TVA

Tennessee Valley Authority, 1101 Market Street, Chattanooga, Tennessee 37402

July 23, 2013

10 CFR Part 51

ATTN: Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Sequoyah Nuclear Plant, Units 1 and 2
Facility Operating License Nos. DPR-77 and DPR-79
NRC Docket Nos. 50-327 and 50-328

Subject: **Response to NRC Request for Additional Information Regarding the Environmental Review of the Sequoyah Nuclear Plant, Units 1 and 2, License Renewal Application (TAC Nos. MF0057 and MF0058)**

References:

1. TVA Letter to NRC, "Sequoyah Nuclear Plant, Units 1 and 2 License Renewal," dated January 7, 2013 (ADAMS Accession No. ML13024A004)
2. NRC Letter to TVA, "Requests for Additional Information for the Environmental Review of the Sequoyah Nuclear Plant, Units 1 and 2, License Renewal Application," dated May 10, 2013 (ADAMS Accession No. ML13119A083)
3. NRC Letter to TVA, "Revised Requests for Additional Information for the Environmental Review of the Sequoyah Nuclear Plant, Units 1 and 2, License Renewal Application," dated June 7, 2013 (ADAMS Accession No. ML13136A358)

By letter dated January 7, 2013 (Reference 1), Tennessee Valley Authority (TVA) submitted an application to the Nuclear Regulatory Commission (NRC) to renew the operating license for the Sequoyah Nuclear Plant, Units 1 and 2. The request would extend the license for an additional 20 years beyond the current expiration date. By letter dated May 10, 2013 (Reference 2), the NRC forwarded a request for additional information (RAI).

Subsequently, the NRC revised the RAI by letter dated June 7, 2013 (Reference 3). The required response date for RAI question numbers 1 through 6 was June 24, 2013. Mr. David Drucker, the NRC Environmental License Renewal Project Manager has given a verbal extension to July 23, 2013 for RAI question numbers 1 through 6.

A035
NRR

Enclosure 1 to this letter provides TVA's response to the Reference 3 RAI question numbers 1 through 6. Enclosure 2 to this letter provides the list of references identified in the responses to those questions. There are no new regulatory commitments contained in this submittal.

Consistent with the standards set forth in 10 CFR 50.92(c), TVA has determined that the additional information, as provided in this letter, does not affect the no significant hazards considerations associated with the proposed application previously provided in Reference 1.

Please address any questions regarding this submittal to Henry Lee at (423) 843-4104.

I declare under penalty of perjury that the foregoing is true and correct.
Executed on this 23rd day of July 2013.

Respectfully,

J. W. Shea
Vice President, Nuclear Licensing

Enclosures:
1. TVA Responses to NRC Request for Additional Information
2. Environmental RAI References List

cc (Enclosures):
NRC Regional Administrator – Region II
NRC Senior Resident Inspector – Sequoyah Nuclear Plant

ENCLOSURE 1

Tennessee Valley Authority
Sequoyah Nuclear Plant, Units 1 and 2 License Renewal
TVA Responses to NRC Request for Additional Information

Note: Many of the responses contained in this enclosure reference supporting TVA documents that are available for NRC review and will be placed on the Sequoyah Nuclear Plant (SQN) docket, if requested. Enclosure 2 provides the complete list of those documents.

NRC RAI 1.a.i

1. Hydrology - Surface Water Resources

Provide the following information in order to allow for a thorough review and evaluation of the impacts of license renewal on surface water resources.

a. National Pollutant Discharge Elimination System-Regulated Discharge Compliance

i. Describe the current status of Sequoyah Nuclear Plant's (SQN's) National Pollutant Discharge Elimination System (NPDES) permit renewal (No. TN0026450, expires October 31, 2013), including, as applicable, milestones achieved, projected timeframe for issuance, etc. If available, provide a copy of the NPDES permit renewal application for docketing.

TVA Response

The current SQN NPDES Permit (TN0026450) is included in the SQN Environmental Report (ER) as Attachment C. The permit renewal application was submitted to the Tennessee Department of Environment and Conservation (TDEC) on May 2, 2013; approval is expected in 2016. The permit renewal application is listed in Enclosure 2 as 1.a.i.

NRC RAI 1.a.ii.1

ii. The rationale section of SQN's February 2011 NPDES permit indicates that metal cleaning wastes were last discharged to the Metal Cleaning Waste Pond in December 2001, which in turn flows to the Low Volume Waste Treatment Pond.

1. Describe the nature of the metal cleaning waste (i.e., what process generated it and from what plant system(s))?

TVA Response

The metal cleaning waste ponds were used for holding waste water from the treatment of boiler cleaning and various piping cleaning wastes.

SQN no longer generates these types of wastes and may pursue decommissioning of the ponds through the NPDES process. The permanent piping to the metal cleaning waste ponds from the plant has been disconnected.

NRC RAI 1.a.ii.2

2. *Have there been more recent discharges and/or does TVA anticipate the need to direct future discharges to the pond?*

TVA Response

NPDES Permit TN0026450 rationale page R-12 of R-41 provides information as to the last metal cleaning waste discharge from the plant and historical averages of monitored effluent parameters. No discharge to the Metal Cleaning Waste Pond was made after December 2001.

The permanent piping to the metal cleaning waste ponds from the plant has been disconnected. SQN no longer generates these types of wastes and may pursue decommissioning of the ponds through the NPDES process.

NRC RAI 1.a.ii.3

3. *Has shallow groundwater sampling been conducted in the vicinity of the pond and, if so, provide a summary of the monitoring results.*

TVA Response

Shallow groundwater sampling has not been conducted in the vicinity of the metal cleaning ponds; this is not an NPDES Permit requirement.

NRC RAI 1.b

b. Thermal Discharge and Receiving Water Methodology and Data

i. Provide a description of the in-stream flow and thermal discharge (mixing zone) compliance computational (modeling) method(s) as discussed during the April 9, 2013, site audit hydrology tour.

1. Include the latest calibration report as discussed during the tour.

2. Also, specifically provide the following information for the models of thermal discharge flow rate and mixing zone temperatures:

a. model description including temporal and spatial discretization and initial and boundary conditions;

b. model calibration approach; and

c. data used to calibrate the most recent model version.

TVA Response

The latest calibration report for the mixing zone model is listed in Enclosure 2 as Enclosure_1.b.i-1. This document provides a description of the thermal discharge (mixing zone) model used to monitor the operation of SQN relative to the NPDES requirements for river water temperature. Within TVA, the mixing zone model is referred to as the "plume model."

Embedded in the mixing zone model is another model for estimating the in-stream river flow at SQN. A description of the embedded flow model is listed in Enclosure 2 as Enclosure_1.b.i-2. Enclosure_1.b.i-1 and Enclosure_1.b.i--2 summarize the basic governing equations, solution methods, and initial and boundary conditions used for the models.

Enclosure_1.b.i-2 contains a description of the temporal and spatial discretization for the flow model. The temporal discretization for the plume model is fifteen minutes (see Enclosure_1.b.i-1). The following discussion explains the spatial discretization.

The computational step for the plume centerline is initialized as 0.1 percent of the flow depth, where the flow depth is defined as the distance between the approximate elevation of the diffuser discharge ports and the elevation of the river water surface. In each subsequent computational step, the centerline distance is increased by a factor of $\sqrt{2}$, up to a maximum distance of 4.0 percent of the flow depth. The mixing zone and flow models are calibrated together by striving to minimize the average error between the computed and measured river temperature at the downstream end of the diffuser mixing zone. The key aspects of the calibration approach, including a summary of the calibration data, are summarized in Enclosure_1.b.i-1.

The following documents are listed in Enclosure 2 as available for NRC review:

1.b Enclosure_1.b.i-1.pdf

"Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from SQN as Required by NPDES Permit No. TN0026450 of March 2011," WR2013-1-45-152, dated April 2013

1.b Enclosure_1.b.i-2.pdf

"Estimation of River Flow at SQN for NPDES Thermal Compliance". TVA white paper prepared in support of RAI 1.b.i, dated May 2013.

NRC RAI 1.b.ii

ii. During the site audit, it was indicated by TVA staff that the Tennessee River/ Chickamauga Reservoir has warmed over the past 15 years.

1. Provide any study(s) or data that depict this trend.

2. Has a predictive analysis of this trend been performed, including any contingency analysis performed relative to SQN operations (e.g., need to add cooling capacity)? Describe and provide a summary of any such analyses.

3. Will the existing cooling capacity be sufficient to address climate warming scenarios through 2041?

TVA Response

An observation was made during the site audit that water temperatures in Chickamauga Reservoir have warmed over the years. TVA has not studied this specific trend in detail. However, TVA has performed a study of the general effect of extreme meteorology on the TVA reservoir system (listed in Enclosure 2 as Enclosure_1.b.ii-1.pdf). In the study, hydrothermal models were developed and calibrated for a variety of reservoirs in the TVA river system. Hydrothermal sensitivities of the reservoirs were examined by performing simulations with uniform, incremental changes in various parameters that influence the transfer of heat between the atmosphere and a waterbody. The study found that for a waterbody such as Chickamauga Reservoir, for each 1°F increase in air temperature, the average water temperature in the reservoir generally increased by an amount between 0.25°F and 0.5°F, at least in the warm months of the year.

Recent data for the SQN NPDES upstream ambient river temperature is shown in Figure 1 (listed in Enclosure 2 as Enclosure_1.b.ii-2.xlsx). The data include the daily maximum, 24-hour average upstream ambient river temperature, measured at a monitoring station located at TRM 490.4, about six miles upstream of the plant. The period of record shown includes June 2007 through May 2013. June 2007 is the first month of implementation of the current version of the NPDES compliance model for the plant thermal discharge. Also of note is that 2007 and 2008 were years of extreme drought in the Tennessee River watershed, and 2010 included a summer of extreme atmospheric heating. Specifications for the measurement of the ambient river temperature are given in the plant NPDES permit (listed in Enclosure 2 as Enclosure_1.b.ii-3.pdf). In particular, the ambient river temperature is specified as that for the layer of water centered at a depth of 5 feet, recorded as the average temperature from three individual sensors located at depths of 3-feet, 5-feet, and 7-feet. Prior to 2007, the SQN compliance model relied on an ambient temperature measurement from a monitoring station located at TRM 484.8, the plant intake skimmer wall. At this location, the temperature measurement was exposed to bias due to the upstream migration of heat from the plant diffuser mixing zone, and thereby is not necessarily representative of the true ambient river temperature.

Please refer to the TVA response to RAI 1.c.vi for additional information related to changes over the years for the plant NPDES water temperature criteria and monitoring requirements.

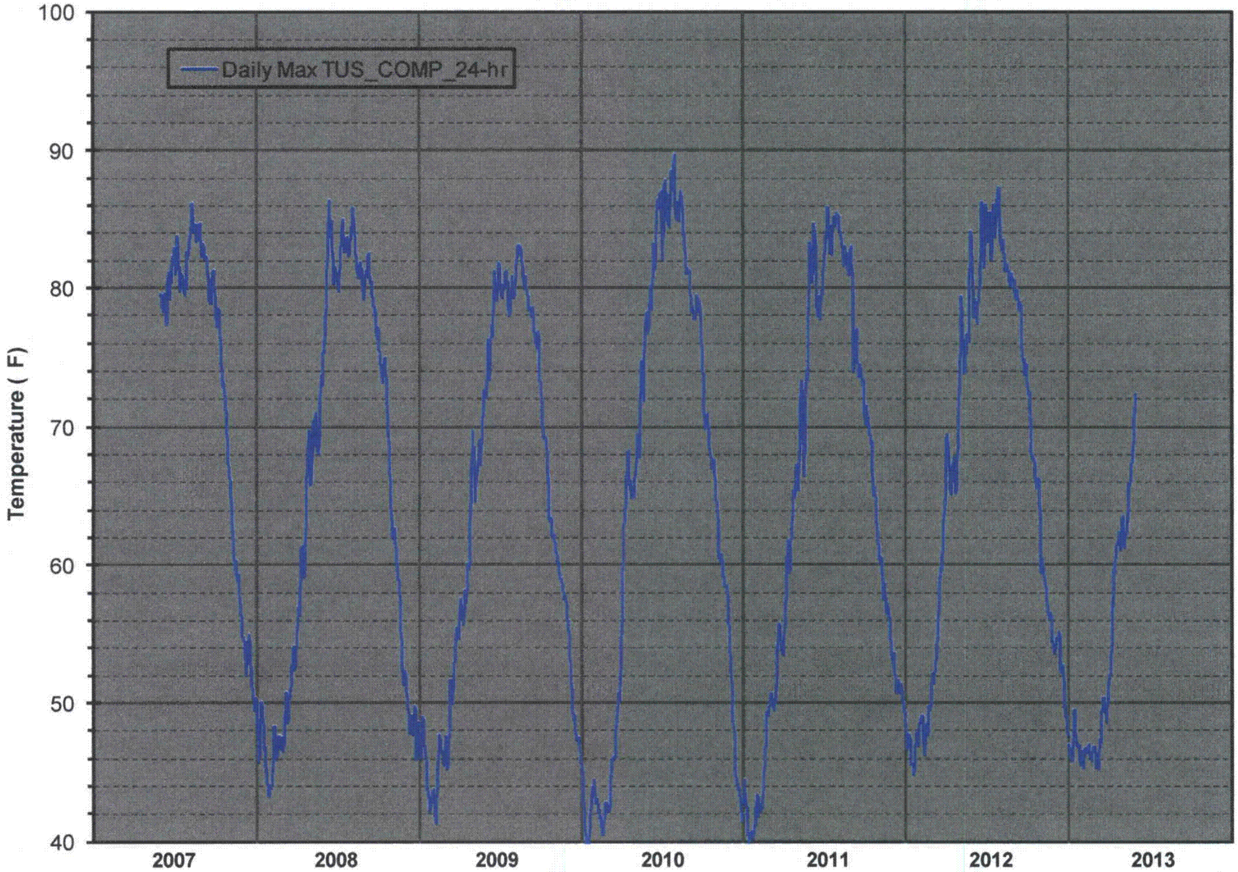


Figure 1. SQN Daily Maximum 24-Hour Average Upstream Ambient River Temperature

In general, extreme caution is recommended in the interpretation of river temperature data such as given in Figure 1 because river temperature is influenced by more than meteorology alone. Antecedent conditions providing the volume and temperature of water in river/reservoir storage are a factor, as well as the manner in which this water is released to supply river flow throughout the year. In this context, in a waterbody such as Chickamauga Reservoir, water temperatures are influenced by the operation of the system over seasonal, weekly, daily, and even hourly time scales. For example, in 1991 and in 2004, TVA changed the operation of the river system to delay summertime drawdown in its tributary reservoirs. In turn, these seasonal adjustments increased the residence time of flow through the main stem reservoirs, providing a greater opportunity for warming by atmospheric heating. At the other extreme, in the past few years and on select reservoirs, hourly adjustments in hydro operations have been made to better control and predict water temperatures at TVA thermal plants. In particular, at times, hourly peaking operations have been suspended for the purpose of providing steadier river flows (see TVA response to RAI 1.c.v for an example of the effect of reservoir sloshing on the upstream transport of thermal discharges, and TVA response to RAI 1.c.viii for SQN-related effects on hydro peaking at Watts Bar Dam and Chickamauga Dam). Whereas this provides better preservation of water temperatures in the bottom of the reservoir, it can lead to intensification of solar heating in the surface layer of the reservoir (e.g., at a depth of 5 feet, as represented by the data in Figure 1). In this manner, evaluating long-term trends in river temperature needs to include the examination of a metric encompassing the total amount of heat in the reservoir vs. the heat at a single point. Overall, given the complexity of all the factors that affect reservoir water temperatures in a regulated river system, a convincing evaluation of temperature trends would, by necessity, require detailed system-wide modeling, such as that used in the study contained in Enclosure_1.b.ii-1.pdf.

To examine the potential effect of climate change on SQN, an evaluation encompassing the basic conclusions of Enclosure_1.b.ii-1.pdf was performed to examine the performance of the plant over the relicensing period. The evaluation also relied on a study by the Electric Power Research Institute (EPRI) that provides an estimate of the potential future increase in air temperature and humidity in the Tennessee Valley due to climate change. The EPRI report is listed in Enclosure 2 as Enclosure_1.b.ii-4.pdf.

In the SQN evaluation, 30 years of plant operation were simulated, 2012–2041. The simulation results suggest that by 2041, helper mode operation may increase in certain years by as much as 70% compared to the average recent operational experience. Although the simulation produced derate and shutdown events in four of the 30 years, the duration of these events were very small compared to the extent of the relicensing period. Furthermore, in all likelihood, the modeling circumstances leading up to these events would not occur in actual operation. This is due to TVA's ability to foresee upcoming extreme hydrothermal conditions, and to implement additional options for mitigating these conditions (both factors which are not included in the current version of the SQN long-term forecasting model).

Overall, the simulation results suggest that the current cooling capacity at SQN will be sufficient throughout the relicensing period. A brief summary of the simulation is provided below.

Long-Term Forecasting Model

The model for the long-term SQN simulation is built upon the thermal discharge (mixing zone) compliance model presented in the response to RAI 1.b.i. The compliance model determines the river temperature, river temperature rise, and river temperature rate-of-change at the downstream end of the diffuser mixing zone based on the temperature, stage and flow of water in the river upstream of the diffusers, and the temperature and flow of SQN condenser cooling water entering the river through the diffusers. Added to the compliance model is an algorithm that estimates the temperature rise of the condenser cooling water across the plant based on the magnitude of plant generation (i.e., MWe) and cooling tower operation (i.e., number of lift pumps in service). In simulating long-term operation, the model includes a series of conditional statements to make hour-by-hour decisions of the need and amount of cooling tower operation and generation load reductions to try to keep the plant within the river temperature limits specified in the NPDES permit.

Inputs

The basic model inputs include hourly time histories for the ambient river temperature, river temperature upstream of the diffuser mixing zone, river stage and discharge, and meteorology. The latter includes the drybulb and wetbulb temperatures and is needed to estimate cooling tower performance (i.e., during those periods wherein cooling tower operation is needed). In the simulations, SQN is assumed to operate at full power, except in those events where the model determines that load reductions are necessary.

To perform the long-term simulation, it was necessary to construct 30 years of projected data for the model inputs. To accomplish this, future time series were developed from historical data, applying modifications, as necessary, based upon the climate change predictions given by EPRI and the effect of such on the river temperature. The 20-year historical period from 1992 through 2011 was selected as analog years for the simulation. This period of record includes a good variety of hydrothermal conditions to test the operation of the plant. This is illustrated in Figure 2, which shows for each year, the summertime deviation in mean air temperature in Chattanooga and summertime deviation in mean natural river flow at Chickamauga Dam (see TVA response to RAI 1.C.1 for a more thorough discussion of the classification of summertime hydrothermal conditions). In the period from 1992 through 2011, 45 percent of the years include summer conditions that are warm and dry. Among these are the warmest year of record (2010) and driest year of record (2007). These types of years provide the greatest challenge for safe, hydrothermal operation of SQN. It should also be emphasized that the initial work for this evaluation was performed in early 2012, which is why the most recent historical calendar year, 2012, was not used in the simulations (and subsequently, why 2012 was chosen as the first forecast/climate change year).

Analog Years

The first simulated climate change year was 2012, which used 1992 as the analog year for the river flow, river stage, river temperature, and meteorology. For 2013, the analog year was 1993, for 2014 the analog year was 1994, and so on. Because 20 analog years were used for a 30 year simulation, it was necessary to reuse some of the analog years. So, for 2031 the analog year was 2011 and for 2032 the analog year was again 1992. Table 1 shows a complete listing of simulation years and the corresponding analog years. Also provided are the deviations in mean air temperature and mean natural flow as depicted in Figure 2.

Drybulb Temperature

According to the ERPI (2009) report, the drybulb air temperature could potentially increase as much as 7.2°F (4.0°C) in the period from 1990 to 2100. Assuming a linear increase in temperature, this yields a projected annual increase in drybulb temperature (ΔT_{db}) of 0.065°F (0.036°C). To account for this increase, a cumulative amount ΔT_{db} was added to the historical drybulb temperatures of each analog year, as shown in Table 2. Over the entire simulation period (2012–2041), the drybulb temperature was increased by approximately 2°F (1.1°C).

Wetbulb Temperature

According to the ERPI report, the humidity in the Tennessee Valley may increase by as much as 12% during non-summer months. Increases in humidity would affect evaporation and, consequently, the performance of the SQN cooling towers. To account for this increase, wetbulb temperatures for each analog year were adjusted for January through April and for November through December by a factor of 1.12. The wetbulb temperatures remained unchanged during the months of May through October for each analog year.

River Temperatures Upstream of Diffusers

As presented earlier, each 1°F increase in air temperature is expected to result in a corresponding increase in average water temperature of between 0.25°F to 0.5°F. Accordingly, the river temperatures for each analog year were increased by 50% of the drybulb increase shown in Table 1. For example, in simulation year 2012 the analog drybulb temperature was increased by 0.065°F and the corresponding analog river temperatures were increased by 0.0325°F. Overall, river temperatures were increased approximately 1°F over the course of the 30 year simulation. Table 3 shows the river temperature increase for all simulation years.

Prior to 2007, the upstream ambient river temperature for SQN was measured at the intake skimmer wall, located at about TRM 484.8. Because of issues related to the recirculation of the diffuser effluent at the skimmer wall, a new ambient temperature station was installed further upstream at TRM 490.4. The new upstream station is used for the sole purpose of providing a control point temperature (i.e., beyond the zone of impact of the plant) for determining the temperature rise at the downstream end of the diffuser mixing zone. However, recall that the 20-year period from 1992 through 2011 was selected as analog years for the SQN simulations. In this manner, for analog years prior to 2007 (i.e., for years 1992 through 2006), no historical data exists for the ambient river temperature at TRM 490.4. In order to ensure that the ambient river temperature was somewhat consistent for all of the analog years, a synthetic record for the upstream ambient river temperature (at TRM 490.4) was generated for the analog years 1992–2006 using a two-dimensional model of Chickamauga Reservoir.

River Flow

In 2004 TVA implemented a new reservoir operating policy for the Tennessee River system. The study providing the bases for the new policy is known as the Reservoir Operations Study (ROS). In a manner similar to that for the upstream ambient river temperature, historical river flows for analog years prior to 2004 are not necessarily representative of the expected future operation of Chickamauga Reservoir based on the ROS operating policy. To provide consistency between analog years prior to and after 2004, the pre-ROS flows for Chickamauga Reservoir were adjusted using a scheduling model that routes the hydrologic inflows for the Tennessee Valley based on the ROS operating policy.

Results

The results of the SQN climate change simulation are summarized in Table 4. In terms of helper mode operation, the results suggest that within the extended life of the plant, cooling towers may be needed in certain years as much as 71 percent more than average recent experience (note: the average helper mode operation for 2007-2011 is about 120 days per year—see TVA response to RAI 1.c.ii).

Over the 30 year simulation, the results suggest only 54 hours of unit load reductions and only 36 hours of unit shutdowns. All of the years where a shutdown was initiated also were accompanied by several hours of derate. In these events the NPDES limits were still exceeded, even with both units off. However, it is important to note that the shutdowns and derates predicted by the model are an artifact of the synthetic temperatures created for the upstream ambient river temperature and/or the model logic used to operate the plant. A closer examination of the synthetic ambient temperatures (in these events) reveals their behavior to be somewhat questionable compared to the historical behavior of the ambient temperature (i.e., outliers). The model logic refers to the conditional statements in the model used to make hour-by-hour decisions for implementing helper mode operation and load reductions. In this process, the helper mode and load reduction algorithms look ahead in time only one hour (i.e., the next hour) to see if helper mode operation and/or derates are required to maintain compliance. Due to this limited foresight, the model often "paints the plant into a corner" relative to options for preventing NPDES exceedances. In contrast, current TVA hydrothermal forecasting procedures are able to look up to two weeks into the future for potential extreme conditions, allowing more time to plan and implement adjustments to avoid unit derates and shutdowns. Furthermore, the long-term forecasting model does not consider all options known to exist for mitigating extreme hydrothermal conditions; rather, it currently includes only those involving "near-term" helper mode operation and derates (i.e., *plant* options). In the past, *river* options also have been used to provide relief in extreme events. Examples include such things as strategically increasing the river flow (e.g., to provide additional dilution for the plant thermal effluent), reducing reservoir sloshing (e.g., limiting hydro peaking and the resulting upstream propagation of plant thermal effluent), and using preferential operation of upstream hydro units (e.g., providing "selective withdrawal" from upstream reservoirs, for example releasing cooler bottom water). These *river* options also will be available in the future. As for *plant* options, "extended-term" operational strategies also exist (which are not considered in the current model logic). For example, helper mode operation often is implemented well before reaching routine temperature triggers for such. This is a common practice at low river flow to help limit the excessive buildup of diffuser effluent in the immediate vicinity of the plant.

Conclusions

To simulate the effect of climate change in the Tennessee Valley, historical data were used to generate synthetic time series for the years 2012–2041. Air temperatures were adjusted upwards by approximately 2°F, river temperatures were increased by approximately 1°F, humidity was increased by 12% in non-summer months, and flow records were modified to account for operation under ROS.

The simulation results suggest that by 2041, helper mode operation may increase in certain years by as much as 71% compared to average recent operational experience. Although the simulation produced derate and shutdown events in 4 of the 30 years, the duration of these events were small compared to the extent of the relicensing period. Furthermore, in all likelihood, the modeling circumstances leading up to these events would not occur in actual operation. This is due to TVA's ability to foresee upcoming extreme hydrothermal conditions, and to implement additional options for mitigating these conditions (both factors which are not included in the current version of the SQN long-term forecasting model).

Overall, the simulation results suggest that the current cooling capacity at SQN will be sufficient throughout the relicensing period.

The following documents are listed in Enclosure 2 as available for NRC review:

1.b.ii.1 Enclosure 1.b.ii-1.pdf

"Sensitivity of the TVA Reservoir and Power Supply Systems to Extreme Meteorology," Report No. WR28-1-680-111, TVA Engineering Laboratory, Norris, Tennessee, June 1993.

1.b.ii.2 Enclosure 1.b.ii-2.xlsx

Excel file containing the SQN daily maximum, 24-hour average upstream ambient river temperature for the from June 2007 through May 2013.

1.b.ii.3 Enclosure 1.b.ii-3.pdf

"NPDES Permit No. TN0026450, Authorization to discharge under the NPDES." Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, Tennessee. January 31, 2011.

1.b.ii.4 Enclosure 1.b.ii-4.pdf

EPRI (2009). "Potential Impact of Climate Change on Natural Resources in the TVA Region." Electric Power Research Institute, Palo Alto, California. November 2009.

Table 1. Reference Year Corresponding to Each Simulation Year

Index	Simulation Year	Analog Year	Historical Hydrothermal Conditions*	
			Deviation in Mean Air Temp in Chattanooga (°F)	Deviation in Mean Natural Flow at Chickamauga Dam (Percent)
1	2012	1992	-3.6	26
2	2013	1993	4.0	-43
3	2014	1994	-1.1	60
4	2015	1995	1.1	-18
5	2016	1996	-0.7	27
6	2017	1997	-1.6	37
7	2018	1998	1.8	14
8	2019	1999	1.9	1
9	2020	2000	1.0	-37
10	2021	2001	-0.2	-1
11	2022	2002	2.0	-55
12	2023	2003	-1.3	85
13	2024	2004	-1.3	30
14	2025	2005	0.4	33
15	2026	2006	1.7	-32
16	2027	2007	2.7	-61
17	2028	2008	1.3	-60
18	2029	2009	1.3	2
19	2030	2010	4.8	-31
20	2031	2011	3.9	-20
21	2032	1992	-3.6	26
22	2033	1993	4.0	-43
23	2034	1994	-1.1	60
24	2035	1995	1.1	-18
25	2036	1996	-0.7	27
26	2037	1997	-1.6	37
27	2038	1998	1.8	14
28	2039	1999	1.9	1
29	2040	2000	1.0	-37
30	2041	2001	-0.2	-1

* Deviations based on historical record from 1948-2012, containing a mean summertime (Jun-Jul-Aug) air temperature of 77.2°F in Chattanooga and a mean summertime natural flow at Chickamauga Dam of 19,800 cfs.

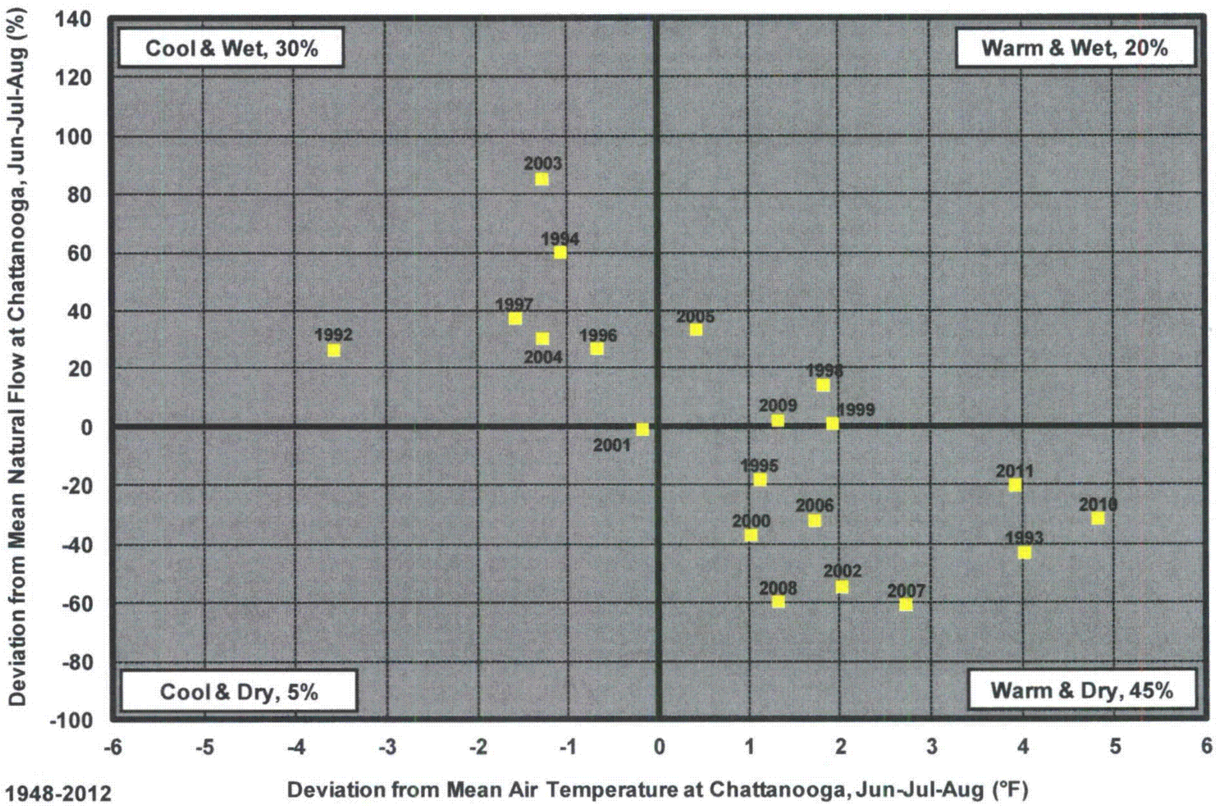


Figure 2. Classification of Hydrothermal Conditions for Analog Years

Table 2. Drybulb Temperature Adjustment for Each Simulation Analog Year

Index	Simulation Year	Drybulb Adjustment (°F)
1	2012	1992 + 0.065
2	2013	1993 + 0.130
3	2014	1994 + 0.195
4	2015	1995 + 0.260
5	2016	1996 + 0.325
6	2017	1997 + 0.390
7	2018	1998 + 0.455
8	2019	1999 + 0.520
9	2020	2000 + 0.585
10	2021	2001 + 0.650
11	2022	2002 + 0.715
12	2023	2003 + 0.780
13	2024	2004 + 0.845
14	2025	2005 + 0.910
15	2026	2006 + 0.975
16	2027	2007 + 1.040
17	2028	2008 + 1.105
18	2029	2009 + 1.170
19	2030	2010 + 1.235
20	2031	2011 + 1.300
21	2032	1992 + 1.365
22	2033	1993 + 1.430
23	2034	1994 + 1.495
24	2035	1995 + 1.560
25	2036	1996 + 1.625
26	2037	1997 + 1.690
27	2038	1998 + 1.755
28	2039	1999 + 1.820
29	2040	2000 + 1.885
30	2041	2001 + 1.950

Table 3. River Temperature Adjustment for Each Simulation Analog Year.

