12	Maximum Design Rate of Water Flow at 100 Percent Load (cubic feet per second)	
13	Maximum Power Requirement at 100 Percent Load (megawatthours)	
INSTALLED COST OF COOLING SYSTEM EXCLUDING LAND AND CONDENSERS (thousand dollars)		
14	Total System	
15	Ponds (if applicable)	
16	Towers (if applicable)	
17	Chlorine Discharge Control Structures and Equipment (if applicable)	

COOLING WATER INTAKE AND OUTLET LOCATIONS

	ITEM	INTAKE (a)	OUTLET (b)
18	Maximum Distance from Shore (feet)		
19	Average Distance below Water Surface (feet)		
20	Latitude (degrees, minutes, seconds)		
21	Longitude (degrees, minutes, seconds)		
22	Enter Datum for Latitude and Longitude, if Known; Otherwise Enter "NA"		

CHECK IF PRE-PRINTED DATA ARE CORRECT [ ] Page of

Figure 3 – Page 11 from the 2005 EIA-767 Form (Source: EIA 2005b)

In addition, nothing in the 767 form instructions is mentioned about how to select the surface water elevation baseline from which the depth of the intake is measured. For example, a plant located on a large river could use the elevation of the surface water resulting from long-term average flow, or could take a maximum or minimum elevation. A second source of variation is where on the intake structure the depth of the intake is measured. Most power plants have very large intake structures or pipes that typically are several feet in diameter. In order to express the depth of the intake below the surface, a utility respondent could select the top of the intake, the bottom of the intake, or a midpoint value. Similarly, no guidance is provided in the form on how to determine distance from shore. For example, distance could be measured from the intake to the shoreline, from the intake to the power plant property line, or even to the point where the cooling water enters the power plant.

No space is allocated on the form for providing comments on how data were derived. Without detailed guidance from EIA, a range of baseline elevations and distance from shore is possible. We have no way of determining which points of reference were used to measure the entered values. Therefore, we must rely on the actual numbers entered in the database as our only source of information addressing intake depth and distance from shore. We make no assumption regarding the basis for the measurements and must accept the values as provided.

The database for fossil fuels represents data collected in 2005, and the database for nuclear plants represents data collected in 2000. An additional assumption has to be that the data collected in

2005 (for fossil fuel plants) and in 2000 (for nuclear plants) are still relevant in 2009. Since few changes in power plant operation and design have taken place in the last few years, the assumption that the data collected are reflective of conditions today is believed to be valid.

An additional consideration regarding the above assumptions is that, in general, the intent of this report is not to identify concerns for individual power plants or even power plants in regional locations. The intent, rather, is to identify trends in intake depth below the water surface and intake distance from the shoreline, and to determine whether there may be a concern regarding a reduction in electrical generation capacity during droughts. Our assumption is that the project database is adequate for this purpose.

Chapter 3 – Database Evaluation

In this chapter, the database is examined to give an indication of how low water levels can drop before a cooling water intakes cease to function. Distance of the intake from the shoreline is also evaluated because of the inferred relationship between that metric and intake water quality and temperature. We assume the closer the intake is to the shoreline the greater the potential for degraded water quality and impaired cooling capability. Although a water level decline may not result in the water falling below the level of the intake, a water decline can result in the shoreline being much closer to the intake, causing higher intake temperatures and suspended solids content, which may impact the ability of the power plant to use the water effectively for cooling.

The distance of the intakes from the shoreline and intake depth are evaluated separately below. Distance and depth are evaluated against a number of different power plant characteristics, such as the nature of the water source (i.e., river vs. lake or reservoir) and the type of plant (nuclear vs. fossil fuel). Case examples are then discussed that examine issues for a water body that supports multiple power plants.

It should be noted that many river and reservoir systems can be operated by effective use of dams so as to maximize certain uses, such as maintaining navigation channels, preserving ecosystem health, and enabling continued power plant operations – even during drought. Priority uses of water during drought are evaluated in Chapter 4. Given the time and budget constraints for this study, we were not able to evaluate whether water levels are actively managed on a water body by water body basis. Therefore, our assumption for the analyses below is that water levels are not managed so as to enable continued power plant operations.

Evaluation of Intake Distance from Shore

While the project database contained many data points for each power plant on the depth of the intakes from the water surface, there were far fewer data presented for intake distance from the shoreline. Of the total of nine oil-fired plants, data on intake distance from shore were presented for only four of the plants (1, 25, 660, and 850 feet). For the one oil/gas combination plant in the database, no data were provided for intake distance from shore. In addition, there were four plants in the project database that did not show the fuel source; for these plants, only one data point was provided for intake distance from shore (20 feet). For the remaining plants, less than half provided data on intake distance from shore.

The data provided regarding intake distance from shore are examined in this report in five data ranges, as follows:

- 0 ft
- 1 to 10 ft
- 11 to 100 ft
- 101 to 1,000 ft
- Greater than 1,000 ft

These data ranges were determined as being the best manner of presentation from a visual examination of the data across all plants.

Many plants provided data on intake distance from shore as “0” feet. It is unknown whether the intakes were literally located at the shoreline, or whether the data were entered into the original EIA-767 database incorrectly. In addition, there were two instances where data on intake distance from shore showed distances greater than a mile (e.g., 7,920 and 8,000 ft). One possible explanation for power plants having intakes located far from shore may be the desire to draw water from locations where the water may be deeper and/or cooler than it would be if it were drawn from locations closer to shore. The reason for locating cooling intakes far from shore, however, was not examined as part of this study. The data are presented as provided and are assumed to be accurate.

Figures 4–8 below show the distribution of intake distance from shore for the above ranges in various categories. Figure 4 shows the distribution of intake distance from shore for all of the power plants where these data were provided. Figure 5 shows the distribution only for coal-fired power plants. Figure 6 shows the distribution for natural gas-fired plants. Figure 7 shows the

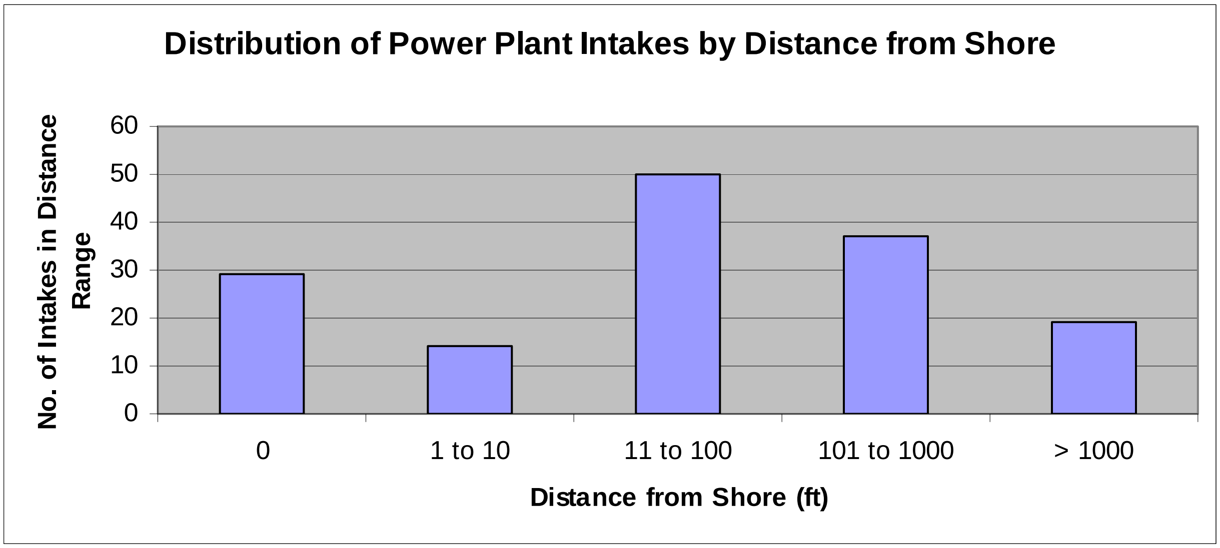


Figure 4 – Distribution of Power Plant Intakes by Distance from Shore for All Power Plants

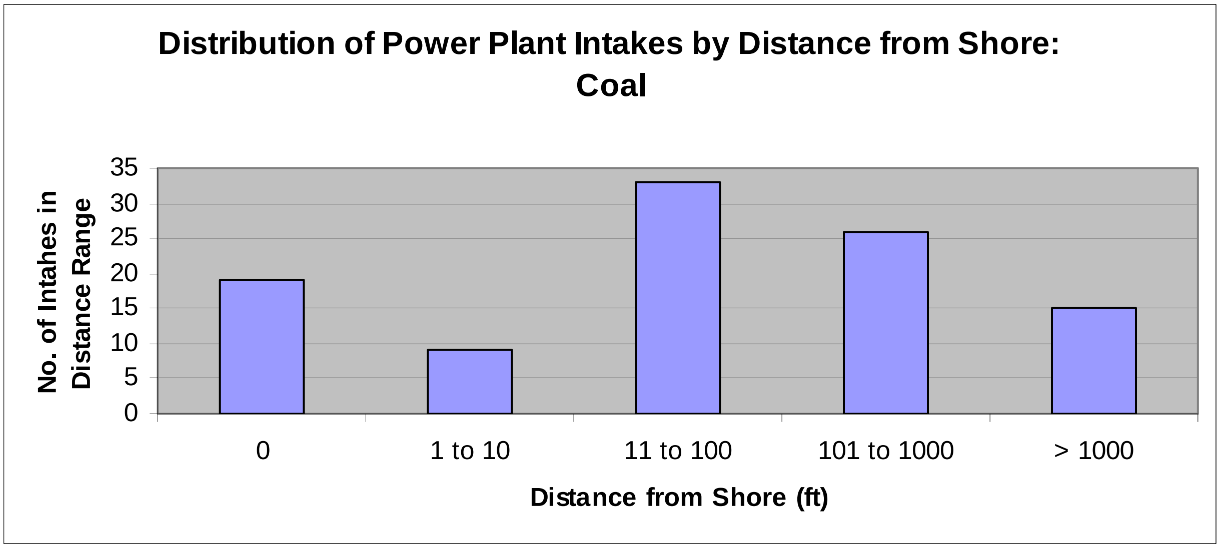


Figure 5 – Distribution of Power Plant Intakes by Distance from Shore for Coal-Fired Power Pants

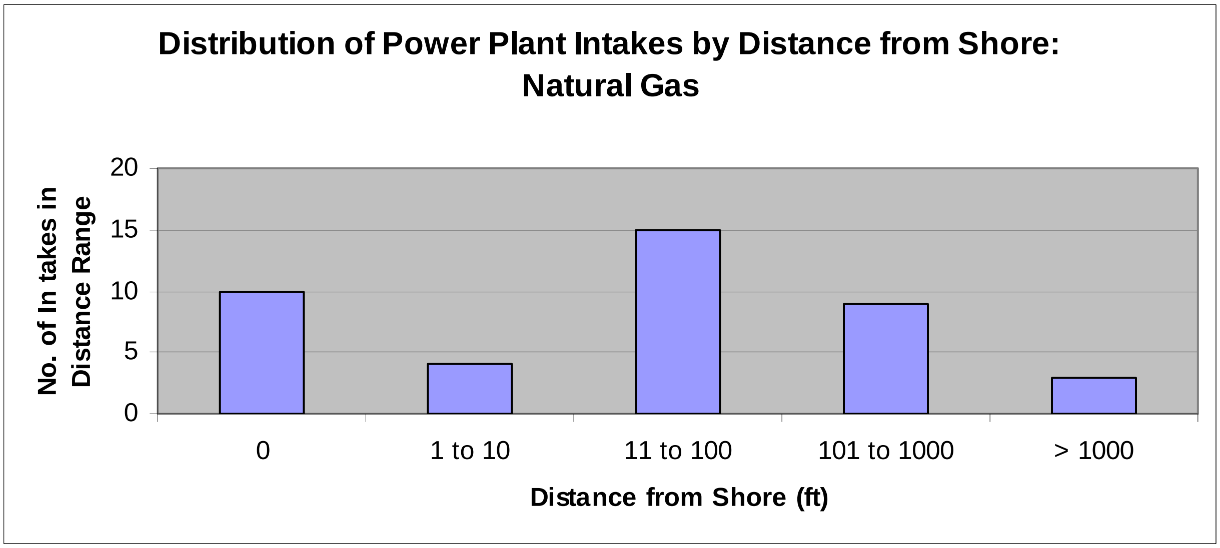


Figure 6 – Distribution of Power Plant Intakes by Distance from Shore for Natural Gas-Fired Power Pants

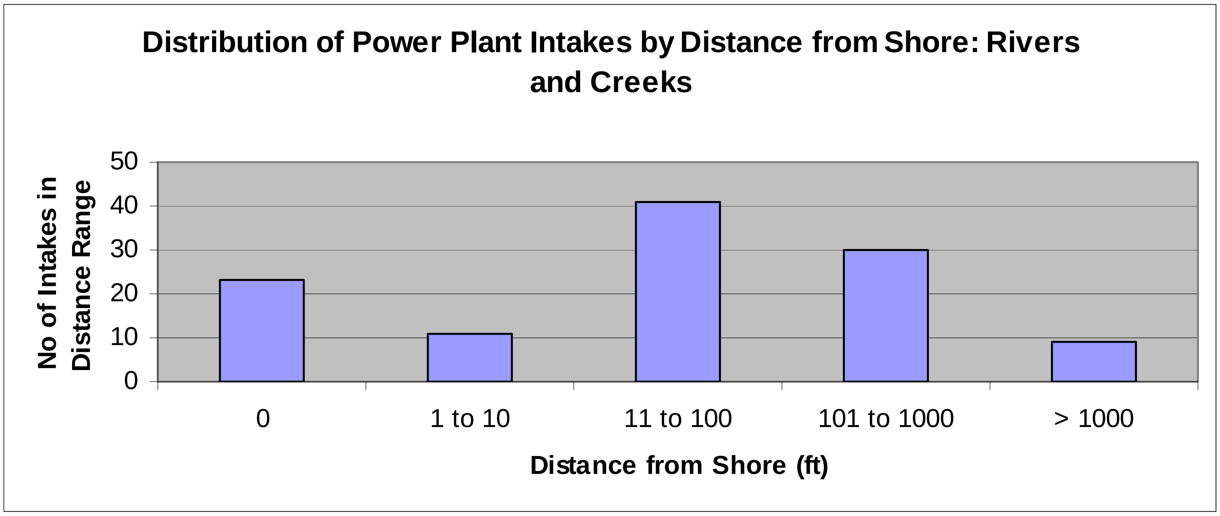


Figure 7 – Distribution of Power Plant Intakes by Distance from Shore for Power Plants Located on Rivers and Creeks

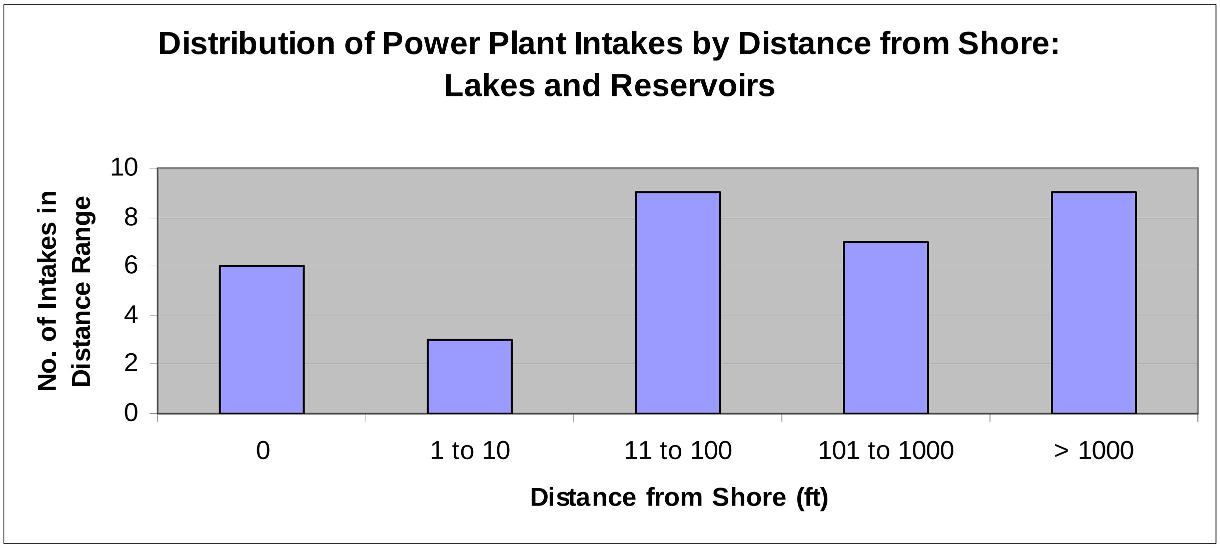


Figure 8 – Distribution of Power Plant Intakes by Distance from Shore for Power Plants Located on Lakes and Reservoirs

distribution for plants located on rivers and creeks. Figure 8 shows the distribution for plants located on lakes and reservoirs. Table 1 provides simple statistical information (range, mean, median, and standard deviation) for each of the above categories.

Table 1: Range, Mean, Median, and Standard Deviation for Intake Distance from Shore for All Categories (ft)

Power Plant Category	Data Range	Mean	Median	Standard Deviation
All	0 to 8,000	486	50	1,254
Coal	0 to 7,920	530	60	1,246
Gas	0 to 8,000	399	28	1,349
Rivers and Creeks	0 to 7,920	396	44	1,154
Lakes and Reservoirs	0 to 8,000	791	95	1,522

As indicated above, and as shown in the above figures, many power plants reported that their intakes were located right at the shoreline (0 feet). Most of the power plants that reported this information, however, show that their intakes are located quite a distance from the shoreline. More than half showed a distance of 50 ft or greater. Perhaps the most interesting trend, however, is that there does not seem to be a significant difference in inlet distance from shore among the power plants as a function of fuel source or water body type.

It is also interesting to examine means and medians for the data categories (Table 1). In every case, the mean is much higher than the median value, suggesting a highly skewed distribution, with most of the intake distances reported as being relatively close to shore. With a substantial number of intake distances reported at greater than 1,000 feet, and two reported at far greater than a mile, the average would be much higher than the median, as shown. The standard deviation also shows a high degree of variability in the data. In these circumstances, the median value is a much better representation of the “average” condition than the mean.

Evaluation of Intake Depth from Surface

The project database contained extensive information on the depth of the intakes from the water surface — overall, 423 power plants reported this information. The available data provide a representative picture of the various plants and the location of their intakes as a function of depth from the water surface.

The data provided regarding intake depth from the surface are examined in this report in thirteen data ranges, as follows:

- 0 ft
- 1 to 5 ft
- 6 to 10 ft
- 11 to 15 ft
- 16 to 20 ft
- 21 to 25 ft
- 26 to 30 ft

- 31 to 35 ft
- 36 to 40 ft
- 41 to 45 ft
- 46 to 50 ft
- 51 to 100 ft (note the difference in range for this category)
- Greater than 100 ft

These data ranges were determined as being the best manner of presentation from a visual examination of the data across all plants. In addition, since water level drops of even several feet can cause significant issues for some power plants, it was appropriate to present the data in tighter ranges than were presented for the data above on the distance from shore.

As shown in Figures 9–14, many plants provided data on intake depth as “0” feet. It is unknown whether the intakes were literally at the water surface for these plants, or whether the data were entered into the original EIA-767 database incorrectly. In addition, there are a number of instances where power plants reported intake depth in round numbers (e.g., 10 feet). In fact, the most commonly reported value for depth in every data category examined was 10 feet. It may be that there are many intakes where the depth is truly 10 feet, or there may be a number of cases where data were rounded or estimated as they were entered into the original EIA-767 database. The reason why many depths were reported as “0” and “10” feet was not examined as part of this study. The data are presented as provided and are assumed to be accurate for the purposes of this study.