Index	Simulation Year	River Temp Adjustment (°F)
1	2012	1992 + 0.0325
2	2013	1993 + 0.0650
3	2014	1994 + 0.0975
4	2015	1995 + 0.1300
5	2016	1996 + 0.1625
6	2017	1997 + 0.1950
7	2018	1998 + 0.2275
8	2019	1999 + 0.2600
9	2020	2000 + 0.2925
10	2021	2001 + 0.3250
11	2022	2002 + 0.3575
12	2023	2003 + 0.3900
13	2024	2004 + 0.4225
14	2025	2005 + 0.4550
15	2026	2006 + 0.4875
16	2027	2007 + 0.5200
17	2028	2008 + 0.5525
18	2029	2009 + 0.5850
19	2030	2010 + 0.6175
20	2031	2011 + 0.6500
21	2032	1992 + 0.6825
22	2033	1993 + 0.7150
23	2034	1994 + 0.7475
24	2035	1995 + 0.7800
25	2036	1996 + 0.8125
26	2037	1997 + 0.8450
27	2038	1998 + 0.8775
28	2039	1999 + 0.9100
29	2040	2000 + 0.9425
30	2041	2001 + 0.9750

Table 4. Helper Mode Operation, Load Reductions, and Shutdowns for Each Simulation Year

Index	Simulation Year	Cooling Tower Operation (% change from avg 2007–2011*)	Total Unit Load Reductions (hr)	Unit Load Reductions (MWH)	Plant Shutdown (hr)
1	2012	-34%	0	0	0
2	2013	+1%	0	0	0
3	2014	-82%	0	0	0
4	2015	+2%	0	0	0
5	2016	-80%	0	0	0
6	2017	-46%	0	0	0
7	2018	-52%	0	0	0
8	2019	-42%	9	21,816	9
9	2020	-1%	0	0	0
10	2021	-55%	0	0	0
11	2022	+29%	0	0	0
12	2023	-99%	0	0	0
13	2024	-91%	9	21,816	9
14	2025	-70%	0	0	0
15	2026	+43%	27	49,626	9
16	2027	+71%	0	0	0
17	2028	+56%	0	0	0
18	2029	-73%	0	0	0
19	2030	+59%	0	0	0
20	2031	+10%	0	0	0
21	2032	-31%	0	0	0
22	2033	+17%	0	0	0
23	2034	-83%	0	0	0
24	2035	+31%	0	0	0
25	2036	-81%	0	0	0
26	2037	-40%	0	0	0
27	2038	-31%	0	0	0
28	2039	-29%	9	21,816	9
29	2040	+38%	0	0	0
30	2041	-24%	0	0	0

* The average helper mode operation for 2007-2011 is about 120 days per year

NRC RAI 1.b.iii

iii. Is there an atmospheric warming trend in the Tennessee River Valley that can be correlated with river/reservoir temperatures noted above? Provide long-term temperature measurements from SQN meteorological stations that depict this trend (include data for average daily high temperatures and nighttime low temperatures).

TVA Response

Figure 1 depicts the 10-Meter Dry-Bulb Air Temperature from SQN Meteorological Station for years 1972 through 2012. This data appears to be supportive of an atmospheric warming trend in the Tennessee River Valley. (The data is contained in the Excel file listed in Enclosure 2 as Enclosure_1.b.iii.xlsx). The data shows a warming trend at the monitoring site. In general, the average daily minimum has warmed slightly faster than the average daily mean and the average daily maximum. Since 1972 (i.e., in the past 41 years), linear regressions suggest that the average daily minimum has increased about 3.4°F, whereas the average daily maximum has increased about 2.5°F. The 5-year moving average, however, appears to suggest a slowing of the trend since about 2002. Although there may be some bias as a result of local changes in land use (i.e., effect on the monitoring site), the data would be supportive of a warming trend in the Tennessee River Valley.

TVA is aware of changes in river temperature that have been observed over the years at its nuclear sites. However, no correlation can be made between the air temperature trend and the river/reservoir temperatures. The response to RAI 1.b.ii contains a brief summary of studies that have been performed to examine the potential correlation with changing meteorology.

The following document is listed in Enclosure 2 as available for NRC review.

1.b.iii Enclosure_1.b.iii.xlsx.

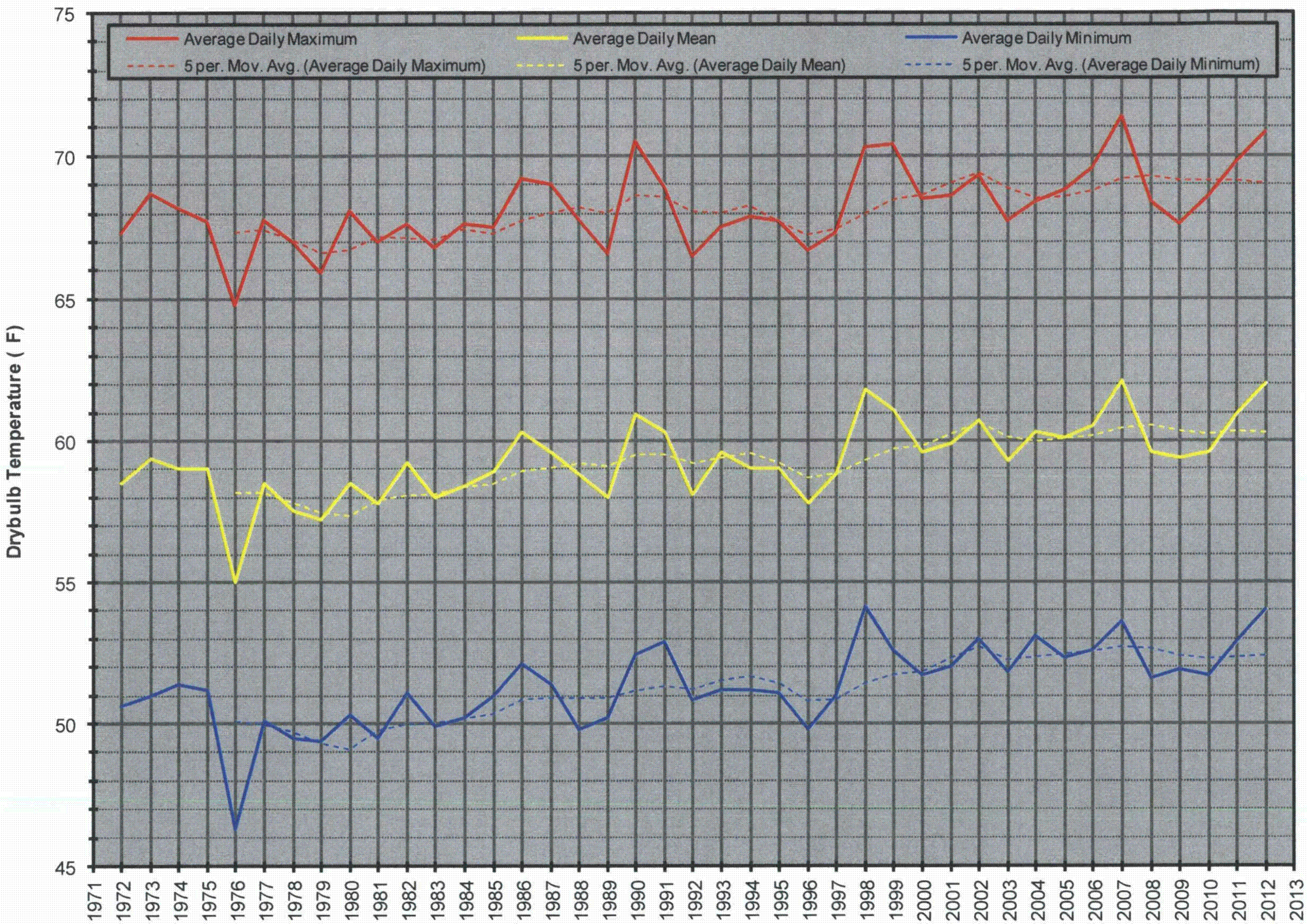


Figure 1. 10-meter dry-bulb air temperature from SQN Meteorological Station

NRC RAI 1.c.i

c. Thermal Discharges and SQN Operational Considerations

i. During the site audit hydrology tour, TVA staff stated that SQN has come close to exceeding but has not exceeded any thermal (e.g., T-max or delta-T) discharge limits.

1. Confirm this statement and describe.

2. In addition, provide additional information surrounding the near exceedances and the operating/ambient conditions under which the near exceedance(s) occurred.

3. Specifically, provide the following information for each standard exceeded or approached, as appropriate (i.e., for the timeframe going back to and encompassing the 2006-2007 drought):

a. standard/limit of concern;

b. measurement value that violated/approached the standard;

c. date, time, location for each such incident; and

d. *hourly discharge, stage, temperature at the time of the violation/near exceedance.*

TVA Response

TVA has not exceeded any thermal discharge limit. Certain instances in which thermal discharges approached but did not exceed thermal discharge limits are included in the discussion below. A summary of the current NPDES instream thermal limits for SQN Outfall 101 is provided in Table 1. Temperature limits are specified for the 24-hour average maximum downstream temperature, the 1-hour average maximum downstream temperature, the 24-hour average maximum downstream temperature rise, and the maximum downstream temperature rate-of-change. Under the current NPDES criteria, operating conditions for the river and the plant cause encroachment on only two of the limits—the 24-hour average maximum downstream temperature, and the 24-hour average maximum downstream temperature rise. The NPDES compliance data for these two parameters are contained in the below-referenced files for the period of record from June 2007 through May 2013. June 2007 is the first month of implementation of the current version of the compliance model, which includes a special allowance for the re-entrainment of diffuser effluent during periods of sustained low river flow; the document listed in Enclosure 2 as 1.c.i.1 Enclosure_1.c.i-1.pdf contains additional information related to the re-entrainment of diffuser effluent. The data are contained in the following individual Excel files listed in Enclosure 2 are available for NRC review:

1.c.i.2 Enclosure_1.c.i_2007.xlsx,

1.c.i.3 Enclosure_1.c.i_2008.xlsx,

1.c.i.4 Enclosure_1.c.i_2009.xlsx,

1.c.i.5 Enclosure_1.c.i_2010.xlsx,

1.c.i.6 Enclosure_1.c.i_2011.xlsx,

1.c.i.7 Enclosure_1.c.i_2012.xlsx, and

1.c.i.8 Enclosure_1.c.i_2013.xlsx.

TVA classifies hydrothermal conditions for the Tennessee Valley based on the air temperature and river flow at Chattanooga, which is centrally located in the Tennessee River watershed. Figure 1 summarizes these conditions via a crossplot showing the deviation in mean air temperature at the Chattanooga airport (x-axis) and the deviation in mean natural flow at Chickamauga Dam (y-axis). Chickamauga Dam is located within the city limits of Chattanooga. The natural flow is a computed theoretical river discharge based on observed rainfall/runoff and assuming no flow regulation (i.e., no dam/impoundments). The natural flow at Chickamauga Dam provides a measure of the magnitude of drought in the eastern part of the Tennessee River watershed. To obtain a measure of conditions when the river temperature is most likely to be extreme, the data in Figure 1 are limited to the warmest months of the year, i.e., June, July, and August. The figure includes data for 1948 through 2012. Callouts are provided for years 2007 through 2012, and as shown, a period of drought and a period of extreme heating are found within this period. Specifically, 2007 and 2008 were years of extreme drought with a natural river flow about 60 percent below normal. 2010 included a summer of extreme atmospheric heating with the average air temperature in Chattanooga about 4.8°F warmer than normal.

Charts of the 24-hour average maximum downstream temperature and the 24-hour average maximum downstream temperature rise are shown in plots provided in Figure 2 and Figure 3, respectively. Confirmation of the statement that SQN has come close to the NPDES limits for these parameters can be found by examining the plots. The following observations are noted:

24-Hour Average Downstream Temperature

- In 2010, 2011, and 2012, events occurred with the 24-hour average downstream temperature climbing within 0.5°F of the NPDES limit of 86.9°F. The dates and times of these events, as well as the measurement values, are available from the listed Excel files.
- In 2010 and 2012, events occurred with the 24-hour average downstream temperature climbing in excess of 86.9°F. These events were not classified as an exceedance of the NPDES limit because of the magnitude of the upstream (ambient) temperature and other conditions. In particular, the NPDES permit states that if the 24-hour average ambient temperature exceeds 29.4°C (84.9°F), and the plant is operated in helper mode, the 24-hour average downstream temperature can exceed 86.9°F, but only as long as the 1-hour average downstream temperature does not exceed 93°F (see note 5 of Table 1). The 24-hour average upstream ambient temperature also is provided in the Figure 2 plots. In the events of 2010 and 2012, the 24-hour average upstream ambient temperature was in excess of 84.9°F, the plant was operating in helper mode (see RAI 1.c.ii), and the 1-hour average downstream temperature did not exceed 93°F.

24-Hour Temperature Rise

- In 2007, 2008, 2009, and 2012, events occurred with the 24-hour average temperature rise climbing within 0.5°F of the NPDES limit. The dates and times of these events, as well as the measurement values, are available from the listed Excel files.
- In 2007, 2008, 2009, and 2012 events, the 24-hour average temperature rise did not exceed the NPDES limit.

In addition to the river temperature, the river stage and estimated flow (as requested) also are provided in the listed Excel files. It needs to be emphasized that the estimated flow past the plant used in the SQN compliance model is based solely on hydro releases from Watts Bar Dam (upstream) and Chickamauga Dam (downstream). In this manner, the estimated flow past the plant does not include the effect of spill/flood events. In such events, thermal compliance for SQN is conservative, because the actual river flow and dilution of the plant thermal effluent are higher than that predicted by the model. In a similar fashion, the estimated flow past SQN also does not include inflows from the Hiwassee River. In general, the regulated inflow into Chickamauga Reservoir from the Hiwassee River tends to be small compared to the through flow contribution of the Tennessee River (typically between 5 and 15 percent, although exceptions occur). Withholding the Hiwassee contribution also makes the overall real-time modeling process more manageable—for example, it precludes the added tributary complexity of the Hiwassee River and Ocoee River, and the need to collect real-time flow data from Apalachia Dam and Ocoee 1 Dam, which would comprise, respectively, the upstream inflow boundaries for these tributaries.

The following documents are listed in Enclosure 2 as available for NRC review:

1.c.i.1 Enclosure_1.c.i-1.pdf

1.c.i.2 Enclosure_1.c.i_2007.xlsx

1.c.i.3 Enclosure_1.c.i_2008.xlsx

1.c.i.4 Enclosure_1.c.i_2009.xlsx

1.c.i.5 Enclosure_1.c.i_2010.xlsx

1.c.i.6 Enclosure_1.c.i_2011.xlsx

1.c.i.7 Enclosure_1.c.i_2012.xlsx

1.c.i.8 Enclosure_1.c.i_2013.xlsx

The Excel files mentioned above contain the following information:

Parameter	Definition	Units
WSEL_SKIM_Inst	Instantaneous river water surface elevation measured at the SQN skimmer wall (Station 13).	feet msl
Q_SQN_Hydro_1-hr	1-hr average hydro river flow at SQN, computed based on 1D unsteady flow model of Chickamauga Reservoir and hydro releases from Watts Bar Dam and Chickamauga Dam.	cfs
TUS_COMP_24-hr	24-hr average compliance ambient river temperature measured at TRM 490.4 (Station 14).	°F
TDS_COMP_24-hr	24-hr average compliance downstream river temperature computed at downstream end of diffuser mixing zone by the SQN compliance model.	°F
TRISE_COMP_24-hr	24-hr average compliance river temperature rise between the measured ambient river temperature (Station 14) and the computed river temperature at the downstream end of the diffuser mixing zone.	°F

Table 1. SQN Instream Thermal Limits for Outfall 101

Type of Limit	Averaging (hrs)	NPDES Limit
Max Downstream Temperature	24	30.5°C (86.9°F)
Max Downstream Temperature	1	33.9°C (93.0°F)
Max Temperature Rise	24	3.0°C (5.4°F) Apr-Oct 5.0°C (9.0°F) Nov-Mar
Max Temperature Rate-of-Change	Mixed	±2 C°/hr (±3.6°F/hr)

Accompanying criteria:

1. Compliance with the river limitations (river temperature, temperature rise, and rate of temperature change) shall be monitored by means of a numerical model that solves the thermohydrodynamic equations governing the flow and thermal conditions in the reservoir. This numerical model will utilize measured values of the upstream temperature profile and river stage; flow, temperature and performance characteristics of the diffuser discharge; and river flow as determined from releases at the Watts Bar and Chickamauga Dams. In the event that the modeling system described here is out of service, an alternate method would be employed to measure water temperatures at least one time per day and verify compliance of the maximum river temperature and maximum temperature rise. Depth average measurements can be taken at a downstream backup temperature monitor at the downstream end of the diffuser mixing zone (left bank Tennessee River mile 483.4) or by grab sampling from boats. Boat sampling will include average 5-foot depth measurements (average of 3, 5, and 7-foot depths). Sampling from a boat shall be made outside the skimmer wall (ambient temperature) and at quarter points and mid-channel at downstream Tennessee River mile 483.4 (downstream temperature). The downstream reported value will be a depth (3, 5, and 7-foot) and lateral (quarter points and midpoint) average of the instream measurements. Monitoring in the alternative mode using boat sampling shall not be required when unsafe boating conditions occur.
2. Compliance with river temperature, temperature rise, and rate of temperature change limitations shall be applicable at the edge of a mixing zone which shall not exceed the following dimensions: (1) a maximum length of 1500 feet downstream of the diffusers, (2) a maximum width of 750 feet, and (3) a maximum length of 275 feet upstream of the diffusers. The depth of the mixing zone measured from the surface varies linearly from the surface 275 feet upstream of the diffusers to the top of the diffuser pipes and extends to the bottom downstream of the diffusers. When the plant is operated in closed mode, the mixing zone shall also include the area of the intake forebay.
3. Information required by the numerical model and evaluations for the river temperature, temperature rise, and rate of temperature change shall be made every 15 minutes. The ambient temperature shall be determined at the 5-foot depth as the average of measurements at depths 3 feet, 5 feet, and 7 feet. The river temperature at the downstream end of the mixing zone shall be determined as that computed by the numerical model at a depth of 5 feet.

4. Daily maximum temperatures for the ambient temperature, the river temperature at the downstream edge of the mixing zone, and temperature rise shall be determined from 24-hour average values. The 24-hour average values shall be calculated every 15 minutes using the current and previous ninety-six 15-minute values, thus creating a 'rolling' average. The maximum of the ninety-six observations generated per day by this procedure shall be reported as the daily maximum value. For the river temperature at the downstream end of the mixing zone, the 1-hour average shall also be determined. The 1-hour average values shall be calculated every 15 minutes using the average of the current and previous four 15-minute values, again creating a rolling average.
5. The daily maximum 24-hour average river temperature is limited to 86.9°F (30.5°C). Since the state's criteria makes exception for exceeding the value as a result of natural conditions, when the 24-hour average ambient temperature exceeds 84.9°F (29.4°C) and the plant is operated in helper mode, the maximum temperature may exceed 86.9°F (30.5°C). In no case shall the plant discharge cause the 1-hour average downstream river temperature at the downstream of the mixing zone to exceed 93.0°F (33.9°C) without the consent of the permitting authority.
6. The temperature rise is the difference between the 24-hour average ambient river temperature measured at Station 14 and the computed 24-hour average temperature at the downstream end of the mixing zone. The 24-hour average temperature rise shall be limited to 5.4F° (3.0 C°) during the months of April through October. The 24-hour average temperature rise shall be limited to 9.0F° (5.0 C°) during the months of November through March.
7. The rate of temperature change shall be computed at 15-minute intervals based on the current 24-hour average ambient river temperature, current 24-hour-hour average river flow, and current values of the flow and temperature of water discharging through the diffuser pipes. The 1-hour average rate of temperature change shall be calculated every 15-minutes by averaging the current and previous four 15-minute values. The 1-hour average rate of temperature change shall be limited to 3.6F° (2 C°) per hour.

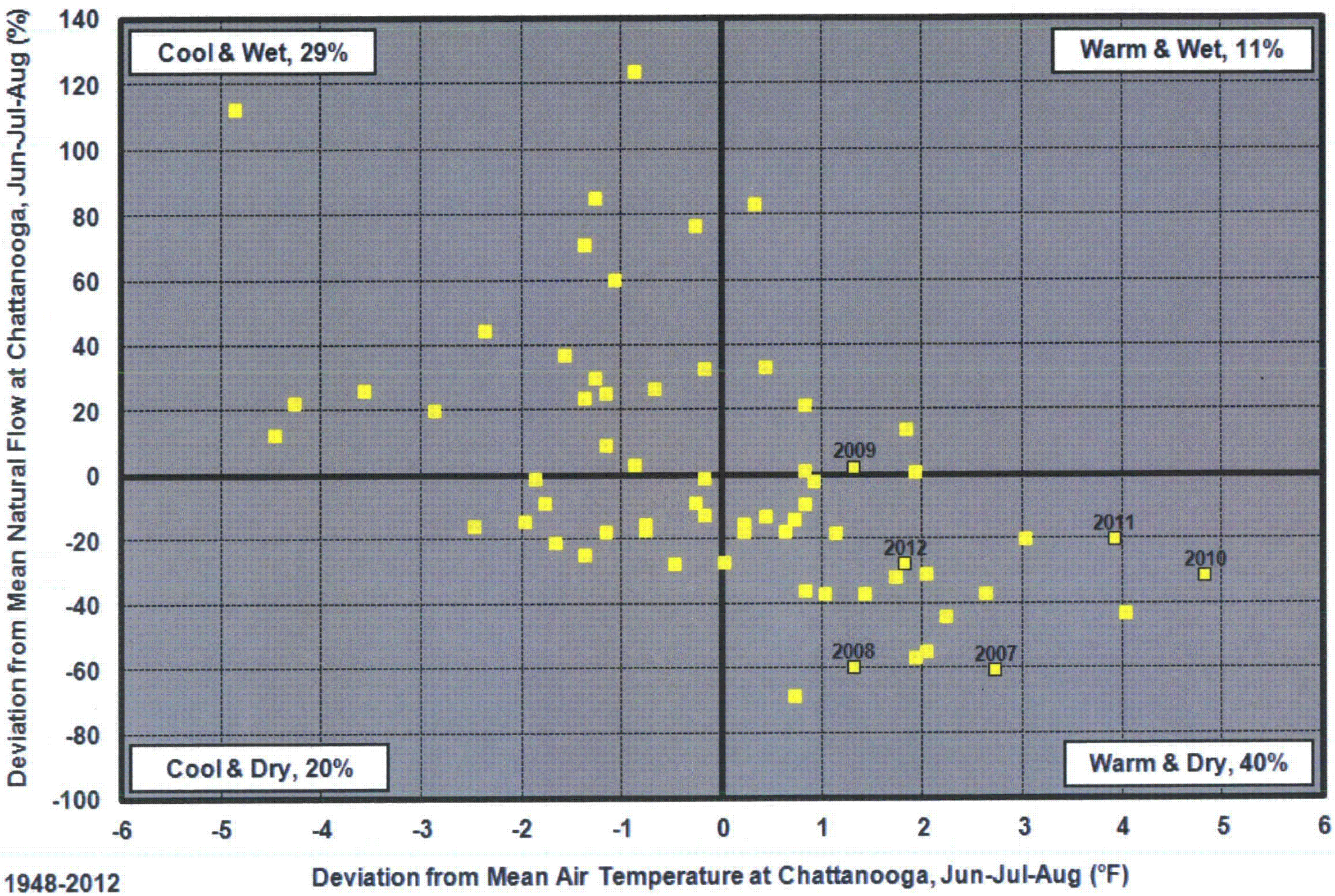


Figure 1. Classification of Hydrothermal Condition for the Tennessee River Valley

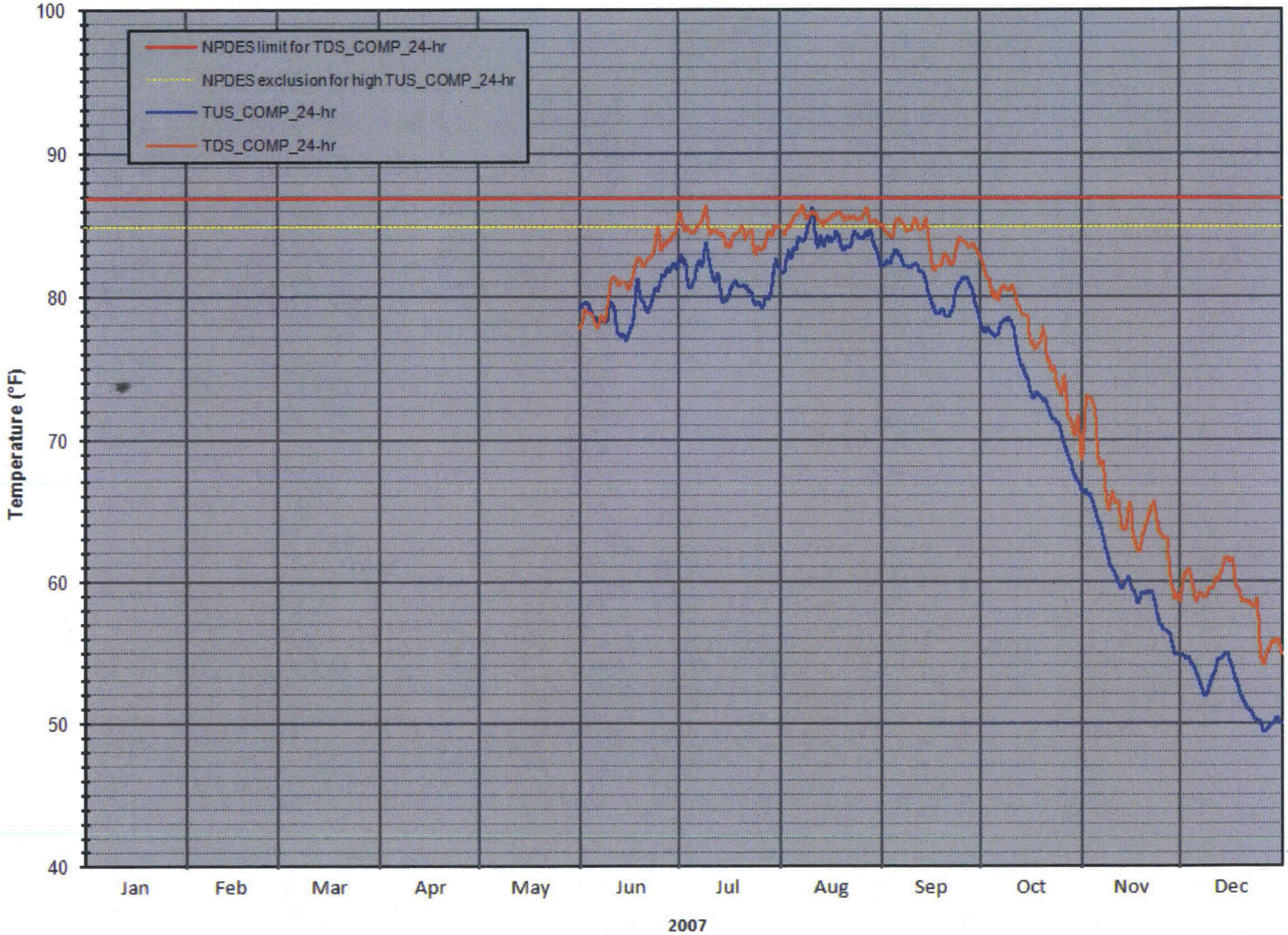


Figure 2-2007. Upstream and Downstream NPDES Compliance Temperatures for Outfall 101, 2007