Figure 9 below shows the distribution of intake depth from surface for all of the power plants where these data were provided. Figure 10 shows the distribution only for coal-fired and oil-fired power plants. Figure 11 shows the distribution for natural gas-fired plants. Figure 12 shows the distribution for nuclear plants. Figure 13 shows the distribution for plants located on rivers and creeks. Figure 14 shows the distribution for plants located on lakes and reservoirs. Table 2, following these figures, provides simple statistical information (range, mean, median, and standard deviation) for each of the above categories.

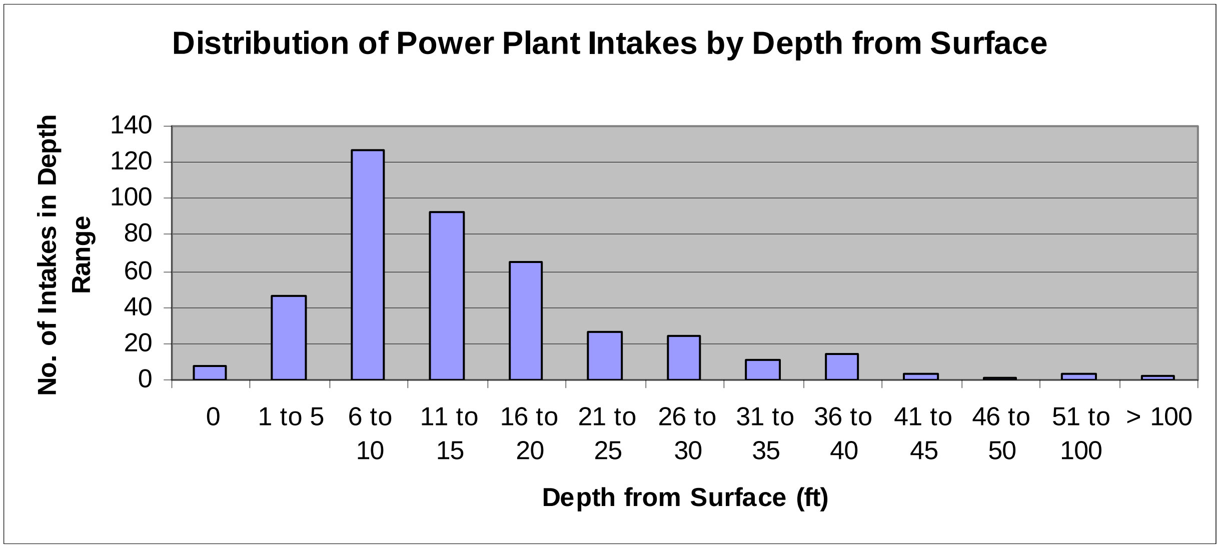


Figure 9 – Distribution of Power Plant Intakes by Depth from Surface for All Power Plants

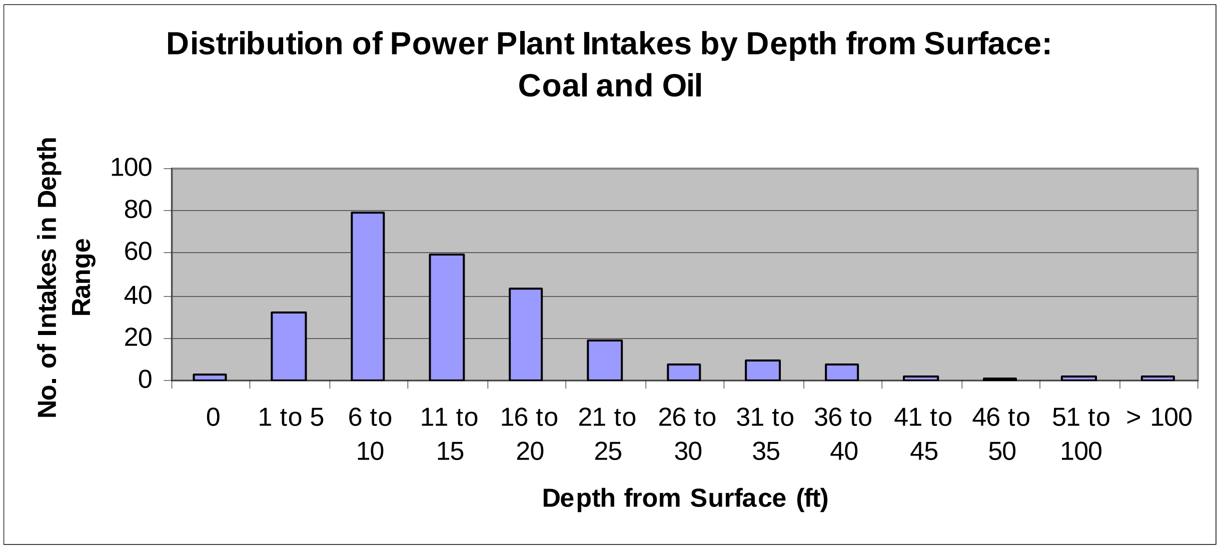


Figure 10 – Distribution of Power Plant Intakes by Depth from Surface for Coal-Fired and Oil-Fired Power Plants

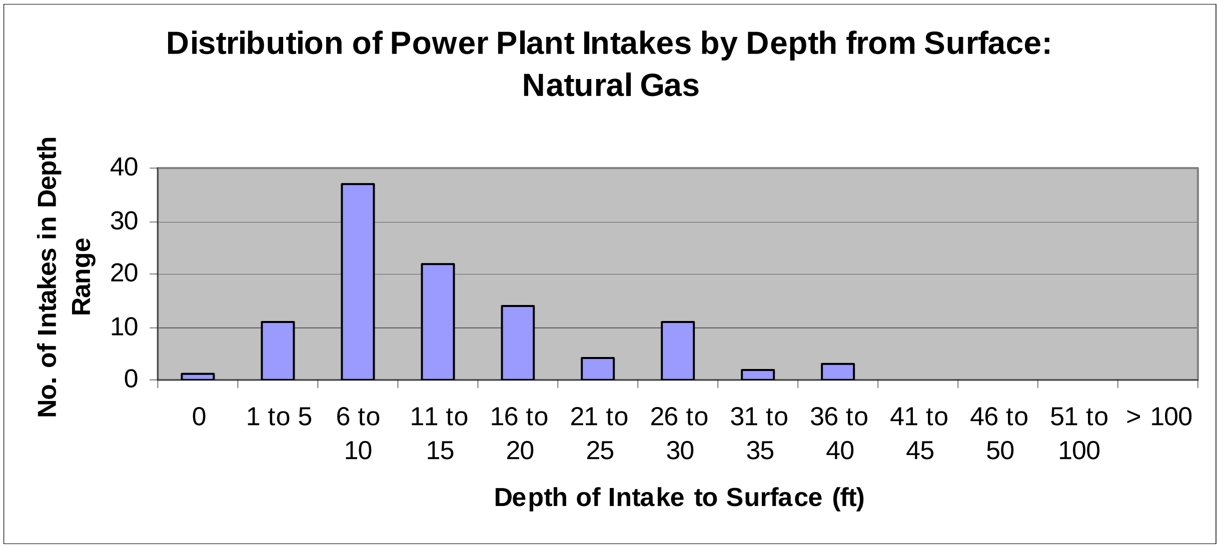


Figure 11 – Distribution of Power Plant Intakes by Depth from Surface for Natural Gas-Fired Power Plants

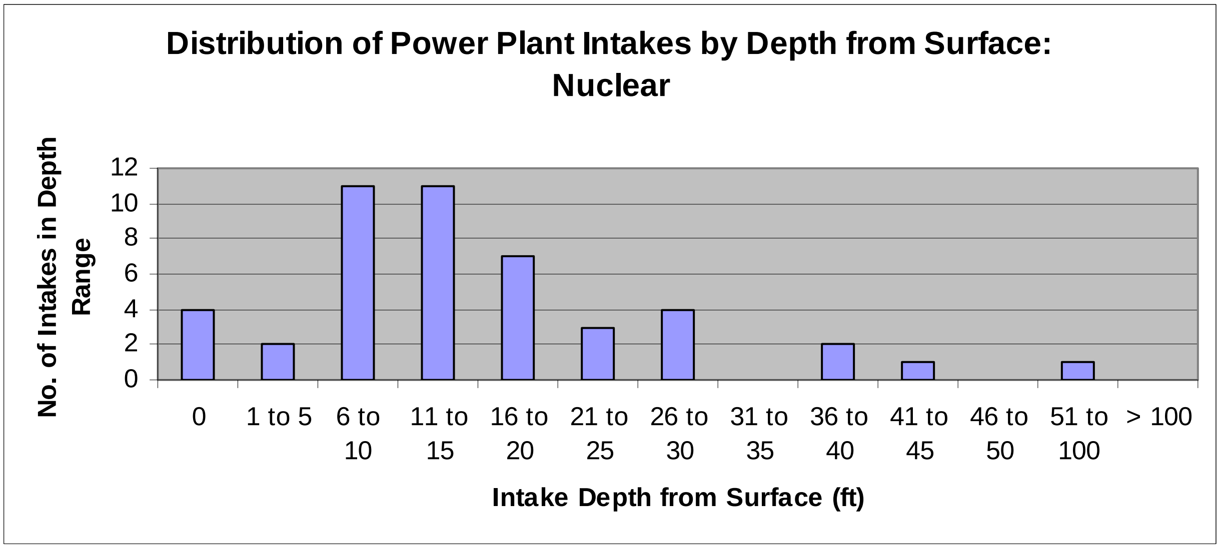


Figure 12 – Distribution of Power Plant Intakes by Depth from Surface for Nuclear Power Plants

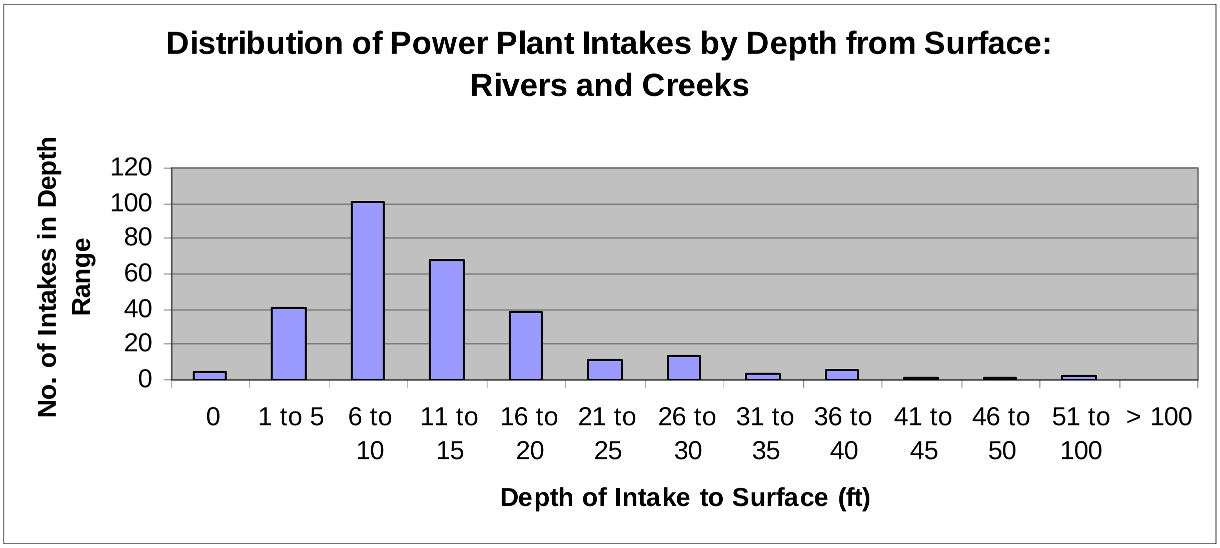


Figure 13 – Distribution of Power Plant Intakes by Depth from Surface for Power Plants Located on Rivers and Creeks

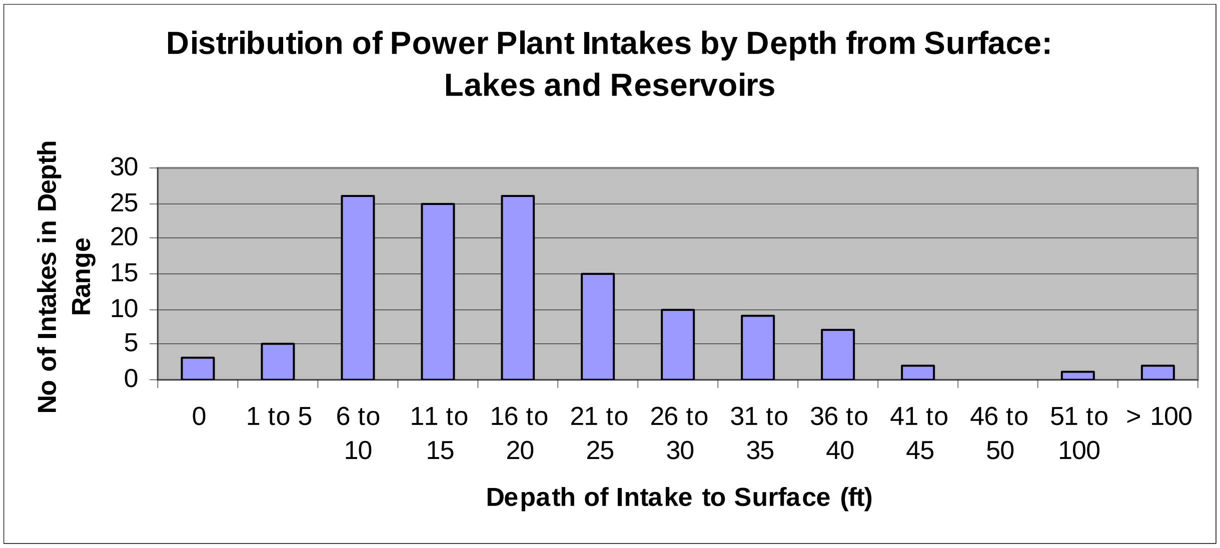


Figure 14 – Distribution of Power Plant Intakes by Depth from Surface for Power Plants Located on Lakes and Reservoirs

Table 2: Range, Mean, Median, and Standard Deviation for Intake Depth from Surface for All Categories (ft)

Power Plant Category	Data Range	Mean	Median	Standard Deviation
All	0 to 220	15.8	12	16.7
Coal and Oil	0 to 220	16.1	12	19.1
Gas	0 to 40	14.4	12	9.0
Nuclear	0 to 95	16.8	13.5	15.5
Rivers and Creeks	0 to 95	13.2	10	9.9
Lakes and Reservoirs	0 to 220	21.6	17	25.2

Evaluation of the above graphical distributions and the data in Table 2 reveals some interesting trends. Most interesting, as referred to above, is the number of power plants reporting 10 feet as their intake depth. In most cases, the differences in statistics for most of the categories are minor. There are only isolated cases where there may be a significant difference in trend. For example, the mean and median intake depth for lakes and reservoirs seems significantly deeper than for rivers and creeks. There is also significantly more variation for lakes and reservoirs as compared to rivers and creeks.

Examination of the median vs. the mean for the various categories, as well as the above graphics, suggests a highly skewed distribution, with the majority of power plant intakes being relatively shallow. What is strikingly significant for this study is the fact that there are a substantial number of power plants where the intakes are on the shallow side, with many located at a depth of 5 feet or less and many more located at a depth of 10 feet or less. Approximately 43% of the power plants overall have intakes at a depth of 10 feet or less, and 65% have intake depths at 15 feet or less. There are nevertheless a significant number of power plants, approximately 26%, with intake depths greater than 20 feet.

Case Examples for Multiple Plants on the Same Water Body

In this section, two example situations are examined with multiple power plants located on the same water body. As indicated at the beginning of this chapter, we assumed that water levels are not actively managed so as to enable preferred uses, such as continued power plant operations.

The Arkansas River supports five power plants (two coal and three natural gas). The power plants are operated in two states by three different utilities. The depth to surface for the intakes for these plants are 2 feet for one plant and 3 feet for another plant — the intakes for the other three plants are deeper than 20 feet. In this situation, the two plants with shallow intakes would be affected first by drought conditions; the remaining plants would be affected only by severe drought.

Another example can be found in the Delaware River, which supports five coal-fired power plants located in two states. The five plants are operated by five different utilities. The intake depths for the five plants are 6, 10, 11, 13, and 15 feet. All of these plants would be affected by a moderate to severe drought. With different utilities operating each plant, determinations of water withdrawal during droughts for cooling could become quite contentious.

Both of these examples assume that the drought conditions would affect surface water body levels equally throughout the portions of the basin in which the power plants are located. For a larger or longer water body, it is less likely that this assumption will be valid.

Clearly, the situation during drought and decisions regarding water withdrawal for cooling can become very difficult. In both of the above situations, it is necessary to also consider the other primary water users, including municipalities (drinking water), farmers (irrigation), navigation and industry. It is also necessary to consider projections for increasing demand into the future within these and other sectors. Water consumption for energy production itself (e.g., oil, gas, coal, and biofuels) is expected to increase dramatically over the next 25 years (Elcock 2008).

In addition, the ecological ramifications of lowered water levels and increasing withdrawals should be factored in. All of these issues can create a potential for the same types of water wars as witnessed for the Klamath River Basin. Competing uses on a regional and watershed basis are examined in the next chapter.

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Chapter 4 – Legal Issues and Agreements Affecting Water Availability

Overview

In July 2003, the GAO released a report describing issues on fresh water supply, where the focus was on identifying the views of the states on how the federal government could help them meet the challenges of expected water shortages (GAO 2003). As background for its report, the GAO found, through the results of a survey, that 36 states anticipated having to deal with issues relating to water shortages even under normal water conditions. This number increased to 46 states under drought conditions.

The GAO report found that the federal government has a limited role in dealing with water use, indicating that, in large part, the states are "primarily responsible for managing the allocation and use of freshwater supplies." The report described a "complex web" of both federal and state laws, regulations, and contractual obligations regarding the allocation and use of freshwater. The report indicated that state law regarding water uses and withdrawals are different for each state in many respects. However, the report referenced two general doctrines for water allocation among the states, referred to as "riparian" and "prior appropriation." These doctrines are summarized as follows:

- Riparian can be described as a "common law" doctrine. Under the riparian doctrine, water rights are linked to land ownership — owners of land bordering a waterway have an equal right to use the water that flows past the land for any reasonable purpose, even if they have never used the water before — and historical use has no bearing on future use.

- Prior appropriation is more of a regulated (e.g., through a state-issued permit) system. Under the prior appropriation doctrine, water rights are not based on land ownership, but rather are linked to priority policy and agreements, as well as determinations of beneficial water use. Even so, users that first obtained water rights generally have seniority, but water rights are predicated on the water being used for "beneficial" purposes. The GAO report describes this policy as "first in time, first in right" and "use it or lose it."

Under drought conditions, users operating under the riparian doctrine "share the shortage in proportion to their rights"; under the prior appropriation doctrine, water shortages under drought conditions would first affect "those who last obtained a legal right to use the water" (GAO 2003). This includes power plants in the steam electric power generating fleet addressed in this report.