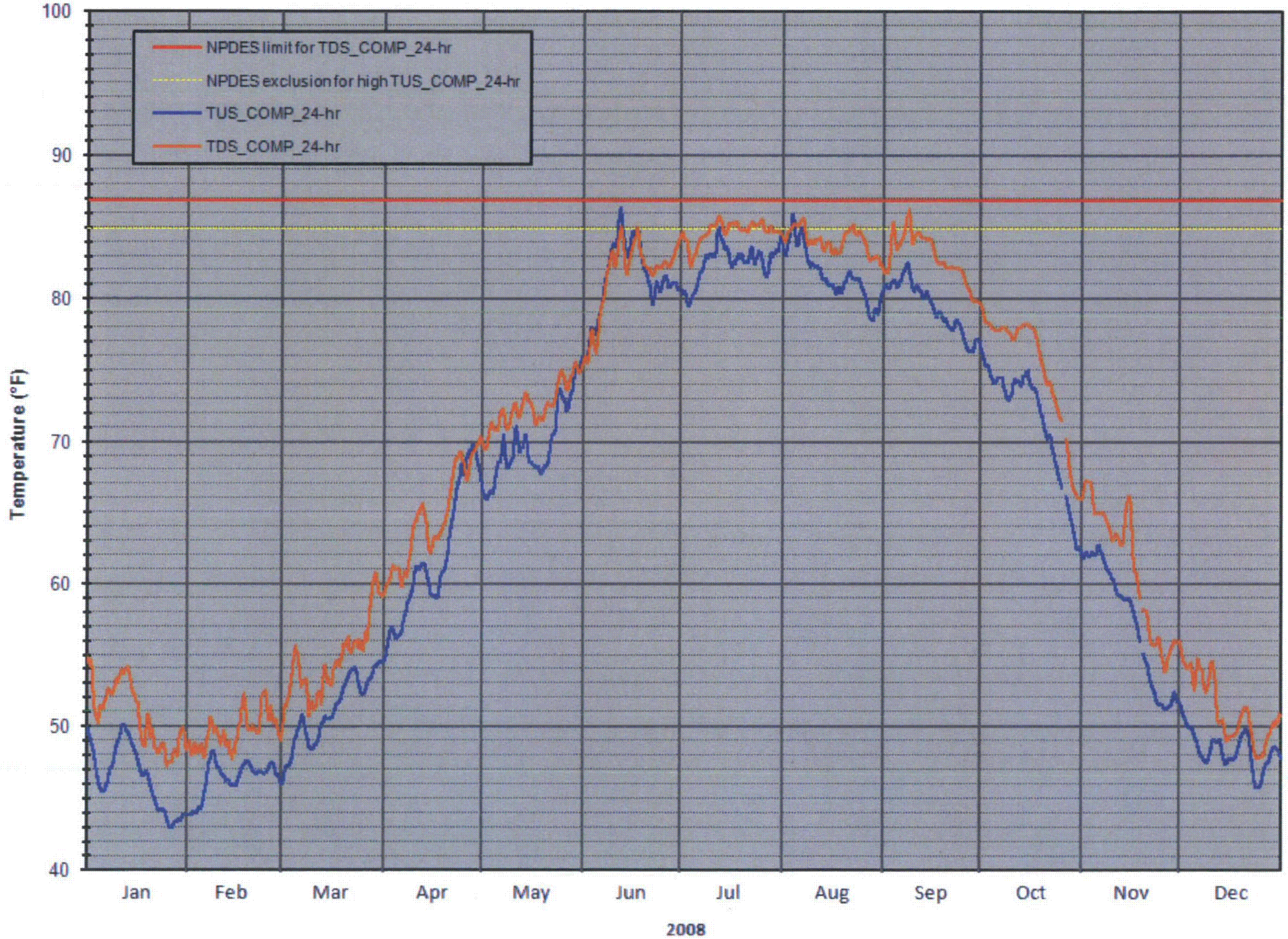


Figure 2-2008. Upstream and Downstream NPDES Compliance Temperatures for Outfall 101, 2008

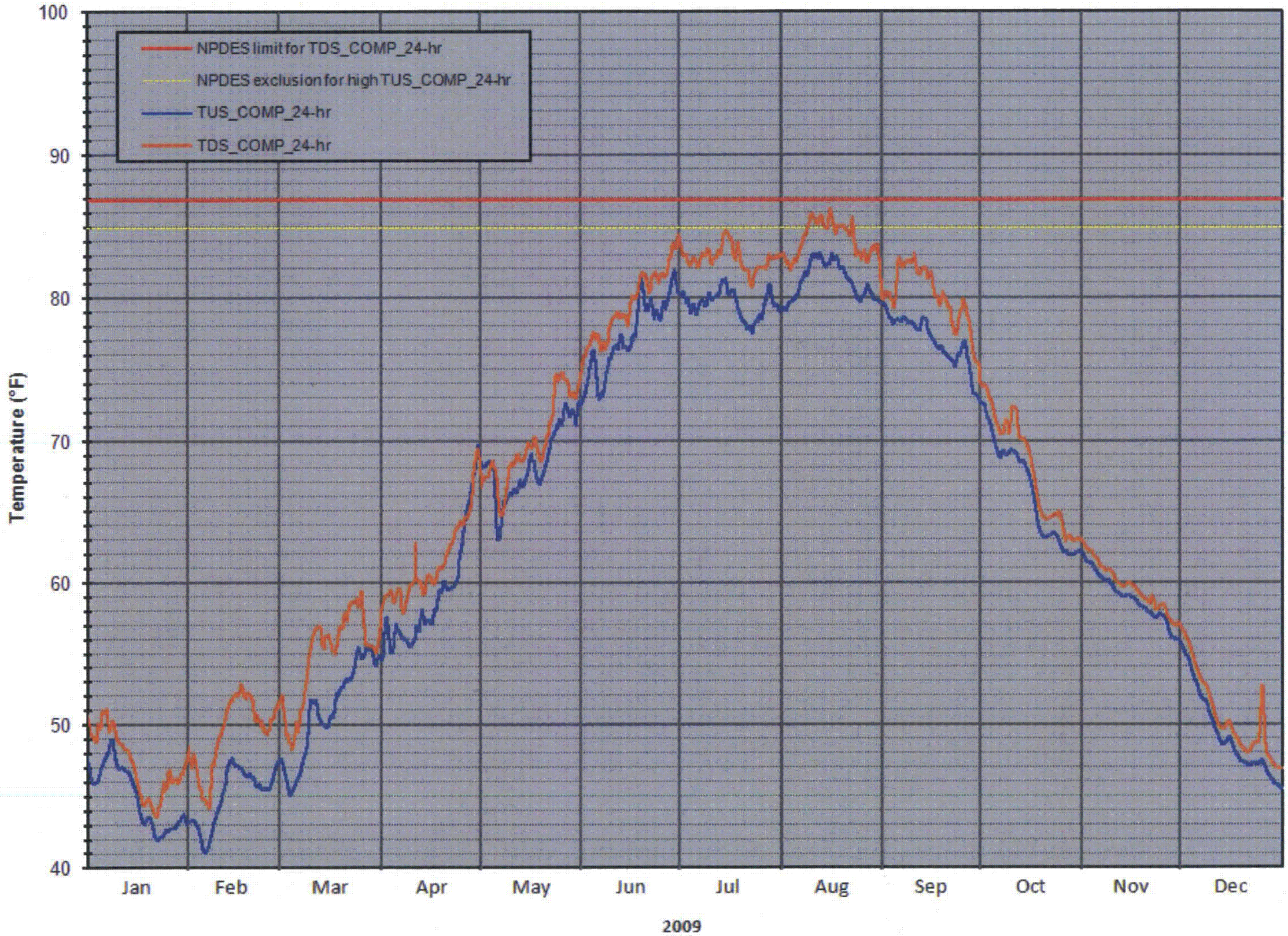


Figure 2-2009. Upstream and Downstream NPDES Compliance Temperatures for Outfall 101, 2009

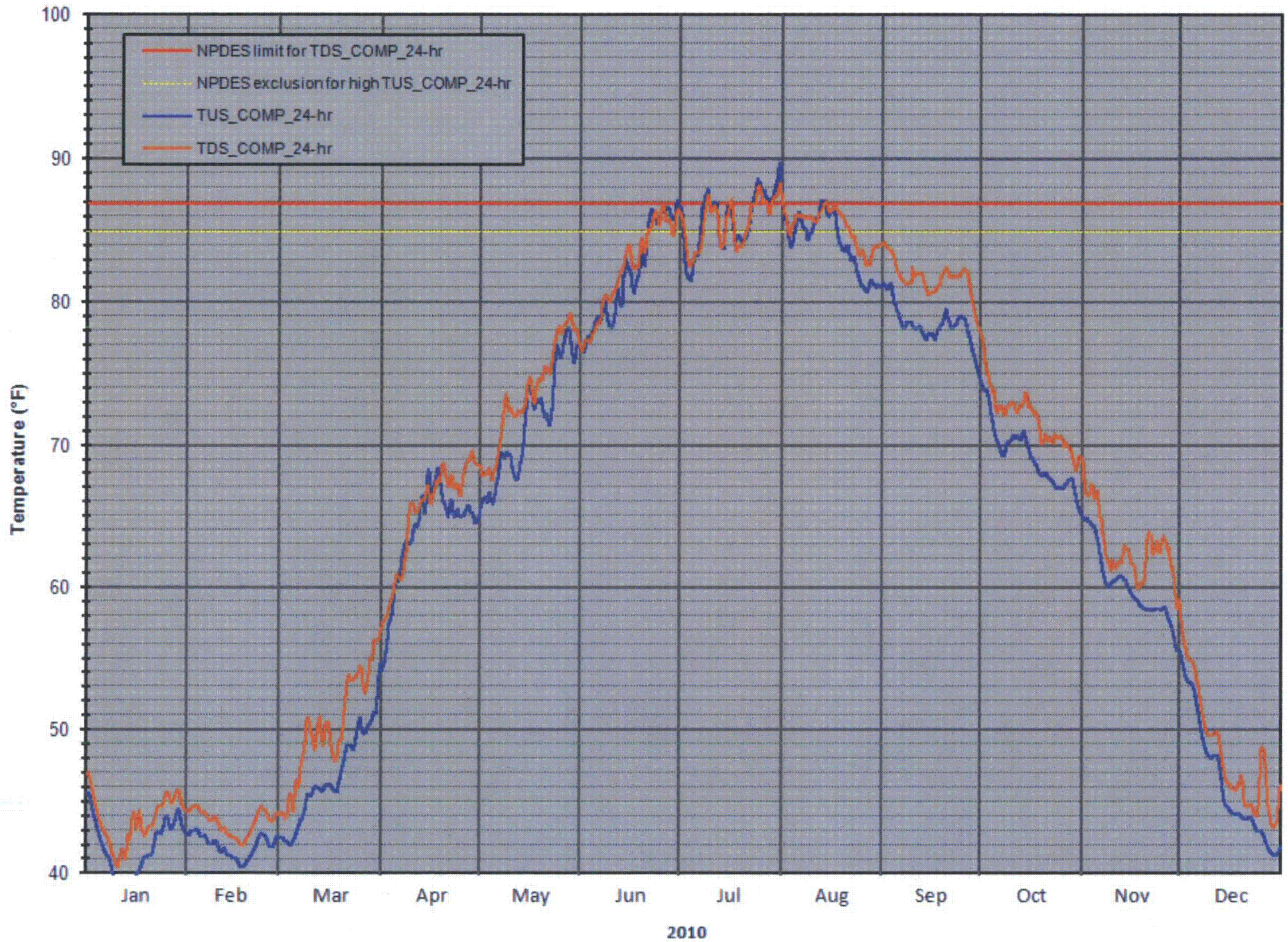


Figure 2-2010. Upstream and Downstream NPDES Compliance Temperatures for Outfall 101, 2010

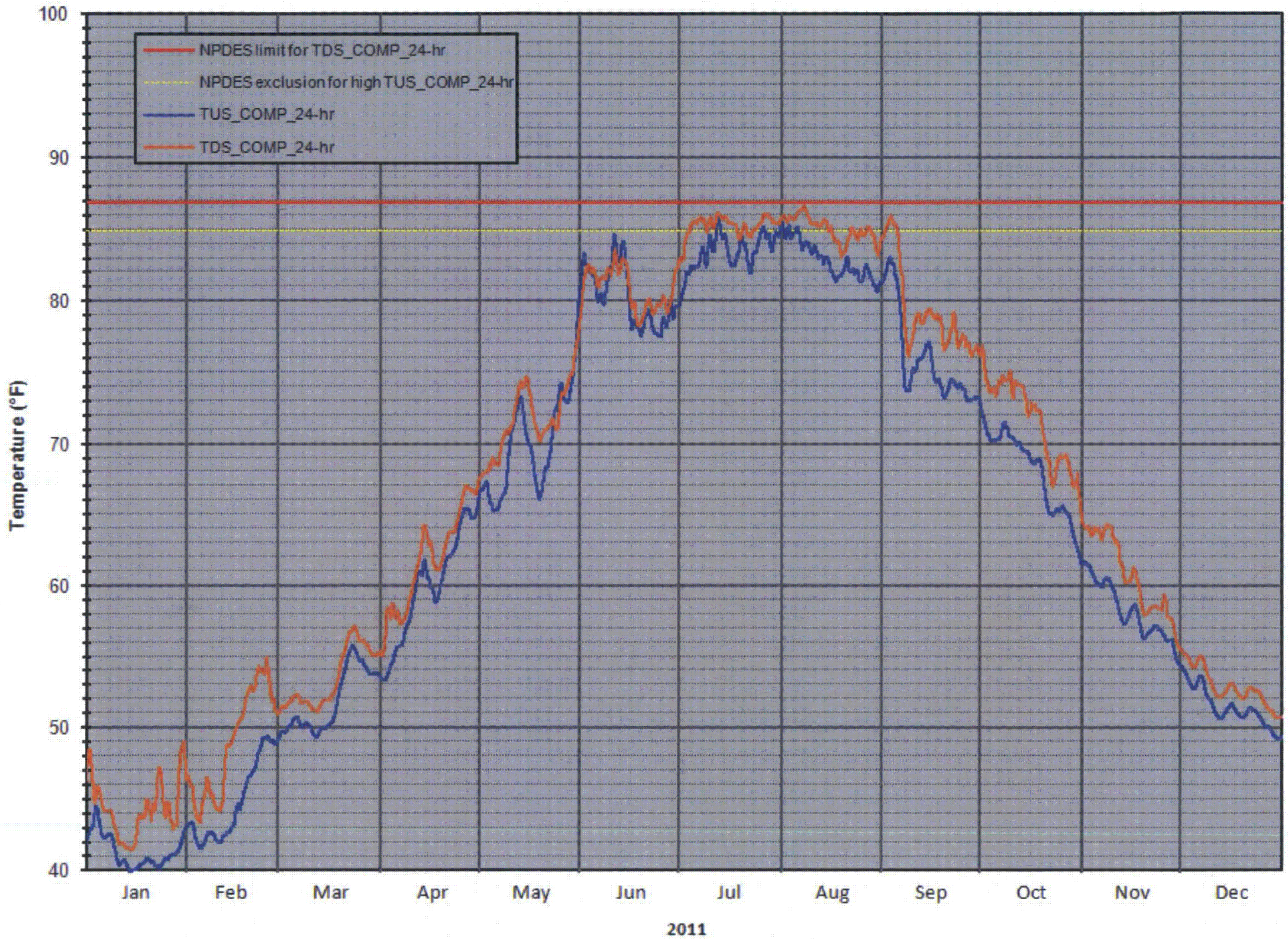


Figure 2-2011. Upstream and Downstream NPDES Compliance Temperatures for Outfall 101, 2011

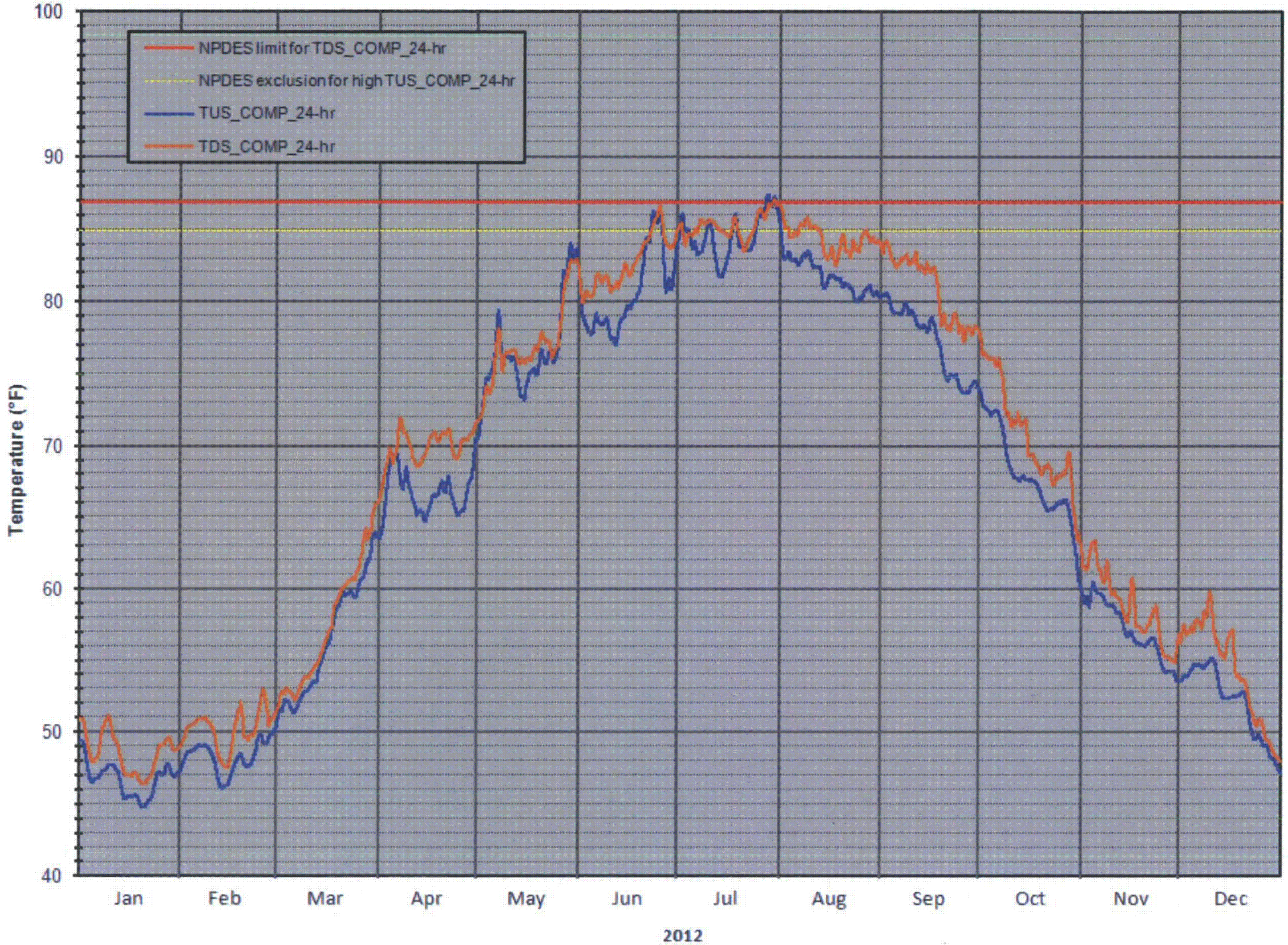


Figure 2-2012. Upstream and Downstream NPDES Compliance Temperatures for Outfall 101, 2012

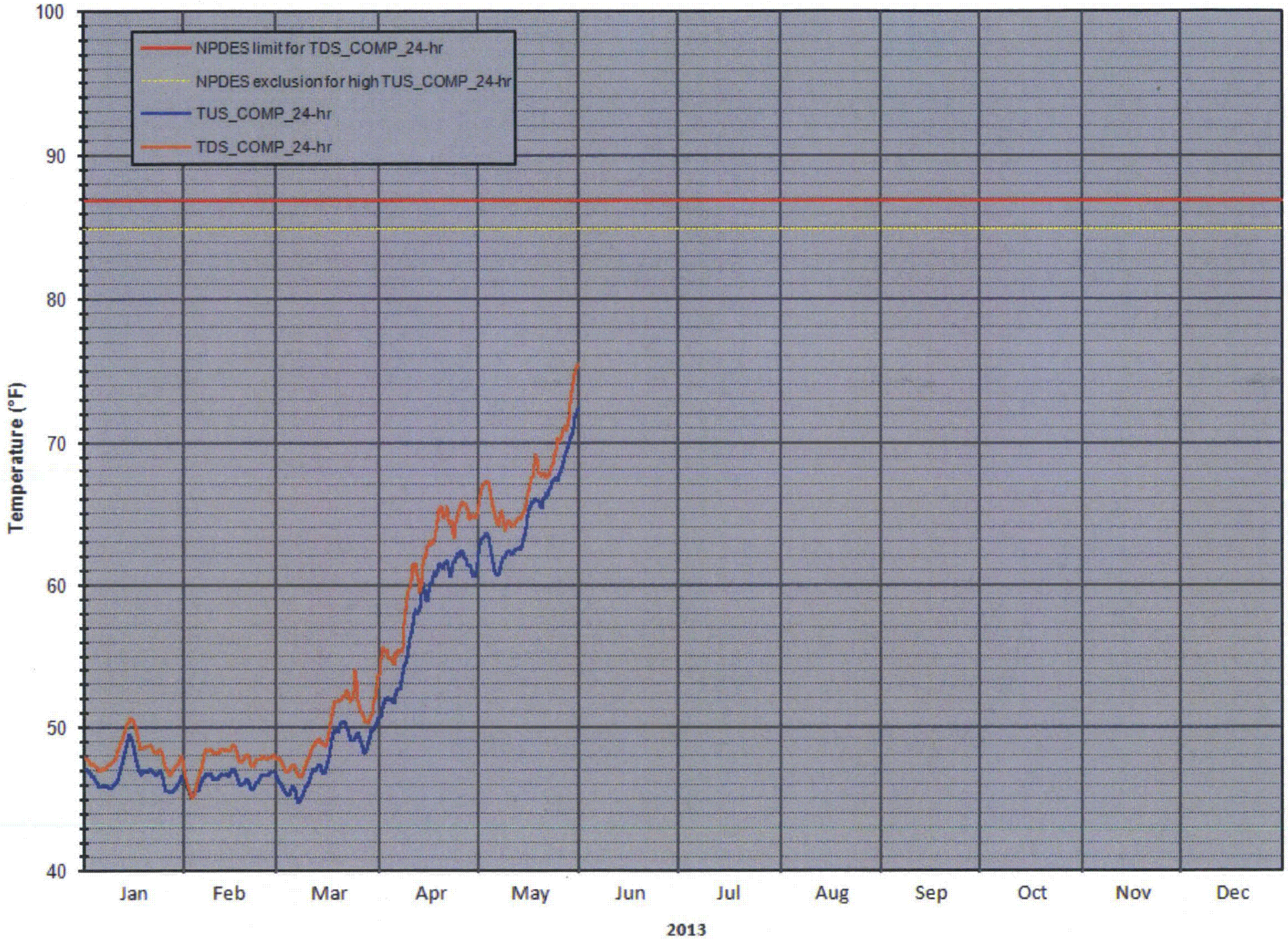


Figure 2-2013. Upstream and Downstream NPDES Compliance Temperatures for Outfall 101, 2013

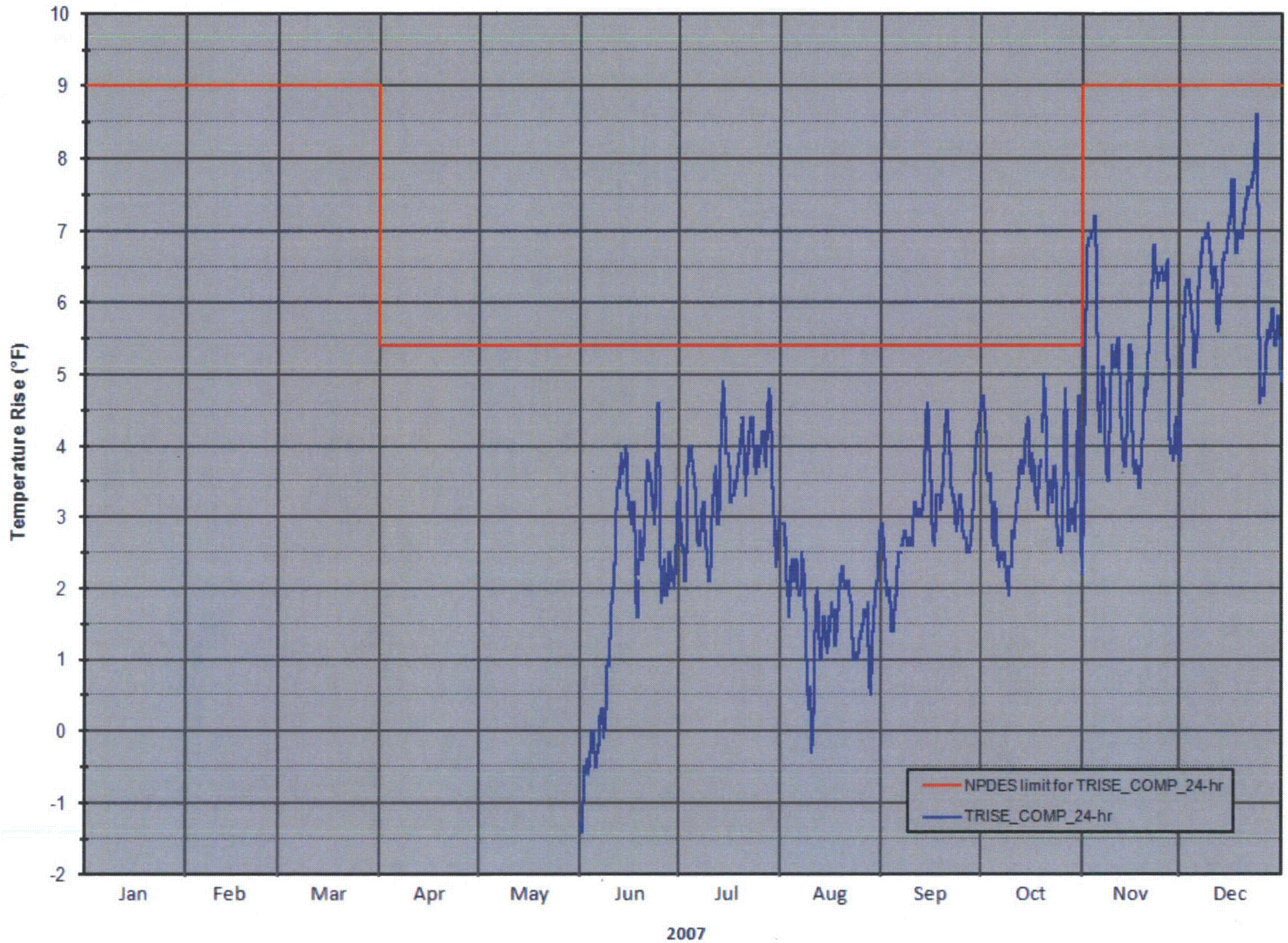


Figure 3-2007. NPDES Compliance Temperature Rise for Outfall 101, 2007

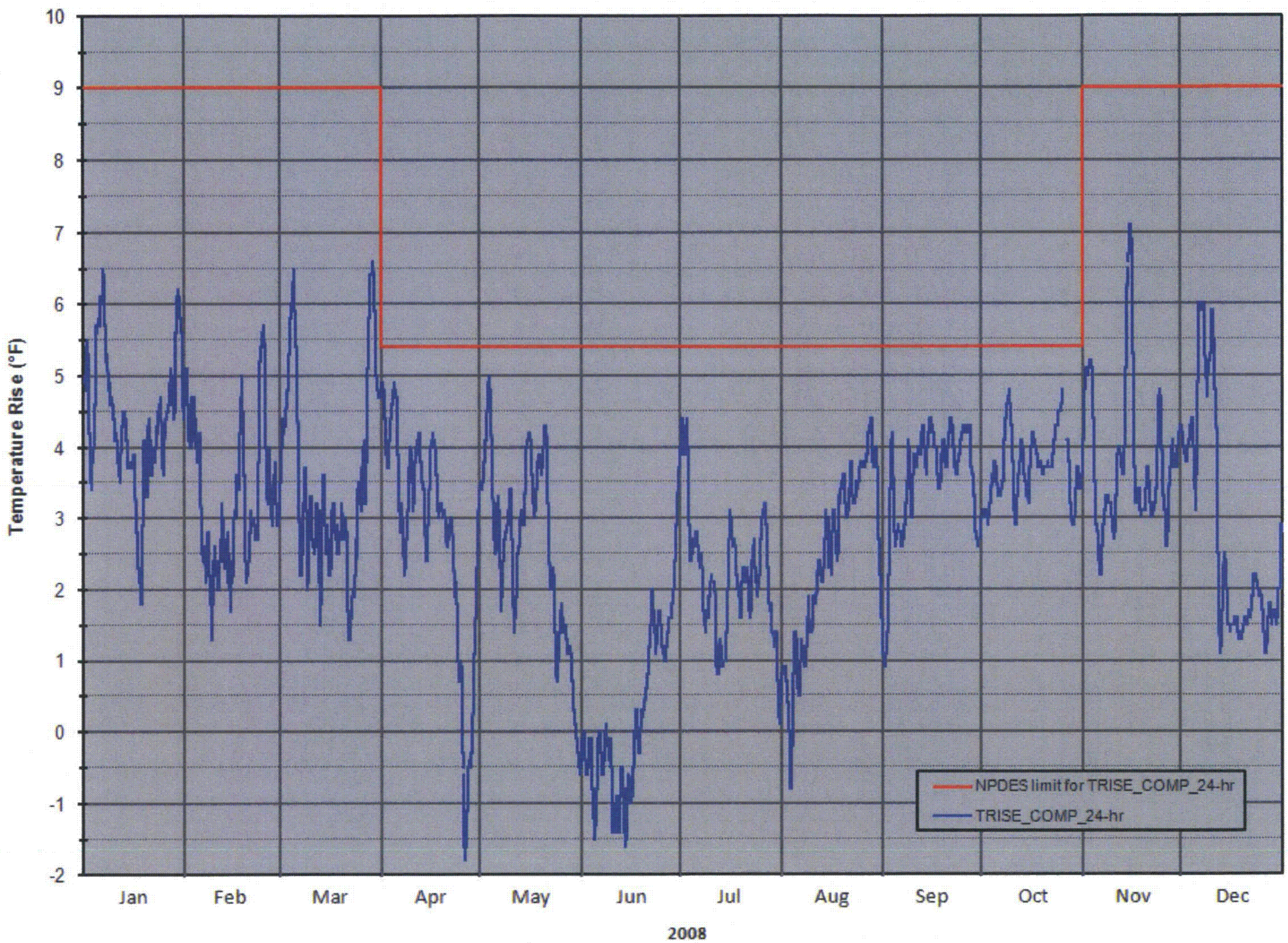


Figure 3-2008. NPDES Compliance Temperature Rise for Outfall 101, 2008

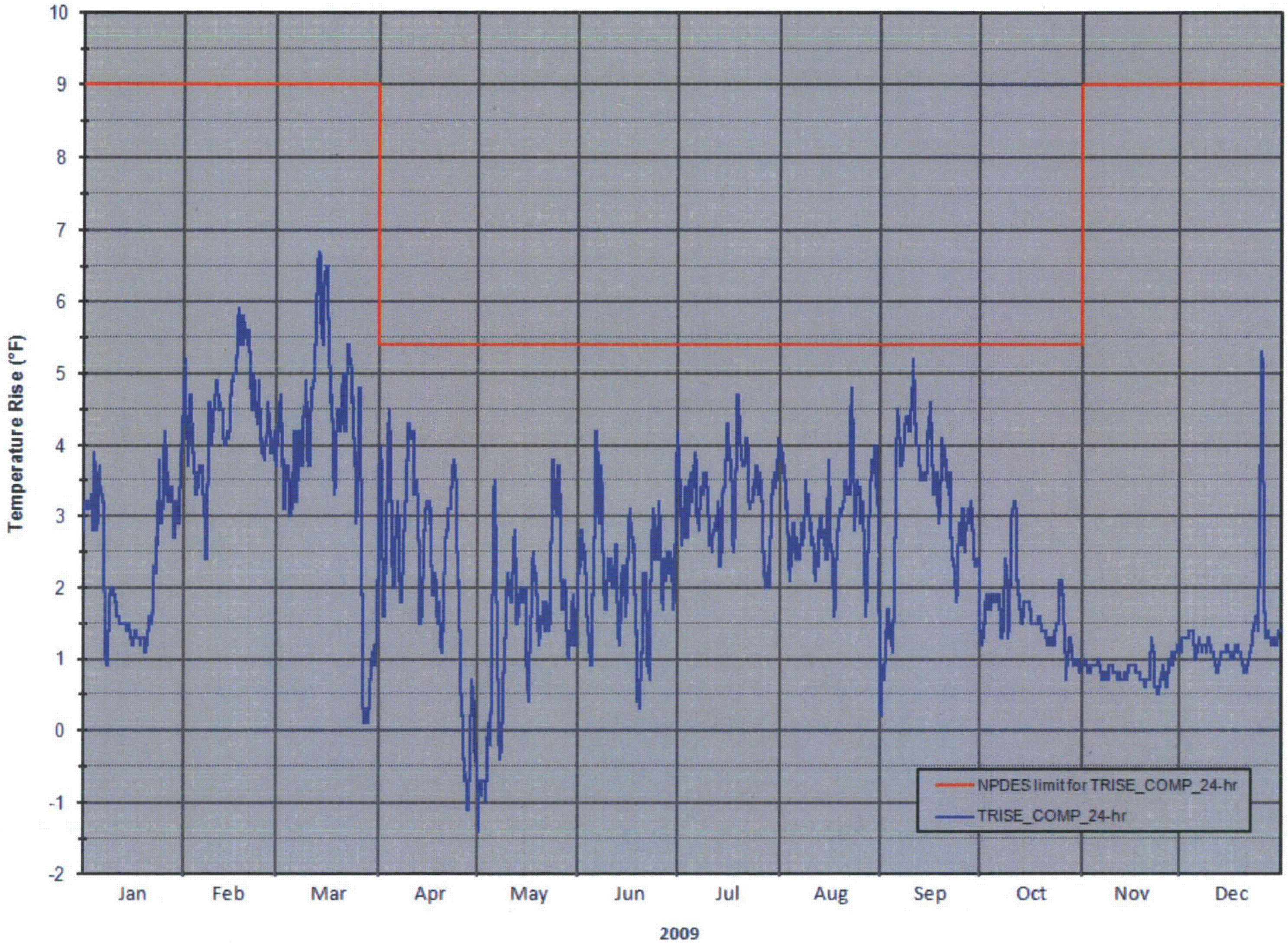


Figure 3-2009. NPDES Compliance Temperature Rise for Outfall 101, 2009

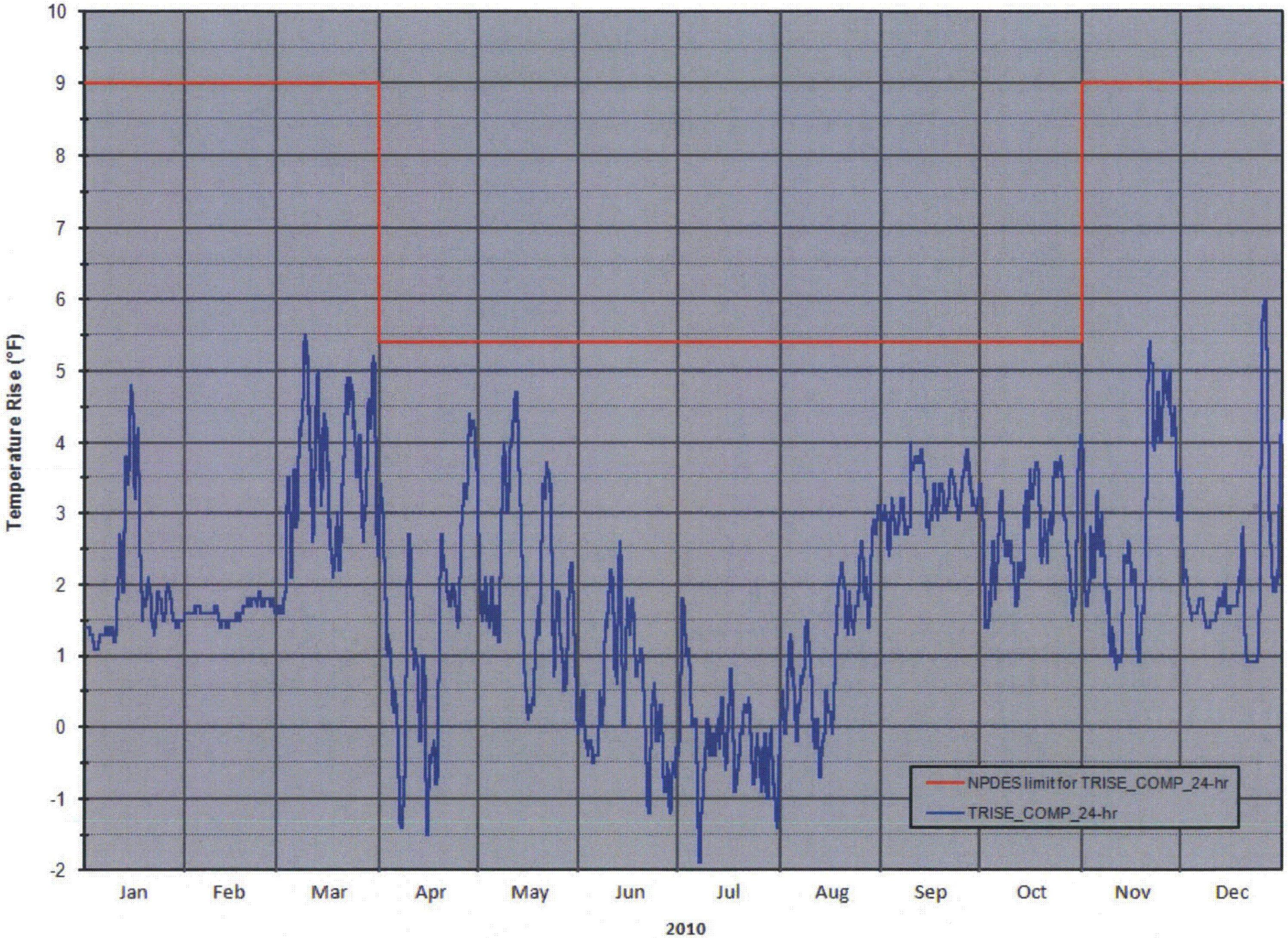


Figure 3-2010. NPDES Compliance Temperature Rise for Outfall 101, 2010

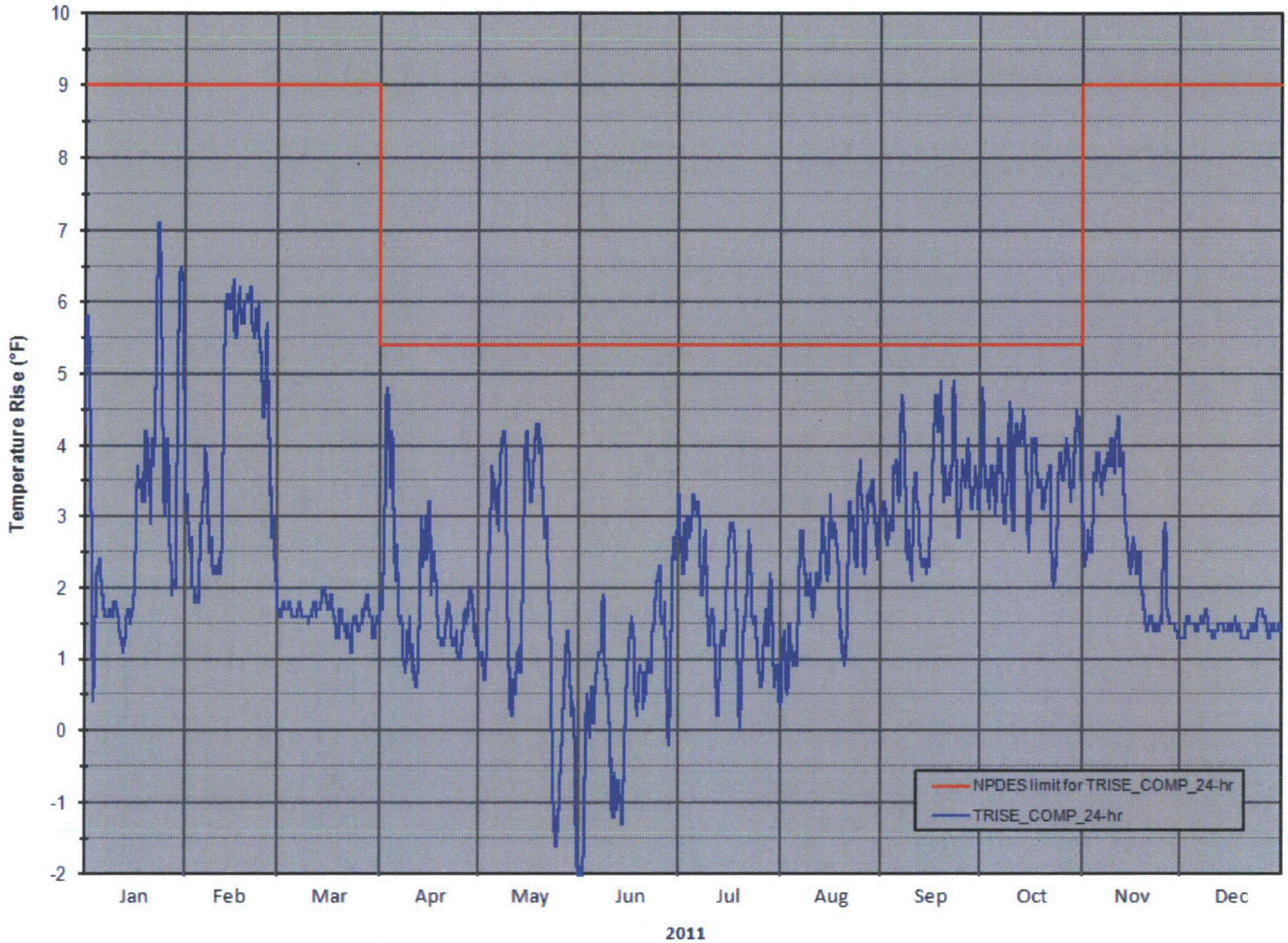


Figure 3-2011. NPDES Compliance Temperature Rise for Outfall 101, 2011

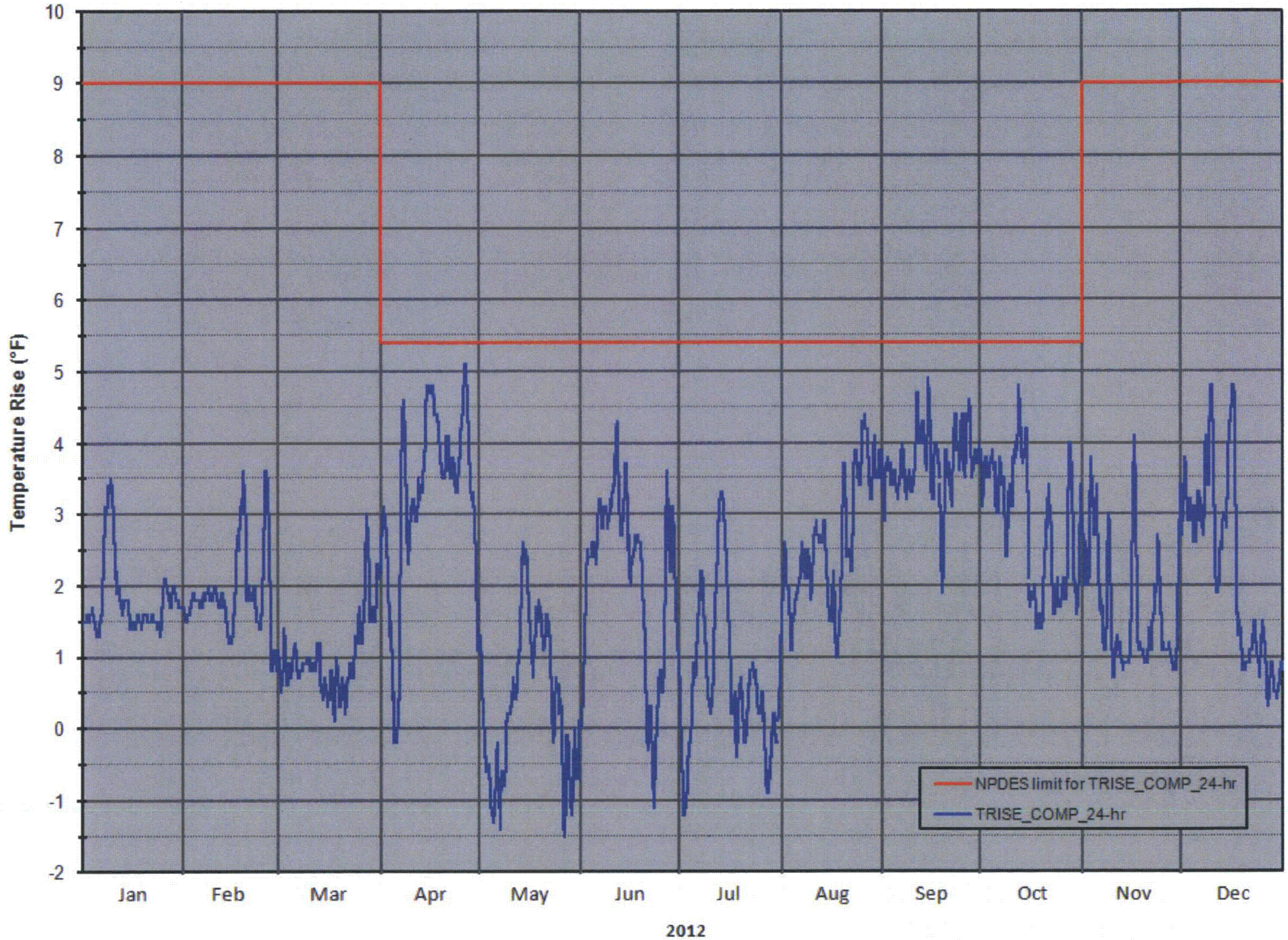


Figure 3-2012. NPDES Compliance Temperature Rise for Outfall 101, 2012

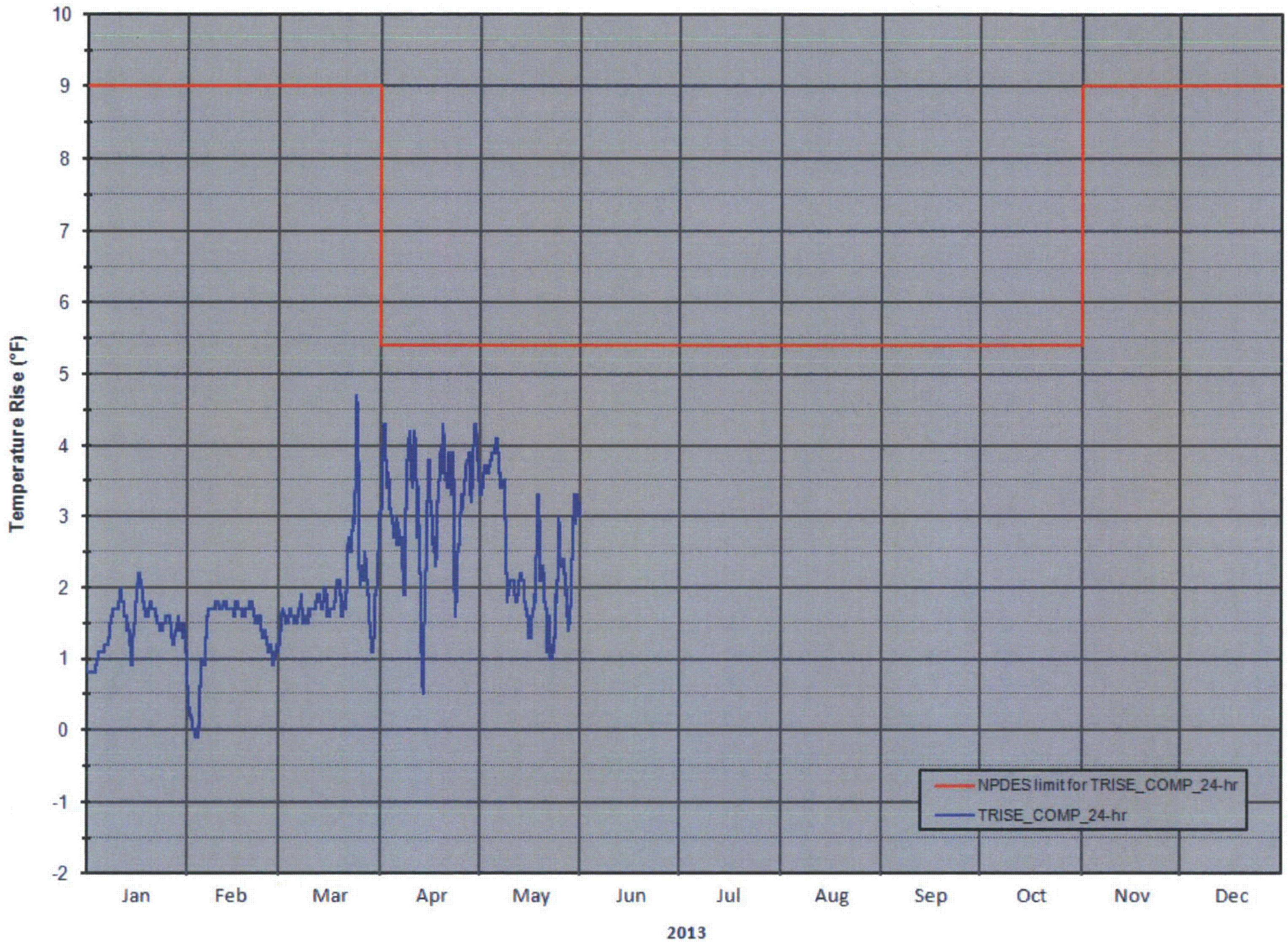


Figure 3-2013. NPDES Compliance Temperature Rise for Outfall 101, 2013

NRC RAI 1.c.ii

ii. Has there been any observable trend in the number of days SQN has had to operate in "helper mode" over the SQN operational history?

1. *Describe and provide the following information when helper mode (cooling towers) was invoked:*
   a. *dates and times when helper mode was operating;*
   b. *number of towers in operation;*
   c. *discharge through cooling towers; and*
   d. *temperature of effluent before river release including measurement location.*
2. *Provide data to cover a sufficiently long timeframe to include the periods of warmest river temperatures and lowest river discharges (e.g., drought).*
3. *For the historical trend, provide the number of days (or hours?) of helper mode for each year of operation.*

TVA Response

TVA has not identified an observable trend in the number of days SQN has had to operate in "helper mode" over the SQN operational history. A summary of the current NPDES instream thermal limits for SQN Outfall 101 is provided in Table 1. Although the NPDES permit specifies the limits in degrees Centigrade, day-to-day monitoring of the plant is performed in degrees Fahrenheit. Temperature limits are specified for the 24-hour average maximum downstream temperature, the 1-hour average maximum downstream temperature, the 24-hour average maximum downstream temperature rise, and the maximum downstream temperature rate-of-change. Under the current NPDES criteria, operating conditions for the river and the plant cause encroachment on only two of the limits—the 24-hour average maximum downstream temperature, and the 24-hour average maximum downstream temperature rise. In such events, helper mode operation with the cooling towers is used to help prevent the plant from exceeding the NPDES limit of concern. In general, a decision to implement helper mode operation depends on how close the river temperature is to the NPDES limit, and the uncertainty regarding the expected future trend in river temperature. Helper mode operation often is implemented when the river temperature climbs to within about 1°F of an NPDES limit. However, if there is strong confidence that the temperature will stabilize or abate, the plant may refrain from implementing or changing the level of helper mode operation. Knowing that the effluent from Outfall 101 can linger in the river and propagate upstream to create recirculation at the plant intake, helper mode operation often is implemented at low river flow, even if there is no immediate threat to an NPDES limit. For example, it is not uncommon in the spring to implement helper mode operation if the daily average river flow past the plant drops below about 8000 cfs.

A schematic of the SQN cooling towers is given in Figure 1. The effluent from the condensers enters a discharge pond upstream of the cooling tower pumping station. In open mode operation, the condenser effluent passes through the pumping station and into the diffuser pond (containing the diffuser discharge structure). In helper mode, control gates are lowered at the pumping station and cooling tower lift pumps (CTLPs) are started to divert the condenser discharge to the cooling towers. The original cooling tower pumping station included eight CTLPs. However, following operational damage, one of the CTLPs was abandoned. The current FSAR design basis for the plant includes only seven CTLPs. The pumping station includes two supply headers. Pumps 1A, 1C, and 1D provide flow for Header 1 and Pumps 2A, 2B, 2C, and 2D provide flow for Header 2. Beyond the pumping station, the headers are interconnected by a crosstie conduit. Control valves downstream of the crosstie conduit allow any of the lift pumps to supply flow to any one or both of the cooling towers. The design flow for each lift pump is 140,000 gpm (311.9 cfs). The design flow for each cooling tower is 560,000 gpm (1247.6 cfs), equivalent to the flow from four CTLPs. In this manner, if five or more CTLPs are placed in service, the headers must be aligned via the control valves to supply flow to both cooling towers. At the exit of the cooling towers, and in helper mode, the treated flow is returned to the diffuser pond through a gate structure. If it were possible to operate the plant in closed mode, a separate gate structure is provided to return the flow to the intake forebay.

In recent years, instrumentation has been installed to provide real-time monitoring of the status of each cooling tower lift pump (i.e., on/off). Data for the approximate number of CTLPs in service, the approximate discharge through the cooling towers, and the measured temperature of the plant effluent at the entrance to the diffusers (i.e., exit of the diffuser pond) are contained in the Excel file listed in Enclosure 2 as Enclosure_1.c.ii.xlsx. The data are given at the top of each hour for years 2007 through 2012, as well as months January through May, 2013. June of 2007 is the first month of implementation of the current version of the compliance model. The term "approximate" is used to emphasize equipment outages at times result in missing CTLP data (particularly 2009). Also, instrumentation does not exist to measure the discharge through the cooling towers. In Enclosure_1.c.ii.xlsx, the discharge through the cooling towers is estimated based on number of CTLPs in service and the CTLP design flow (i.e., 311.9 cfs per pump). The actual discharge through the cooling towers may differ based on the condition of the pumps and other operating circumstances (e.g., heads, gate positions).

Whereas data are automatically archived for the number of CTLPs in service, such is not the case for the number of cooling towers in service (i.e., one or two). As emphasized above, if five or more CTLPs are in service, the flow must be aligned to both cooling towers. In general, the process of closing and opening the control valves downstream of the crosstie conduit to toggle the CTLP alignment between one and two cooling towers is arduous. The valves can be safely operated only when the CTLPs are removed from service. To avoid situations where an NPDES limit is threatened and the CTLPs must be removed from service to change the tower alignment from one to two towers, helper mode operation often is implemented with four or less CTLPs aligned to both towers, even though operation with one tower is sufficient. In these situations, even though tower capability is low (e.g., the flow from four or fewer CTLPs would not completely fill the upper distribution rings for two towers), if needed, it allows the plant to quickly ramp up to seven CTLPs to respond to sudden excursions in river temperature (i.e., without temporarily removing the towers from service). Regarding the number of towers in service: (1) if the number of CTLPs in service is five or more, both cooling towers are in use, (2) if the number of CTLPs is four or less, in most cases, both cooling towers are in use.

With this background, plots for the number of CTLPs in service and the diffuser discharge temperature are provided in Figure 2 for 2007 through 2013. Provided in Figure 3 is a summary of the number of equivalent days of cooling tower operation (i.e., helper mode operation) for 2007 through 2012. The equivalent days of cooling tower operation is based on the number of hours of cooling tower operation wherein at least one CTLP is in service. The total amount of CTLP operation also can be expressed by the number of CTLP-hours, where one CTLP-hour is equivalent to the operation of one CTLP for one hour. Provided in Figure 4 is the number of CTLP-hours for 2007 through 2012. The span from 2007 through 2012 includes a period of drought and a period of extreme heating. Specifically, 2007 and 2008 were years of extreme drought with a natural river flow about 60 percent below normal. 2010 included a summer of extreme atmospheric heating with the average air temperature in Chattanooga about 4.8°F warmer than normal. See the response to RAI 1.c.i for additional details concerning the classification of summer air temperatures and river flows. Overall, the data in Figure 3 and Figure 4 do not suggest any recent, chronologically-related trend in the number of days of helper mode operation.

At SQN, the river temperature and corresponding trend in helper mode operation is perhaps most closely related to river flow. Higher river flows come in periods of higher rainfall/runoff and cooler meteorology. Lower river flows come in periods of lower rainfall/runoff and warmer meteorology. Higher river flows provide greater dilution for the SQN diffuser effluent, and lower river flows the opposite. River temperatures and the need for helper mode operation follow in a similar manner i.e., higher river flow/cooler meteorology/higher dilution results in less helper mode operation and lower river flow/warmer meteorology/lower dilution results in more helper mode operation. This is perhaps best illustrated in Figure 5, which provides the total number of CTLP-hours for 2007 through 2012 vs. the percent deviation from mean average summertime natural flow at Chickamauga Dam. The increasing trend in CTLP-hours for lower natural river flow is apparent. Figure 6 provides the total number of CTLP-hours for 2007 through 2012 vs. the deviation from mean average summertime air temperature in Chattanooga. In contrast to natural flow, there is no significant trend in CTLP-hours as related to air temperature.

The Excel file mentioned above contains the following information:

Parameter	Definition	Units
	Approximate number of CTLPs in service, hour by hour from January 1, 2007 through May 31, 2013.	NA
	Approximate discharge through the cooling towers, hour by hour from January 1, 2007 through May 31, 2013.	cfs
TDIFF_Inst	Measured temperature of the plant effluent at the entrance to the diffuser pipes, hour by hour from January 1, 2007 through May 31, 2013.	°F

Table 1. SQN Instream Thermal Limits for Outfall 101

Type of Limit	Averaging (hrs)	NPDES Limit
Max Downstream Temperature	24	30.5°C (86.9°F)
Max Downstream Temperature	1	33.9°C (93.0°F)
Max Temperature Rise	24	3.0°C (5.4°F) Apr-Oct 5.0°C (9.0°F) Nov-Mar
Max Temperature Rate-of-Change	Mixed	±2 C°/hr (±3.6°F/hr)

Accompanying criteria:

1. Compliance with the river limitations (river temperature, temperature rise, and rate of temperature change) shall be monitored by means of a numerical model that solves the thermohydrodynamic equations governing the flow and thermal conditions in the reservoir. This numerical model will utilize measured values of the upstream temperature profile and river stage; flow, temperature and performance characteristics of the diffuser discharge; and river flow as determined from releases at the Watts Bar and Chickamauga Dams. In the event that the modeling system described here is out of service, an alternate method would be employed to measure water temperatures at least one time per day and verify compliance of the maximum river temperature and maximum temperature rise. Depth average measurements can be taken at a downstream backup temperature monitor at the downstream end of the diffuser mixing zone (left bank Tennessee River mile 483.4) or by grab sampling from boats. Boat sampling will include average 5-foot depth measurements (average of 3, 5, and 7-foot depths). Sampling from a boat shall be made outside the skimmer wall (ambient temperature) and at quarter points and mid-channel at downstream Tennessee River mile 483.4 (downstream temperature). The downstream reported value will be a depth (3, 5, and 7-foot) and lateral (quarter points and midpoint) average of the instream measurements. Monitoring in the alternative mode using boat sampling shall not be required when unsafe boating conditions occur.

2. Compliance with river temperature, temperature rise, and rate of temperature change limitations shall be applicable at the edge of a mixing zone which shall not exceed the following dimensions: (1) a maximum length of 1500 feet downstream of the diffusers, (2) a maximum width of 750 feet, and (3) a maximum length of 275 feet upstream of the diffusers. The depth of the mixing zone measured from the surface varies linearly from the surface 275 feet upstream of the diffusers to the top of the diffuser pipes and extends to the bottom downstream of the diffusers. When the plant is operated in closed mode, the mixing zone shall also include the area of the intake forebay.

3. Information required by the numerical model and evaluations for the river temperature, temperature rise, and rate of temperature change shall be made every 15 minutes. The ambient temperature shall be determined at the 5-foot depth as the average of measurements at depths 3 feet, 5 feet, and 7 feet. The river temperature at the downstream end of the mixing zone shall be determined as that computed by the numerical model at a depth of 5 feet.

4. Daily maximum temperatures for the ambient temperature, the river temperature at the downstream edge of the mixing zone, and temperature rise shall be determined from 24-hour

average values. The 24-hour average values shall be calculated every 15 minutes using the current and previous ninety-six 15-minute values, thus creating a 'rolling' average. The maximum of the ninety-six observations generated per day by this procedure shall be reported as the daily maximum value. For the river temperature at the downstream end of the mixing zone, the 1-hour average shall also be determined. The 1-hour average values shall be calculated every 15 minutes using the average of the current and previous four 15-minute values, again creating a rolling average.

5. The daily maximum 24-hour average river temperature is limited to 86.9°F (30.5°C). Since the state's criteria makes exception for exceeding the value as a result of natural conditions, when the 24-hour average ambient temperature exceeds 84.9°F (29.4°C) and the plant is operated in helper mode, the maximum temperature may exceed 86.9°F (30.5°C). In no case shall the plant discharge cause the 1-hour average downstream river temperature at the downstream of the mixing zone to exceed 93.0°F (33.9°C) without the consent of the permitting authority.
6. The temperature rise is the difference between the 24-hour average ambient river temperature measured at Station 14 and the computed 24-hour average temperature at the downstream end of the mixing zone. The 24-hour average temperature rise shall be limited to 5.4F° (3.0 C°) during the months of April through October. The 24-hour average temperature rise shall be limited to 9.0F° (5.0 C°) during the months of November through March.
7. The rate of temperature change shall be computed at 15-minute intervals based on the current 24-hour average ambient river temperature, current 24-hour-hour average river flow, and current values of the flow and temperature of water discharging through the diffuser pipes. The 1-hour average rate of temperature change shall be calculated every 15-minutes by averaging the current and previous four 15-minute values. The 1-hour average rate of temperature change shall be limited to 3.6F° (2 C°) per hour.