The GAO report identified a third category as "other doctrine," which in many cases is a combination of riparian and prior appropriation, and also indicated that some states do not regulate water use and withdrawals at all. The GAO report indicated that all states vary in their water laws, but that eastern states generally held to the riparian doctrine and western states generally followed the prior appropriation doctrine. Figure 15, taken from the GAO report,

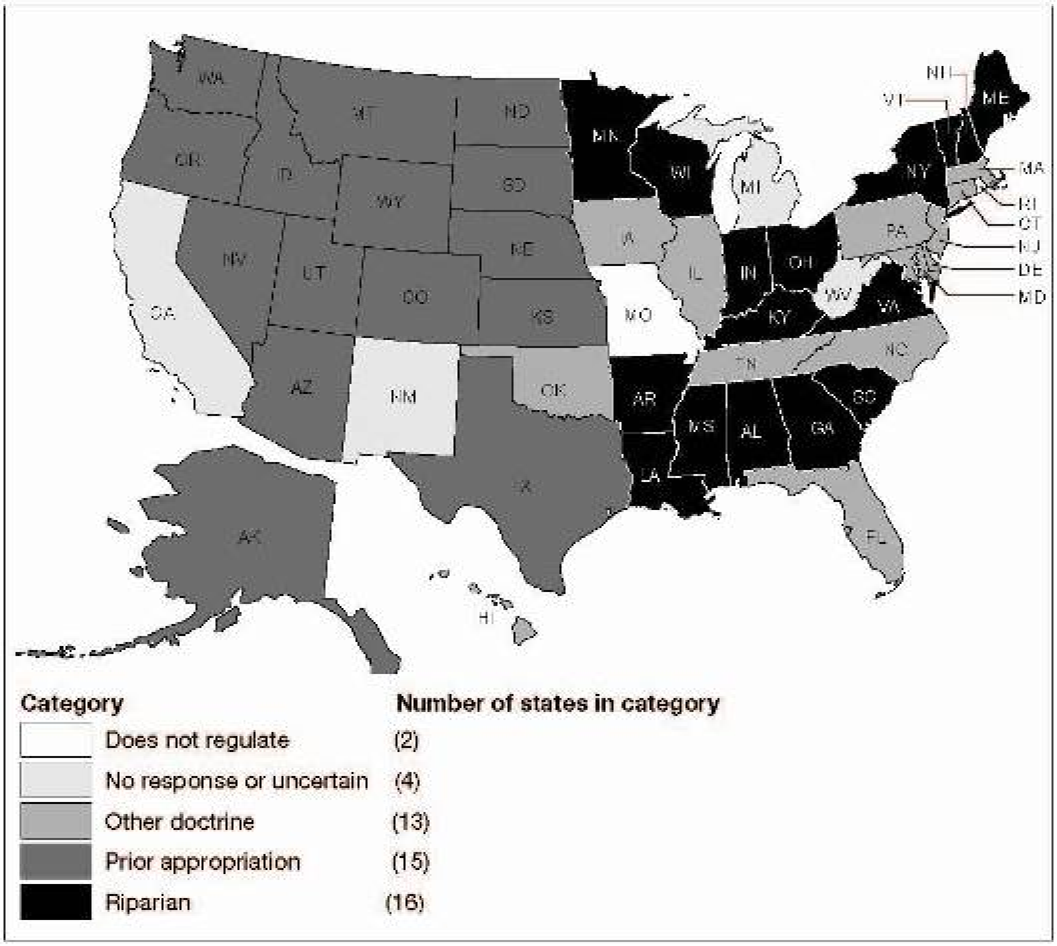

Figure 15 – Doctrines Used by States to Govern Surface Water Allocation (Source: GAO 2003)

shows state preferences regarding water doctrine based on a survey taken specifically for use in the report.

Irrespective of the above, compacts and commissions or watershed managers have been established to govern or at least coordinate water use and withdrawals on specific watersheds throughout the United States. These are examined further below.

Water Commissions and Compacts

A number of water commissions, compacts, or similar organizations have been established throughout the United States that have specific responsibilities regarding the management or oversight of the waters within specific geographical areas, basins, or watersheds. These commissions or compacts are in many cases independent of state programs and in other cases are part of state programs. Many include members from multiple states wherein the watershed lies and/or that use waters from the watershed for municipal or other purposes. Other members of many of the commissions or compacts include elements within the federal government, such as the U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation. Some also include representatives of one or more Indian tribes. Some programs are federally mandated and operated, including, for example, the Tennessee Valley Authority.

These commissions and compacts were identified nationwide, and a number of them were selected for in-depth evaluation. Commissions or compacts were selected for specific examination with the general intent of providing a representative view of these types of organizations throughout the United States. Those selected for more in-depth study include the following:

- Interstate Commission on the Potomac River Basin (ICPRB)
- Susquehanna River Basin Commission (SRBC)
- Delaware River Basin Commission (DRBC)
- Tennessee Valley Authority (TVA)
- Ohio River Valley Water Sanitation Commission (ORSANCO)
- Great Lakes Basin Compact (GLBC)
- Columbia River Gorge Commission (CRGC)
- Colorado River Authorities

In addition, conversations with the Columbia River Gorge Commission led to further research with the Washington State Conservation Commission (WSCC) and the Northwest Power and Conservation Council (NPCC).

Results of research with each of the above commissions or compacts are presented below. For each of these organizations, the primary research focus was to explore the nature of any compacts or agreements that give priority to certain users under drought conditions, for example, to determine which users (e.g., municipalities, farmers, power plants) must stop or reduce withdrawing water first. Initial research began with the Internet, as it was anticipated that each organization would maintain an Internet website. This was true in all cases but one. The websites of these organizations are provided under “Other Organizations or Organization Websites Contacted,” included within the reference section of this report.

The websites provided varying degrees of information; few specifically addressed compacts or agreements that give priority to certain users under drought conditions. The next step was to follow up the Internet research with a phone call to each organization as a means of obtaining more information or more accurate information. In most cases, individuals within the commissions and compacts were very willing to provide additional information, while, in other cases, individuals were reluctant to divulge any information at all. The Argonne research team that collected the information and discussed the issues with the commission or compact members is very grateful for the help provided by those compacts or commissions that were willing to provide information.

In addition to the above commissions and compacts, the Argonne research team also contacted associations and similar organizations that represented the common interests of multiple commissions or compacts. These included the Interstate Council on Water Policy (ICWP) and the Western States Water Council (WSWC). The websites of these organizations are also provided in the reference section of this report. In addition to examination of the websites of these organizations, the Argonne research team also followed up with a phone call and email exchanges and obtained additional information. The Argonne research team is very grateful for the help provided by these associations.

Interstate Commission on the Potomac River Basin

According the ICPRB website, the ICPRB was "established by Congress in 1940 to help the Potomac basin states and the federal government to enhance, protect, and conserve the water and associated land resources of the Potomac River Basin through regional and interstate cooperation." The commission is directed by appointed commissioners from its member states, including Maryland, Pennsylvania, Virginia, and West Virginia. It also includes representatives from the District of Columbia and the federal government.

The drainage area of the Potomac includes over 14,000 square miles in the above-named four states (ICPRB website).   Four major reservoirs located within the basin may be used to enhance flow during conditions of low flow (i.e., drought). A graphic of the Potomac basin showing the four reservoirs is presented in Figure 16, excerpted from an ICPRB's report, published in 2000, that forecasted water demand and availability for a 20-year period (ICPRB 2000).

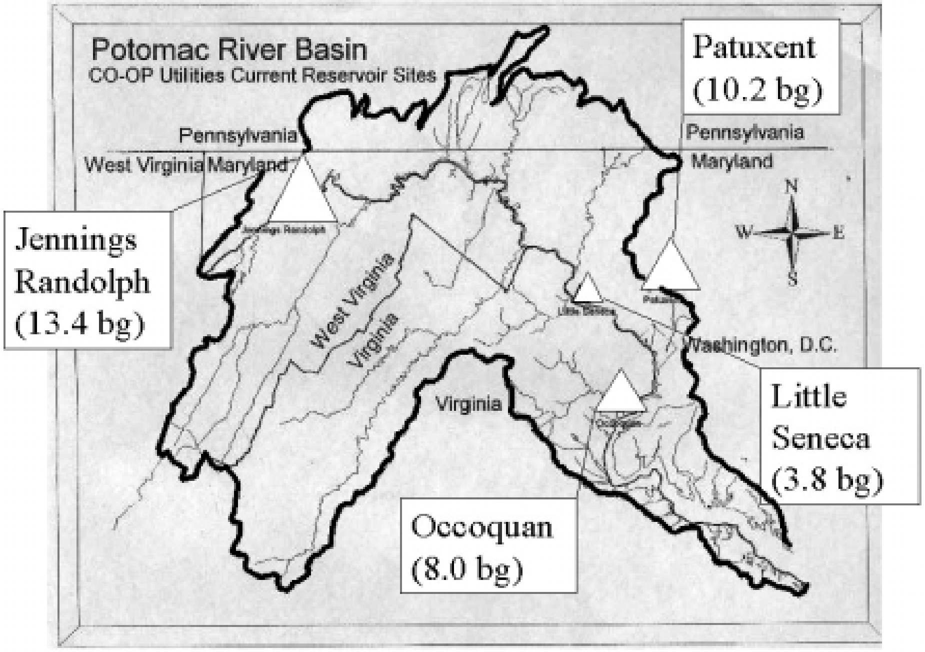

Figure 16 – Potomac River Basin Showing Current Reservoir Sites (Source: ICPRB 2000)

Only two of the above reservoirs are located above the Potomac River tidal zone and can be used to enhance flow when needed over the non-tidal Potomac. These include the Jennings Randolph and Little Seneca reservoirs. Releases from these reservoirs can be executed when consumptive demand, including that required to maintain environmental flow requirements, is predicted to exceed availability (ICPRB 2000) (i.e., during emergency drought conditions). Consumptive demand, according to the U.S. Geological Survey (USGS 1998), is "that part of water withdrawn that is evaporated, transpired, incorporated into products or crops, consumed by humans or livestock, or otherwise removed from the immediate water environment." Consumptive use upstream would reduce availability downstream by water utilities within the Washington, D.C., metropolitan area.

Management of drought and releases from the reservoirs within the Potomac basin is described in the ICPRB's drought operations manual (ICPRB 1988), which amends the original Potomac Water Supply Coordination Agreement established for the Potomac basin in 1982 (ICPRB 1982). To date, there has been only one instance, during the 1999 drought, when releases from one of the Potomac reservoirs (Little Seneca) was necessary to augment Potomac non-tidal flow (ICPRB 2000). The ICPRB reported that "cooperative operations…ran smoothly and the augmented flow of the Potomac provided all the water required by utilities" (ICPRB 2000). The report concluded that "the current system of resources is adequate to meet the *most likely* and *high growth* estimates of 2020 demands even if the worst drought of record was to be repeated" (ICPRB 2000).

In addition to defining conditions for release of reservoir reserves to augment flow to the Potomac, the ICPRB's Drought Operations Manual (ICPRB 1988) further outlines requirements for "suppliers" to report use for the previous day and a projection of demand for the coming day. "Suppliers," though undefined in the Drought Operations Manual, is presumed to be the reservoir operators. In addition, the manual (ICPRB 1988) provides the means to set restricted withdrawal rates whenever the Water Supply Coordination Agreement (ICPRB 1982), initiated during emergency low-flow events, is in effect. However, major users of the waters of the Potomac (other than water utilities) are not defined in either the Drought Operations Manual (ICPRB 1988) or in the agreement (ICPRB 1982).

Our conclusion is that, within the Potomac River Basin, the authority to restrict consumptive use during drought conditions exists, even though users (other than water utilities) are not specifically identified. In addition, no priority is established as to which users would be required to reduce or stop withdrawals first. Presumably, because the Drought Operations Manual (ICPRB 1988) and the original Agreement (ICPRB 1982) focus on water replenishment by reservoirs and water withdrawal by water utilities, the utilities would receive priority during drought conditions.

It is interesting to note also for the Potomac basin that the ICPRB oversees an annual drought emergency exercise that is designed to simulate emergency conditions and the associated coordinated response (ICPRB 2007). This is the only instance within all of the research conducted to prepare this report that a commission or compact operated an annual emergency response exercise. This is highly commendable. Emergency exercises of this sort, however, might be more useful if they were to include upstream users, such as power plants.

Susquehanna River Basin Commission

The SRBC website indicates that the SRBC operates under the Susquehanna River Basin Compact. The compact was established by the U.S. Congress in 1970 and adopted by the SRBC member states: Pennsylvania, New York, and Maryland. The 1970 compact contains the basic provisions by which the water resources within the Susquehanna basin are managed.

The basin itself drains an area of more than 27,000 square miles in the three states noted above and drains eventually in the Chesapeake Bay (SRBC 2006) at Havre de Grace, Maryland. Figure 17 provides an overview of the basin and its various subbasins (SRBC 2008a). The Susquehanna is described as one of the most flood-prone areas in the United States, experiencing a major flood on average every 14 years (SRBC 2006).

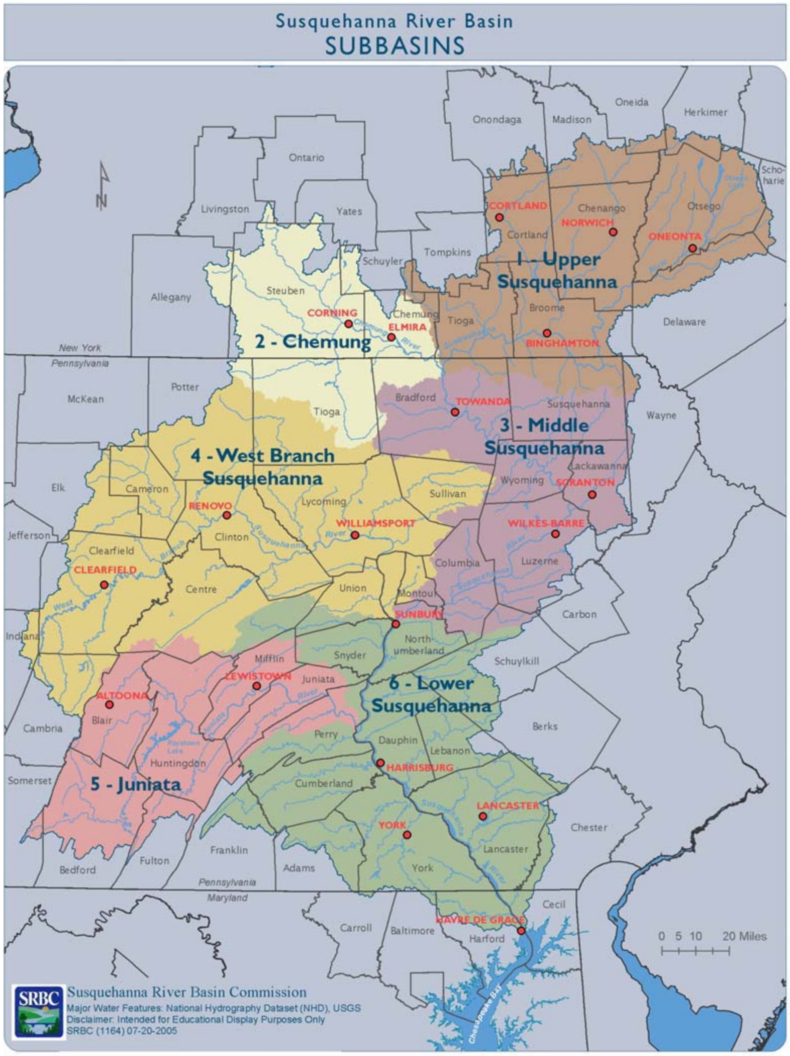

Figure 17 – Susquehanna River Basin and Subbasins (Source: SRBC 2008a)

While, as indicated above, the Susquehanna is declared to be one of the most flood-prone river systems in the nation, the historical frequency of droughts indicates that it is also highly prone to drought, with droughts occurring throughout the 1990s and several times thus far this decade (SRBC 2007a).

Regulation of specific projects within the Susquehanna basin is established within the *Code of Federal Regulations* (CFR) at Title 18, Parts 801, 806, 807, and 808 (SRBC 2007b). Section 801.3 is particularly relevant to this study, and is repeated in its entirety below (SRBC 2006):

> *(4) In the matter of drought, disasters or catastrophes, natural or manmade, which cause actual and immediate shortage of available and usable water supply, determine and delineate the area of shortage and by unanimous vote declare a state of water supply emergency therein, and impose direct controls on any and all allocations, diversions and uses of water to meet the emergency condition.*

During drought emergencies, SRBC acts to avoid depleting water resources, protect public health and safety, and support essential and high-priority water uses (SRBC 2007b). While high-priority water uses are not specifically defined, SRBC has the authority, among other actions, to reduce diversions and water allocations and coordinate reservoir operations within the basin as needed to preserve public health and protect the environment (SRBC 2007b). SRBC has direct authority to require drought restrictions among all the member states and is specifically authorized to review and approve water diversions and regulate consumptive use (SRBC 2007b) (see definition of "consumptive use" in USGS 1998).

According to SRBC Policy No. 2003-1 (SRBC 2002), "the commission utilizes passby flows, conservation releases, and consumptive use compensation to help protect aquatic resources, competing users, and in-stream flow uses downstream from the point of withdrawal." Further, "passby flow is a prescribed quantity of flow that must be allowed to pass a prescribed point downstream from a water supply intake at any time during which a withdrawal is occurring. When the natural flow is equal to, or less than, the prescribed passby flow, no water may be withdrawn from the water source, and the entire natural flow shall be allowed to pass the point of withdrawal….A conservation release is a prescribed quantity of flow from an impoundment structure that must be continuously maintained downstream from the impoundment structure. Conservation releases are intended to help protect aquatic resources and downstream uses. Additionally, conservation releases are intended to prevent water quality degradation and adverse lowering of stream flow levels downstream from the impoundment. Conservation releases achieve these purposes through flow augmentation from storage, not only during periods of low flow, but throughout the life of the reservoir, including periods when the reservoir is replenishing its storage during refilling."

Reservoir operation within the Susquehanna basin is described in two informational sheets published by the SRBC, one for operation of Cowanesque Lake (SRBC 2005a) and the other for operation of the Curwensville Project (SRBC 2005b). As described within the Cowanesque Lake informational sheet (SRBC 2005a), SRBC regulations on consumptive water uses (SRBC 2002) require large water users, consuming water in excess of 20,000 gallons per day over a 30-day average, to compensate for their water uses during low flows. For instance, just one electric generating plant in the Susquehanna River Basin consumptively uses an estimated 40 million gallons of water each day (SRBC 2005a). By requiring large water users to compensate for their water use, SRBC insures that fresh water will be available for downstream users, habitat preservation, and for maintaining flow to the Chesapeake Bay. Compensation in this case refers to fees consumptive users must pay when water is released from the Susquehanna reservoirs to compensate for low flows (SRBC 2005a,b).

To summarize, the SRBC is one of the few watershed commissions that have direct control, through regulation, to control consumptive use during drought conditions, and consumptive users, including power plants, are required to compensate the SRBC for releases from lakes and reservoirs needed to replenish flows to maintain the river system. There seems to be no priority established within the SRBC program as to which users would be required to reduce use first; the program seems to apply equally to all large-volume consumptive users (consuming water in excess of 20,000 gallons per day over a 30-day average).

Pertinent to this study, the depth of the water intake seems not to be an issue for power plants within the Susquehanna system. In fact, an email from one member of the SRBC (SRBC 2008b) indicated that there was only one instance where a power plant within the Susquehanna system was required to reduce operations. This was not because of the depth of the intake, however, but rather was due to the temperature of the water being too warm to be able to achieve the cooling needed to run the plant at full capacity.

Delaware River Basin Commission

The website for the DRBC indicates that the Delaware is the longest river east of the Mississippi with no dams. It extends 330 miles, with the watershed covering more than 13,000 square miles, draining areas within Delaware, Pennsylvania, New Jersey, and New York. The Delaware watershed is shown in Figure 18.

Figure 18 – Delaware River Basin Showing Major Tributaries (Source: DRBC 2004)

The DRBC operates much like the SRBC. The DRBC was created in 1961 when President Kennedy and the governors of Delaware, Pennsylvania, New Jersey, and New York co-signed legislation creating the Delaware River Basin Compact. The DRBC was created as a regional body with regulatory authority to manage and oversee the resources of the Delaware without regard to political boundaries. Like the SRBC, the DRBC is guided by appointed members of the representative states, with federal representation, as well. DRBC programs include water quality, water supply allocation, regulatory review and permitting, water conservation, watershed planning, drought and flood management, and recreation (DRBC 20007).

According to DRBC's Water Resources Program, the dominant users of water on the basin include thermoelectric power generation, public water supply, and industrial use, with the rising demand for thermoelectric power generation posing the potential for "significant additional future demand on water supplies" (DRBC 2008). DRBC's role includes regulation and arbitration of conflicts regarding withdrawals and diversions, as well as water allocation, among other functions (DRBC 2008). DRBC's objective for the allocation of water during drought includes allocation decisions and use restrictions, and maintaining the ecological integrity of the overall ecosystem (DRBC 2004).