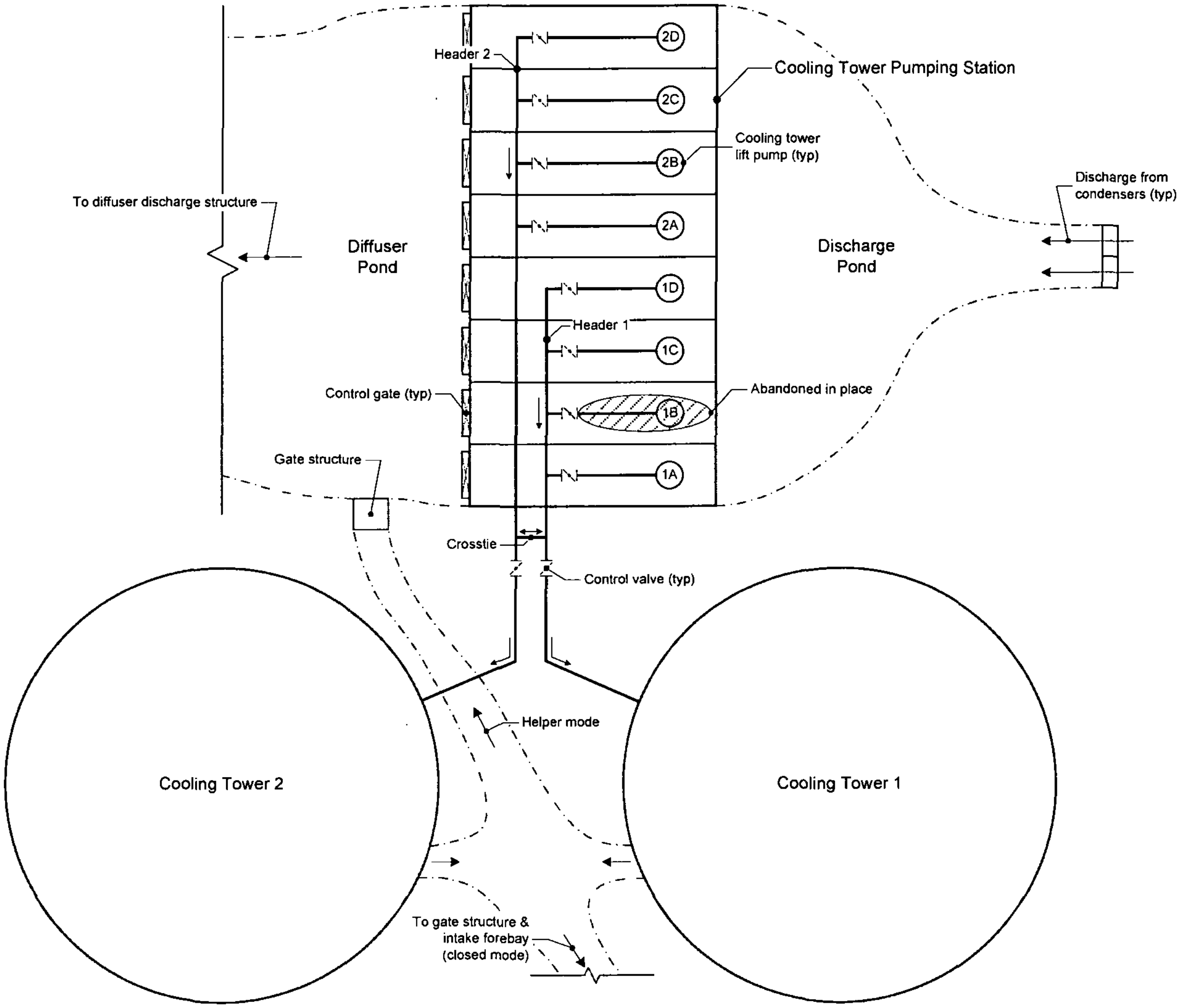


Figure 1. Schematic of SQN Cooling Towers

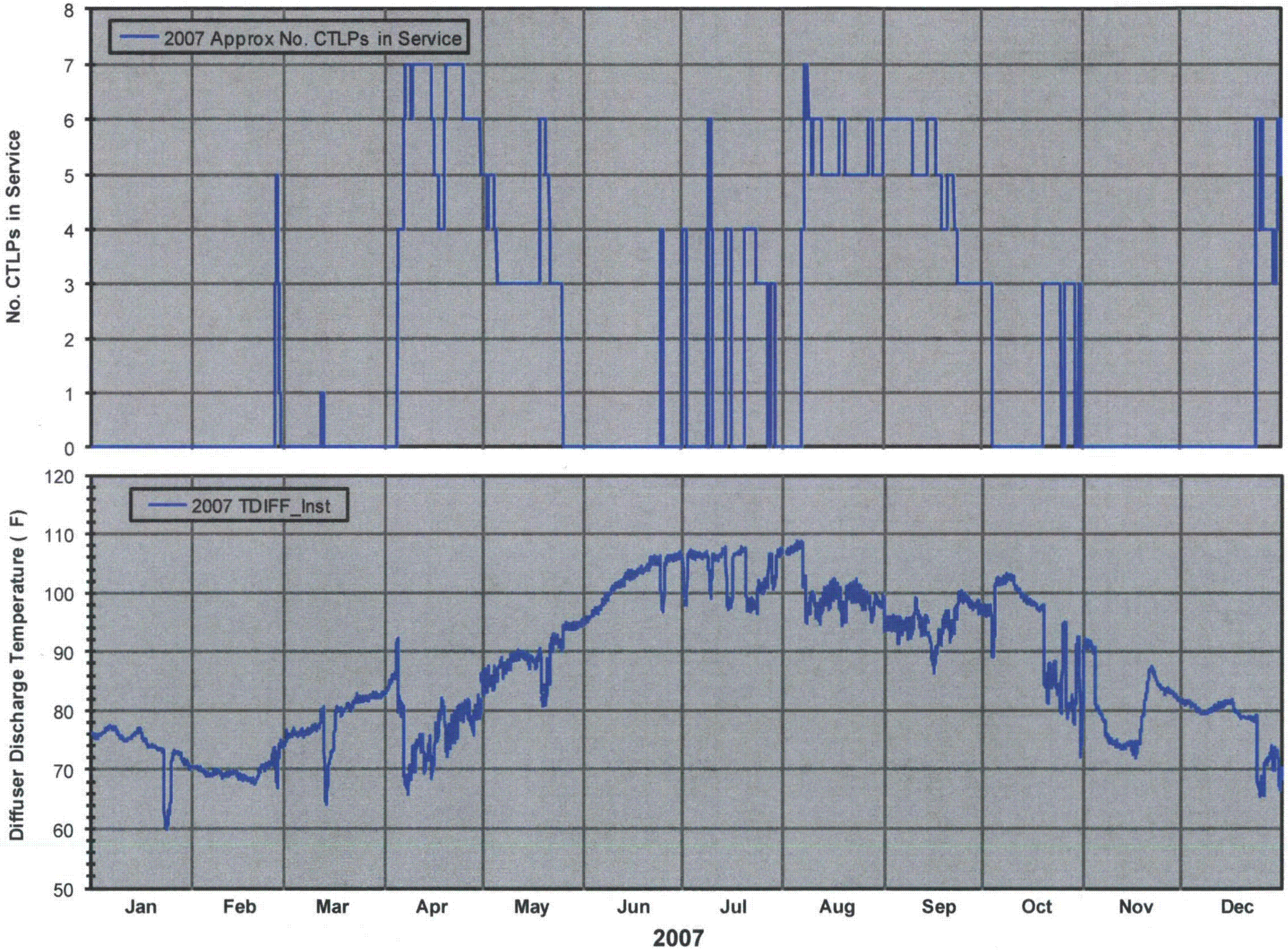


Figure 2-2007. Number of CTLPs in operation and Diffuser Discharge Temperature, 2007

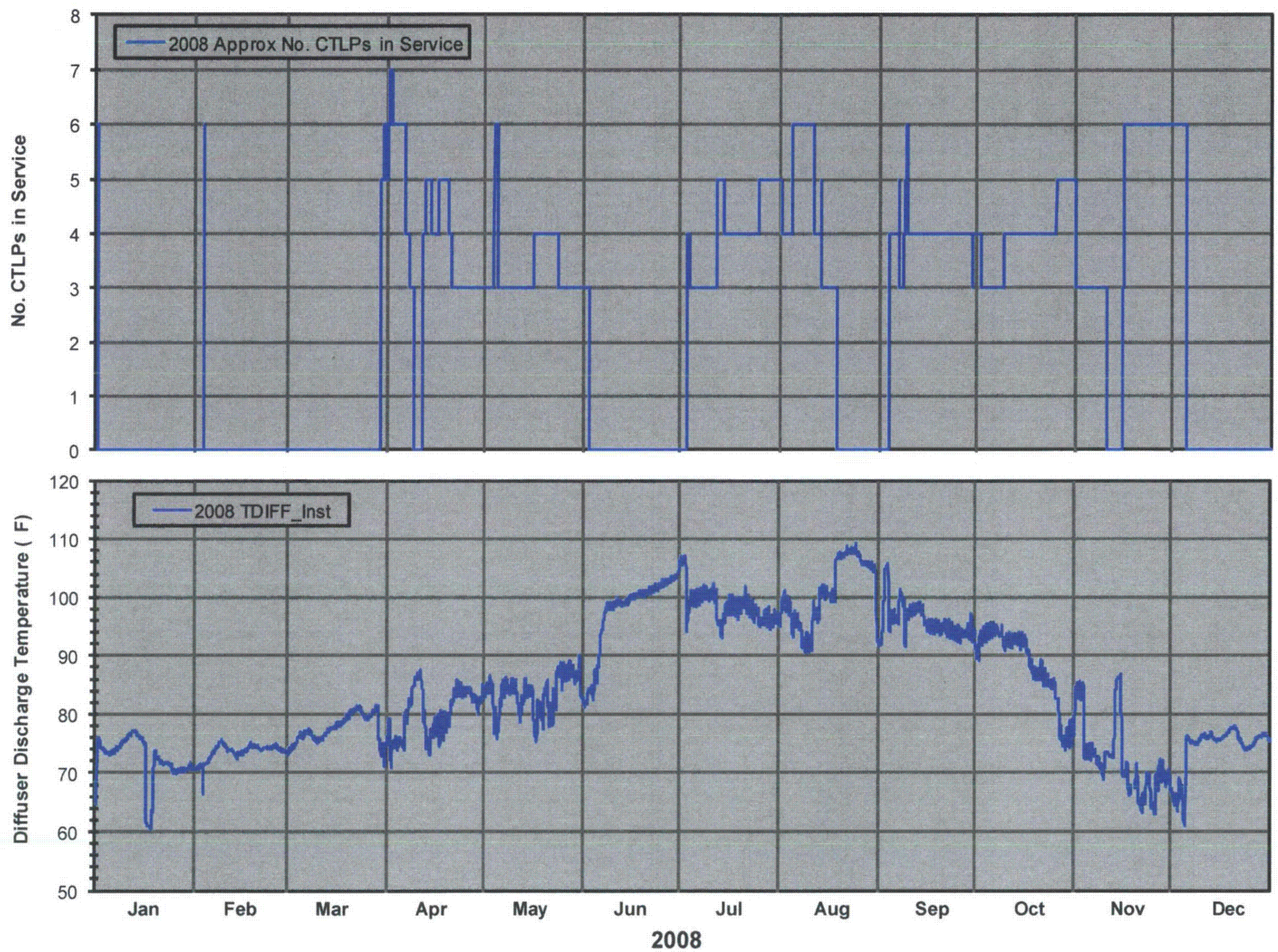


Figure 2-2008. Number of CTLPs in operation and Diffuser Discharge Temperature, 2008

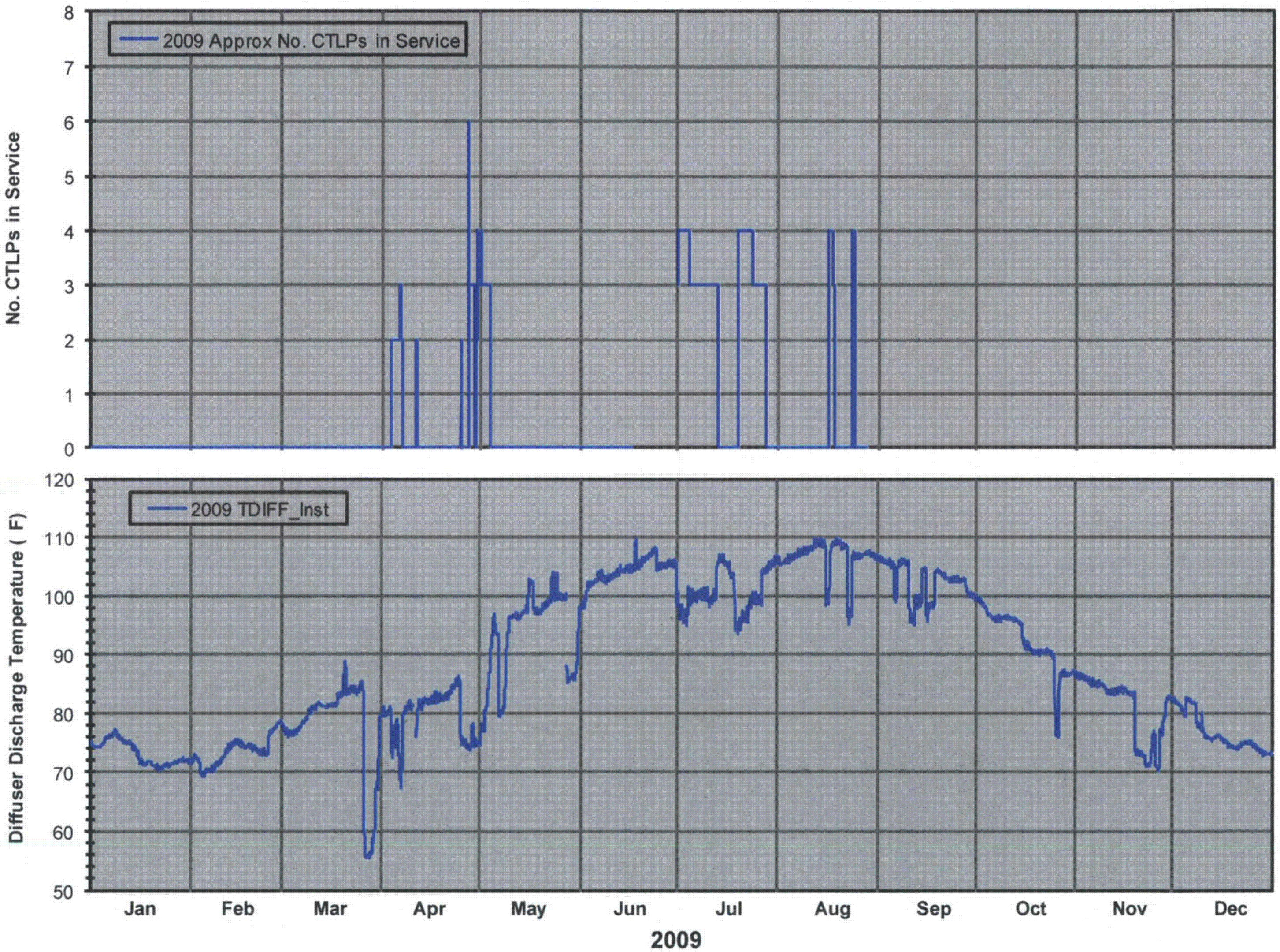


Figure 2-2009. Number of CTLPs in operation and Diffuser Discharge Temperature, 2009

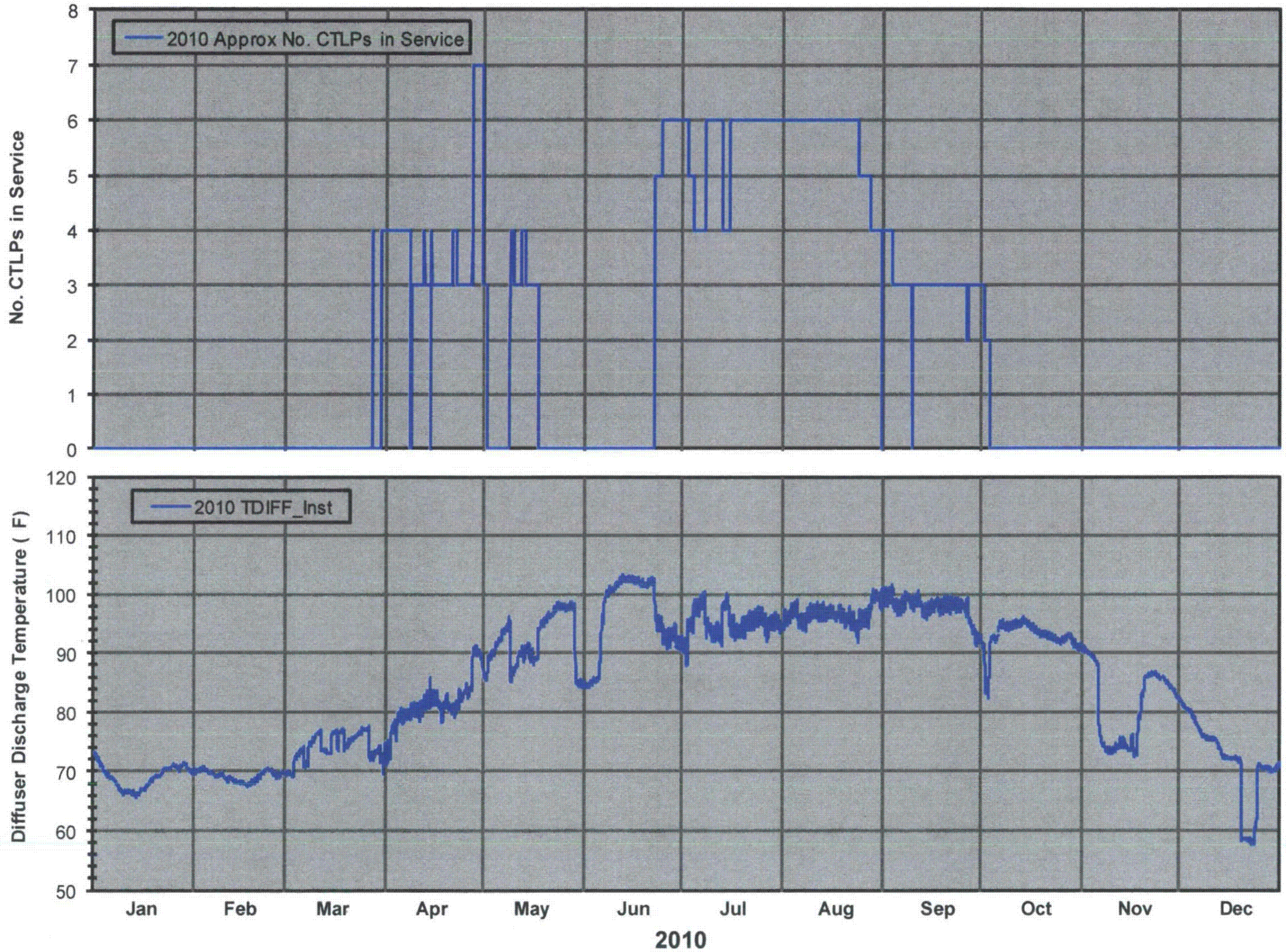


Figure 2-2010. Number of CTLPs in operation and Diffuser Discharge Temperature, 2010

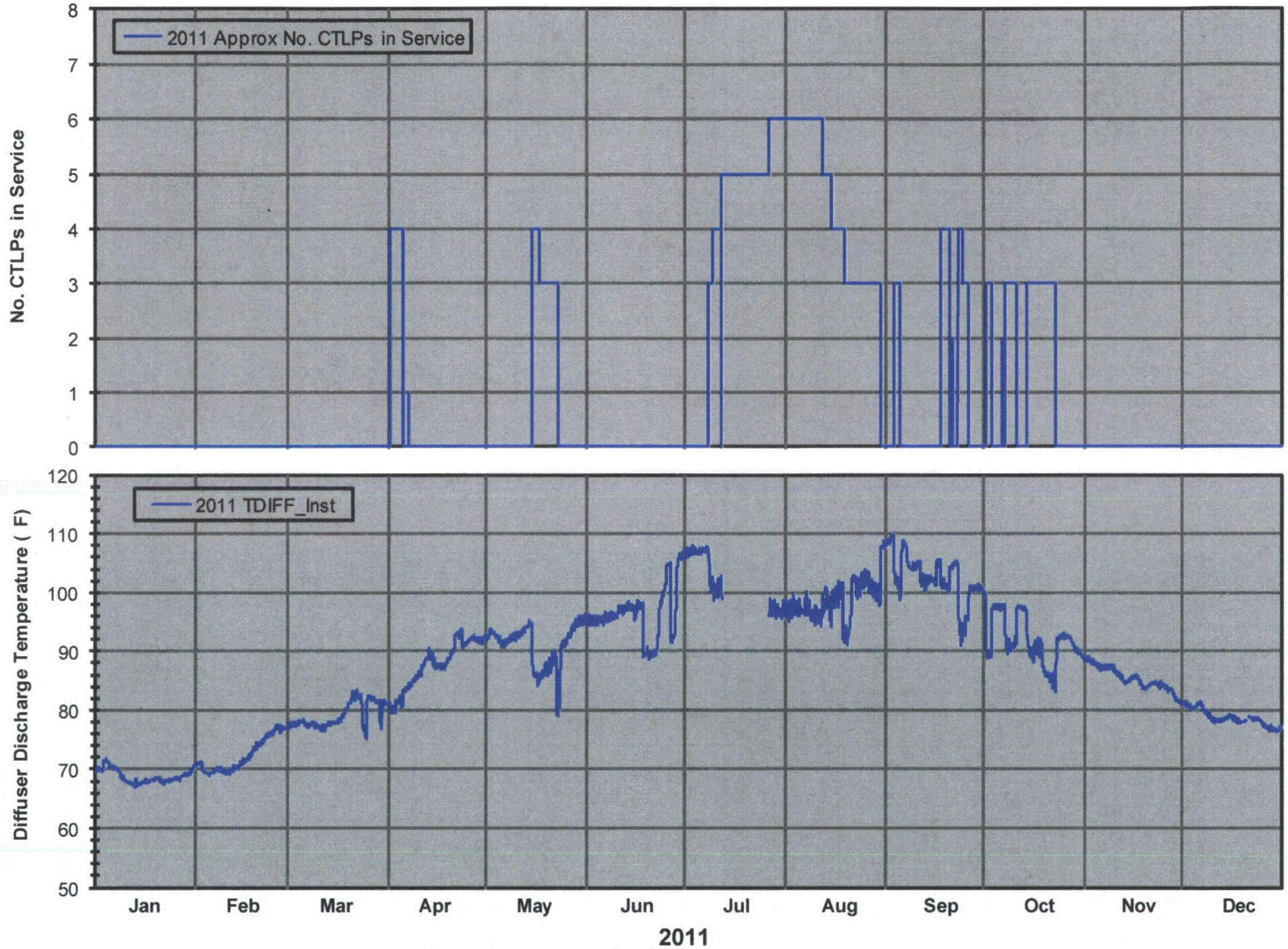


Figure 2-2011. Number of CTLPs in operation and Diffuser Discharge Temperature, 2011

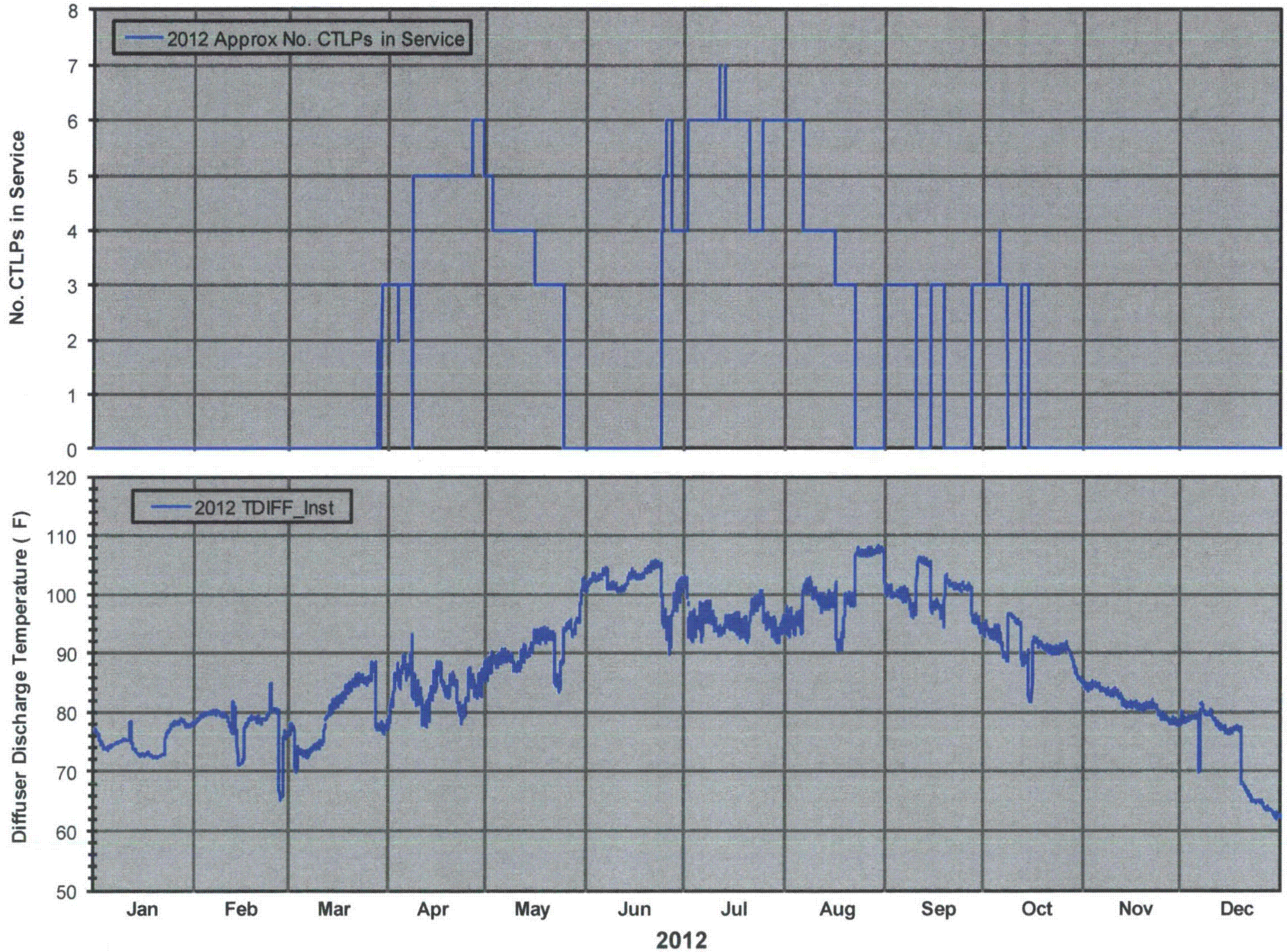


Figure 2-2012. Number of CTLPs in operation and Diffuser Discharge Temperature, 2012

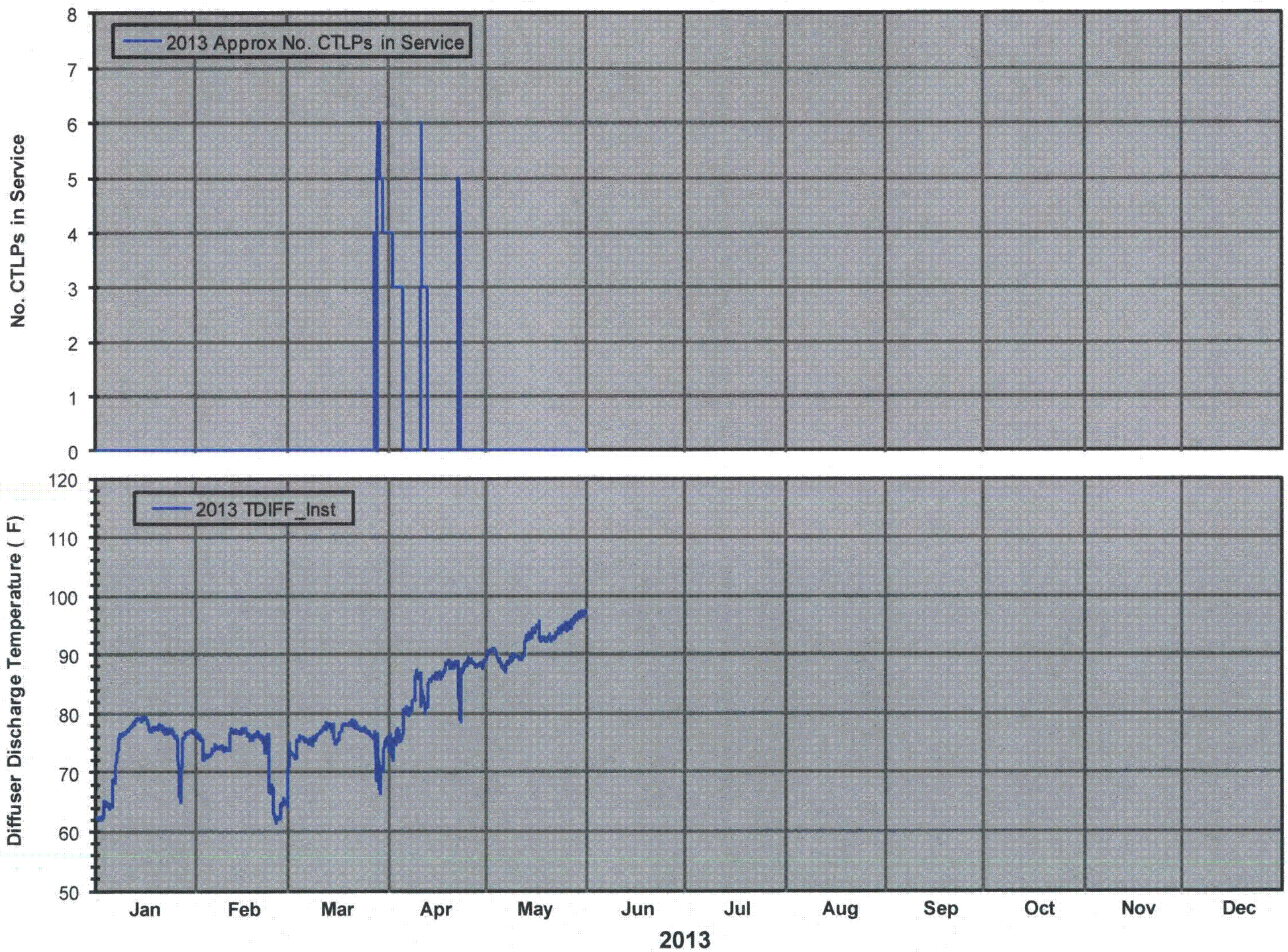


Figure 2-2013. Number of CTLPs in operation and Diffuser Discharge Temperature, 2013