To summarize, the DRBC operates much like the SRBC, with the authority to exercise direct control, through regulation, to control consumptive use during drought conditions. However, once again, there seems to be no priority established within the DRBC program as to which users would be required to reduce use first.

Tennessee Valley Authority

The TVA was established as one of the many New Deal programs to help bring the nation out of the Great Depression. The TVA, as envisioned by President Roosevelt, is "a corporation clothed with the power of government but possessed of the flexibility and initiative of a private enterprise". Created by Congress in 1933 as the TVA Act, the TVA's many programs included dam construction, power production, navigation, flood control, erosion control, and reforestation. TVA's purview includes the Tennessee River System, a system with drainage through parts of Tennessee, Illinois, Kentucky, Virginia, North Carolina, Georgia, Alabama, and Mississippi (http://www.tva.gov). Figure 19 shows the TVA drainage area and power service area, as well as the location of its many fossil fuel and nuclear power plants.

In accordance with a Programmatic Environmental Impact Statement (PEIS) Record of Decision (ROD) released in 2004 (TVA 2004), the TVA has adopted a new approach for managing the Tennessee River and reservoir system. This new approach resulted from a reservoir operations study conducted to examine the impacts and benefits of various approaches for optimizing reservoir operations and flows along the river system. The approach selected, referred to as the "preferred alternative," is "designed to provide increased recreation opportunities while avoiding or reducing adverse impacts on other operating objectives and resource areas" (TVA 2004). These other operating objectives include flood control, power production (both hydroelectric and steam-electric), improving water quality, and navigation. The PEIS ROD does not speak specifically to managing flows during drought conditions. Therefore, the goal of providing increased recreational opportunities while avoiding or reducing adverse impacts on other

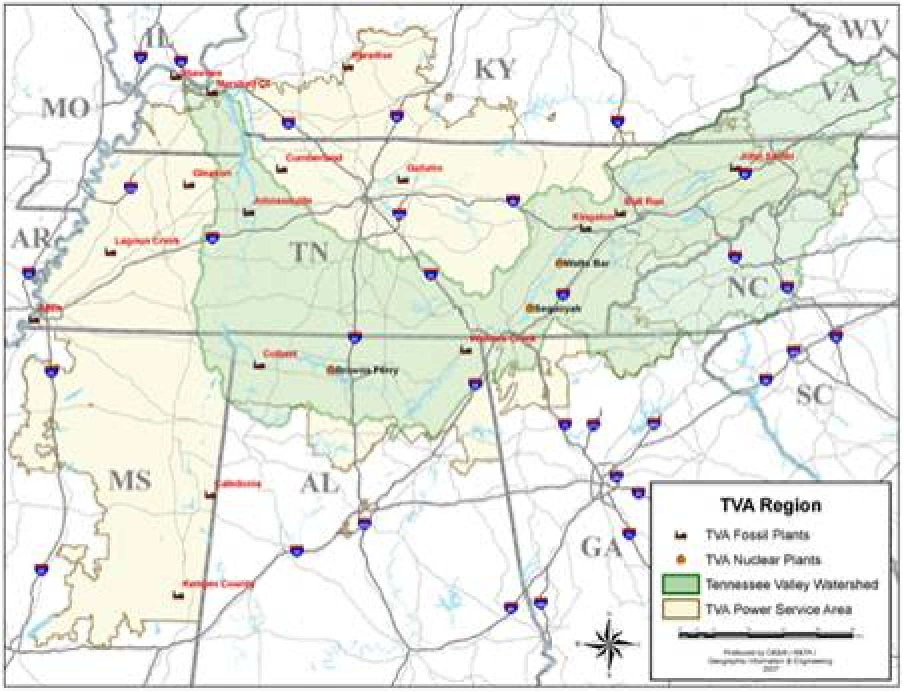

Figure 19 – Tennessee Valley Authority Jurisdiction
(Source: https://maps.tva.com/)

operating objectives and resource areas remains the same. However, during drought, concerns about maintaining navigation channels (i.e., sufficient depth to accommodate commercial and recreational use) are very important (TVA 2009).

The TVA area was especially impacted by the 2006/2007 drought and is still experiencing the effects of the drought today. TVA serves as a host and facilitator for the Tennessee Valley Water Partnership, a group established in 2005 to improve regional cooperation in water resource management. The group includes representatives from all TVA states, as well as from the U.S. Environmental Protection Agency (EPA) and the USGS. Its basis is not regulatory, but rather to coordinate issues recognizing state interests, laws, and regulations (TVA 2007a). The group has reviewed drought management plans developed by some of the member states, and TVA has drafted a Drought Management Plan for the Tennessee Valley Water Partnership Drought Committee (TVA 2007b).

The Drought Management Plan (TVA 2007b) provides the basis for coordinating actions through the Tennessee Valley Water Partnership Drought Committee. Response actions, however, are not specifically identified, nor is there a priority established for which types of uses must begin curtailing water withdrawals or stopping water withdrawals altogether. Decisions regarding response actions would be made collectively through the Drought Committee, considering the provisions of the TVA Act and the 2004 PEIS ROD.

TVA (TVA 2008, 2009) has indicated that it has had to curtail operations at some of its operating nuclear plants due to the drought. However, these actions were not due to water levels falling below cooling water intakes, but rather due to the temperatures of the receiving water being too warm. As indicated above, the problem is the discharge of heated water used for cooling back into waterways that are just too warm to keep temperatures at levels required to meet state water quality standards.

Ohio River Valley Water Sanitation Commission

The Ohio River runs a total of 981 miles, starting at the confluence of the Monongahela and Allegheny Rivers in Pennsylvania and ending when the Ohio intersects the Mississippi River at Cairo, Illinois. There are a series of 20 dams along the Ohio, with 49 hydroelectric power generating stations (http://www.orsanco.org/rivinfo/facts.asp). The dams and hydroelectric stations are operated by the U.S. Army Corps of Engineers. Figure 20 provides an overview of the Ohio River Basin and shows the locations of the various dams.

Figure 20 – Ohio River Basin (Source: http://www.orsanco.org/rivinfo/basin/basin.asp)

According to the ORSANCO website, ORSANCO was established as a compact in 1948. Member states include Illinois, Indiana, Kentucky, New York, Ohio, Pennsylvania, Virginia, and West Virginia. ORSANCO's mission is to control and abate pollution in the Ohio River Basin. ORSANCO sets waste water discharge standards, performs biological assessments, monitors the river and its tributaries against chemical and biological makers, and conducts surveys and studies as needed. While ORSANCO does respond to spills and accidents within its purview, its mission does not include flood control or drought management.

In a conversation with an ORSANCO official (ORSANCO 2008), the Ohio was described as being "rich in water" where droughts are not commonly experienced. Further, the official indicated that there were a number of coal-fired power plants along the river, and none of them have ever (in memory) experienced problems associated with droughts. While the official acknowledged that the U.S. Army Corps of Engineers would control the dams in the event of a flood or drought, because of the water-rich environment, he was not aware of any compacts or agreements that give priorities to the users (i.e., which users must stop withdrawing water first). The individual did, however, suggest that state programs within the Ohio River system may have such stipulations. State programs are reviewed below under the section on federal and state programs.

Great Lakes Basin Compact

The Great Lakes Basin Compact was adopted in 1955 by the eight states bordering the Great Lakes (Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin) and associate members from the Canadian Provinces of Ontario and Quebec. It resulted in the formation of the Great Lakes Commission (GLC), as shown in Figure 21. The GLC "carries out policy research, advocacy, coordination, and communication functions promoting the orderly, efficient, and balanced development use and conservation of the Great Lakes-St. Lawrence River System" (GLC 2007).

Figure 21 – Great Lakes Basin Map (Source: http://www.michigan.gov/deq/0,1607,7-135-3313_3677-15926--,00.html)

In the Great Lakes, drought management policy accepted by GLC membership is embodied within a regional policy statement developed by the Task Force on Drought Management and Great Lakes Water Levels, which was established in 1989 (GLC 2007). The Task Force published a draft report in 1989 (GLC 1989), which still serves today as a guide to drought planning, management, and water level changes in the Great Lakes. This 1989 report specifically addresses impacts of drought on electrical power generation. However, water levels falling below submerged intakes are not recognized as a problem within the Great Lakes.

Rather, the problem in the Great Lakes seems to be more a function of the release of heated cooling water from power stations to waters where the ambient temperatures are too high to be able to accommodate the heated cooling water. Lower water levels and increased air temperatures result in elevated water temperatures within the lake system, and the addition of heated cooling water from the power plants reduces dissolved oxygen levels below levels needed for sustaining the local ecology (GLC 1989).

Water rights and water laws in the Great Lakes states are also reviewed within the 1989 policy statement (GLC 1989). The policy statement indicates that the water rights system in the Great Lakes states and provinces follow the riparian doctrine. Hence, land owners have a right to reasonable beneficial use of the water, although what is accepted as reasonable during normal conditions may differ from what is accepted as reasonable during droughts. In addition, some but not all of the Great Lakes states require large water users to obtain water withdrawal permits. In addition, as of 1989, only Minnesota was known to have established a formal system defining water use priorities. In general, public water suppliers have priority over individual users to serve public needs (GLC 1989). It is unclear how this relates to electrical power generation facilities.

With respect to the Great Lakes, it is also important to mention that drought and water policy positions are established through other government organizations as well as the GLC. The Great Lakes-St. Lawrence River Water Management Regional Body, coordinated by the Council of Great Lakes Governors, was created through the Great Lakes-St. Lawrence River Basin Sustainable Water Resources Agreement (Council of Great Lakes Governors 2005). The Agreement details how the Great Lakes states, Ontario, and Québec will manage the Great Lakes Basin. Article 203 of the agreement specifically addresses decision making for water withdrawals and consumptive use (Council of Great Lakes Governors 2005). It does not, however, define priority uses during drought.

Columbia River Gorge Commission

According to the website of the Columbia River Gorge Commission (CRGC) (http://www.gorgecommission.org/), the commission "was established in 1987 to develop and implement policies and programs that protect and enhance the scenic, natural, cultural, and recreational resources of the Gorge, while encouraging growth within existing urban areas of the Gorge and allowing development outside urban areas consistent with resource protection."

Examination of the commission website did not reveal any information regarding participation in programs relating to drought and power plant cooling water intakes. In a conversation with an official of the commission (CRGC 2008), it was revealed that the commission programs deal mainly with conservation and have little to do with power generation capacity unless hydroelectric operations impact the general ecology of the river system.

The commission official explained first that the Columbia basin is "water rich" and rarely faces serious drought conditions. He also indicated that the Columbia basin itself is very large and controlled by many different government and quasi-government organizations. Figure 22 presents an overview of the Columbia basin.

Figure 22 – Columbia River Basin (Source: http://www.nwd-wc.usace.army.mil/report/colmap.htm)

The CRGC official suggested that policy and decision-making authority with respect to drought and power plant operations would probably be controlled by any one of a number of other authorities active in the Pacific Northwest. A few such organizations were identified, including the Northwest Power Planning Council, the Washington State Conservation Commission, the Washington Department of Ecology, the Upper Columbia River Water Compact, the U.S. Army Corps of Engineers, the Bonneville Power Administration, and water authorities within each of the states within the Columbia drainage system. He indicated that water management in the Northwest is very complicated and that each of the above organizations would likely have at least some role in any decision regarding water levels and power management.

Following this CRGC communication, the websites of several of the above organizations were visited, and for some of the organizations, follow-up phone calls were made, as well. An official within the Columbia River Program of the Washington Department of Ecology (Washington Department of Ecology 2009) indicated that water code in the Columbia system is based on "Western Water Law." The premise is the "priority doctrine," which was summarized as "first in time, first in right." (Note that the priority doctrine referred to in the above quote is assumed to be the same as the prior appropriation doctrine mentioned previously). The official estimated that there were well over 300 holders of "interruptible water rights" in the Columbia basin and that at least one of these belonged to a power plant. They are interruptible because their water rights were issued after the state's adopted in-stream flow right (Washington Administrative Code WAC 173-563).

This same message regarding Western Water Law was reiterated in a conversation with an official from the Northwest Power and Conservation Council (NWPCC) (NWPCC 2009). The NWPCC official referred to it as a system of "junior vs. senior" rights.

An overview of western water rights is provided following the discussion on the Colorado River Authorities.

Colorado River Authorities

The following, from the U.S. Bureau of Reclamation's lower Colorado River website, provides a summary of what has become know as the "Law of the River" (http://www.usbr.gov/lc/):

> *The Colorado River is managed and operated under numerous compacts, federal laws, court decisions and decrees, contracts, and regulatory guidelines collectively known as the "Law of the River." This collection of documents apportions the water and regulates the use and management of the Colorado River among the seven basin states and Mexico.*

The primary compact governing management and operation of the Colorado River is the Colorado River Compact of 1922 (U.S. Bureau of Reclamation's lower Colorado River website, (http://www.usbr.gov/lc/). The following is a synopsis of the compact:

> *The cornerstone of the "Law of the River," this Compact was negotiated by the seven Colorado River Basin states and the federal government in 1922. It defined the relationship between the upper basin states, where most of the river's water supply originates, and the lower basin states, where most of the water demands were developing. At the time, the upper basin states were concerned that plans for Hoover Dam and other water development projects in the lower basin would, under the Western water law doctrine of prior appropriation, deprive them of their ability to use the river's flows in the future.*
>
> *The states could not agree on how the waters of the Colorado River Basin should be allocated among them, so the Secretary of Commerce Herbert Hoover suggested the basin be divided into an upper and lower half, with each basin having the right to develop and use 7.5 million acre-feet (maf) of river water annually. This approach reserved water for future upper basin development and allowed planning and development in the lower basin to proceed.*

There are many other laws, contracts, and documents that are part of the "Law of the River." Several of these pertain to international treaties and similar agreements with Mexico. These can be reviewed by going to the U.S. Bureau of Reclamation's lower Colorado River website (http://www.usbr.gov/lc/). In addition to these provisions, the federal Endangered Species Act and various Native American water claim settlements affect the extent to which water developments and diversions can be utilized in the Colorado River Basin.

In general, and as an outgrowth of the Colorado River Compact of 1922, management of the Colorado and its tributaries has been split among the upper and lower Colorado states. Figure 23 provides a map showing the areas included within the Lower Colorado Region. Figure 24 provides a map showing the areas included within the Upper Colorado Region.

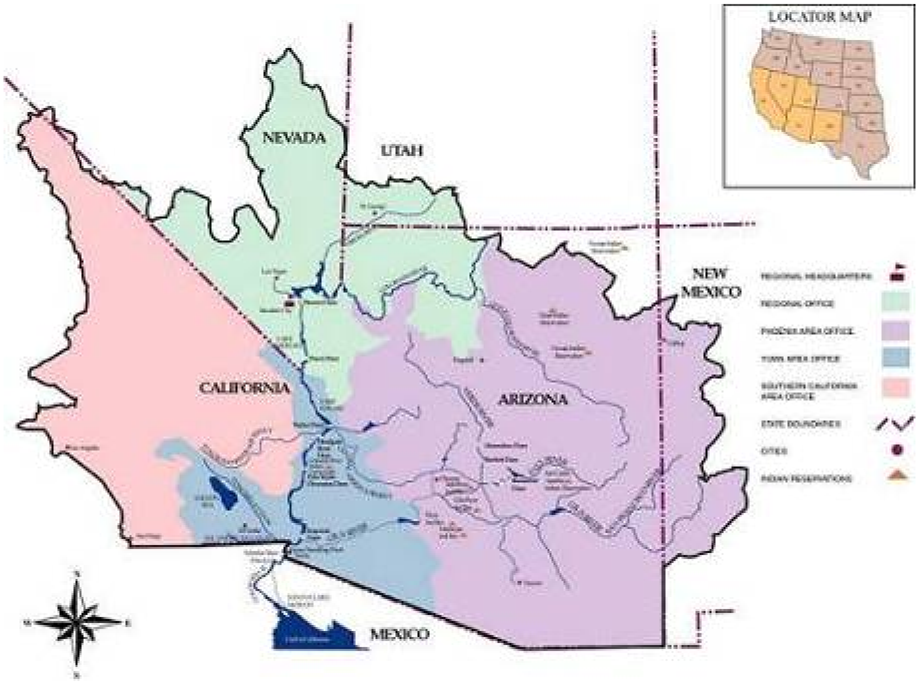

Figure 23 – Lower Colorado Region (Source: http://www.usbr.gov/lc/)

Figure 24 – Upper Colorado Region (Source: http://www.usbr.gov/uc/)

As referred to above and in the discussion for the Columbia River Basin, the Western Water Law doctrine of prior appropriation generally governs use of the waters of the Colorado by individual users. Western water rights are reviewed below. Keep in mind as the discussion proceeds that many power plants in the West, and the vast majority of power plants in the Lower Colorado Region, draw their cooling water from ground water sources (Colorado River Commission of Nevada 2008).

Western Water Rights Overview

The website of the Colorado River Energy Distributors Association (CREDA) provides a good introduction to the evolution of what has become known as "Western Water Law" (http://www.creda.org/Pages/Background.html):

> *As the water supplies in the West became more intensively used in the early part of the twentieth century, the "water wars" began. As a result, western water law evolved through a series of legislative as well as court-related actions. Many of the issues were local in nature; however, they also evolved into interstate and eventually international issues. A great amount of attention focused on the Colorado River because it is one of the most heavily used rivers for multipurpose activities.*

Western Water Law developed due to the relative scarcity of water in the southwest states as compared to the rest of the United States. Water scarcity resulted in the evolution to a system of water rights that are different from the "water rich" regions of the country. In essence, water rights in the southwest are similar to those established for real property. These rights are somewhat independent of the land or shoreline from which the water is derived. The water rights, known generally as "prior appropriation," are established by actual use of the water, and maintained by continued use and need. The premise behind prior appropriation is that the right to use water for beneficial purposes is not associated with ownership. No one person, company, or jurisdiction owns the water, but all have the right to use it for beneficial purposes. As indicated above in the Columbia River discussion, water use is based on the premise of "first in time, first in right."

As indicated above, an official from the NWPCC (NWPCC 2009) referred to Western Water Law as a system of "junior vs. senior" rights. The "senior" in this case is the first entity (person, jurisdiction, corporation) to use the water, while the "junior" refers to entities that later use the water for whatever purpose. The only requirement is that the use have some benefit. The resulting system, fraught with arguments as to who is senior and who is junior and what constitutes a beneficial use, among other things, has been the subject of local and state laws, policies, and numerous disagreements and lawsuits.

For steam generating power plants that would use the water for cooling, the determination of which user would be required to begin curtailing use, or stopping use altogether, would fall on the determination of senior vs. junior, again the premise of "first in time, first in right."

In most of the western states, a state agency (e.g., department of water resources) or official is charged with the administration of all water rights within the state. In addition, each state may differ in the manner in which it administers the water program. An overview of some of the state programs, including those that apply the riparian doctrine as well as those that follow prior appropriation, is provided below, along with a brief discussion of federal programs.

Federal and State Programs

Federal Programs

The primary agency within the federal government responsible for emergency management is the Federal Emergency Management Agency (FEMA), a component of the Department of Homeland Security (DHS). FEMA is in the process of producing a series of Comprehensive Program Guides (CPGs) that address many aspects of emergency management. The first guide, CPG 101 "Producing Emergency Plans: A Guide for All-Hazard Operations Planning for State, Territorial, Local, and Tribal Governments (Interim)," was released for comment in August 2008 (FEMA 2008). FEMA plans to release supplemental guides as well, including those pertaining to natural hazards such as drought. While any drought plan should serve as a guide for the development of mitigation and response strategies, it is unclear whether FEMA will recommend establishing priorities for essential and non-essential uses during drought.

FEMA is not the only federal agency however, that has a role in drought response. Many other federal agencies are also involved in drought planning and mitigation. The U.S. Army Corps of Engineers and the U.S. Bureau of Reclamation have been mentioned previously. Many other federal agencies also have a role.

The State of California Department of Water Resources, in cooperation with the U.S. Bureau of Reclamation, recently published the *Urban Drought Guidebook* (State of California Department of Water Resources and U.S. Bureau of Reclamation 2008). Among many other recommendations, the Guidebook recommends establishing priorities for essential and non-essential water uses during droughts. One such priority included "commercial, industrial, and institutional — maintain economic base, protect jobs." Directly related to this priority is the need to include use of water for power plant operation.

State Programs

Many state programs also deal directly with drought management. The National Drought Mitigation Center, operated by University of Nebraska-Lincoln, includes a summary of the status of state drought programs (http://www.drought.unl.edu/mitigate/status.htm):

> *Because water shortfalls are initially local and regional issues, and because of the lack of a cohesive U.S. water policy, states have emerged as important innovators in devising ways to reduce long-term vulnerability to drought. During the widespread U.S. drought of 1976–77, no state had a formal drought plan, and in 1982, only three states had drought plans. But as of October 2006, thirty-seven states had drought plans.*

Figure 25 below provides an overview of the status of state drought planning as of 2006. As of the time of this compilation, only nine states did not have formal drought plans. Some states such as Alabama (see below) have since established such programs.

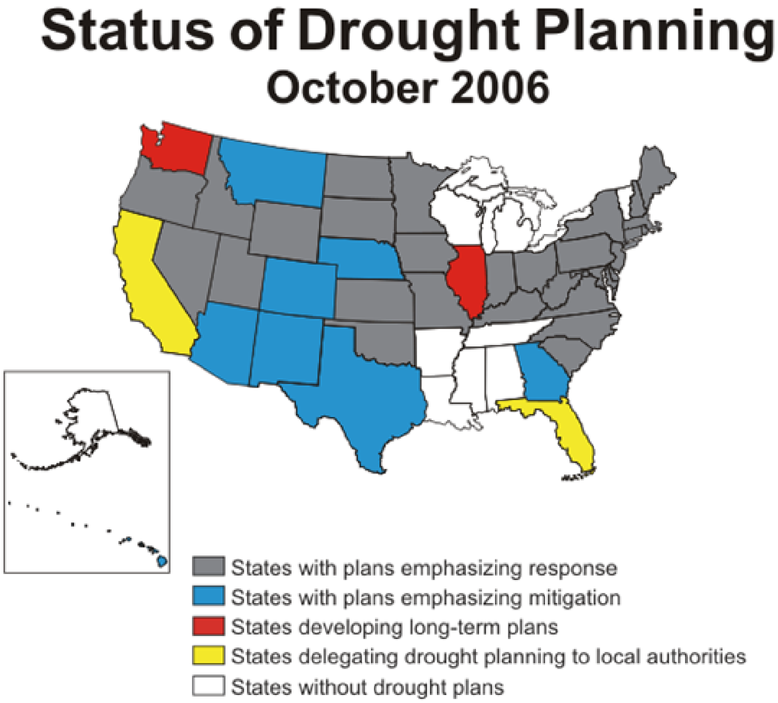

Figure 25 – Status of State Program Drought Planning
(Source: http://www.drought.unl.edu/mitigate/status.htm)

In addition to an examination of the water commissions and compacts, a number of the states were examined to determine the nature and extent of the drought measures put in place. The focus, as with the water commissions and compacts, was to explore the nature of any compacts or agreements that give priority to certain users under drought conditions, for example, to determine which users (e.g., municipalities, farmers, power plants) must stop or reduce withdrawing water first.

The initial scope of this study did not envision examining federal or state programs at all. As we began looking at the compacts and commissions, and after talking with their staffs, however, it became apparent that some of the types of priority information that we were looking for might turn out to be associated with state programs. Hence, while research on state programs was initially unintended, it was conducted to ensure that we looked into what turned out to be a very pertinent source of information. Research, however, was limited to the Internet. Further, there were insufficient funds within the initial budget to look at all state programs. Therefore, the states were selected for examination with the general intent of providing a representative view of the states throughout the United States.

As the effort began to look at state programs, it also became apparent that many of the states differed in how they assigned responsibility for drought mitigation and management. Some states assigned this responsibility to state emergency management organizations, and others to state water boards, others to state environmental departments. Many states also established working groups or task forces made up of representatives of these agencies, as well as others, such as agriculture and commerce. Hence, finding drought-related programs and documentation within state programs may be qualified as hit or miss.

Alabama

Alabama's Drought Management Plan was developed by the Alabama Department of Economic and Community Affairs (Alabama Department of Economic and Community Affairs 2004). The Alabama plan did not establish any hard and fast priorities for certain users; however, it did promote conservation within various sectors. The industrial sector, for example, was:

> *"…encouraged to coordinate water usage and constraints during drought conditions by:*
>
> *1. Establishing more direct drought communication between the industrial sector and state and local governments and the appropriate water systems;*
> *2. Conduct voluntary water audits for businesses that use water for a production or service, especially in an area that has a history of drought related water shortages;*
> *3. Encourage the development and implementation of water conservation and drought contingency plans to limit any unnecessary consumption and interbasin transfers, if applicable, during droughts; and*
> *4. Identify vulnerable water dependent industries and, as necessary and as funding is available, work to determine their impacts and provide assistance with procedures to curtail water use during droughts and/or identify alternative water sources for emergency use.*
> *5. Implement industrial water reduction opportunities previously identified (i.e., use less water in producing products and services during drought, and thereby reducing quantity of wastewater in stream).*

Arizona

The Arizona Division of Emergency Management established an Emergency Response and Recovery Plan (Arizona Division of Emergency Management 2006) with a very comprehensive annex dealing with drought. No priority system for essential or non-essential use was established within this plan. The Arizona Department of Water Resources, however, published a Drought Preparedness – Operational Drought Plan in 2004 (Arizona Department of Water Resources 2004). This plan also did not establish priorities or essential/non-essential uses per se, but it did establish a "response progress" that requires reductions in use in various "Work Group" categories. For example, the Municipal and Industrial Work Group may recommend state or locally imposed short-term emergency restrictions during a drought emergency, including water use restrictions on public facilities and industrial user conservation programs and partnerships.

Colorado

In Colorado, drought mitigation planning is the responsibility of the Colorado Water Conservation Board. The Board produced *The Colorado Drought Mitigation and Response Plan* in 2001 (Colorado Water Conservation Board 2001). No specific priority system for essential or non-essential uses was established; however, comprehensive treatment on preparedness and mitigation for all sectors was stressed, and the plan indicated that "competing interests could require suspension of [the] current water rights system."

Connecticut

The State of Connecticut is developing the *Connecticut Drought Management Plan* (http://www.drought.state.ct.us/mgmtplan.htm), although it is not yet available through the Internet. Connecticut does, however, have the *Connecticut Drought Preparedness and Response Plan* that defines non-essential uses of water during drought and authorizes the government to take a number of conservation actions during drought.

Idaho

The Idaho Department of Water Resources developed the *Idaho Drought Plan* in 2001 (Idaho Department of Water Resources 2001). The Idaho plan establishes a number of coordinating committees, although no priorities for essential or non-essential uses are established. One of the coordinating committees deals with energy. The following regarding the Energy Subcommittee is excerpted from the plan:

> *Energy Subcommittee*
>
> *1. Evaluate and monitor energy supplies; coordinate with other subcommittees.*
> *2. Coordinate with the state member of the Northwest Power Planning Council.*
> *3. Membership should include, Idaho Northwest Power Planning Council, Public Utilities Commission, Bonneville Power Administration, Idaho Power Co., IDWR, the Association of Commerce and Industry, COE, and BOR.*

Indiana

The State of Indiana has the *Indiana's Water Shortage Plan* developed in 1994 by a task force of the Indiana Department of Natural Resources. The task force was composed of professionals representing public water supply utilities, agriculture, steam electric generating utilities, industry, municipalities, environmentalists, consumer advocates, economic development advocates, academia, and the public. The plan established a conservation program for a water shortage emergency and defined a number of non-essential uses geared mainly for industry and the public. The plan established specific provisions for electrical generating facilities, indicating that:

> *The Department and the Utility Regulatory Commission will jointly consult with all major electric utilities in the region to ascertain the current status and projection of electric use demand, associated water requirements, and potential for energy and water conservation during the water shortage emergency. Consultations will consider the potential for: (a) shifting a portion of electric energy demand to generation from plants*

> *outside the area affected by the emergency (including increased wheeling of energy); (b) increasing energy production from plants with lower consumptive water use rates per unit of energy; and (c) adjustment of plant production and maintenance schedules within the system to reduce water use in the affected area.*

Maryland

The Maryland Statewide Water Conservation Advisory Committee (2000) developed the *Drought Monitoring and Response Plan* in 2000. The plan provides the Governor with a series of responsibilities, including implementation of mandatory restrictions on non-essential water uses. In addition, business and industry are required to comply with water conservation plans to reduce water use by at least 10% and evaluate possible reduced hours of operation.

Massachusetts

Massachusetts describes itself as a “water rich” state, but a 1999 drought caused activation of a Drought Management Task Force, which resulted in the *Massachusetts Drought Management Plan*, a working draft of which was released in 2001 (Massachusetts Drought Management Task Force 2001). The plan required municipalities and water suppliers to submit plans to establish priority among competing users, indicating that the government has the right under eminent domain authority to establish priorities among competing users:

> *During a state of water emergency, DEP may issue orders, applicable within or outside the affected area of the water emergency, to: (1) establish priorities for the distribution of any water or quantity of water use; (2) permit any person engaged in the operation of a water supply system to reduce or increase by a specified amount or to cease the distribution of that water; to distribute a specified amount of water to certain users as specified by the department; or to share any water with other water supply systems; (3) direct any person to reduce, by a specified volume, the withdrawal or use of any water; or to cease the withdrawal or use of any water; (4) require the implementation of specific water conservation measures; and, (5) mandate the denial, for the duration of the state of water emergency, of all applications for withdrawal permits within the areas of the commonwealth to which the state of water emergency applies.*

Missouri

The Missouri State Emergency Management Agency’s *Missouri State Hazard Mitigation Plan* (Missouri State Emergency Management Agency 2007) gives a great deal of attention to drought, but much of the discussion is academic and historical in nature. The *Missouri Drought Plan*, however, produced by the State Department of Natural Resources in 2006, established a priority system for allocation of water during drought (Missouri Department of Natural Resources 2006). The priority system was divided into three classes, where Class 1 is designated “Essential Water Uses,” Class 2 is designated “Socially or Economically Important Uses of Water,” and Class 3 is designated “Non-Essential Uses of Water.” Use of water for electrical power generation was included within Class 1, right behind domestic use, health care facilities, fire-fighting, and waste-water management.

Montana

The Montana Department of Disaster and Emergency Services' *State of Montana Disaster and Emergency Plan* (Montana Department of Disaster and Emergency Services 2006) includes Volume X, "Montana Drought Plan." This plan establishes a drought advisory committee with many recommendations. The following is excerpted from Volume X:

> *Managers of hydroelectric facilities develop annual operating plans based on energy demand and projected surface water supplies. Arrangements to accommodate downstream fisheries, flatwater recreation, and navigation needs are considered in the annual operating plan. In the Columbia River drainage, reservoir operating agencies work closely with the Northwest Power Planning Council (NPPC) and agencies such as DFWP to balance instream flow and energy requirements. Changes to reservoir plans may be made each year to reflect changes in the water supply outlook. Final operating plans are formulated after comprehensive assessments are made. Public comment on reservoir operations is documented at open meetings and taken under advisement by managing agencies. Reservoir plans for the season are announced by the Bureau of Reclamation and Montana Power Company through press releases as summer approaches.*

In addition to the above, the state has *The Montana Drought Response Plan* developed by an Advisory Committee on Drought and published in 1995 (Montana Advisory Committee on Drought 1995). The plan is very detailed, but no priority system for essential and non-essential uses is established within the plan.

North Carolina

The North Carolina Division of Emergency Management, operating under the North Carolina Department of Crime Control and Public Safety, established the *State of North Carolina Emergency Operations Plan* in 2002 (North Carolina Division of Emergency Management 2002). Drought is addressed in Appendix 3 of this document. In accordance with the appendix, drought is addressed by five different task forces, one of which deals with energy loss. Among other responsibilities, the task force is required to produce assessments that include total energy loss attributable to drought and an evaluation of water shortage impacts on electrical power generation, as well as identification of other major potential problem areas.

Ohio

The website of the Ohio Department of Public Safety Emergency Management Agency (OEMA) (http://ema.ohio.gov/index.aspx) contains the State of Ohio Emergency Operations Plan Drought Incident Annex (OEMA 2003). This annex, very similar to that of Missouri, as discussed above, established a priority system for allocation of water during drought. The priority system was divided into three classes, where Class 1 is designated "Essential Water Uses," Class 2 is designated "Socially or Economically Important Uses of Water," and Class 3 is designated "Non-Essential Uses of Water." As with Missouri, use of water for electrical power generation was included within Class 1, right behind domestic use, health care facilities, fire-fighting, and waste-water management.

South Carolina

The South Carolina Department of Natural Resources developed the South Carolina Drought Response Plan (South Carolina Department of Natural Resources, undated). The plan appears geared for public use and is not very useful for determining priorities or essential/non-essential uses. Regulations prepared by the South Carolina Department of Natural Resources are more detailed in this regard (South Carolina Department of Natural Resources, DNR Chapter 121, undated). These regulations provide that:

> *During severe or extreme drought conditions, the South Carolina Department of Natural Resources may require mandatory reduction or curtailment of non-essential water use in affected drought management areas if recommended by the Drought Response Committee in accordance with R.121-11.6. The curtailment of water use may involve adjusting the quantity of water used; adjusting the quality of water to meet the water use; adjusting the time of water use; and/or utilizing different sources of water.*

Further, the Drought Response Committee is required to consider a number of factors, including, among other things, the purpose of the use, suitability of the use to the watercourse, lake, or aquifer, and the economic and social value of the use.

Virginia

The Virginia Department of Environmental Quality (DEQ) has responsibility for drought management (http://www.deq.virginia.gov/waterresources/drought.php) and, through a Drought Response Technical Advisory Committee, developed the *Drought Assessment and Response Plan* (Virginia Department of Environmental Quality 2003). Many requirements are established during a drought emergency, including a number of mandatory use restrictions. For example, public waterworks and self-supplied water users who withdraw more than 10,000 gallons per day are required to initiate mandatory water conservation requirements contained in drought water conservation and contingency plans. Further, the Director of the Department of Environmental Quality is authorized to allocate ground water and surface water resources and to restrict any withdrawals based upon the adequacy of the resource to meet the necessary beneficial uses as set forth in §62.1-44.36 of the Code of Virginia. Such allocations may apply to any withdrawer and override any existing authorizations to use or withdraw surface water or ground water.

Chapter 5 – Findings and Conclusions

The findings and conclusions are presented separately with respect to “Database of Power Plants and Cooling Water Intakes”; “Distance to Shore for Power Plant Intakes”; “Depth of Power Plant Intakes”; and “Commission, Compact, and Federal/State Programs.” While our findings and conclusions are limited to these areas, it should be recognized that the database developed to support this project can be used to examine many different aspects of the relationship between power plant intake distance and depth as a function of many other factors.

Database of Power Plants and Cooling Water Intakes

Findings

- The project database of electric steam generation power plants, developed from the EIA-767 form data collection effort, does not include all power plants nationwide. It includes data from 423 plants in 44 states. Data collected for fossil fuel plants were current as of 2005 and for nuclear plants, as of 2000.

- The project database of electric steam generation power plants, developed from the EIA-767 form data collection effort, includes a substantial amount of data on cooling water intake distance from shore and depth from surface.

- The project database is subject to some uncertainty because the original data in the EIA-767 database were entered by representatives of many different utilities and other power generators across the county. The database was provided to utility associations for a review of accuracy. Some errors in data entry were identified and corrected as part of this effort; however, additional errors are possible.

Conclusion

In spite of the uncertainty mentioned in the third bullet above, the project database is considered representative of power plants nationwide, at least as it relates to intake distance from shore and depth from surface, and is considered robust enough to enable drawing conclusions regarding the effect of drought on power plant operations as a function of intake cooling.

Distance to Shore for Power Plant Intakes

Findings

- Data from the EIA 767 form database regarding intake distance from shore were not as complete as data regarding depth from surface.

- There is a tremendous range in distance to shore for power plant intakes, ranging from 0 feet to well over a mile.

- Many power plants reported that their intakes were located right at the shoreline (i.e., 0 feet from the shore).

- More than half of the power plants showed an intake distance from shore of 50 ft or greater.

- There does not seem to be a significant difference in intake distance from shore among the power plants as a function of fuel source or water body type.

- The distribution of data on intake distance from shore shows a mean value that is much higher than the median value, suggesting a highly skewed, non-normal distribution, with most of the intake distances reported as being relatively close to shore.

- There are nevertheless a substantial number of power plants with intake distances reported at greater than 1,000 feet, and two reported at far greater than a mile.

- The standard deviation of the distribution of power plant intake distance from shore shows a high degree of variability.

Conclusion

The EIA-767 form data on intake distance from shore represent a wide range and high variability, with no clear pattern among the power plants as a function of fuel source or water body type. Distance from shore has far less bearing than inlet depth from surface during drought conditions, unless the reason why some intakes are located far from shore has to do with lower temperatures or other factors.

Depth of Power Plant Intakes

Findings

- All power plants in all categories (fuel type, water body type) reported 10 feet most often as their intake depth.

- In all cases but one, the differences in statistics for intake depth for most of the categories (fuel type, water body type) are minor.

- The mean and median intake depth for lakes and reservoirs are substantially deeper than for rivers and creeks.

- There is substantially more variation in intake depth for lakes and reservoirs as compared to rivers and creeks.

- There are many power plants where the intakes are relatively shallow. Approximately 43% of the power plants overall have intakes at a depth of 10 feet or less, and 65% have intake depths at 15 feet or less.

- There are, nevertheless, a substantial number of power plants, approximately 26%, with intake depths greater than 20 feet.

Conclusion

Because of shallow intake depth, some power plants nationwide may be at risk of having to curtail or shut down operations in case of moderate or severe drought. Elevated temperature of the intake water may cause disruptions, however, prior to the water falling below the level of the intake. Active management of water levels so as to enable preferred uses, such as continued power plant operations, may help to reduce risk.

Commissions, Compacts, and Federal/State Programs

Findings

- There are many different federal, state, and local government and quasi-government organizations that would have a role in responding to droughts, including decisions pertaining to water use and withdrawal and prioritization among competing users. In some cases, task forces or working groups are established to facilitate agreement and coordinate implementation.

- Some river basin/watershed commissions or compacts have established controls over basins and watersheds (e.g., use of reservoirs to supplement flow or a payment system to subsidize uses). Such systems may serve to avoid the need to have to control uses and withdrawals during drought.

- No river basin/watershed commissions or compacts have established a system of priorities for essential and non-essential uses during drought. Some river basin/watershed commissions have indirect authority, subject to approval by different authorities (e.g., officials in multiple states), to manage water use during drought situations. Priorities, when they need to be set, would be established on a case-specific basis.

- The federal government has a minor role, at best, for responding to drought; most of the authority rests with the states.

- While most states prescribe to either the riparian or prior appropriation doctrine regarding water rights, each state program is different in at least some respects. Water systems (reservoirs, river basins) that span more than one state may be managed differently in each state during drought situations. The exception is when a commission or compact has been given direct regulatory authority to manage water use during drought situations, has been given a coordinating role, or where a task force or working group has been established to facilitate agreement and coordinate implementation.

- Most states have developed provisions (e.g., drought plans) for responding to drought situations. Many such provisions have been developed by multi-organizational task forces or working groups. Some state programs would directly control water allocations in accordance with classifications of essential and non-essential uses established to address drought conditions.

- Many states identify non-essential water uses that should be curtailed or stopped during drought, but have not identified or prioritized essential uses. Of the two state programs that have established a system of priorities for essential and non-essential uses during drought, power production is rated within the highest priority category.

- Most reported cases where power plants have had to curtail or shut down operations were not due to shallow depth of the intake, but rather were due to the high temperature of the cooling water and the relatively high temperature of the receiving water, and the concern of protecting the ecosystem.