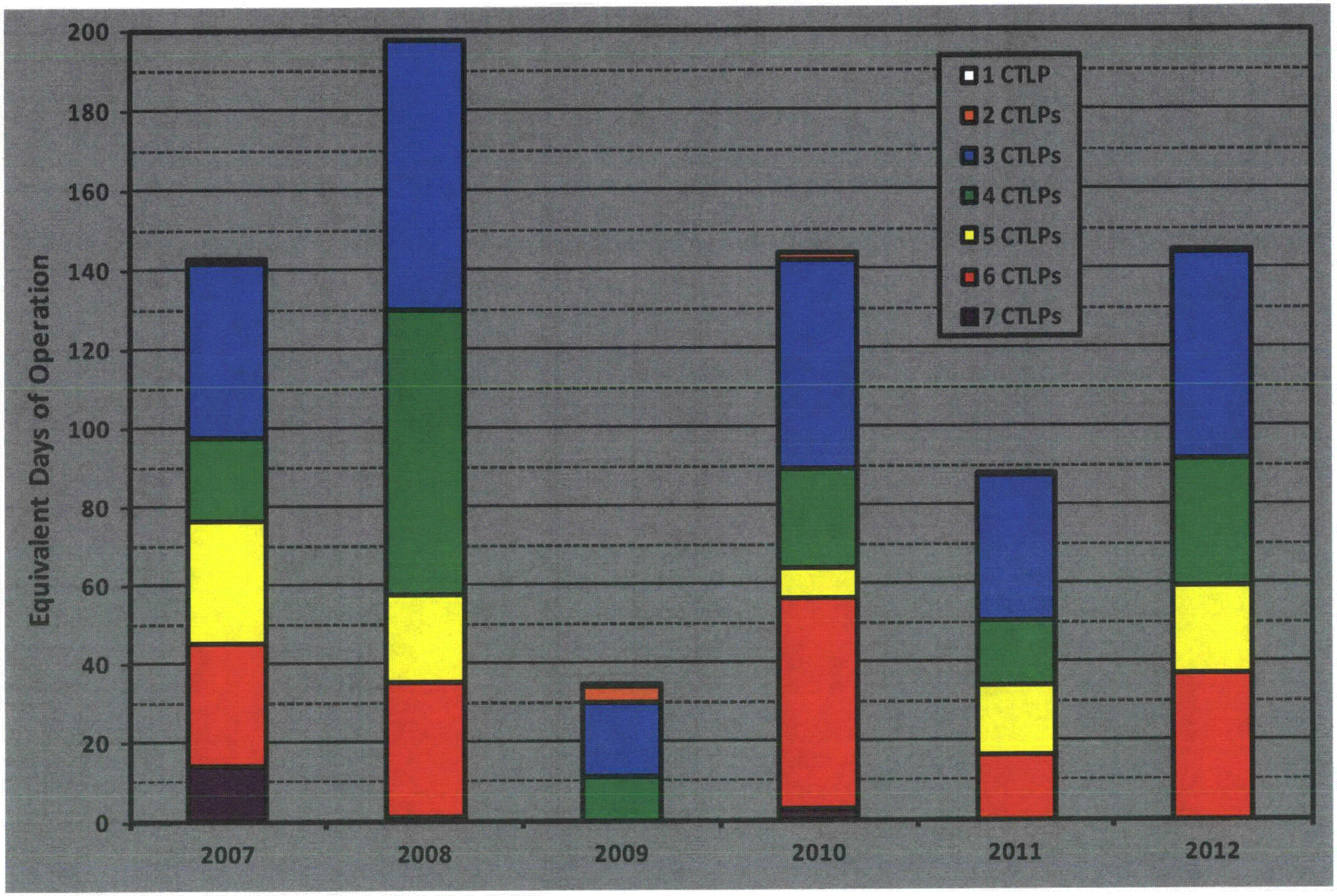


Figure 3. SQN Approximate Equivalent Number of Days of Cooling Tower Operation, 2007-2012

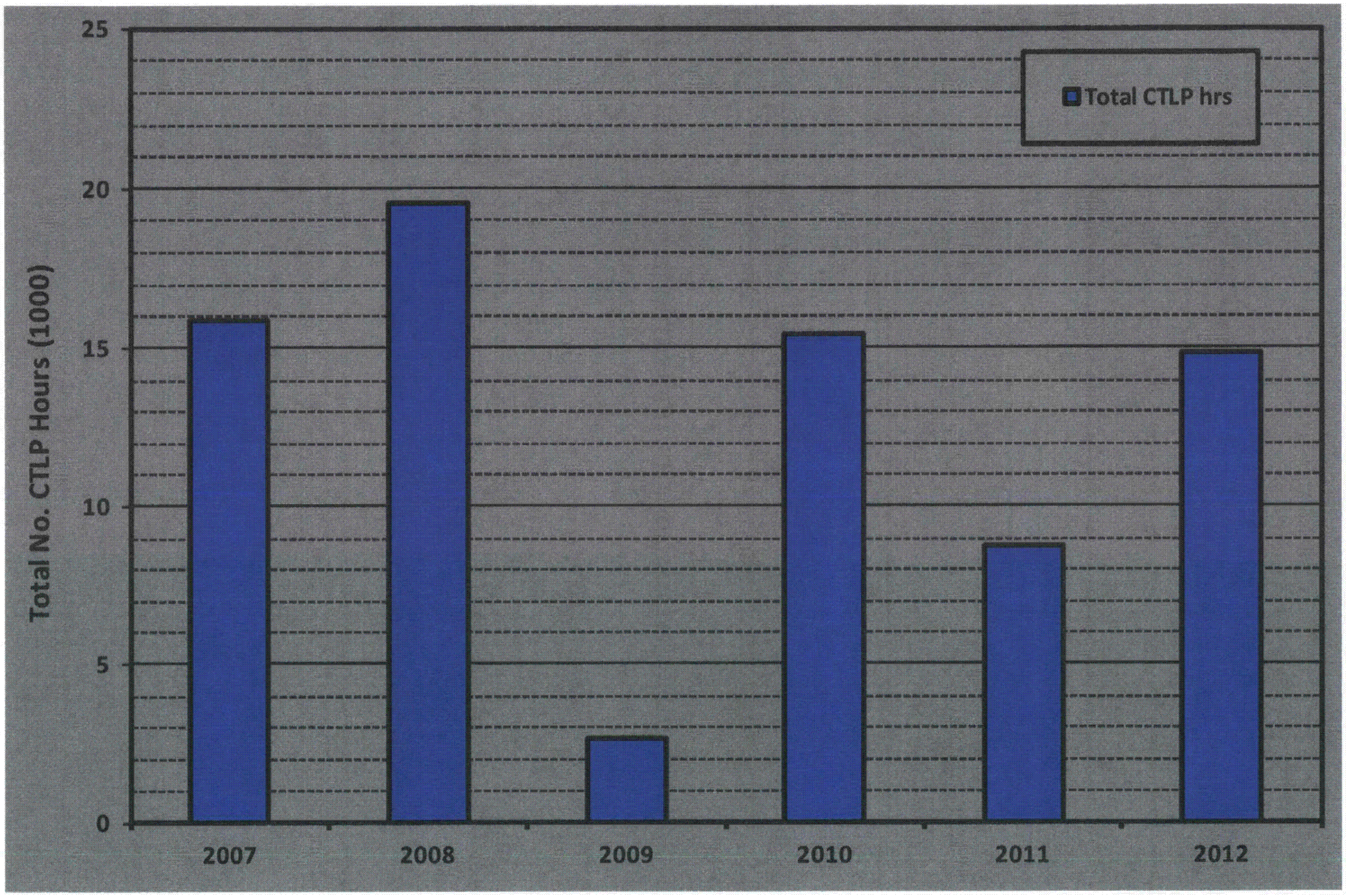


Figure 4. SQN approximate Number of Cooling Tower CTLP-Hours of Operation, 2007-2012

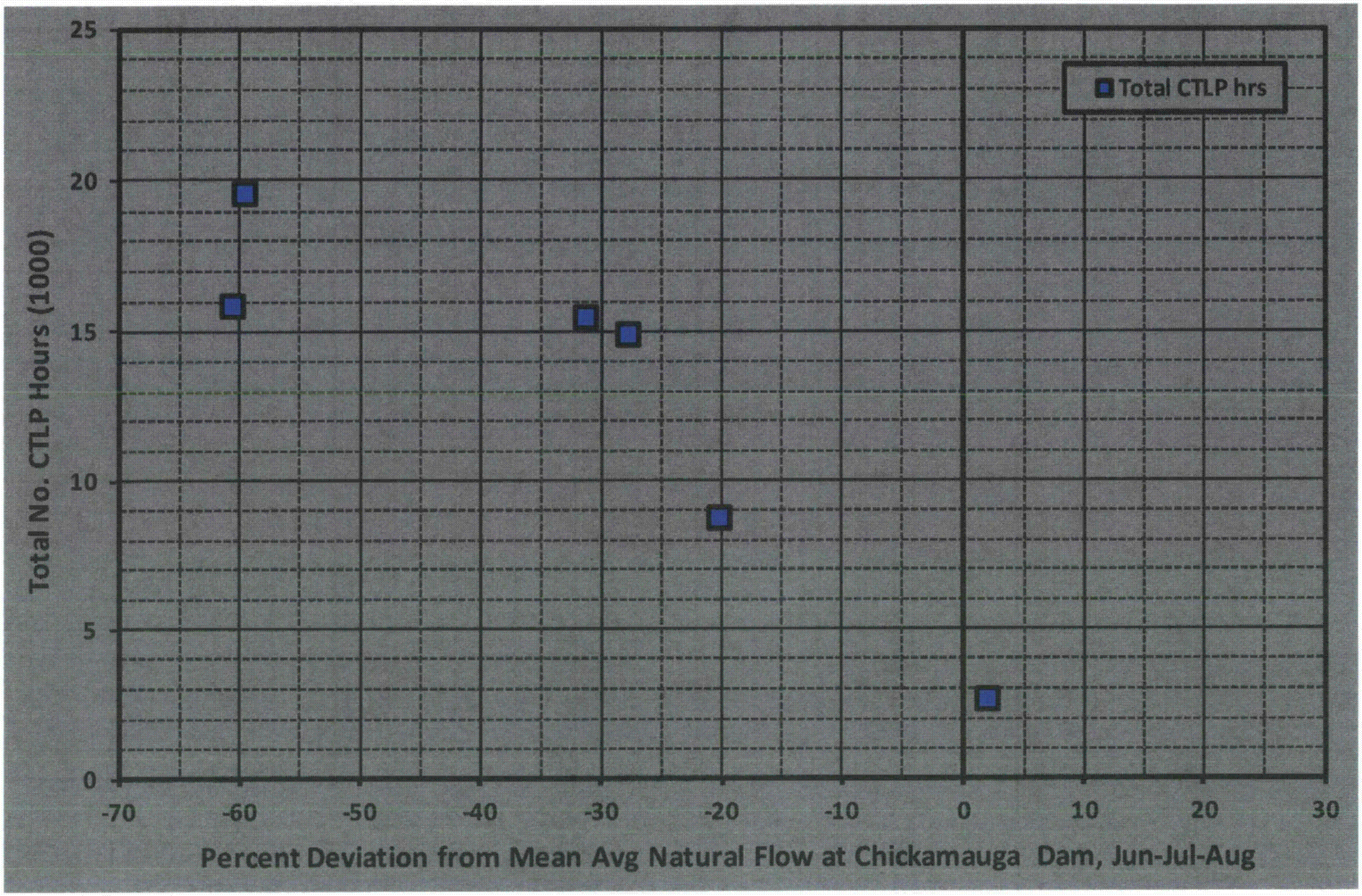


Figure 5. SQN Total CTLP-Hours vs. Percent Deviation from Mean Average Natural Flow at Chickamauga Dam, 2007-2012

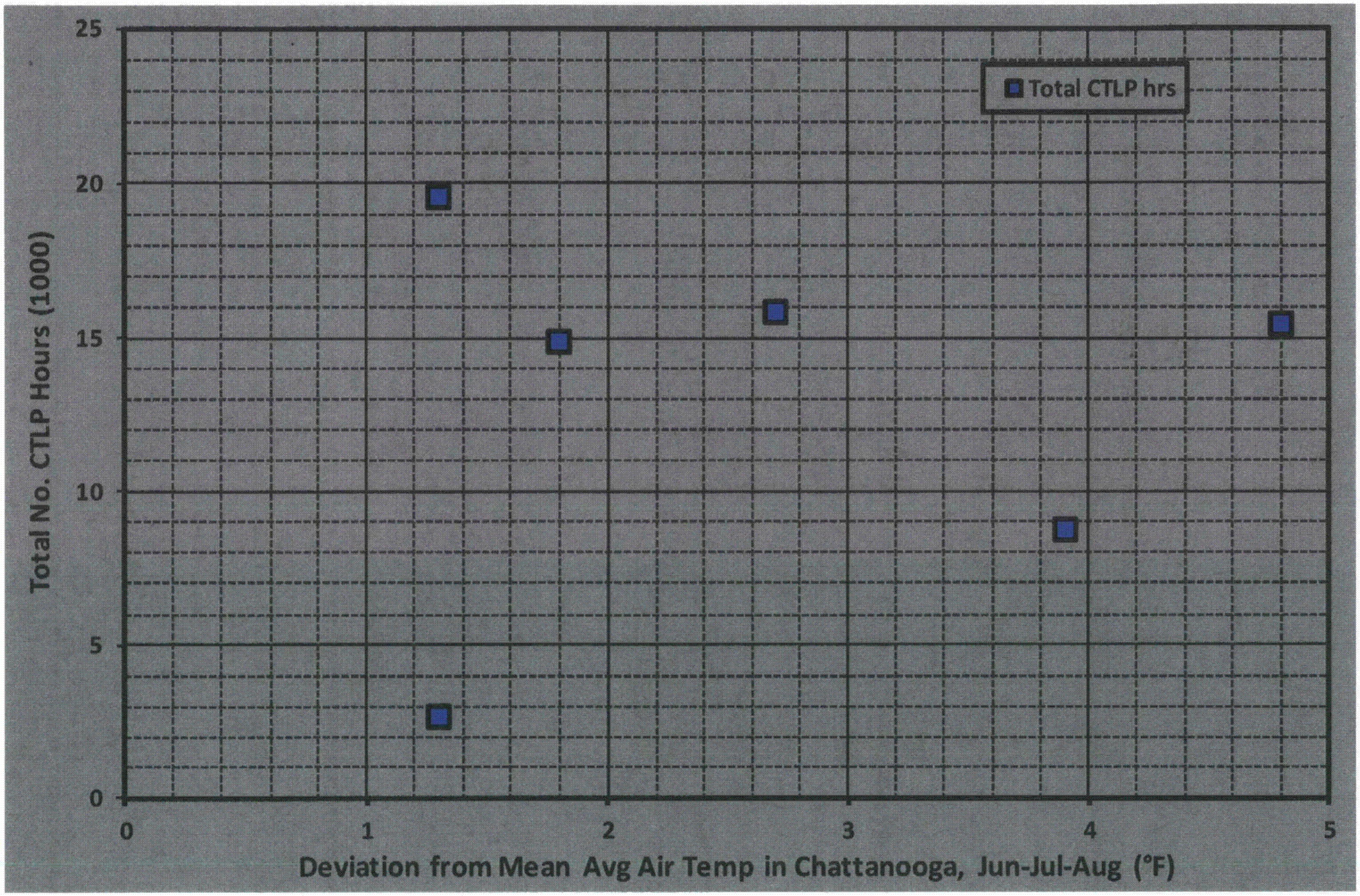


Figure 6. SQN Total CTLP-Hours vs. Deviation from Mean Average Air Temperature in Chattanooga, 2007-2012

NRC RAI 1.c.iii

iii. How do river stage, discharge, and influent temperature affect the thermal discharge temperature?

1. *How does helper mode affect thermal discharge temperature?*
2. *Have there been any trends in the plant thermal discharges and temperatures over the SQN operational history? If so, describe them.*
3. *Related to the above, provide the following information for the thermal discharge and temperature (before release into the river):*
    a. *measurement location;*
    b. *dates and times; and*
    c. *thermal discharge and temperature (15 minute or hourly data) data covering a sufficiently long timeframe to include periods of warmest river temperatures and lowest river discharges (e.g., drought).*
4. *For the historical trend: (daily or weekly or monthly), provide average thermal discharge temperatures.*

TVA Response

As clarification, the *influent* temperature is the temperature of the water at the plant intake, and the thermal *discharge* temperature is the temperature of the water before it enters the river (i.e., through the diffusers). In this context, the *influent* temperature is referred to herein as the *intake* temperature.

The intake-discharge flow includes the plant condenser circulating water (CCW) and contributions from other plant systems, such as the essential raw cooling water (ERCW) system. The latter contributions, however, are small compared to the condenser cooling water. The nominal CCW flow through the condensers with both SQN units in operation is about 2384 cfs (1,070,000 gpm). Other plant systems typically provide, at most, 10 percent of additional flow.

The intake and discharge water temperatures are related by the amount of heat added to the water by the plant operation. The plant condensers add heat to the water, and when operated in helper mode, the plant cooling towers reject/remove heat from the water (i.e., helper mode reduces the thermal discharge temperature). Other sources and sinks of heat occur along the path of flow of the condenser cooling water, but in a manner similar to that of the volume of condenser cooling water, these sources and sinks are small compared to the contributions by condensers and the cooling towers. In simple terms, therefore, the intake and discharge temperature are related by:

$$T_{DIS} \approx T_{IN} + \Delta T_{COND} - \Delta T_{CT}. \qquad (1)$$

In Eq. (1), T_{DIS} is the temperature of water entering the diffusers, T_{IN} is the temperature of water at the plant intake, ΔT_{COND} is the temperature change added by the condensers, and ΔT_{CT} is the temperature change subtracted by the cooling towers. By Eq. (1) it can be seen that the discharge temperature varies directly with the intake (*influent*) temperature. That is, when the intake temperature increases, the discharge temperature increases, and vice versa.

The river stage affects the plant thermal discharge temperature only in as much that it affects the water temperature in the plant intake withdrawal zone (i.e., per Eq. (1). When the river temperature is uniform, the river stage has little effect on the plant intake temperature, and thus has little effect on the plant discharge temperature. This usually is the case in the late fall, winter, and early spring. From late spring through early fall, the portion of Chickamauga Reservoir surrounding SQN often becomes stratified. In this case, the river stage may have some influence on the location of the thermocline relative to the location of the withdrawal zone for the plant intake. However, the river discharge is a more significant factor. During hydro peaking operations (i.e., for higher river discharges), higher levels of flow turbulence increase the depth of mixing of warm surface water, exposing the withdrawal zone and plant intake to higher water temperatures. In turn, the plant discharge temperature is increased. If hydro peaking is considered too detrimental to the plant intake water temperature, such operations are reduced or suspended in favor of providing calmer, steadier flows in Chickamauga Reservoir, which tend to stabilize the intake water temperature at SQN.

The magnitude of the plant CCW flow and the level of generation by the plant (i.e., amount of waste steam processed by the condensers) both have a direct impact on the plant thermal discharge temperature. In general, for a given level of plant generation, a higher CCW flow provides a lower condenser rise (ΔT_{COND}), and subsequently, a lower plant discharge temperature. A lower CCW flow causes the opposite. For a given CCW flow, higher plant generation causes a higher condenser rise, and subsequently, a higher plant discharge temperature. Lower plant generation causes the opposite.

The temperature rise across the plant is given by,

$$\Delta T_P = T_{DIS} - T_{IN} \approx \Delta T_{COND} - \Delta T_{CT} \qquad (2)$$

Of the factors discussed above, those having the most dramatic impact on the temperature rise across the plant ΔT_P, and subsequently, the plant thermal discharge temperature T_{DIS}, are the plant CCW flow, the plant generation, and cooling tower operation. For the period from January 2007 through May 2013, hourly data for these factors are included in the file listed in Enclosure 2 as 1.c.iii Enclosure_1.c.iii.xlsx. June 2007 is the first month of implementation of the current version of the NPDES compliance model for the plant thermal discharge. Within this period, 2007 and 2008 were years of extreme drought in the Tennessee River watershed, and 2010 included a summer of extreme atmospheric heating (see TVA response to RAI 1.C.1 for a more thorough discussion of the classification of hydrothermal conditions for the Tennessee River Valley). Descriptions of the data contained in the Excel file listed in Enclosure 2 as Enclosure_1.c.iii.xlsx are summarized in Table 1. To help visualize the effect of these various factors, charts of the data contained in Enclosure_1.c.iii.xlsx are given for each calendar year in Figure 1. The following comments are provided.

- Each chart includes five plots:
  - ✓ The hourly average discharge from the plant (Q_SQN_1-hr, cfs), which primarily comprises the plant CCW flow,
  - ✓ The plant total gross generation (MW_SQN_Inst, MWe),
  - ✓ The number of cooling tower lift pumps (CTLPs) in operation, which is a measure of the level of helper mode/cooling tower operation,
  - ✓ The plant intake skimmer wall bottom temperature (TSKIM_Inst, °F), which is essentially, the plant intake water temperature, T_{IN}, and the plant diffuser discharge temperature (TDIFF_Inst, °F), which is essentially the plant thermal discharge temperature T_{DIS},
  - ✓ The temperature rise across the plant (ΔT_P _Inst, °F).
- In general, in examining the plots, changes in the plant thermal discharge temperature and temperature rise across the plant can be correlated to a change in plant flow (Q_SQN_1-hr), a change in plant generation (Q_SQN_Inst), and/or a change in helper mode/cooling tower operation (CTLPs).
- Considering the period from January 2007 through May 2013, 80 percent of the time, the temperature rise across the plant falls in the range between about 14°F and 28°F. By way of comparison, when rejecting waste at full load operation, the increase in water temperature across the plant condensers is about 29.5°F.
- A good example of the effect of plant discharge on the plant discharge temperature and temperature rise is given in late February and March of 2009. In this case the plant discharge (Q_SQN_1-hr) dropped from about 2490 cfs to 2180 cfs, most likely due to a reduction in the number of CCW pumps in operation. The plant generation remained essentially unchanged. The corresponding increase in the plant discharge temperature and temperature rise are apparent. For example, the plant discharge temperature rise (ΔT_P_Inst) increased from about 27.5°F to about 31.5°F.
- With both SQN units at full load, the plant gross generation is about 2400 MWe. Reductions in generation occur due to planned and unplanned downpower events and outages. In any of the years shown in Figure 1, there are a number of events where reduced plant generation has occurred (i.e., drops in MW_SQN_Inst). In those events where the plant discharge remains unchanged (Q_SQN_1-hr), the effect of lower power on the plant discharge temperature and temperature rise are apparent. A simple example is found in January 2007, when one unit was shutdown with plant discharge unchanged. In the event, the plant discharge temperature rise (ΔT_P_Inst) dropped from about 27°F to 14°F.

- In any of the years shown in Figure 1, the effect of helper mode operation also is apparent. Almost anytime CTLPs are brought into service, corresponding reductions in the plant discharge temperature and temperature rise are observed. These reductions can be large, at times in excess of 10°F. A good example is when helper mode operation was initiated with seven CTLPs in April 2007. In this event, the plant discharge temperature rise (ΔT_P_Inst) dropped from about 27°F to below 10°F.

Basic statistical properties for the SQN plant thermal discharge (i.e., diffuser discharge temperature) are shown in Figure 2. Data are given for years 2007 through 2012. Recall that the current version of the NPDES compliance model for the plant thermal discharge was placed in service in 2007. Included are the minimum, 90% exceedance, 50% exceedance, 10% exceedance, and maximum instantaneous plant discharge temperatures. Since 2007, the 10% exceedance and maximum discharge temperatures have perhaps trended slightly downward. In contrast, the minimum, 90% exceedance, and 50% exceedance discharge temperatures appear to have trended slightly upward. Data for the trends depicted in Figure 2 also are contained in the Excel file listed in Enclosure 2 as Enclosure_1.c.iii.xlsx.

Table 1. Enclosure_1.c.iii Hourly Data

Parameter	Definition	Units
Approx No. CTLPs in Service	Approximate number of cooling tower lift pumps (CTLPs) in service, hour by hour from January 1, 2007 through May 31, 2013. (See TVA response to RAI 1.c.ii)	NA
Approx Discharge Thru Cooling Towers	Approximate discharge through the cooling towers, hour by hour from January 1, 2007 through May 31, 2013. (See TVA response to RAI 1.c.ii)	cfs
TDIFF_Inst	Instantaneous effluent water temperature (i.e., thermal discharge temperature) measured at the top of the hour by sensors located at the entrances to the plant diffuser pipes located at TRM 483.6. (See TVA response to RAI 1.c.ii) TDIFF_Inst is the same as the plant thermal discharge temperature TDIS.	°F
TSKIM_Inst	Instantaneous river temperature measured at the top of the hour by a sensor located at the intake skimmer wall at TRM 484.8. The sensor is located at EL 637 msl, which is near the middle of the skimmer wall bottom opening (note: the top of the skimmer wall opening is at about EL 641.6). Being located in the skimmer wall opening, TSKIM_Inst provides a measure of the plant intake temperature TIN. The actual plant intake temperature TIN may differ slightly from TSKIM_Inst because the temperature of the plant intake withdrawal zone is not necessarily uniform along the length of the skimmer wall. However, TSKIM_Inst is selected for this analysis because the sensors, instrumentation platform, sampling times/frequencies, etc. are the same as that for TDIFF_Inst.	°F
ΔTP_Inst	Approx instantaneous temperature rise across the plant at the top of the hour, computed as TDIFF_Inst - TSKIM_Inst.	°F
Q_SQN_1-hr	1-hr average flow through the SQN diffuser pipes. Q_SQN_1-hr includes all flows exiting the plant through the diffusers, but is comprised primarily of the plant CCW flow.	cfs
MW_SQN_Inst	Approximate instantaneous SQN total gross generation at top of the hour.	MWe

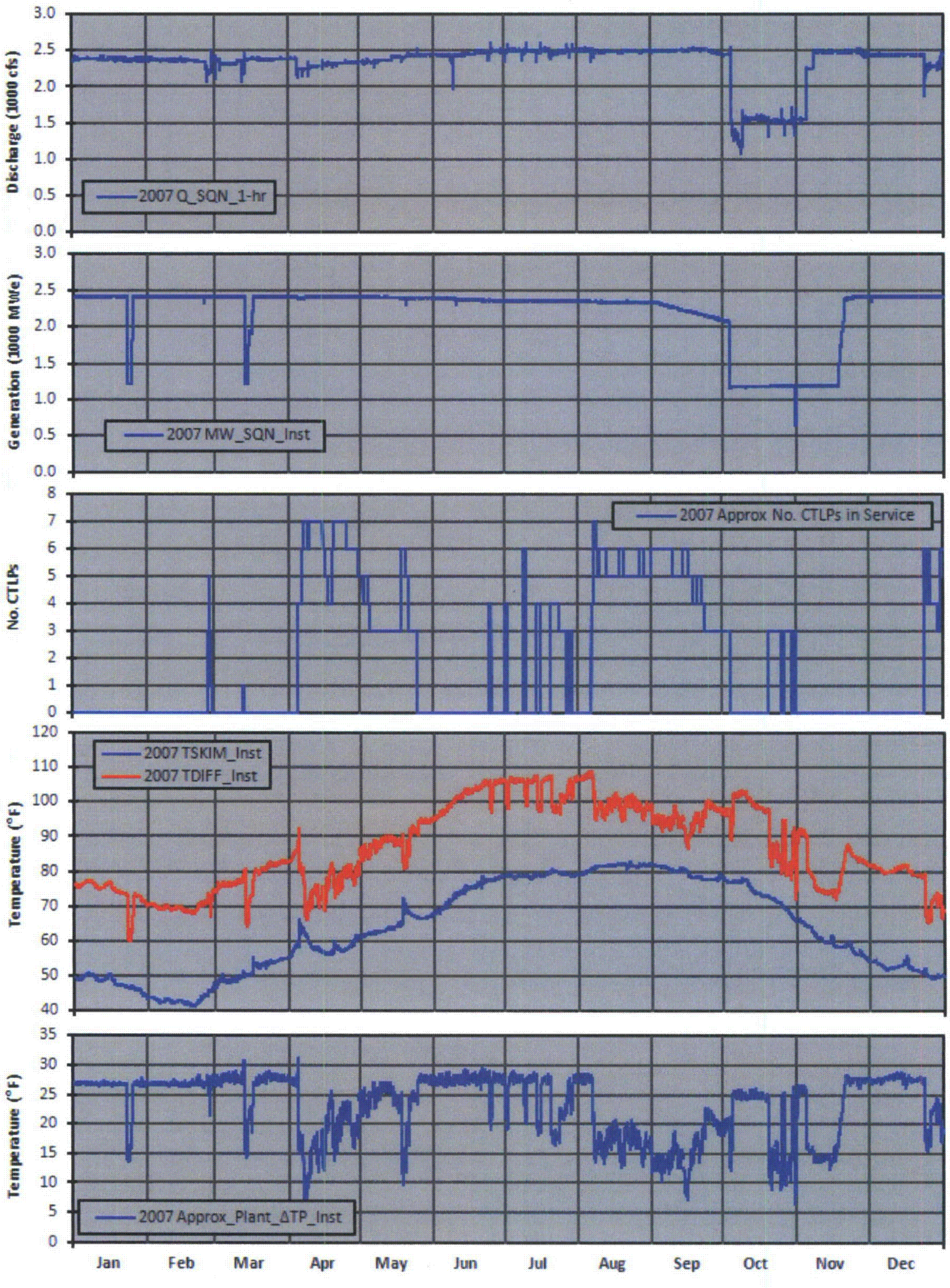


Figure 1-2007. Factors Affecting the SQN Plant Discharge Temperature/Temperature Rise