Conclusions

The system of water rights in the United States (riparian vs. prior appropriation) and water control (commission/compact vs. state) is very different in different parts of the nation. The prospect of drought is unlikely to force a change in this system. It seems that few authorities (i.e., commission/compact vs. state) have established priority systems of essential and non-essential uses during droughts. Where such priority has been established, power production is rated within the highest priority category.

Also pertinent for this study, however, is the finding that most reported cases where power plants have had to curtail or shut down operations were not due to shallow depth of the intake, but rather were due to the high temperature of the cooling water and the relatively high temperature of the receiving water, and the concern of protecting the ecosystem.

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No specific website identified

U.S. Bureau of Reclamation, Lower Colorado Region
http://www.usbr.gov/lc/

U.S. Bureau of Reclamation, Upper Colorado Region
http://www.usbr.gov/uc/

U.S. Army Corps of Engineers Columbia Basin Water Management Division
http://www.nwd-wc.usace.army.mil/

Utility Water Act Group (UWAG)
No specific website identified

Washington State Conservation Commission
http://www.scc.wa.gov/

Western States Water Council (WSWC)
http://www.westgov.org/wswc/

Appendix A – Database of Power Plants and Cooling Water Intakes (Selected Fields)

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Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Charles R Lowman	AL	Alabama Electric Coop Inc	Coal	1.5	River	10	200
Barry	AL	Alabama Power Co	Coal	0	Mobile River	10	NA
E C Gaston	AL	Alabama Power Co	Coal	0.1	Coosa River	16	NA
Farley	AL	Alabama Power Co	Nuclear	NA	Chattahoochee River	14	NA
Gadsden	AL	Alabama Power Co	Coal	0.7	Coosa River	25	NA
Gorgas	AL	Alabama Power Co	Coal	12.8	Warrior River	14	3,300
Greene County	AL	Alabama Power Co	Coal	0.9	Black Warrior	5	NA
James H Miller Jr	AL	Alabama Power Co	Coal	12.74	Mulberry Fork	40	5
Decatur Energy Center	AL	Calpine Construction Fin Co Lp	Gas	NA	Tennessee River	10	NA
H Allen Franklin Combined Cycle	AL	Georgia Power Co	Gas	1.24	Chattahoochee River	15	50
E B Harris Electric Generating Plant	AL	Southern Co	Gas	38.1	Alabama River	30	NA
Browns Ferry	AL	Tennessee Valley Authority	Nuclear	NA	Wheeler Reservoir	21	NA
Colbert	AL	Tennessee Valley Authority	Coal	0	Tennessee River	14	NA
Widows Creek	AL	Tennessee Valley Authority	Coal	0	Tennessee River	10	1,120
Carl Bailey	AR	Arkansas Electric Coop Corp	Gas	0	White River	15	100
Mcclellan	AR	Arkansas Electric Coop Corp	Gas	0	Ouachita River	8	20
Ashdown	AR	Domtar Industries Inc	Gas	0	Millwater System	15	900
Cecil Lynch	AR	Entergy Arkansas Inc	Gas	0.03	Arkansas River	20	50
Hamilton Moses	AR	Entergy Arkansas Inc	Gas	NA	L'anquille River	6	25
Independence	AR	Entergy Arkansas Inc	Coal	10	River	16	0
Lake Catherine	AR	Entergy Arkansas Inc	Gas	0	Lake Catherine	36	90
Robert E Ritchie	AR	Entergy Arkansas Inc	Gas	NA	Mississippi River	31	NA
White Bluff	AR	Entergy Arkansas Inc	Coal	10.4	Arkansas River	30	125
Arkansas One	AR	Entergy Operations Inc	Nuclear	NA	Lake Dardanelle	14	NA
Flint Creek	AR	Southwestern Electric Power Co	Coal	0.1	Flint Creek Reservoir	20	NA
Kyrene	AZ	Salt River Proj Ag I & P Dist	Gas	NA	Canal Well	3	NA
Navajo	AZ	Salt River Proj Ag I & P Dist	Coal	10.9	Lake Powell	220	NA
South Point Energy Center	AZ	South Point Energy Center LLC	Gas	2.7	Colorado River	8	15
El Centro	CA	Imperial Irrigation District	Gas	0.26	Dogwood Canal	14	NA
Hayden	CO	Public Service Co of Colorado	Coal	3.9	Yampa River	8	2,640
Valmont	CO	Public Service Co of Colorado	Coal	5.1	South Boulder Creek	0	0

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Craig	CO	Tri-State G & T Assn Inc	Coal	6.6	Yampa River	8	7,920
Nucla	CO	Tri-State G & T Assn Inc	Coal	2.2	San Miguel River	5	NA
Middletown	CT	Nrg Middletown Operations Inc	Oil	0	Connecticut River	11	1
Putnam	FL	Florida Power & Light Co	Gas	0	St Johns River	5	NA
Sanford	FL	Florida Power & Light Co	Oil	0	St Johns River	6	660
Indiantown Cogeneration Lp	FL	Indiantown Cogeneration Lp	Gas	4.4	Taylor Creek	6	NA
Suwannee River	FL	Progress Energy Florida Inc	Oil	0	Suwannee River	9	NA
Seminole	FL	Seminole Electric Coop Inc	Coal	13.5	St Johns River	5	350
Bowen	GA	Georgia Power Co	Coal	10.2	Etowah River	15	NA
Hammond	GA	Georgia Power Co	Coal	0	Coosa River	12	0
Harllee Branch	GA	Georgia Power Co	Coal	0	Lake Sinclair	25	NA
Hatch	GA	Georgia Power Co	Nuclear	NA	Altamaha River	18	NA
Jack Mcdonough	GA	Georgia Power Co	Coal	5	Chattahoochee River	12	NA
Mcintosh	GA	Georgia Power Co	Coal	0	Savannah River	12	NA
Mitchell	GA	Georgia Power Co	Coal	0	Flint River	10	NA
Scherer	GA	Georgia Power Co	Coal	12.1	Lake Juliette	26	130
Vogtle	GA	Georgia Power Co	Nuclear	NA	Savannah River	0	NA
Georgia Pacific Cedar Springs	GA	Georgia-Pacific Corp	Gas	29	Chattahoochee River	10	NA
Duane Arnold	IA	Ies Utilities Inc	Nuclear	NA	Cedar River	6	NA
Burlington	IA	Interstate Power & Light Co	Coal	8	Mississippi River	13	NA
Lansing	IA	Interstate Power & Light Co	Coal	0	Mississippi River	6	NA
Milton L Kapp	IA	Interstate Power & Light Co	Gas	0	Mississippi River	6	NA
Prairie Creek	IA	Interstate Power & Light Co	Gas	0	Cedar River	6	NA
Ottumwa	IA	Interstate Power And Light	Coal	5.1	Des Moines River	5	NA
Council Bluffs	IA	Midamerican Energy Co	Coal	0	Missouri River	16	NA
George Neal North	IA	Midamerican Energy Co	Coal	11.4	Missouri River	12	NA
George Neal South	IA	Midamerican Energy Co	Coal	0	Missouri River	12	NA
Riverside	IA	Midamerican Energy Co	Coal	0	Miss River	9	NA
Muscatine Plant #1	IA	Muscatine City Of	Coal	0	Mississippi River	13	40
Potlatch Idaho Pulp Paper	ID	Potlatch Forest Products Corp	Gas	1	Clearwater River	20	15
Coffeen	IL	Ameren Energy Generating Co	Coal	0	Mcdavid Branch	10	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Hutsonville	IL	Ameren Energy Generating Co	Coal	0	Wabash River	14	NA
Meredosia	IL	Ameren Energy Generating Co	Coal	0	Illinois River	13	0
Newton	IL	Ameren Energy Generating Co	Coal	0	Laws Creek, Sandy Creek	17	NA
E D Edwards	IL	Ameren Energy Resources Generating	Coal	0	Illinois River	12	NA
Braidwood	IL	Commonwealth Edison Co	Nuclear	NA	Kankakee River	10	NA
Byron	IL	Commonwealth Edison Co	Nuclear	NA	Rock River	8	NA
Dresden	IL	Commonwealth Edison Co	Nuclear	NA	Kankakee River (I)	10	NA
Lasalle	IL	Commonwealth Edison Co	Nuclear	NA	Illinois River	17	NA
Quad Cities	IL	Commonwealth Edison Co	Nuclear	NA	Mississippi River	9	NA
Kincaid Generation LLC	IL	Dominion Energy Services Co	Coal	0	Lake Sangchris	32	0
Baldwin Energy Complex	IL	Dynegy Midwest Generation Inc	Coal	0	Kaskaskia River	10	NA
Havana	IL	Dynegy Midwest Generation Inc	Gas	0	Illinois River	10	NA
Hennepin Power Station	IL	Dynegy Midwest Generation Inc	Gas	1.9	Illinois River	10	NA
Vermilion	IL	Dynegy Midwest Generation Inc	Gas	3.1	Vermilion Reservoir	10	NA
Wood River	IL	Dynegy Midwest Generation Inc	Gas	0	Mississippi River	12	NA
Joppa Steam	IL	Electric Energy Inc	Coal	2.6	Ohio River	0	175
Clinton	IL	Illinois Power Co	Nuclear	NA	Clinton Lake	25	NA
Kendall County Generation Facility	IL	Ls Power Development LLC	Gas	0.7	Illinois River	8	200
Crawford	IL	Midwest Generations Eme LLC	Coal	0	Chicago Sanitary And Ship	11	NA
Fisk Street	IL	Midwest Generations Eme LLC	Coal	0	Chicago River- South Bra	6	NA
Joliet 29	IL	Midwest Generations Eme LLC	Coal	0	Desplaines River	5	NA
Joliet 9	IL	Midwest Generations Eme LLC	Coal	0	Desplaines River	5	NA
Powerton	IL	Midwest Generations Eme LLC	Coal	20	Illinois River	10	NA
Waukegan	IL	Midwest Generations Eme LLC	Coal	0	Lake Michigan	5	NA
Will County	IL	Midwest Generations Eme LLC	Coal	0	Chicago Sanitary And Ship	17	NA
Marion	IL	Southern Illinois Power Coop	Coal	7.3	Lake Egypt	25	NA
Dallman	IL	Springfield City Of	Coal	6.7	Lake Springfield	24	NA
Warrick	IN	Alcoa Power Generating Inc	Coal	0	Ohio River	33	NA
Frank E Ratts	IN	Hoosier Energy R E C Inc	Coal	0	White River	16	NA
Merom	IN	Hoosier Energy R E C Inc	Coal	0	Turtle Creek Reservoir	8	NA
Rockport	IN	Indiana Michigan Power Co	Coal	0	Ohio River	18	136

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Tanners Creek	IN	Indiana Michigan Power Co	Coal	0	Ohio River	10	36
Clifty Creek	IN	Indiana-Kentucky Electric Corp	Coal	0	Ohio River	11	270
Aes Petersburg	IN	Indianapolis Power & Light Co	Coal	0.7	White River	5	NA
Eagle Valley	IN	Indianapolis Power & Light Co	Coal	0	West Fork of White River	4	0
Harding Street	IN	Indianapolis Power & Light Co	Coal	17.2	West Fork of White River	10	600
Burns Harbor Plant	IN	International Steel Group	Gas	0	Lake Michigan	40	3,500
Bailly	IN	Northern Indiana Pub Serv Co	Coal	36.9	Lake Michigan	20	1,500
Dean H Mitchell	IN	Northern Indiana Pub Serv Co	Coal	NA	Lake Michigan	10	NA
Michigan City	IN	Northern Indiana Pub Serv Co	Gas	NA	Lake Michigan	8	NA
R M Schahfer	IN	Northern Indiana Pub Serv Co	Coal	0	Kankakee River	15	150
Cayuga	IN	Psi Energy Inc	Coal	0	Wabash River	10	0
Edwardsport	IN	Psi Energy Inc	Coal	0	West Fork White River	9	0
Gibson	IN	Psi Energy Inc	Coal	0	Wabash River	9	0
R Gallagher	IN	Psi Energy Inc	Coal	0	Ohio River	9	0
Wabash River	IN	Psi Energy Inc	Coal	0	Wabash River	17	0
A B Brown	IN	Southern Indiana Gas & Elec Co	Coal	0	Ohio River	20	30
F B Culley	IN	Southern Indiana Gas & Elec Co	Coal	0	Ohio River	27	NA
State Line Energy	IN	State Line Energy LLC	Coal	0	Lake Michigan	7	0
Gary Works	IN	United States Steel Corp	Gas	0.96	Lake Michigan	7	NA
Kaw	KS	Kansas City City Of	Coal	NA	Kaw River	10	10
Nearman Creek	KS	Kansas City City Of	Coal	0	Missouri River	19	NA
Quindaro	KS	Kansas City City Of	Coal	0	Missouri River	15	10
La Cygne	KS	Kansas City Power & Light Co	Coal	0	La Cygne Reservoir	8	NA
Jeffrey Energy Center	KS	Westar Energy	Coal	32.1	Kansas River	6	15
Wolf Creek (Ks)	KS	Wolf Creek Nuc Oper Corp	Nuclear	NA	John Redmond Reser (M)	14	NA
East Bend	KY	Duke Energy Kentucky	Coal	0	Ohio River	36	48
Cooper	KY	East Kentucky Power Coop Inc	Coal	0	Cumberland River	45	60
Dale	KY	East Kentucky Power Coop Inc	Coal	0	Kentucky River	5	NA
Big Sandy	KY	Kentucky Power Co	Coal	0	Big River Sandy	5	NA
E W Brown	KY	Kentucky Utilities Co	Coal	2	Herrington Lake	25	10
Ghent	KY	Kentucky Utilities Co	Coal	19.4	Ohio River	20	50