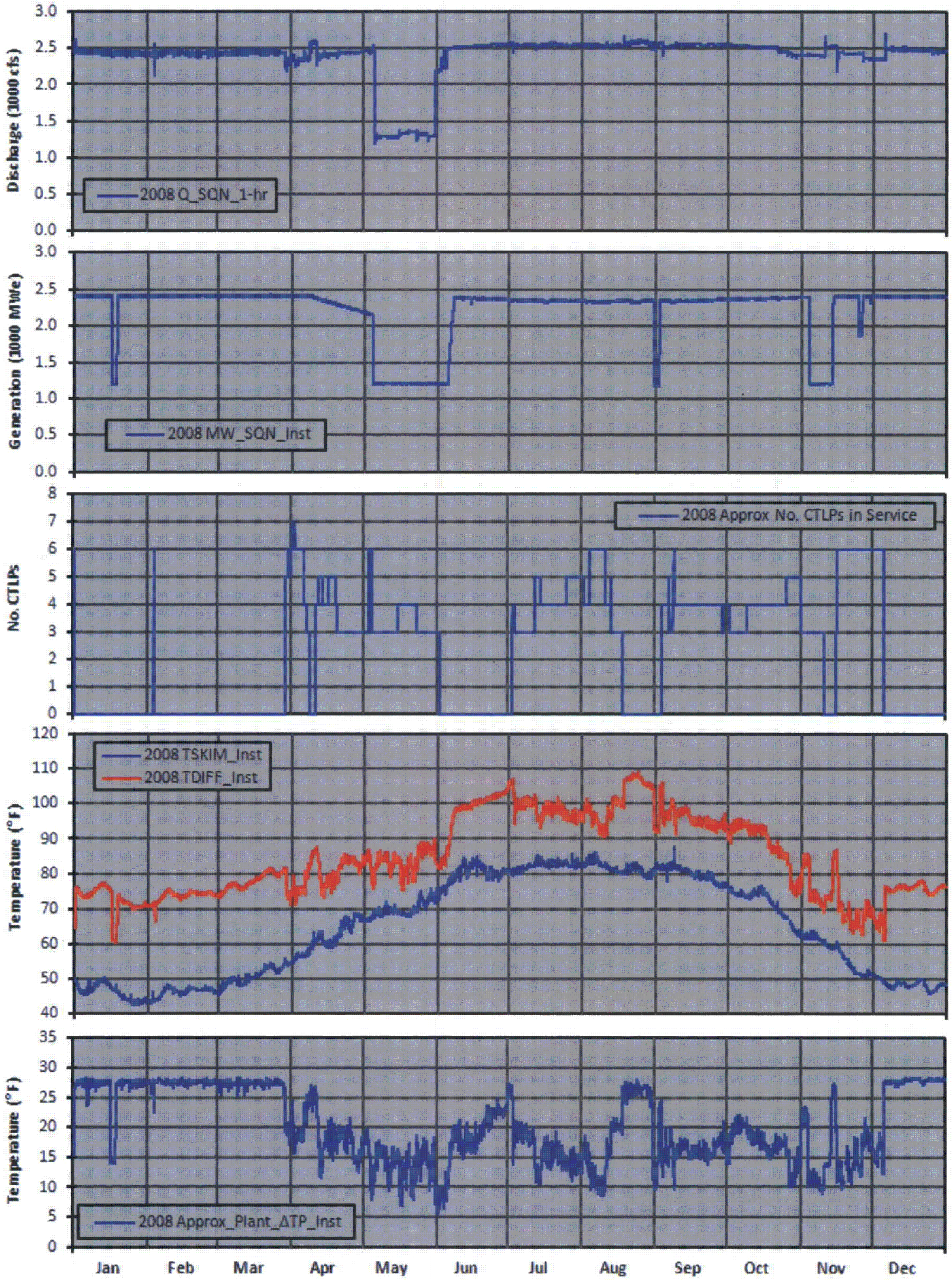


Figure 1-2008. Factors Affecting the SQN Plant Discharge Temperature/Temperature Rise

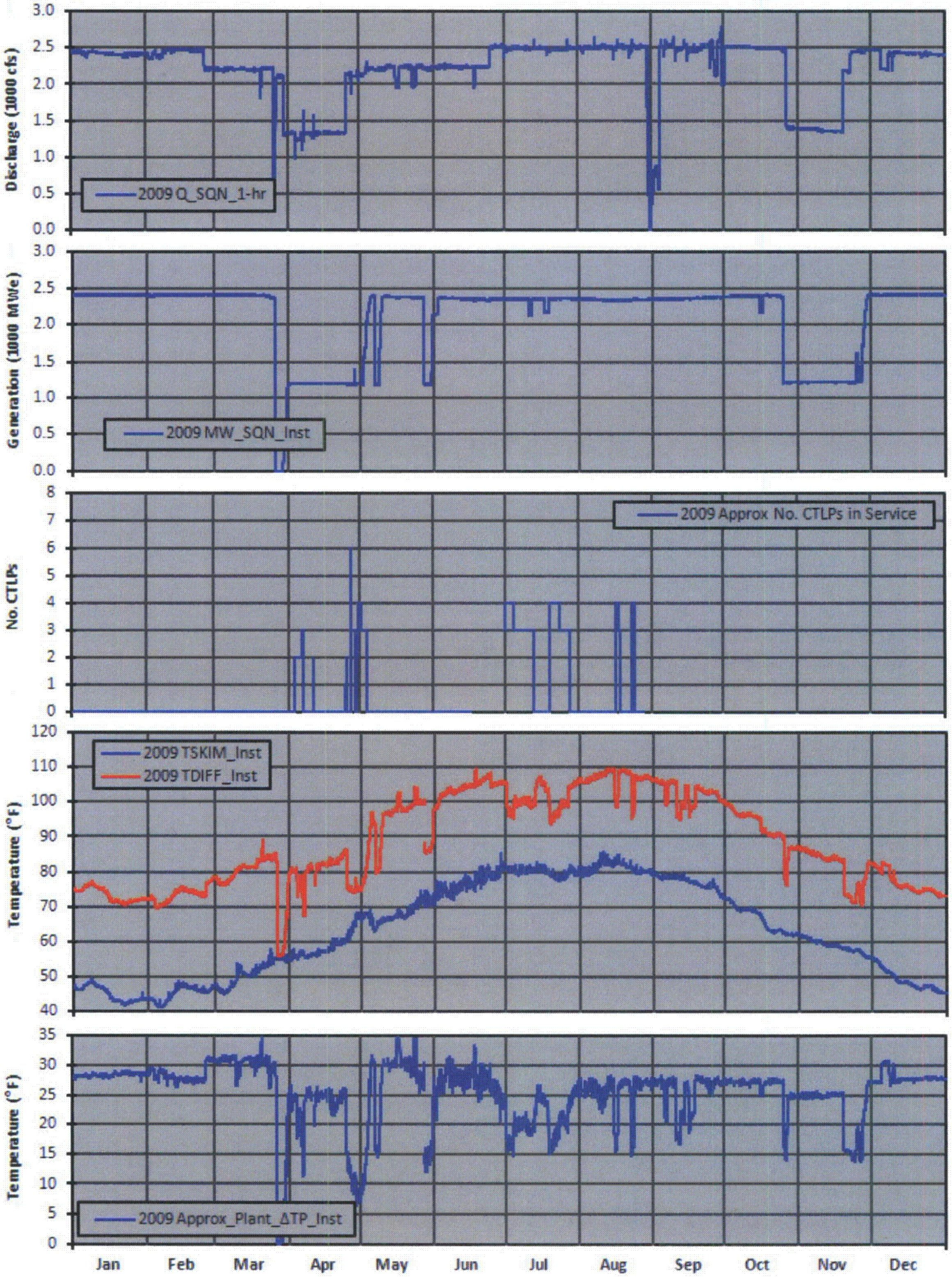


Figure 1-2009. Factors Affecting the SQN Plant Discharge Temperature/Temperature Rise

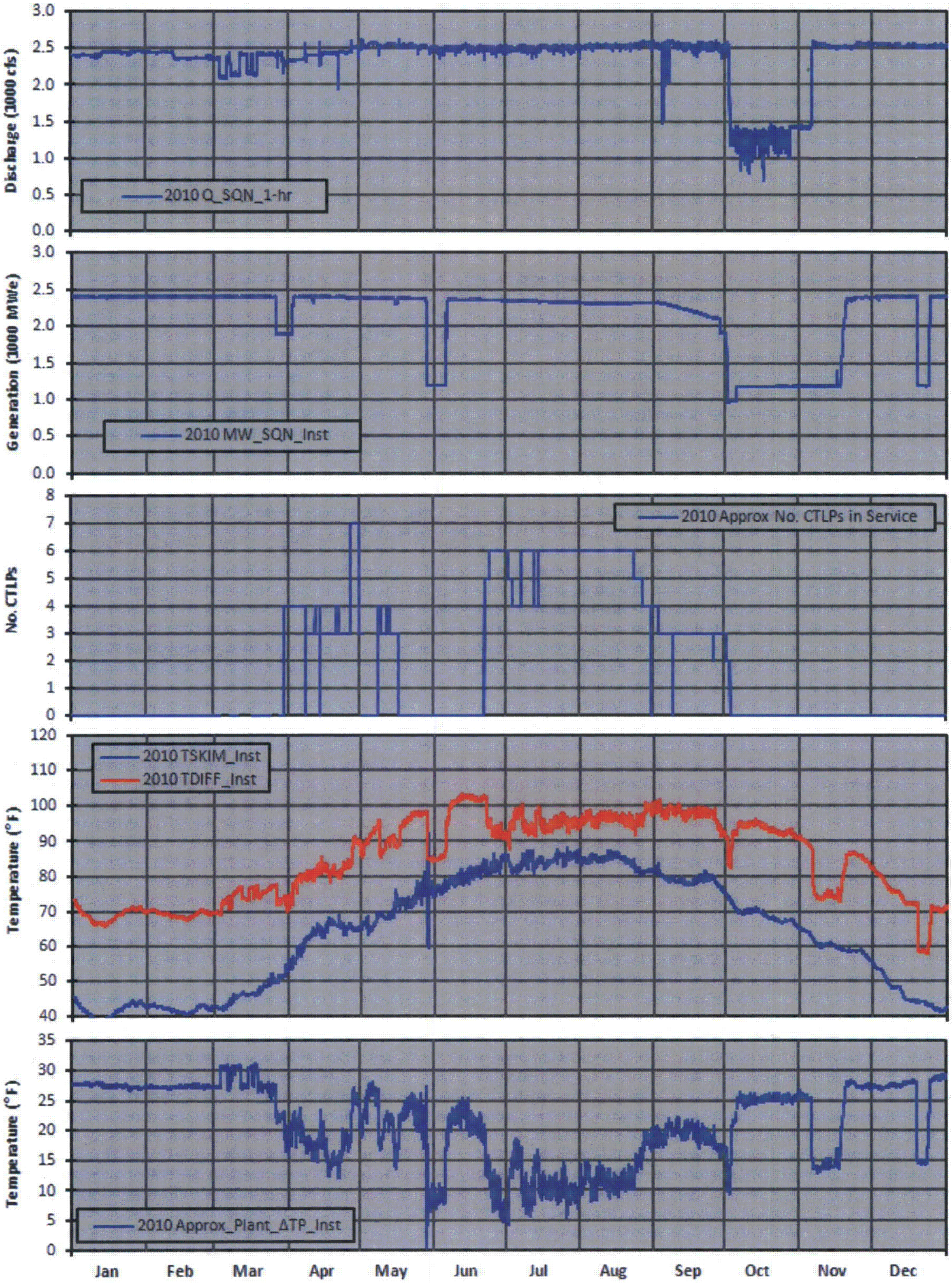


Figure 1-2010. Factors Affecting the SQN Plant Discharge Temperature/Temperature Rise

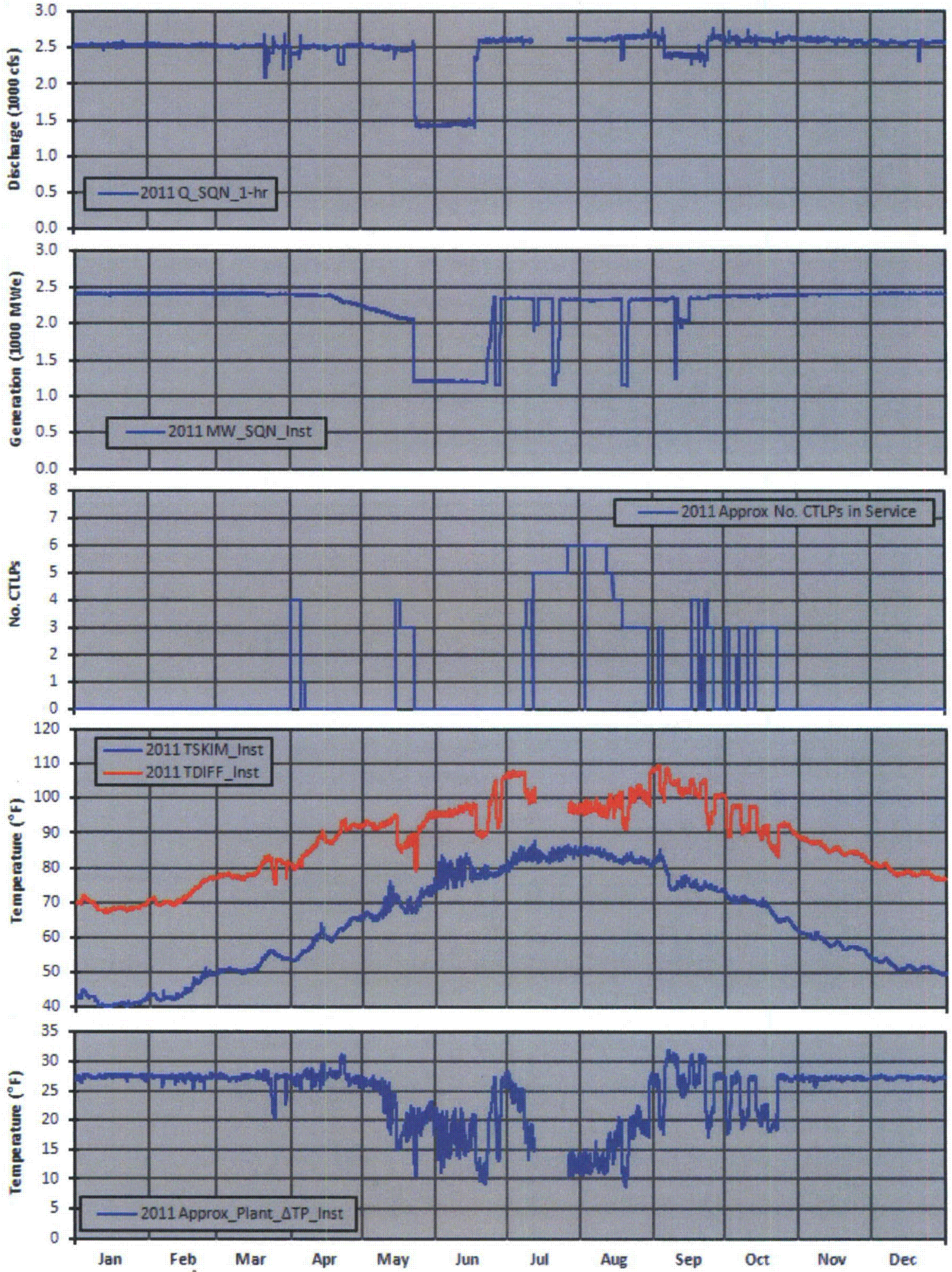


Figure 1-2011. Factors Affecting the SQN Plant Discharge Temperature/Temperature Rise

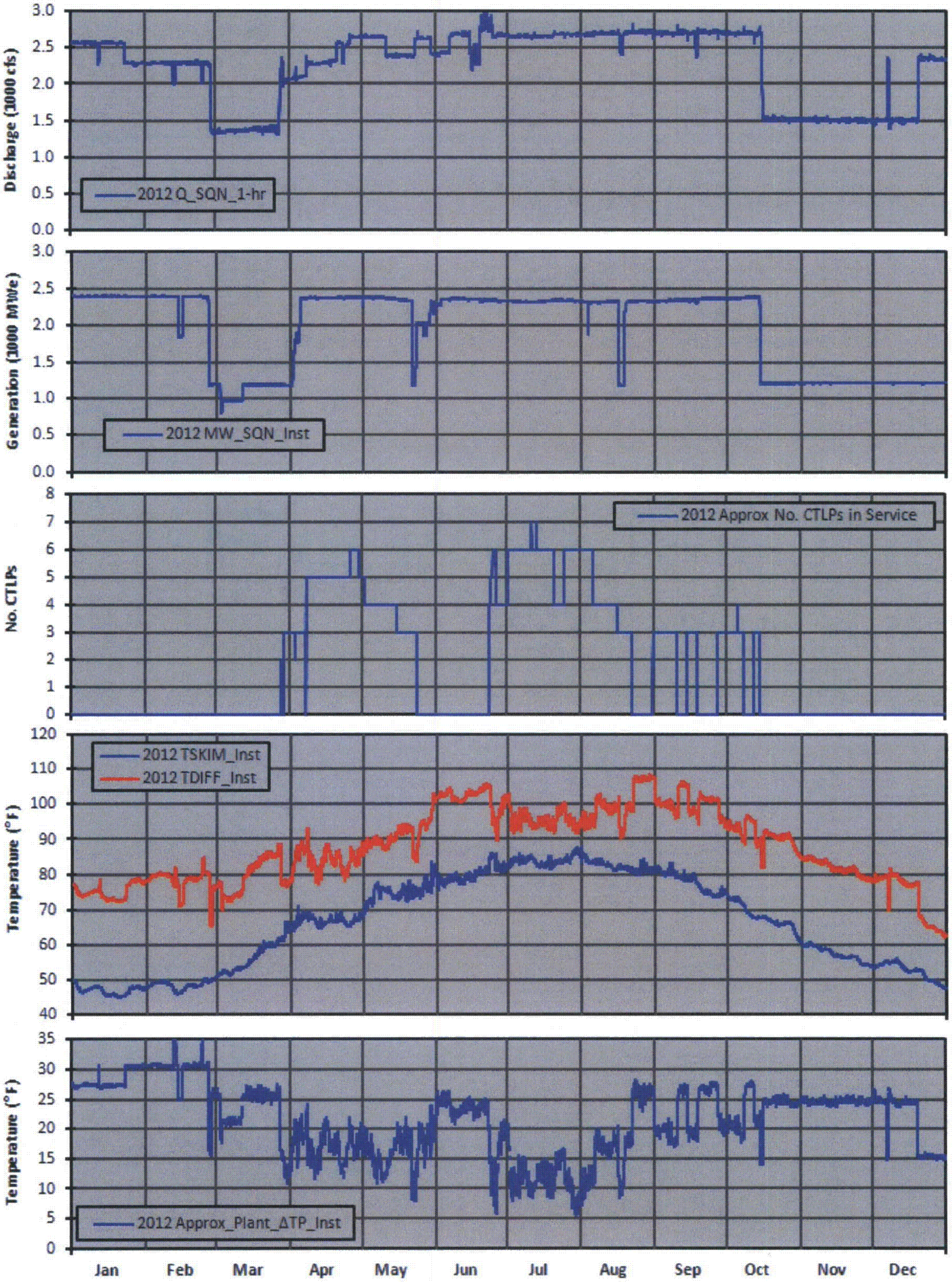


Figure 1-2012. Factors Affecting the SQN Plant Discharge Temperature/Temperature Rise

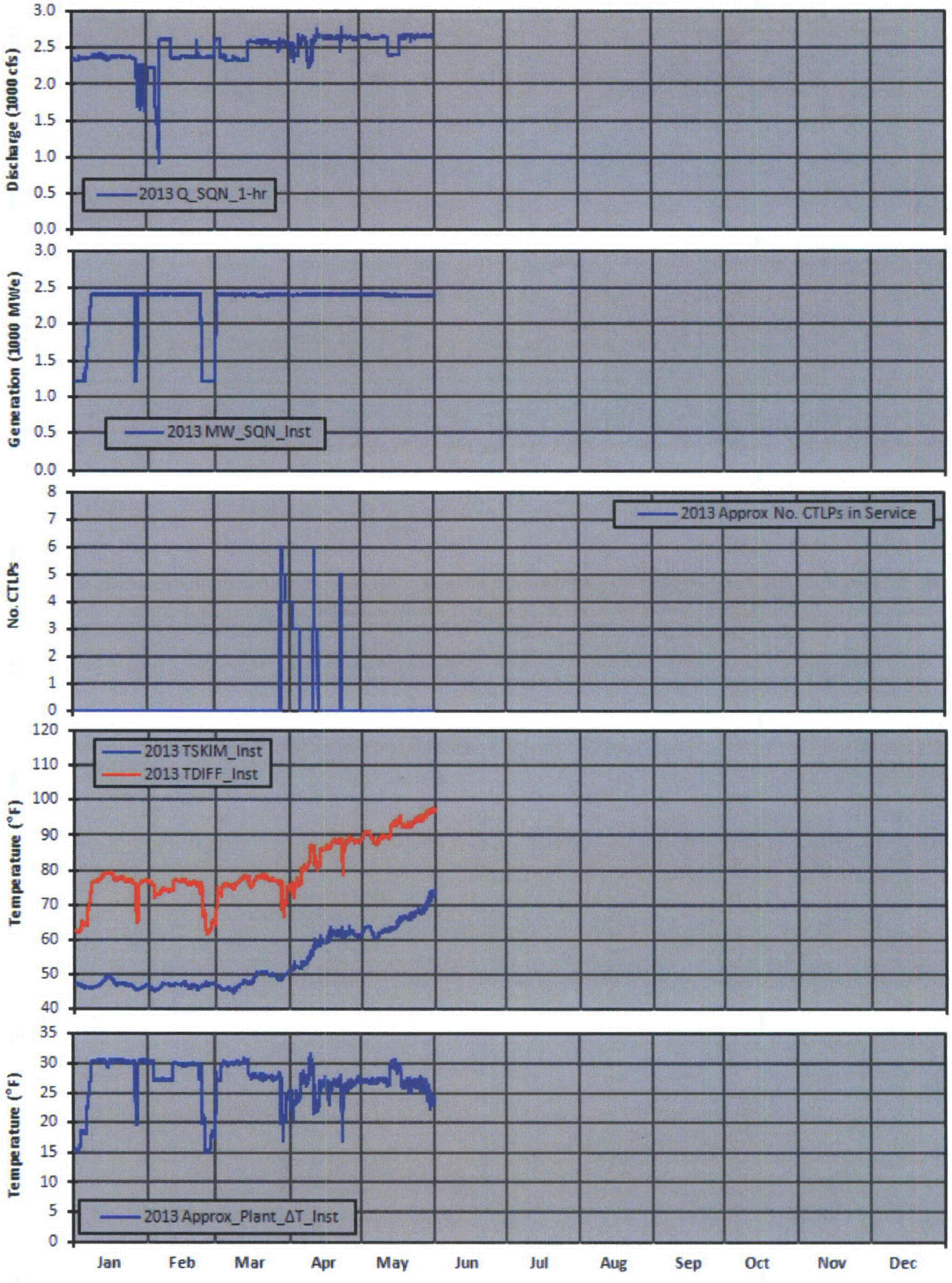


Figure 1-2013. Factors Affecting the SQN Plant Discharge Temperature/Temperature Rise

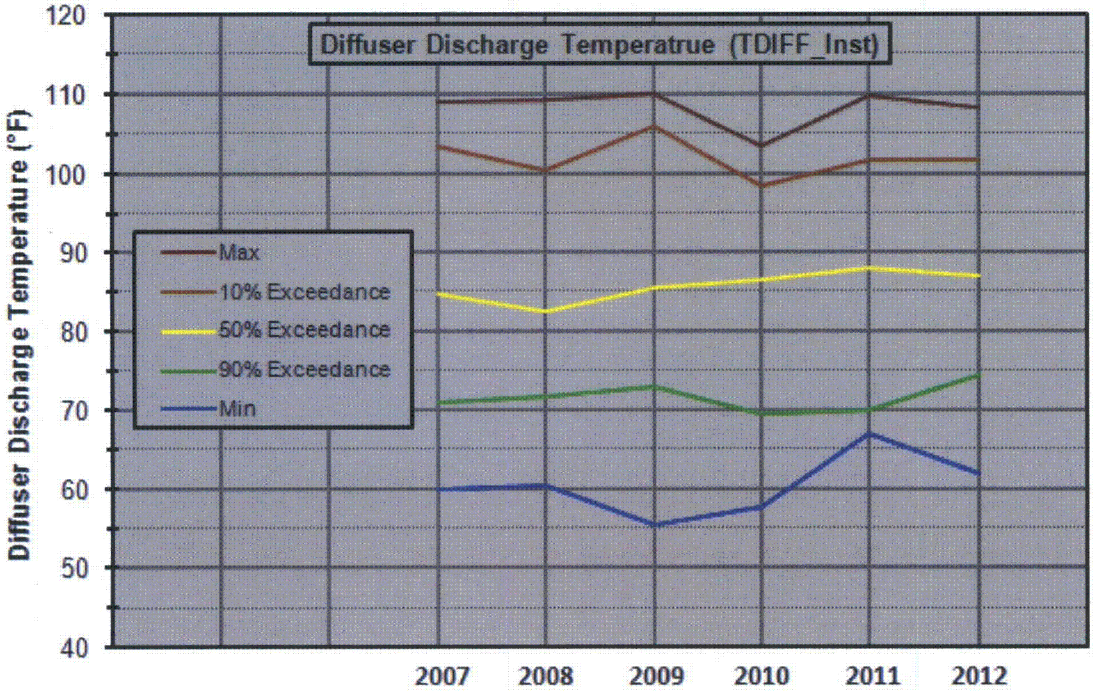


Figure 2. Basic Statistical Properties for SQN Diffuser Discharge Temperature, 2007-2012

NRC RAI 1.c.iv

iv. How effective has the river/reservoir been in attenuating elevated temperatures from the thermal discharge through the diffuser pipes?

1. *Provide an explanation of how river stage, discharge and upstream (without SQN impact) temperature affect the magnitude and distribution of temperatures upstream and downstream of the diffuser pipes, and outside of the main channel?*
2. *Related to the above, provide archived data to explain the interactions of SQN thermal discharges with the reservoir.*
3. *Provide the following information on river temperature, discharge, and stage:*
   a. *measurement locations including upstream background, SQN stations, Hiwassee River and tributaries;*
   b. *dates and times of measurements; and*
   c. *river discharge, stage, and temperature (15 minute or hourly data) covering a sufficiently long timeframe to include the periods of warmest river temperatures and lowest river discharges (e.g., drought).*
4. *For the historical trend (daily or weekly or monthly), provide average river discharge, stage, and temperature.*

TVA Response

Since SQN began operation, there have been no NPDES thermal violations. Therefore the river/reservoir and diffuser pipes, in conjunction with the cooling towers, have been 100 percent effective in attenuating elevated temperatures from the plant thermal discharge.

Between 2007 and 2013, SQN operated cooling towers an average of 125 equivalent days per year, with a minimum of 34 equivalent days in 2009 and a maximum of 197 equivalent days in 2008 (see the response to RAI 1.c.ii). On an annual basis, this indicates that the river/reservoir in combination with sole operation of the diffusers (without cooling towers) has successfully attenuated the plant thermal discharge between 46 and 91 percent of the time, with an average of about 64 percent of the time.

The manner in which river stage, discharge and upstream temperature affect the magnitude and distribution of temperatures upstream and downstream of the diffuser pipes, and outside of the main channel is best described by the formulation of the thermal discharge computational model. A document describing the formulation of the model is referenced in the response to RAI 1.b.i. The following general comments also are provided:

- The larger the depth of flow in the river, the longer the "entrainment path" to the river water surface for the diffuser discharge. Thus, in general, a higher river stage yields greater dilution of the plant thermal discharge, and vice versa.
- The mixed downstream temperature of the plant thermal discharge is directly proportion to the temperature of the upstream water entrained by the discharge. Thus, the warmer the temperature of the upstream water, the warmer the mixed temperature of the diffuser discharge, and vice versa.
- Due to the heat added by SQN operation, the temperature of the diffuser discharge is warmer than that of the ambient water in the river. In this manner, due to the fact that the density of water decreases with increasing temperature, the diffuser discharge possesses buoyancy relative to ambient water in the river. The resulting buoyancy force contributes to the vertical acceleration of the diffuser effluent in the river, and consequently, the amount of ambient entrainment. In general, buoyancy is smaller at lower water temperatures. As a result, buoyancy-related mixing is less during the time of the year when the river is cool. In this manner, in the vicinity of the SQN mixing zone, the amount of dilution of the diffuser discharge tends to be less in cooler months of the year. As a result, the plant-induced instream temperature rise tends to be higher in the period from late fall through early spring compared to the period from late spring through early fall (i.e., winter compared to summer). During this time, another contributing factor to a higher instream temperature rise is the reservoir stage, which is lower in the cooler months of the year (e.g., first bullet above).
- Stratification in the river, which occurs primarily in months April through September, is another important factor. The NPDES criteria are based on water temperatures in the river centered at a depth of 5 feet. When stratification occurs, the water in this layer is warmer than the water in the bottom of the river. In these circumstances, upwelling caused by the diffuser jets and buoyancy can at times cause cooling in the surface layer of the river in and around the diffuser mixing zone. The action of the river flow passing up and over the underwater dam (located about 250 feet upstream of the diffusers) also can contribute to upwelling. This phenomenon is identified relative to a reverse flow event summarized in the response to RAI 1.c.v. In cases of extreme stratification, the diffuser discharge can be so cooled relative to the temperature of the water at the 5-foot depth, that the effluent reaches a level of neutral buoyancy below a depth of 5 feet, prompting the diffuser effluent to remain submerged. In general, due to these processes, river stratification reduces the instream temperature rise caused by the diffuser discharge (i.e., compared to river conditions without stratification).
- Higher river discharges cause greater dilution of the plant thermal discharge, and vice versa. At lower river discharges, the plant effluent begins to propagate upstream of the diffusers and re-entrains upon itself. The SQN hydrothermal model includes special allowances for this phenomenon (refer to the response to RAI 1.b.i for additional information). In addition the response to RAI 1.c.v, references an enclosure summarizing the results of field studies elucidating TVA's current understanding of the

interactions between the SQN thermal discharge and the river/reservoir (i.e., including the effect of the river discharge on the distribution of the plant thermal effluent upstream and downstream of the diffuser pipes, and outside of the main channel).