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Green River	KY	Kentucky Utilities Co	Coal	0	Green River	13	12
Tyrone	KY	Kentucky Utilities Co	Coal	NA	Kentucky River	15	NA
Cane Run	KY	Louisville Gas & Electric Co	Gas	0	Ohio River	4	NA
Mill Creek	KY	Louisville Gas & Electric Co	Gas	0	Ohio River	10	0
Trimble County	KY	Louisville Gas & Electric Co	Coal	14.8	Ohio River	23	NA
Elmer Smith	KY	Owensboro City Of	Coal	0	Ohio River	50	100
Paradise	KY	Tennessee Valley Authority	Coal	0	Green River	20	160
Shawnee	KY	Tennessee Valley Authority	Coal	0	Ohio River	15	NA
D B Wilson	KY	Western Kentucky Energy Corp	Oil	0	Green River	9	NA
Hmp&L Station Two Henderson	KY	Western Kentucky Energy Corp	Coal	17.7	Green River	10	40
Kenneth C Coleman	KY	Western Kentucky Energy Corp	Coal	0	Ohio River	9	NA
R D Green	KY	Western Kentucky Energy Corp	Coal	5.4	Green River	10	NA
Evangeline Power Station	LA	Cleco Evangeline LLC	Gas	0	Bayou Cocodrie	9	NA
Dolet Hills	LA	Cleco Power LLC	Coal	794.05	Makeup Pond On Property	0	0
Rodemacher	LA	Cleco Power LLC	Gas	0	Rodemacher Lake	10	0
Willow Glen	LA	Entergy Gulf States Inc	Gas	0	Mississippi River	12	339
Little Gypsy	LA	Entergy Louisiana Inc	Gas	0	Mississippi River	10	0
Monroe	LA	Entergy Louisiana Inc	Gas	NA	Ouachita River	20	20
Nine Mile Point	LA	Entergy Louisiana Inc	Gas	0	Mississippi River	15	0
Sterlington	LA	Entergy Louisiana Inc	Gas	0	Ouachita River	15	0
Waterford 1 & 2	LA	Entergy Louisiana Inc	Gas	0.2	Mississippi River	10	0
River Bend	LA	Gulf States Utilities	Nuclear	NA	Mississippi River	20	NA
Big Cajun 2	LA	Louisiana Generating LLC	Coal	8.9	Mississippi River	10	1,000
Waterford	LA	Louisiana Power & Light	Nuclear	NA	Mississippi River	10	NA
Ouachita Generating Plant	LA	Ouachita Operating Sevices LLC	Gas	1.57	Quachita River	11	195
Arsenal Hill	LA	Southwestern Electric Power Co	Gas	0.48	Arsenal Hill Cooling Pond	17	NA
Lieberman	LA	Southwestern Electric Power Co	Gas	0	Caddo Lake	10	NA
West Springfield	MA	Consolidated Edison E Ma Inc	Oil	0	Connecticut River	9	NA
Mount Tom	MA	Northeast Generation Services Co	Coal	0	Connecticut River	13	NA
R Paul Smith Power Station	MD	Allegheny Energy Supply Co LLC	Coal	0	Potomac River	7	NA
Dickerson	MD	Mirant Mid-Atlantic LLC	Coal	0	Potomac River	7	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
J H Campbell	MI	Consumers Energy Co	Coal	NA	Lake Michigan	35	NA
Palisades (Mi)	MI	Consumers Power Co	Nuclear	NA	Lake Michigan	0	NA
Mistersky	MI	Detroit City Of	Gas	0.22	Detroit River	6	NA
Fermi	MI	Detroit Edison Co	Nuclear	NA	Lake Erie	12	NA
Dc Cook	MI	Indiana Michigan Power Co	Nuclear	NA	Lake Michigan	20	NA
Erickson Station	MI	Lansing City Of	Coal	0.4	Grand River	5	NA
New Covert Generating Facility	MI	New Covert Generating Company LLC	Gas	9.48	Lake Michigan	14	1,300
Presque Isle	MI	Wisconsin Electric Power Co	Coal	0	Lake Superior	20	1,200
Clay Boswell	MN	Allete Inc	Coal	0	North Blackwater Lake	13	NA
Syl Laskin	MN	Allete Inc	Coal	1.2	Colby Lake	11	NA
Taconite Harbor Energy Center	MN	Allete Inc	Coal	0.1	Lake Superior	22	NA
Silver Bay Power	MN	Cleveland Cliffs Inc	Gas	4.9	Lake Superior	30	NA
Fox Lake	MN	Interstate Power & Light Co	Gas	0	Fox Lake	8	NA
Allen S King	MN	Northern States Power Co	Coal	1.3	Lake St. Croix	6	NA
Black Dog	MN	Northern States Power Co	Coal	0	Minnesota River	8	NA
High Bridge	MN	Northern States Power Co	Gas	0	River	4	NA
Monticello (Mn)	MN	Northern States Power Co	Nuclear	NA	Mississippi River	7	NA
Prairie Island	MN	Northern States Power Co	Nuclear	NA	Mississippi River	17	NA
Sherburne County	MN	Northern States Power Co	Coal	24.7	Mississippi River	6	NA
Hoot Lake	MN	Otter Tail Power Co	Oil	0	Otter Tail River	9	NA
Labadie	MO	Ameren UE	Coal	0	Missouri River	25	30
Meramec	MO	Ameren UE	Coal	0	Mississippi River	22	60
Rush Island	MO	Ameren UE	Coal	0	Mississippi River	32	30
Sioux	MO	Ameren UE	Coal	0	Mississippi River	20	1,750
Lake Road	MO	Aquila Inc	Gas	0	Missouri River	9	0
Sibley	MO	Aquila Inc	Coal	0	Missouri River	15	NA
New Madrid	MO	Associated Electric Coop Inc	Coal	6.1	Mississippi River	26	NA
Thomas Hill	MO	Associated Electric Coop Inc	Coal	11.5	Thomas Hill Lake	35	50
Hawthorn	MO	Kansas City Power & Light Co	Coal	0	Missouri River	13	NA
Latan	MO	Kansas City Power & Light Co	Coal	0	Missouri River	15	NA
Montrose	MO	Kansas City Power & Light Co	Coal	0	Montrose Reservoir	8	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
James River Power Station	MO	Springfield City Of	Gas	9.2	Lake Springfield	14	NA
Callaway	MO	Union Electric Co	Nuclear	NA	Missouri River	10	NA
Baxter Wilson	MS	Entergy Mississippi Inc	Gas	0	Mississippi River	30	0
Delta	MS	Entergy Mississippi Inc	Gas	0.7	Sunflower River	8	10
Gerald Andrus	MS	Entergy Mississippi Inc	Gas	NA	Mississippi River	20	NA
Rex Brown	MS	Entergy Mississippi Inc	Gas	0	Cooling Pond	10	10
Grand Gulf	MS	Entergy Operations Inc	Nuclear	NA	Mississippi River	95	NA
Batesville Generation Facility	MS	Lsp Energy Ltd Partnership	Gas	1.63	Little Tallahtchie River	30	150
Weyerhaeuser Columbus Ms	MS	Weyerhaeuser Co	Coal	1.4	Tennessee-Tombigbee Waterway	28	NA
Colstrip	MT	Ppl Montana LLC	Coal	15	Yellowstone River	15	200
Hardin Generator Project	MT	Rocky Mountain Power Inc	NA	0	Bighorn River	3	20
Harris (Nc)	NC	Carolina Power & Light Co	Nuclear	NA	Harris Lake	0	NA
Belews Creek	NC	Duke Energy Corp	Coal	7.6	Belews Lake	18	NA
Buck	NC	Duke Energy Corp	Coal	0.5	Yadkin River/High Rock	26	NA
Cliffside	NC	Duke Energy Corp	Coal	0.4	Broad River	4	NA
Dan River	NC	Duke Energy Corp	Coal	0.7	Dan River	6	NA
G G Allen	NC	Duke Energy Corp	Coal	1.5	Lake Wylie	16	NA
Marshall	NC	Duke Energy Corp	Coal	4.1	Lake Norman	31	NA
Mcguire	NC	Duke Energy Corp	Nuclear	NA	Lake Norman	45	NA
Riverbend	NC	Duke Energy Corp	Coal	0.7	Catawba River	18	NA
Asheville	NC	Progress Energy Carolinas Inc	Coal	1.1	Lake Julian	6	NA
Cape Fear	NC	Progress Energy Carolinas Inc	Coal	0.6	Cape Fear River	15	NA
Lee	NC	Progress Energy Carolinas Inc	Coal	13	H F Lee Lake	5	NA
Mayo	NC	Progress Energy Carolinas Inc	Coal	24	Mayo Lake	12	NA
Roxboro	NC	Progress Energy Carolinas Inc	Coal	0	Lake Hyco	10	NA
Antelope Valley	ND	Basin Electric Power Coop	Coal	6.5	Lake	67	2,170
Coal Creek	ND	Great River Energy	Coal	18.69	Missouri River	4	NA
Stanton	ND	Great River Energy	Coal	0.1	Missouri River	9	40
R M Heskett	ND	Mdu Resources Group Inc	Coal	0	Missouri River	17	NA
Milton R Young	ND	Minnkota Power Coop Inc	Coal	0	Nelson Lake	20	0
Coyote	ND	Otter Tail Power Co	Coal	7.1	Missouri River	10	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Canaday	NE	Nebraska Public Power District	Oil/Gas	0	Tri-County Supply Canal	2	NA
Fort Calhoun	NE	Omaha Public Power Dist	Nuclear	NA	Missouri River	4	NA
Nebraska City	NE	Omaha Public Power District	Coal	0	Missouri River	8	NA
North Omaha	NE	Omaha Public Power District	Coal	0	Missouri River	8	2
Merrimack	NH	Public Service Co Of NH	Coal	0	Merrimack River	7	NA
Chambers Cogeneration Lp	NJ	Chambers Cogeneration Lp	Coal	4	Salem Canal	4	60
Oyster Creek	NJ	Gpu Nuclear Corp	Nuclear	NA	Forked River (I)	14	NA
Logan Generating Plant	NJ	Logan Generating Co Lp	Coal	3.6	Delware River	13	NA
Pseg Mercer Generating Station	NJ	Pseg Fossil LLC	Coal	4.8	Delaware River	15	NA
Four Corners	NM	Arizona Public Service Co	Coal	34.3	San Juan River	5	NA
Tracy	NV	Sierra Pacific Power Co	Gas	2.68	Truckee River	10	NA
Aes Cayuga	NY	Aes Cayuga LLC	Coal	0.7	Cayuga Lake	44	526
Aes Greenidge LLC	NY	Aes Greenidge LLC	Coal	0	Seneca Lake	11	NA
Aes Somerset LLC	NY	Aes Somerset LLC	Coal	0	Lake Ontario	16	NA
Dunkirk Generating Station	NY	Dunkirk Power LLC	Coal	0	Lake Erie	21	NA
Danskammer Generating Station	NY	Dynegy Northeast Gen Inc	Coal	0	Hudson River	5	NA
Roseton Generating Station	NY	Dynegy Northeast Gen Inc	Gas	0	Hudson River	29	254
Fitzpatrick	NY	New York Power Authority	Nuclear	NA	Lake Ontario	12	NA
C R Huntley Generating Station	NY	Nrg Huntley Operations Inc	Coal	0	Niagara River	10	NA
Oswego Harbor Power	NY	Nrg Oswego Power Operations Inc	Oil	0	Lake Ontario	20	850
Pseg Albany Generating Station	NY	Pseg Power New York Inc	Gas	0	Hudson River	24	NA
Ginna	NY	Rochester Gas & Elec Corp	Nuclear	NA	Lake Ontario	15	NA
Rochester 7	NY	Rochester Gas & Electric Corp	Coal	0	Lake Ontario	36	NA
Richard Gorsuch	OH	American Mun Power-Ohio Inc	Coal	0	Ohio River	12	NA
Cardinal	OH	Cardinal Operating Co	Coal	13.5	Ohio River	12	7
Perry (Oh)	OH	Cleveland Elec Illum Co	Nuclear	NA	Lake Erie	18	NA
Ashtabula	OH	Cleveland Electric Illum Co	Coal	0	Lake Erie	20	1,000
Eastlake	OH	Cleveland Electric Illum Co	Coal	33	Lake Erie	20	NA
Lake Shore	OH	Cleveland Electric Illum Co	Coal	0	Lake Erie	20	500
Conesville	OH	Columbus Southern Power Co	Coal	0	Muskingum River	11	NA
Picway	OH	Columbus Southern Power Co	Coal	0	Scioto River	7	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
J M Stuart	OH	Dayton Power & Light Co	Coal	3.5	Ohio River	40	100
Killen Station	OH	Dayton Power & Light Co	Coal	12.5	Ohio River	17	140
O H Hutchings	OH	Dayton Power & Light Co	Gas	0	Great Miami River	4	175
Hanging Rock Energy Facility	OH	Duke Energy Hanging Rock LLC	Gas	2.17	Ohio River	16	91
Miami Fort	OH	Duke Energy Kentucky	Coal	0	Ohio River	22	NA
W H Zimmer	OH	Duke Energy Ohio	Coal	0	Ohio River	12	40
Walter C Beckjord	OH	Duke Energy Ohio	Coal	0	Ohio River	6	25
Hamilton	OH	Hamilton City Of	Gas	0	Miami River	10	NA
R E Burger	OH	Ohio Edison Co	Coal	0	Ohio River	10	NA
W H Sammis	OH	Ohio Edison Co	Coal	0	Ohio River	21	NA
General James M Gavin	OH	Ohio Power Co	Coal	0	Ohio River	10	NA
Muskingum River	OH	Ohio Power Co	Coal	0	Muskingum River	15	NA
Kyger Creek	OH	Ohio Valley Electric Corp	Coal	0	Ohio River	13	180
Avon Lake	OH	Orion Power Midwest Lp	Coal	0	Lake Erie	20	NA
Bay Shore	OH	Toledo Edison Co	Coal	0	Lake Erie	14	NA
Davis Besse	OH	Toledo Edison Co	Nuclear	NA	Lake Erie	11	NA
Aes Shady Point	OK	Aes Shady Point LLC	Coal	4.32	Poteau River	3	NA
Grda	OK	Grand River Dam Authority	Coal	7.35	Grand River	40	73
Horseshoe Lake	OK	Oklahoma Gas & Electric Co	Gas	0.8	Cooling Pond	4	NA
Muskogee	OK	Oklahoma Gas & Electric Co	Gas	NA	Arkansas River	30	10
Sooner	OK	Oklahoma Gas & Electric Co	Coal	15.3	Arkansas River	3	NA
Northeastern	OK	Public Service Co of Oklahoma	Gas	1.9	Verdigris River	40	NA
Southwestern	OK	Public Service Co of Oklahoma	Gas	0.7	Ft. Cobb	4	8,000
Tulsa	OK	Public Service Co of Oklahoma	Gas	1.42	Arkansas	2	NA
Hugo	OK	Western Farmers Elec Coop Inc	Coal	5.2	Kiamichi River	10	90
Boardman	OR	Portland General Electric Co	Coal	18	Columbia River	23	NA
Port Westward	OR	Portland General Electric Co	NA	NA	Columbia River	16	NA
Aes Beaver Valley Partners Beaver Valley	PA	Aes Beaver Valley	Coal	0	Ohio River	6	NA
Armstrong Power Station	PA	Allegheny Energy Supply Co LLC	Coal	0	Allegheny River	16	NA
Hatfields Ferry Power Station	PA	Allegheny Energy Supply Co LLC	Coal	6.5	Monongahela River	14	NA
Mitchell Power Station	PA	Allegheny Energy Supply Co LLC	Gas	12.6	Monongahela River	15	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Fayette Energy Facility	PA	Duke Energy Fayette LLC	Gas	0.4	Monongahela River	14	97
Beaver Valley	PA	Duquesne Light Co	Nuclear	NA	Ohio River	11	NA
Cromby Generating Station	PA	Exelon Generation Co LLC	Coal	0	Schuylkill River	12	NA
Eddystone Generating Station	PA	Exelon Generation Co LLC	Coal	0.6	Delaware River	10	NA
Schuylkill Generating Station	PA	Exelon Generation Co LLC	Oil	0	Schuylkill River	18	NA
Three Mile Island	PA	Gpu Nuclear Corp	Nuclear	NA	Susquehanna River	13	NA
Homer City Station	PA	Midwest Generation	Coal	26	Two Lick Creek	6	0
Brunot Island	PA	Orion Power Midwest Lp	Gas	0.2	Ohio River	6	NA
Cheswick Power Plant	PA	Orion Power Midwest Lp	Coal	0	Allegheny River	8	NA
Elrama Power Plant	PA	Orion Power Midwest Lp	Coal	3.7	Monongahela River	8	NA
New Castle Plant	PA	Orion Power Midwest Lp	Coal	0	Beaver River	2	NA
P H Glatfelter	PA	P H Glatfelter Co	Coal	0	North Codorus	4	100
Limerick	PA	Peco Energy Co	Nuclear	NA	Schuylkill River (M)	10	NA
Peach Bottom	PA	Peco Energy Co	Nuclear	NA	Susquehanna River	0	NA
Susquehanna	PA	Pennsylvania Power & Lt	Nuclear	NA	Susquehanna River	4	NA
Bruce Mansfield	PA	Pennsylvania Power Co	Coal	22.3	Ohio River	15	12
Northampton Generating Company	PA	Pg&E National Energy Group	Coal	1.7	Lehigh River	5	NA
Ppl Brunner Island	PA	Ppl Corp	Coal	4.1	Susquehanna River	15	0
Ppl Martins Creek	PA	Ppl Corp	Coal	0	Delaware River	11	NA
Ppl Montour	PA	Ppl Corp	Coal	14	Susquehanna River	5	350
Seward	PA	Reliant Energy Inc	Coal	5.7	Conemaugh River	20	NA
Portland	PA	Reliant Energy Mid-Atlantic Ph	Coal	2	Delaware River	6	5
Shawville	PA	Reliant Energy Mid-Atlantic Ph	Coal	0	Susquehanna River	3	1,760
Titus	PA	Reliant Energy Mid-Atlantic Ph	Coal	2.1	Schuylkill River	5	70
Wps Energy Servs Sunbury Gen	PA	Sunbury Generation LLC	Coal	0	Susquehanna River	7	NA
Colver Power Project	PA	Tifd Viii-W Inc	Coal	1.8	Vetera Reservoir	25	90
G F Weaton Power Station	PA	Zinc Corp of America	Gas	0	Ohio River	12	NA
Robinson	SC	Carolina Power & Light Co	Nuclear	NA	Lake Robinson	40	NA
Catawba	SC	Duke Energy Corp	Nuclear	NA	Lake Wylie	29	NA
Oconee	SC	Duke Energy Corp	Nuclear	NA	Lake Keowee	36	NA
W S Lee	SC	Duke Energy Corp	Coal	1.1	Saluda River	8	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
International Paper Eastover Facility	SC	International Paper Co-Eastovr	Biomass	0	Wateree River	11	NA
H B Robinson	SC	Progress Energy Carolinas Inc	Coal	0	Lake Robinson	40	15
Summer	SC	South Carolina Elec & Gas	Nuclear	NA	Monticello Reservoir	16	NA
Canadys Steam	SC	South Carolina Electric&Gas Co	Coal	4.75	Edisto River	10	NA
Cope	SC	South Carolina Electric&Gas Co	Coal	5.5	South Fork/Edisto River	6	NA
Mcmeekin	SC	South Carolina Electric&Gas Co	Coal	0	Lake Murray	185	NA
Urquhart	SC	South Carolina Electric&Gas Co	Coal	0	Savannah River	9	NA
Wateree	SC	South Carolina Electric&Gas Co	Coal	0	Wateree River	20	800
Dolphus M Grainger	SC	South Carolina Pub Serv Auth	Coal	0	Waccamaw River	3	NA
Stone Container Florence Mill	SC	Stone Container Corp	Oil	0	Great Pee Dee River	10	25
Big Stone	SD	Otter Tail Power Co	Coal	6	Big Stone Lake	13	NA
Tennessee Eastman Operations	TN	Eastman Chemical Co-Tn Ops	Coal	0	South Fork - Holston River	9	NA
Sequoyah	TN	Tennessee Valley Auth	Nuclear	NA	Chickamauga Reservoir	27	NA
Allen Steam Plant	TN	Tennessee Valley Authority	Coal	0	Mississippi River	16	NA
Bull Run	TN	Tennessee Valley Authority	Coal	0	Clinch River	25	NA
Cumberland	TN	Tennessee Valley Authority	Coal	0	Cumberland	28	400
Gallatin	TN	Tennessee Valley Authority	Coal	0	Cumberland	17	NA
John Sevier	TN	Tennessee Valley Authority	Coal	0	Holston River	12	800
Johnsonville	TN	Tennessee Valley Authority	Coal	0	Tennessee River	12	4,000
Kingston	TN	Tennessee Valley Authority	Coal	0	Emory River	20	4,400
Watts Bar Fossil	TN	Tennessee Valley Authority	Coal	NA	Tennessee River	24	200
Sandow Station	TX	Alcoa Inc	Coal	NA	Alcoa Lake Treatment System	15	NA
Decker Creek	TX	Austin City Of	Gas	0	Lake Long	10	NA
Sand Hill	TX	Austin City Of	Gas	0	Lower Colorado River	3	NA
R W Miller	TX	Brazos Electric Power Coop Inc	Gas	1	Lake Palo Pinto	30	0
Brazos Valley Generating Facility	TX	Brazos Valley Energy	Gas	4.1	Brazos River	7	NA
Dansby	TX	Bryan City Of	Gas	0	Lake	27	28
J K Spruce	TX	City Public Service of San Antonio	Coal	13.1	Calaveras Lake	21	NA
J T Deely	TX	City Public Service of San Antonio	Coal	9	Calaveras Lake Make-Up FR	10	NA
O W Sommers	TX	City Public Service of San Antonio	Gas	1.2	Calaveras Lake; Make-Up Fr	10	NA
V H Braunig	TX	City Public Service of San Antonio	Gas	0.6	VH Braunig Laek; Make Up FR	6	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Handley	TX	Extex Laporte LP	Gas	4.7	Lake Arlington	15	NA
Mountain Creek	TX	Extex Laporte LP	Gas	1.4	Mountian Creek Lake	20	NA
Ray Olinger	TX	Garland City Of	Gas	NA	Lake Lavon	15	20
Guadalupe Generating Station	TX	Guadalupe Power Partners Lp	Gas	3.5	Lake Dunlap	16	60
Cottonwood Energy Project	TX	Intergen Oper Co (Cottonwood)	Gas	0	Sabine River	1	50
Fayette Power Project	TX	Lower Colorado River Authority	Coal	0	Fpp Lake	9	8
Sim Gideon	TX	Lower Colorado River Authority	Gas	0	Colorado River/Lk Bastrop	12	NA
Thomas C Ferguson	TX	Lower Colorado River Authority	Gas	1.1	Lake LBJ	25	NA
Limestone	TX	Nrg	Coal	23.11	Lake Limestone	40	1,886
W A Parish	TX	Nrg	Gas	0	Brazos River	0	0
Knox Lee	TX	Southwestern Electric Power Co	Gas	0	Lake Cherokee	12	NA
Pirkey	TX	Southwestern Electric Power Co	Gas	8	Brandy Branch Reservoir	25	NA
Welsh	TX	Southwestern Electric Power Co	Coal	1.6	Swauano Creek Reservoir	25	NA
Wilkes	TX	Southwestern Electric Power Co	Gas	0	Johnson Creek Reservoir	20	NA
Gibbons Creek	TX	Texas Municipal Power Agency	Coal	0	Gibbons Creek	16	NA
Comanche Peak	TX	Texas Utilities Elec Co	Nuclear	NA	Squaw Creek Reservoir	29	NA
Coleto Creek	TX	Topaz Power Group LLC	Coal	2	Coleto Creek Reservoir	5	NA
La Palma	TX	Topaz Power Group LLC	Gas	1.18	Resaca De Las Palmas	10	NA
Victoria	TX	Topaz Power Group LLC	Gas	NA	Guadalupe River	8	NA
Big Brown	TX	Txu Electric Co	Coal	0	Fairfield Lake	12	NA
Decordova Steam Electric Station	TX	Txu Electric Co	Gas	0.3	Lake Granbury	33	NA
Eagle Mountain	TX	Txu Electric Co	Gas	0.2	Eagle Mountain Reservoir	30	190
Graham	TX	Txu Electric Co	Gas	186	Lake Graham	15	NA
Lake Creek	TX	Txu Electric Co	Gas	0.1	Lake Creek Lake	10	NA
Lake Hubbard	TX	Txu Electric Co	Gas	NA	Lake Ray Hubbard	18	NA
Martin Lake	TX	Txu Electric Co	Coal	0	Martin Lake	32	NA
Monticello	TX	Txu Electric Co	Coal	0	Monticello Reservoir	10	NA
Morgan Creek	TX	Txu Electric Co	Gas	NA	Lake Colorado City	15	NA
North Lake	TX	Txu Electric Co	Gas	NA	North Lake	21	NA
Sandow No 4	TX	Txu Electric Co	Coal	NA	Lake Alcoa	35	NA
Stryker Creek	TX	Txu Electric Co	Gas	0	Stryker Creek Reservoir	17	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Tradinghouse	TX	Txu Electric Co	Gas	0.6	Tradinghouse Creek Reservoir	17	NA
Trinidad	TX	Txu Electric Co	Gas	0	Trinidad Lake	17	NA
Valley	TX	Txu Electric Co	Gas	0	Valley Lake	15	NA
Bonanza	UT	Deseret Generation & Tran Coop	Coal	10.6	Green River	36	20
Intermountain Power Project	UT	Los Angeles City Of	Coal	13.9	Dmad Reservoir	20	NA
Carbon	UT	Pacificorp	Coal	1.7	Price River	13	NA
Gadsby	UT	Pacificorp	Gas	0.1	Jordan River	6	NA
Hunter	UT	Pacificorp	Coal	8.4	Cottonwood Creek	14	NA
Huntington	UT	Pacificorp	Coal	8.2	Huntington Creek	12	NA
Clinch River	VA	Appalachian Power Co	Coal	0	Clinch River	5	5
Glen Lyn	VA	Appalachian Power Co	Coal	0	New River	10	NA
Birchwood Power	VA	Birchwood Power Partners Lp	Coal	3.3	Rappahannock River	18	120
Cogentrix Of Richmond	VA	Cogentrix Of Richmond Inc	Coal	3.9	James River	30	6,300
Mecklenburg Power Station	VA	Dps Mecklenburg LLC	Coal	167.8	John H Kerr Reservoir	34	100
North Anna	VA	Virginia Elec & Power Co	Nuclear	NA	Lake Anna	27	NA
Clover	VA	Virginia Electric & Power Co	Coal	NA	Roanoke River	7	30
Vermont Yankee	VT	Vermont Yankee Nuc Power	Nuclear	NA	Connecticut River	10	NA
Transalta Centralia Generation	WA	Transalta Centralia Gen LLC	NA	0.4	Skookumchuk River	30	NA
Columbia	WA	Washington Pub Pwr Supply	Nuclear	NA	Columbia River	11	NA
Alma	WI	Dairyland Power Coop	Coal	0	Mississippi River	12	0
Genoa	WI	Dairyland Power Coop	Coal	0	Mississippi River	11	NA
John P Madgett	WI	Dairyland Power Coop	Coal	0	Mississippi River	12	NA
Green Bay West Mill	WI	Fort James Operating Co	Gas	17	Lower Fox River	12	NA
Blount Street	WI	Madison Gas & Electric Co	Gas	0	Lake Monona	10	390
Manitowoc	WI	Manitowoc Public Utilities	Gas	0	Lake Michigan	27	NA
Point Beach	WI	Wisconsin Elec Power Co	Nuclear	NA	Lake Michigan	10	NA
Elm Road Generating Station	WI	Wisconsin Electric Power Co	NA	NA	Lake Michigan	35	NA
Pleasant Prairie	WI	Wisconsin Electric Power Co	Coal	9.4	Lake Michigan	11	1,750
South Oak Creek	WI	Wisconsin Electric Power Co	Coal	0	Lake Michigan	17	NA
Edgewater	WI	Wisconsin Power & Light Co	Coal	0	Lake Michigan	10	1,500
Nelson Dewey	WI	Wisconsin Power & Light Co	Coal	0	Mississippi River	10	NA

Plant Name	State	Utility Name	Fuel Type	Average Consumption (cfs)	Cooling Water Source	Intake Depth Below Surface (ft)	Intake Distance From Shore (ft)
Rock River	WI	Wisconsin Power & Light Co	Gas	0.6	Rock River	4	NA
Kewaunee	WI	Wisconsin Public Service	Nuclear	NA	Lake Michigan	25	NA
Pulliam	WI	Wisconsin Public Service Corp	Coal	0	Green Bay	6	12
Weston	WI	Wisconsin Public Service Corp	Coal	0	Wisconsin River	6	20
John E Amos	WV	Appalachian Power Co	Coal	14.1	Kanawha River	5	75
Kanawha River	WV	Appalachian Power Co	Coal	0	Kanawha River	15	NA
Mountaineer	WV	Appalachian Power Co	Coal	NA	Ohio River	19	290
Philip Sporn	WV	Central Operating Co	Coal	0	Ohio River	24	28
Albright	WV	Monongahela Power Co	Coal	NA	Cheat River	19	0
Fort Martin Power Station	WV	Monongahela Power Co	Coal	6.2	Monongahela River	14	NA
Harrison Power Station	WV	Monongahela Power Co	Coal	12.67	West Fork River	10	NA
Pleasants Power Station	WV	Monongahela Power Co	Coal	14.6	Ohio River	10	NA
Rivesville	WV	Monongahela Power Co	Coal	0	Monongahela River	20	0
Willow Island	WV	Monongahela Power Co	Gas	0	Ohio River	18	10
Kammer	WV	Ohio Power Co	Coal	0	Ohio River	19	256
Ppg Natrium Plant	WV	Ppg Industries Inc	Gas	0	Ohio River	30	NA
Laramie River Station	WY	Basin Electric Power Coop	Coal	8.3	Laramie River	54	140
Dave Johnston	WY	Pacificorp	Coal	0.9	North Platte River	7	NA
Jim Bridger	WY	Pacificorp	Coal	7.7	Green River	8	NA
Naughton	WY	Pacificorp	Coal	1.7	Hams Fork River	5	NA

Appendix B – Database of Power Plants Filtered Out (Selected Fields)

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Plant Name	State	Utility Name	Reason for Deletion from Database
Union Power Station	AR	Union Power Partners LP	No depth data in EIA-767
Hot Spring Power Project	AR	Hot Spring Power Co LLC	No depth data in EIA-767
KGen Hot Spring Generating Facility	AR	Cinergy Solutions O&M LLC	No depth data in EIA-767
Santan	AZ	Salt River Proj Ag I & P Dist	Not surface water
Desert Basin	AZ	Salt River Proj Ag I & P Dist	No depth data in EIA-767
AES Alamitos LLC	CA	AES Alamitos LLC	Salt/tidal water
Humboldt Bay	CA	Pacific Gas & Electric Co	Salt/tidal water
Morro Bay Power Plant	CA	Duke Energy North America LLC	Salt/tidal water
Moss Landing Power Plant	CA	Duke Energy North America LLC	Salt/tidal water
AES Huntington Beach LLC	CA	AES Huntington Beach LLC	Salt/tidal water
Encina	CA	Cabrillo Power I LLC	Salt/tidal water
Haynes	CA	Los Angeles City of	Salt/tidal water
AES Redondo Beach LLC	CA	AES Redondo Beach LLC	Salt/tidal water
Diablo Canyon	CA	Pacific Gas & Elec Co	Salt/tidal water
El Segundo Power	CA	El Segundo Power LLC	Salt/tidal water
Mandalay	CA	Reliant Energy Mandalay LLC	No depth data in EIA-767
Ormond Beach	CA	Reliant Energy Ormond Bch LLC	Salt/tidal water
San Onofre	CA	Southern Calif Edison Co	Salt/tidal water
Pittsburg Power	CA	Mirant Delta LLC	Salt/tidal water
South Bay Power Plant	CA	Duke Energy North America LLC	Salt/tidal water
Hunters Point	CA	Pacific Gas & Electric Co	Salt/tidal water
Potrero Power	CA	Mirant Potrero LLC	Salt/tidal water
Contra Costa	CA	Mirant Delta LLC	Salt/tidal water
Scattergood	CA	Los Angeles City of	Salt/tidal water
Comanche	CO	Public Service Co of Colorado	No depth data in EIA-767
Arapahoe	CO	Public Service Co of Colorado	No depth data in EIA-767
Cherokee	CO	Public Service Co of Colorado	No depth data in EIA-767
Zuni	CO	Public Service Co of Colorado	No depth data in EIA-767
Fort St Vrain	CO	Public Service Co of Colorado	No depth data in EIA-767
Rocky Mountain Energy Center	CO	Rocky Mountain Energy Ctr LLC	No depth data in EIA-767
Bridgeport Station	CT	PSEG Power Connecticut LLC	Salt/tidal water
Devon Station	CT	NRG Devon Operations Inc	Salt/tidal water
NRG Norwalk Harbor	CT	NRG Norwalk Harbor Operations	Salt/tidal water
New Haven Harbor	CT	PSEG Power Connecticut LLC	Salt/tidal water
Millstone	CT	Northeast Nuc Energy Co	Salt/tidal water
AES Thames	CT	AES Thames LLC	Salt/tidal water
Montville Station	CT	NRG Montville Operations Inc	Salt/tidal water
Benning	DC	Mirant Mid-Atlantic Serc LLC	Salt/tidal water
Edge Moor	DE	Conectiv Energy Supply Inc	Salt/tidal water
Delaware City Plant	DE	Motiva Enterprises LLC	Salt/tidal water
Indian River Generating Station	DE	Indian River Operations Inc	Salt/tidal water
Anclote	FL	Progress Energy Florida Inc	Salt/tidal water
St Lucie	FL	Florida Power & Light Co	Salt/tidal water
Cutler	FL	Florida Power & Light Co	Salt/tidal water
Turkey Point	FL	Florida Power & Light Co	No depth data in EIA-767
Crist	FL	Gulf Power Co	Salt/tidal water

Plant Name	State	Utility Name	Reason for Deletion from Database
Crystal River	FL	Progress Energy Florida Inc	Salt/tidal water
Big Bend	FL	Tampa Electric Co	Salt/tidal water
Cape Canaveral	FL	Florida Power & Light Co	Salt/tidal water
Henry D King	FL	Fort Pierce Utilities Auth	Salt/tidal water
Indian River	FL	Reliant Energy Florida LLC	Salt/tidal water
Vero Beach Municipal Power Plant	FL	Vero Beach City of	Salt/tidal water
Port Everglades	FL	Florida Power & Light Co	Salt/tidal water
Riviera	FL	Florida Power & Light Co	Salt/tidal water
Manatee	FL	Florida Power & Light Co	No depth data in EIA-767
Lansing Smith	FL	Gulf Power Co	Salt/tidal water
St Johns River Power Park	FL	JEA	No depth data in EIA-767
Northside Generating Station	FL	JEA	No depth data in EIA-767
Martin	FL	Florida Power & Light Co	No depth data in EIA-767
P L Bartow	FL	Progress Energy Florida Inc	Salt/tidal water
Blue Heron Energy Center	FL	Calpine Eastern Corp	No depth data in EIA-767
Yates	GA	Georgia Power Co	No depth data in EIA-767
McIntosh Combined Cycle Facility	GA	Savannah Electric & Power Co	No depth data in EIA-767
Kraft	GA	Savannah Electric & Power Co	Salt/tidal water
McManus	GA	Georgia Power Co	Salt/tidal water
Augusta Energy Center	GA	Augusta Energy Center LLC	No depth data in EIA-767
Longleaf Energy Station	GA	Longleaf Energy Associates, LLC	No depth data in EIA-767
Honolulu	HI	Hawaiian Electric Co Inc	Salt/tidal water
Kahe	HI	Hawaiian Electric Co Inc	Salt/tidal water
Waiau	HI	Hawaiian Electric Co Inc	Salt/tidal water
Duck Creek	IL	Ameren Energy Resources Generating	Salt/tidal water
Holland Energy Facility	IL	Holland Energy LLC	No depth data in EIA-767
Prairie State Generating Station	IL	Prairie State Generating Co LLC	No depth data in EIA-767
Prairie State Generatng Station	IL	Prairie State Generating Co LLC	No depth data in EIA-767
Indeck Elwood Energy Center	IL	Indeck-Elwood LLC	No depth data in EIA-767
Whiting Clean Energy	IN	Whiting Clean Energy Inc	No depth data in EIA-767
Estill County Energy Partners LLC	KY	Estill County Energy Partners LLC	No depth data in EIA-767
Kentucky Mountain Power LLC	KY	Kentucky Mountain Power LLC	No depth data in EIA-767
H L Spurlock	KY	East Kentucky Power Coop Inc	No depth data in EIA-767
J K Smith	KY	East Kentucky Power Coop Inc	No depth data in EIA-767
Thoroughbred Generating Station	KY	Thoroughbred Generating Station Co	No depth data in EIA-767
Perryville Power Station	LA	Perryville Energy Partners	No depth data in EIA-767
Teche	LA	Cleco Power LLC	Salt/tidal water
A B Paterson	LA	Entergy New Orleans Inc	Salt/tidal water
Michoud	LA	Entergy New Orleans Inc	Salt/tidal water
R S Nelson	LA	Entergy Gulf States Inc	No depth data in EIA-767
Salem Harbor	MA	U S Gen New England Inc	Salt/tidal water
New Boston Generating Station	MA	Exelon New England Holdings LLC	Salt/tidal water
Pilgrim	MA	Boston Edison Co	Salt/tidal water
Canal	MA	Mirant Canal LLC	Salt/tidal water
Brayton Point	MA	Dominion Energy New England	Salt/tidal water
Mystic Generating Station	MA	Boston Generating LLC	Salt/tidal water

Plant Name	State	Utility Name	Reason for Deletion from Database
Cleary Flood	MA	Taunton City of	Salt/tidal water
Somerset Station	MA	Somerset Power LLC	Salt/tidal water
Calvert Cliffs	MD	Baltimore Gas & Elec Co	Salt/tidal water
Vienna Operations	MD	Vienna Operations Inc	Salt/tidal water
Sparrows Point	MD	International Steel Group	No depth data in EIA-767
Brandon Shores	MD	Constellation Power Source Gen	Salt/tidal water
Herbert A Wagner	MD	Constellation Power Source Gen	Salt/tidal water
Chalk Point LLC	MD	Mirant Mid-Atlantic LLC	Salt/tidal water
Morgantown Generating Plant	MD	Mirant Mid-Atlantic LLC	Salt/tidal water
C P Crane	MD	Constellation Power Source Gen	Salt/tidal water
Rumford Cogeneration	ME	MeadWestvaco Corp	No depth data in EIA-767
William F Wyman	ME	FPL Energy Wyman LLC	Salt/tidal water
Somerset Plant	ME	S D Warren Co	Salt/tidal water
Conners Creek	MI	Detroit Edison Co	No depth data in EIA-767
River Rouge	MI	Detroit Edison Co	No depth data in EIA-767
Eckert Station	MI	Lansing City of	No depth data in EIA-767
Harbor Beach	MI	Detroit Edison Co	No depth data in EIA-767
B C Cobb	MI	Consumers Energy Co	No depth data in EIA-767
J R Whiting	MI	Consumers Energy Co	No depth data in EIA-767
Dan E Karn	MI	Consumers Energy Co	No depth data in EIA-767
J C Weadock	MI	Consumers Energy Co	No depth data in EIA-767
Marysville	MI	Detroit Edison Co	No depth data in EIA-767
St Clair	MI	Detroit Edison Co	No depth data in EIA-767
Belle River	MI	Detroit Edison Co	No depth data in EIA-767
Midland Cogeneration Venture	MI	Midland Cogeneration Venture	No depth data in EIA-767
Trenton Channel	MI	Detroit Edison Co	No depth data in EIA-767
Jack Watson	MS	Mississippi Power Co	Salt/tidal water
Caledonia	MS	Caledonia Operating Services LLC	No depth data in EIA-767
Lone Oak Energy Center	MS	Calpine Construction	No depth data in EIA-767
J E Corette Plant	MT	PPL Montana LLC	No depth data in EIA-767
Brunswick (Nc)	NC	Carolina Power & Light Co	Salt/tidal water
L V Sutton	NC	Progress Energy Carolinas Inc	No depth data in EIA-767
W H Weatherspoon	NC	Progress Energy Carolinas Inc	No depth data in EIA-767
Leland Olds	ND	Basin Electric Power Coop	No depth data in EIA-767
Gerald Gentleman	NE	Nebraska Public Power District	No depth data in EIA-767
Seabrook	NH	North Atlantic Energy	Salt/tidal water
Newington	NH	Public Service Co of NH	Salt/tidal water
Schiller	NH	Public Service Co of NH	Salt/tidal water
PSEG Sewaren Generating Station	NJ	PSEG Fossil LLC	Salt/tidal water
Deepwater	NJ	Atlantic City Electric Co	Salt/tidal water
Hope Creek	NJ	Public Service Elec & Gas	Salt/tidal water
Salem (NJ)	NJ	Public Service Elec & Gas	Salt/tidal water
B L England	NJ	Atlantic City Electric Co	No depth data in EIA-767
PSEG Hudson Generating Station	NJ	PSEG Fossil LLC	Salt/tidal water
PSEG Kearny Generating Station	NJ	PSEG Fossil LLC	Salt/tidal water
San Juan	NM	Public Service Co of NM	No depth data in EIA-767

Plant Name	State	Utility Name	Reason for Deletion from Database
Reid Gardner	NV	Nevada Power Co	No depth data in EIA-767
E F Barrett	NY	KeySpan Generation LLC	Salt/tidal water
Astoria Generating Station	NY	Astoria Generating Co LP	Salt/tidal water
Charles Poletti	NY	Power Authority of State of NY	Salt/tidal water
East River	NY	Consolidated Edison Co-NY Inc	Salt/tidal water
Ravenswood	NY	KeySpan-Ravenswood Inc	Salt/tidal water
Glenwood	NY	KeySpan Generation LLC	Salt/tidal water
Bowline Point	NY	Mirant Bowline LLC	Salt/tidal water
Indian Point	NY	Consolidated Edison Co	Salt/tidal water
Indian Point Three	NY	New York Power Authority	Salt/tidal water
Lovett	NY	Mirant New York Inc	No depth data in EIA-767
Northport	NY	KeySpan Generation LLC	Salt/tidal water
Port Jefferson	NY	KeySpan Generation LLC	Salt/tidal water
Arthur Kill Generating Station	NY	Arthur Kill Power LLC	Salt/tidal water
Far Rockaway	NY	KeySpan Generation LLC	Salt/tidal water
AES Westover	NY	AES Westover LLC	No depth data in EIA-767
Niles	OH	Orion Power Midwest LP	No depth data in EIA-767
AEP Waterford Facility	OH	Columbus Southern Power Co	No depth data in EIA-767
Muskogee Mill	OK	Fort James Operating Co	No depth data in EIA-767
Mustang	OK	Oklahoma Gas & Electric Co	No depth data in EIA-767
Coyote Springs 2	OR	Avista Corporation	No depth data in EIA-767
Conemaugh	PA	Reliant Energy NE Mgt Co	No depth data in EIA-767
Keystone	PA	Reliant Energy NE Mgt Co	No depth data in EIA-767
River Hill Power Company LLC	PA	River Hill Power Company, LLC	No depth data in EIA-767
Williams	SC	South Carolina Genertg Co Inc	Salt/tidal water
Cross	SC	South Carolina Pub Serv Auth	No depth data in EIA-767
Jefferies	SC	South Carolina Pub Serv Auth	No depth data in EIA-767
Winyah	SC	South Carolina Pub Serv Auth	Salt/tidal water
Haywood Energy Center LLC	TN	Haywood Energy Center LLC	No depth data in EIA-767
Lon C Hill	TX	Topaz Power Group LLC	No depth data in EIA-767
Webster	TX	Texas Genco	Salt/tidal water
South Texas	TX	Houston Lighting & Power	Salt/tidal water
Corpus Christi Energy Center	TX	Corpus Christi Cogeneration LP	Salt/tidal water
Eastman Cogeneration Facility	TX	Eastman Cogeneration LP	No depth data in EIA-767
P H Robinson	TX	Texas Genco	No depth data in EIA-767
Sam Bertron	TX	Texas Genco	No depth data in EIA-767
Barney M Davis	TX	Topaz Power Group LLC	Salt/tidal water
Lewis Creek	TX	Entergy Gulf States Inc	No depth data in EIA-767
Deer Park Energy Center	TX	Deer Park Energy Center	No depth data in EIA-767
Nueces Bay	TX	Topaz Power Group LLC	Salt/tidal water
Laredo	TX	Topaz Power Group LLC	Salt/tidal water
Sabine	TX	Entergy Gulf States Inc	Salt/tidal water
Cedar Bayou	TX	Texas Genco	Salt/tidal water
Arthur Von Rosenberg	TX	San Antonio Public Service Bd	No depth data in EIA-767
Currant Creek	UT	PacifiCorp	No depth data in EIA-767
Chesapeake	VA	Virginia Electric & Power Co	Salt/tidal water

Plant Name	State	Utility Name	Reason for Deletion from Database
Bremo Bluff	VA	Virginia Electric & Power Co	No depth data in EIA-767
Chesterfield	VA	Virginia Electric & Power Co	No depth data in EIA-767
Surry	VA	Virginia Elec & Power Co	Salt/tidal water
Possum Point	VA	Virginia Electric & Power Co	No depth data in EIA-767
Potomac River	VA	Mirant Mid-Atlantic LLC	Salt/tidal water
Yorktown	VA	Virginia Electric & Power Co	Salt/tidal water
Sumas Energy 2 Generation Fac	WA	Sumas Energy 2 Inc	No depth data in EIA-767
Port Washington Generating Station	WI	Wisconsin Electric Power Co	No depth data in EIA-767
Mt Storm	WV	Virginia Electric & Power Co	No depth data in EIA-767