In addition to the above information, the enclosures referenced in the response to RAI 1.c.vii contain discussions about the aspects of Chickamauga Reservoir that are relevant to the effect/interaction of the SQN thermal discharge as presented above.

At a basic level, the interaction between SQN and the reservoir can be characterized by five fundamental variables: the river discharge, the ambient river temperature, the river stage, the SQN diffuser discharge, and the temperature of the SQN diffuser discharge. Archived data for these parameters are provided in the TVA responses for RAI 1.c.i and RAI 1.c.iii, as summarized in Table 1. At a minimum, these data includes the period from June 2007 through May 2013. June 2007 is the first month of implementation of the current version of the NPDES compliance model for the plant thermal discharge. Within this period, 2007 and 2008 were years of extreme drought in the Tennessee River watershed, and 2010 included a summer of extreme atmospheric heating (see TVA response to RAI 1.C.1 for a more thorough discussion of the classification of hydrothermal conditions for the Tennessee River Valley).

Table 1. Archived Data Provided in TVA Responses to Other RAIs

Variable	RAI	Parameter
River Discharge	1.c.i	Q_SQN_Hydro_1-hr
River Stage	1.c.i	WSEL_SKIM_Inst
Ambient River Temperature	1.c.i	TUS_COMP_24-hr
SQN Diffuser Discharge	1.c.iii	Q_SQN_1-hr
SQN Diffuser Discharge Temperature	1.c.iii	TDIFF_Inst

Beyond that identified by Table 1, and again for the period from June 2007 through May 2013, additional data for river flow and reservoir stage are contained in the following Excel files listed in Enclosure 2 as:

1.c.iv.1 Enclosure_1.c.iv_Flow&Stage_2007.xlsx
1.c.iv.2 Enclosure_1.c.iv_Flow&Stage_2008.xlsx
1.c.iv.3 Enclosure_1.c.iv_Flow&Stage_2009.xlsx
1.c.iv.4 Enclosure_1.c.iv_Flow&Stage_2010.xlsx
1.c.iv.5 Enclosure_1.c.iv_Flow&Stage_2011.xlsx
1.c.iv.6 Enclosure_1.c.iv_Flow&Stage_2012.xlsx
1.c.iv.7 Enclosure_1.c.iv_Flow&Stage_2013.xlsx

A summary of the data found in these "flow & stage" files is given Table 2. The Excel files include both data tables and charts.

Additional data for river temperature are contained in the following Excel files listed in Enclosure 2 as:

1.c.iv.8 Enclosure_1.c.iv_Temps_2007.xlsx
1.c.iv.9 Enclosure_1.c.iv_Temps_2008.xlsx
1.c.iv.10 Enclosure_1.c.iv_Temps_2009.xlsx
1.c.iv.11 Enclosure_1.c.iv_Temps_2010.xlsx
1.c.iv.12 Enclosure_1.c.iv_Temps_2011.xlsx
1.c.iv.13 Enclosure_1.c.iv_Temps_2012.xlsx
1.c.iv.14 Enclosure_1.c.iv_Temps_2013.xlsx

A summary of the data found in these "temperature" files is given Table 3. Again, the Excel files include both data tables and charts. Of particular note for the temperature data is that information is given for the skimmer wall location. At this location measurements are provided throughout the depth of flow. That is, it provides valuable information relative to the exposure of plant thermal discharge to river stratification. It also needs to be emphasized that the temperature data of Table 3 is raw, unvalidated data. In this context, it includes erroneous records from excessive sensor drift, disturbances to temperature strings, communication and data processing irregularities, and so on. Periods where data were totally unrecoverable are highlighted. These lost records typically are due to more "sizeable" equipment events, such as a temporary loss in power supply, or damages caused by flooding of monitoring stations, lightning strikes, and so on. The original data is contained in the Excel files to provide a sense of the level of data recoverability. In general, erroneous data are recognizable in the Excel charts by an irregular drift in measurements compared to expected patterns/trends in time and space (e.g., measurements from adjacent sensors). Hydrothermal (river temperature monitoring) is not provided for releases from the Apalachia and Ocoee 1 Dams.

Average discharges, stages, and temperatures (daily, weekly, monthly) can be determined from the data contained in the Excel files referenced in this RAI, as well as that referenced in support of other hydrothermal-related RAIs.

Table 2. Archived River Flow and Stage Data in the referenced Excel Files

Parameter	Location	Definition
Q_WBH_1-hr_avg	TRM_529.9	Hourly average total release from Watts Bar Dam on the Tennessee River into Chickamauga Reservoir, cfs.
Q_APH_1-hr-avg	HRM_66.0	Hourly average total release from Apalachia Dam on the Hiwassee River, cfs. The Hiwassee River empties into Chickamauga Reservoir.
Q_O1H_1-hr_avg	ORM_11.9	Hourly average total release from Ocoee 1 Dam on the Ocoee River, cfs. The Ocoee River empties into the Hiwassee River downstream of Apalachia Dam.
Q_CHH_1-hr_avg	TRM_471.0	Hourly average total release from Chickamauga Dam (i.e., out or Chickamauga Reservoir) on the Tennessee River into Nickajack Reservoir, cfs
HWEL_CHH_Inst	TRM_471.0	Instantaneous headwater elevation at Chickamauga Dam, recorded at the end of the hour, feet mean sea level.

TRM = Tennessee River Mile
HRM = Hiwassee River Mile
ORM = Ocoee River Mile

Table 3. Archived Water Temperature Data in referenced Excel Files

Parameter	Location	Definition
T_WBH_TREL_15-min	TRM_529.9	Temperature of release from Watts Bar Dam, measured every 15 minutes in the tailrace of the powerhouse, °F.
SQN_TUS_3FT_15-min	TRM_490.4	River temperature from the SQN ambient temperature monitor, measured every 15 minutes by sensor located at depth 3 feet, °F.
SQN_TUS_5FT_15-min	TRM_490.4	River temperature from the SQN ambient temperature monitor, measured every 15 minutes by sensor located at depth 5 feet, °F.
SQN_TUS_7FT_15-min	TRM_490.4	River temperature from the SQN ambient temperature monitor, measured every 15 minutes by sensor located at depth 7 feet, °F.
SQN_TSKIM_3FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at depth 3 feet, °F.
SQN_TSKIM_5FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at depth 5 feet, °F.
SQN_TSKIM_7FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at depth 7 feet, °F.
SQN_TSKIM_EL673FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at elevation 673 feet mean sea level, °F.
SQN_TSKIM_EL671FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at elevation 671 feet mean sea level, °F.
SQN_TSKIM_EL667FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at elevation 6667 feet mean sea level, °F.
SQN_TSKIM_EL656FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at elevation 656 feet mean sea level, °F.
SQN_TSKIM_EL646FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at elevation 646 feet mean sea level, °F.
SQN_TSKIM_EL637FT_15-min	TRM_484.8	River temperature from the SQN skimmer wall monitor, measured every 15 minutes by sensor located at elevation 637 feet mean sea level, °F.
SQN_TDS_MEAS_3FT_15-min	TRM_483.4	River temperature from the SQN monitor located near the downstream southern corner of the diffuser mixing zone, measured every 15 minutes by sensor located at depth 3 feet, °F.
SQN_TDS_MEAS_5FT_15-min	TRM_483.4	River temperature from the SQN monitor located near the downstream southern corner of the diffuser mixing zone, measured every 15 minutes by sensor located at depth 5 feet, °F.
SQN_TDS_MEAS_7FT_15-min	TRM_483.4	River temperature from the SQN monitor located near the downstream southern corner of the diffuser mixing zone, measured every 15 minutes by sensor located at depth 7 feet, °F.

TRM = Tennessee River Mile

NRC RAI 1.c.v

v. *Is upstream surface flow on the Tennessee River an important thermal transport mechanism?*

   1. *Is wind shear the principal driver for upstream surface flow? If so, provide a description.*
   2. *Provide the following information:*
      a. *depth-dependent river velocity measurements;*
      b. *surface wind velocity measurements;*
      c. *conditions for winds from downriver predominating (diurnal, seasonal and interannual);*
      d. *surface wind velocity (15 minute or hourly data) covering a sufficiently long timeframe to include periods of strongest upriver winds and longest period of upriver winds.*
   3. *For the historical trend: (daily, weekly or monthly), provide wind velocity frequency distribution from the SQN meteorological station.*

TVA Response

Upstream surface flow on the Tennessee River can be an important thermal transport mechanism, depending primarily on the magnitude of river flow at the plant. A brief description of the effect of river flow on the transport of thermal effluent from the diffuser mixing zone is contained in the file listed in Enclosure 2 as Enclosure_1.c.v-1.pdf, in particular, section 4.2.1, Basic Hydrothermal Aspects of Diffuser Discharge and Effluent Plume. The current TVA understanding is that lateral spreading of thermal effluent from the diffuser mixing zone into adjacent shallow and shoreline areas becomes more pronounced as the river flow drops below about 17,000 cfs. In these "slack" areas, eddy-type recirculation patterns and reverse flow, created and sustained by velocity gradients between the flow in the main channel of the river and the shore (i.e., shear), mix and transport the thermal effluent upstream. Upstream flow at the surface also occurs due to buoyancy and momentum along the length of the diffuser boil at the water surface (e.g., a thermal wedge created by a line source in a crossflow).

Sloshing of the reservoir due to peaking operations at Watts Bar Dam (upstream) and Chickamauga Dam (downstream) is another mechanism that contributes to upstream surface flow in the river. In reservoir sloshing, the cross-sectional average discharge in the river completely reverses and moves in the upstream direction. In this manner, in addition to eddy-type "diffusion," the thermal effluent also is transported upstream by advection. A good example of upstream surface flow resulting from reservoir sloshing is shown in Figure 1, which shows the results from a reverse flow test conducted on September 9, 1989. The test was performed as part of a TVA study of the effect of SQN on dissolved oxygen in Chickamauga Reservoir (listed in Enclosure 2 as Enclosure_1.c.v-2.pdf). The event was captured by infrared photography, which is sensitive to temperature variations in the surface layer of the river. At the beginning of the event, with a river flow in excess of 30,000 cfs and in the downstream (d/s) direction, all of the thermal effluent from the diffusers is assimilated downstream (infrared image at 12:01 AM). As the river flow decelerates, the effluent spreads laterally into the adjacent shallow and shoreline areas, clearly shown in the infrared images captured at 1:57 AM and 4:04 AM. The latter image shows how the effluent tends to travel upstream along the shoreline opposite of the plant. The reverse flow event peaks at about 6:00 AM with an average discharge in the river of about 7000 cfs in the upstream direction. Afterwards, the river flow shifts back to the downstream direction, slowly "clearing" the river of effluent earlier transported upstream by the basic mechanisms suggested above (images captured at 10:33 AM and 5:43 PM). Of note in the image captured at 10:33 AM is the "donut hole" of cooler water immediately upstream of the diffusers. This area includes upwelling of cooler bottom water, caused by the underwater dam and the action of the diffusers. Also in this image, mixing in the wake of a tow moving upstream suggests that the warm surface layer is fairly shallow.

Over a period of 24 hours (i.e., the basis for the SQN NPDES instream temperature limits), and in comparison to events such as that summarized in Figure 1, no significant behavior in the reservoir has been witnessed that would suggest wind shear as a principal driver of upstream surface flow for the SQN thermal effluent. In calm areas of the reservoir it is likely that wind can cause some upstream surface flow. Shown in Figure 2 is a wind rose for data collected at a height of about 10 meters at the SQN Environmental Data Station. The period of record is years 2000 through 2009. To create significant upstream surface flow, a strong wind would be needed out of the southwest or south-southwest for sustained periods of time. Data from the wind rose suggests that wind from these directions occurs only about 27 percent of the time, and strong winds from these directions (e.g., in excess of 5.4 mph) only about 5 percent of the time. Also in these directions, the fetch for feeding wind energy into the diffuser mixing zone is somewhat limited. In general, the reservoir is rarely calm in the vicinity of the SQN diffusers. Since 2007, daily average releases from Chickamauga Dam (located about 13.5 miles downstream of the plant) have been in excess of 6000 cfs over 99 percent of the time. Inertia imparted by the river flow, by the intense action of the diffuser jets (issuing at about 9.5 feet per second), and by buoyancy from the thermal discharge provide the major sources of energy (most of the time) for the advection and diffusion of the plant thermal effluent in the reservoir surface, both in directions upstream and downstream of the plant.

Surface wind data for trend analyses by NRC is contained in the Excel file listed in Enclosure 2 as Enclosure_1.c.v-3.xlsx. Included are the hourly 10-meter wind speed and wind direction from the SQN Environmental Data Station for the period of record from January 2000 through May 2013. This includes the period of record for the wind rose shown in Figure 2. The response to RAI 1.c.vii contains depth-dependent river velocity measurements.

The following documents are listed in Enclosure 2 as available for NRC review:

1.c.v.1 Enclosure_1.c.v-1.pdf

TVA (2009), "Ambient Temperature and Mixing Zone Studies for SQN as Required by NPDES Permit No. TN0026450 of September 2005," Report No.WR2009-1-45-151, TVA, River Operations, January 2009.

1.c.v.2 Enclosure_1.c.v-2.pdf

TVA (1990), "The Effect Of SQN On Dissolved Oxygen In Chickamauga Reservoir", Report No. TVA/WR/WQ--90/10, TVA, Resource Development, River Basin Operations, Water Resources, September 1990.

1.c.v.3 Enclosure_1.c.v-3.xlsx

Excel file containing hourly 10-meter average wind speed and wind direction data from the SQN Environmental Data Station for the period of record from January 2000 through May 2013.

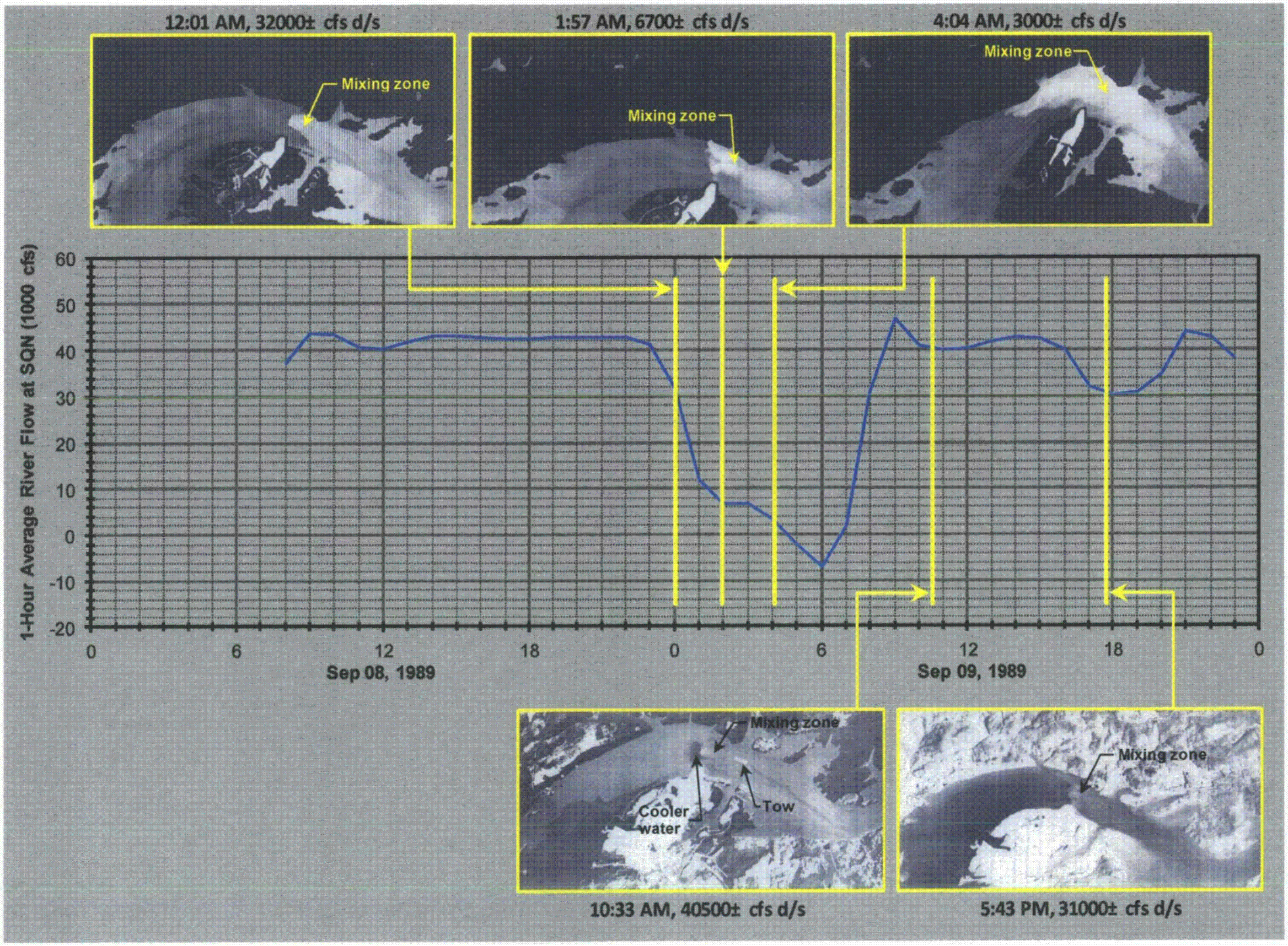


Figure 1. Reverse Flow Event at SQN on September 9, 1989

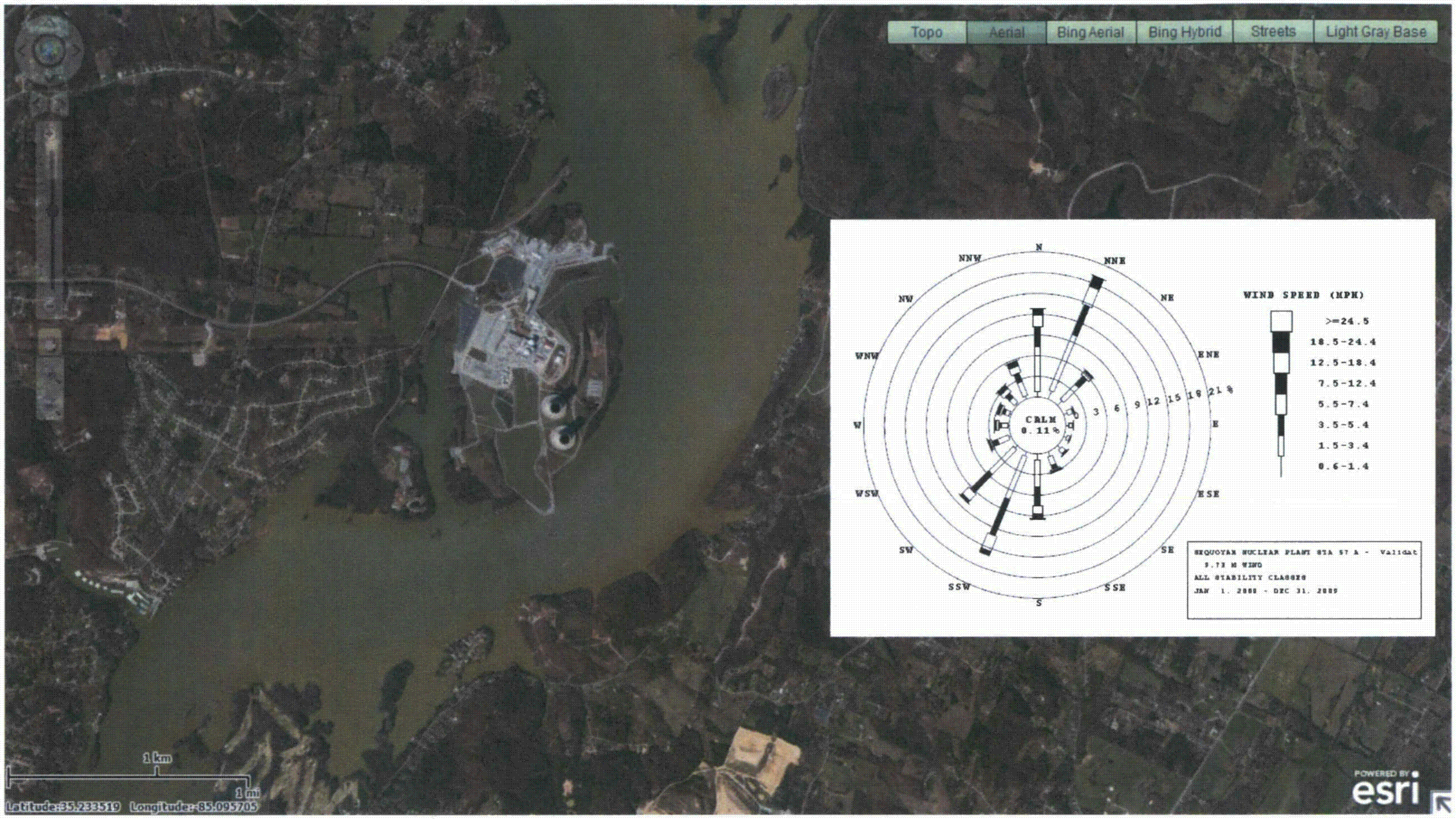


Figure 2. Wind Rose for SQN Environmental Data Station, Approx 10-Meter Height, 2000 through 2009

NRC RAI 1.c.vi

vi. Have there been any changes to river water quality regulatory limits (especially thermal) or measurement protocols other than those described in the Environmental Report (ER)? If so, provide history of all changes including:

1. previous and revised standard; and

2. date and rationale for change.

TVA Response

Over the years, there have been a number of changes in the NPDES requirements for monitoring the effect of the SQN thermal discharge on the Tennessee River. A history of these changes is given in Enclosure_1.c.vi-1. This report was submitted to the Tennessee Department of Environment and Conservation in fulfillment of requirements given in the plant NPDES permit for the permit cycle beginning September 2005 and ending February 2011. For this inquiry, the most relevant sections of the report are "2.0 BACKGROUND THROUGH 2001" and "4.1.3 *Relocation of Ambient Monitoring Station, March 2006*". These sections describe previous and revised monitoring requirements and the dates and rationale for the changes.

The following document is listed in Enclosure 2 as available for NRC review:

1.c.vi Enclosure_1.c.vi-1.pdf

TVA. 2009. "Ambient Temperature and Mixing Zone Studies for SQN as Required by NPDES Permit No. TN0026450 of September 2005". WR2009-1-45-151. January 2009.

NRC RAI 1.c.vii

> *vii. Provide the following information from non-routine intensive monitoring campaigns including:*
>
> *1. sampling locations, dates, and times; and*
>
> *2. river temperature, discharge, velocity, and stage.*

TVA Response

The files cited below include summaries of special studies (i.e., non-routine monitoring campaigns) in support of NPDES requirements for the effect of the SQN thermal discharge on the Tennessee River/Chickamauga Reservoir. Please note the following:

- Data for river temperature, discharge, velocity, and stage can be found in the files cited below.
- The first seventeen files include published reports; the last file includes unpublished data for river velocity from measurements conducted in 2003.
- The file listed in Enclosure 2 as Enclosure_1.c.vii-16_WR2009-1-45-151.pdf is the same as Enclosure_1.c.vi-1.pdf referenced in the response to RAI 1.c.vi.
- The file listed in Enclosure 2 as Enclosure_1.c.vii-17_WR2009-1-45-152.pdf is the same as Enclosure_1.b.i-1.pdf referenced in the response to RAI 1.b.i.
- In general, data presentations are accompanied with descriptions of the basic circumstances and conditions wherein the information were collected (e.g., goals of monitoring campaigns, conditions of the river and plant, dates, times, sampling locations, and so on).
- Caution is recommended in interpreting information found in the files cited below, because NPDES requirements for the plant have changed over time (see TVA response to RAI 1.c.vi). In this context, circumstances that were feasible at one point in time may not be feasible at another point in time (and vice versa). A good example is the revision made in September 2001, when the temporal basis for some instream temperature limits was changed from 1-hour averaging to 24-hour averaging. In general, because of such changes, TVA focuses primarily on the most recent compliance publications, in particular, from June 2007, when the current version of the NPDES compliance model for the plant thermal discharge was placed into service. To minimize the misinterpretation of data, as well as to allow the completion of answers in a reasonable amount of time, TVA has attempted to provide this focus in responses to the hydrothermal RAIs.

The following documents are listed in Enclosure 2 as available for NRC review:

1.c.vii.1 Enclosure_1.c.vii-1_WR28-1-45-100.pdf

TVA (1978), "The Natural Thermal Regime of Chickamauga Reservoir in the Vicinity of SQN" Report No. WR28-1-45-100, TVA, Division of Water Management, Water Systems Development Branch, February 1978.

1.c.vii.2 Enclosure_1.c.vii-2_WR28-1-45-101.pdf

TVA (1978), "Effect of SQN Discharges on Chickamauga Lake Water Temperatures" Report No. WR28-1-45-101, TVA, Division of Water Management, Water Systems Development Branch, April 1978.

1.c.vii.3 Enclosure_1.c.vii-3_WR28-1-45-103.pdf

TVA (1979), "Model Study and Analysis of SQN Submerged Multiport Diffuser," Report No. WR28-1-45-103, TVA, Division of Water Management, Water Systems Development Branch, March 1979.

1.c.vii.4 Enclosure_1.c.vii-4_WR28-1-45-110.pdf

TVA (1982), "A Field Verification of SQN Diffuser Performance Model: One-Unit Operation," Report No. WR28-1-45-110, TVA, Office of Natural Resources, Division of Air and Water Resources, Water Systems Development Branch, October 1982.

1.c.vii.5 Enclosure_1.c.vii-5_WR28-1-45-115.pdf

TVA (1983), "Validation of Computerized Thermal Compliance and Plume Development at SQN," Report No.WR28-1-45-115, TVA, Office of Natural Resources, Division of Air and Water Resources, Water Systems Development Branch, August 1983.

1.c.vii.6 Enclosure_1.c.vii-6_WR28-4-45-125.pdf

TVA (1986), "Hydrothermal Aspects Of Chickamauga Reservoir," Report No.WR28-4-45-125, TVA, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Engineering Laboratory, November 1986.

1.c.vii.7 Enclosure_1.c.vii-7_WR28-1-45-128.pdf

TVA (1987), "SQN Historical Thermal Evaluation," Report No. WR28-1-45-128, TVA, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Engineering Laboratory, March 1983.

1.c.vii.8 Enclosure_1.c.vii-8_WR28-3-45-134.pdf

TVA (1987), "Quality Program For Verification Of SQN Thermal Computed Compliance System," Report No. WR28-3-45-134, TVA, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Engineering Laboratory, September 1987.

1.c.vii.9 Enclosure_1.c.vii-9_WR28-2-45-135.pdf

TVA (1987), "SQN," Report No. WR28-2-45-135, TVA, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Engineering Laboratory, September 1987.

1.c.vii.10 Enclosure_1.c.vii-10_WR28-1-45-136.pdf

TVA (1988), "The Effect of SQN on Temperature and Dissolved Oxygen in Chickamauga Reservoir During Summer 1988," Report No. WR28-1-45-136, TVA, Engineering Laboratory, October 1987.

1.c.vii.11 Enclosure_1.c.vii-11_TVA-WR-AB--89-11.pdf

TVA (1989), "A Predictive Section 316(a) Demonstration for an Alternative Winter Thermal Discharge Limit for SQN, Chickamauga Reservoir, Tennessee," Report No. TVA/WR/AB--89/11, TVA, Resource Development, Nuclear Power, August 1989.

1.c.vii.12 Enclosure_1.c.vii-12_TVA-WR-WQ--980-10.pdf

TVA (1990), "The Effect of SQN on Dissolved Oxygen in Chickamauga Reservoir," Report No. TVA/WR/WQ--980/10, TVA, Resource Development, River Basins Operations, September 1990.

1.c.vii.13 Enclosure_1.c.vii-13_WR96-1-45-145.pdf

TVA (1996), "A Supplemental 316(a) Demonstration For Alternative Thermal Discharge Limits For SQN, Chickamauga Reservoir, Tennessee," Report No. WR96-1-45-145, TVA, Resource Group, Engineering Services, Engineering Laboratory, December 1996.

1.c.vii.14 Enclosure_1.c.vii-14_WR2003-1-45-149.pdf

TVA (2003), "Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from SQN as Required by NPDES Permit No. TN0026450 of August 2001 (DRAFT)," TVA, River Systems Operations & Environment, River Operations, June 2003.

1.c.vii.15 Enclosure_1.c.vii-15_WR2009-1-45-150.pdf

TVA (2009), "Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from SQN as Required by NPDES Permit No. TN0026450 of September 2005" Report No. WR2009-1-45-150, TVA, River Operations, January 2009.

1.c.vii.16 Enclosure_1.c.vii-16_WR2009-1-45-151.pdf

TVA (2009), "Ambient Temperature and Mixing Zone Studies for SQN as Required by NPDES Permit No. TN0026450 of September 2005," Report No. WR2009-1-45-151, TVA, River Operations, January 2009. *(Same as Enclosure_1.c.vi-1.pdf provided in TVA response to RAI 1.c.vi)*

1.c.vii.17 Enclosure_1.c.vii-17_WR2009-1-45-152.pdf

TVA (2013), "Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from SQN as Required by NPDES Permit No. TN0026450 of September 2011," Report No. WR2009-1-45-152, TVA, River Operations, April 2013. *(Same as Enclosure_1.b.i-1.pdf provided in TVA response to RAI 1.b.i)*

1.c.vii.18 Enclosure_1.c.vii-18.xlsx

Excel file containing velocity measurements recorded at nine locations on July 30-31, 2003.

NRC RAI 1.c.viii

viii. With respect to extreme operational considerations, is there a maximum fraction of river flow that can be safely diverted to the plant? At the lowest predicted river discharge, what fraction of the river flow will pass through SQN?

TVA Response

In this response, the term "safely" is interpreted to refer to the maximum fraction of river flow that can be diverted through SQN while maintaining compliance with the water temperature limits specified in the NPDES permit. In general, at any point in time, the safety of operating the plant is determined by the thermal discharge compliance model. Refer to the response to RAI 1.b.i. for information providing a detailed description of the model formulation. By the formulation, in addition to river flow, the safe operation of the plant depends on:

1) The upstream ambient temperature measured at TRM 490.4,
2) The river stage measured at TRM 484.7 (plant skimmer wall),
3) The temperature throughout the depth of flow, again measured at TRM 484.7,
4) The plant discharge measured at the diffusers, and
5) The plant discharge temperature measured at the diffusers.

Given values for these five variables, the compliance model can be used to determine the minimum river flow allowing compliance with the NPDES water temperature limits. In this manner, the minimum river flow under which the plant can safely operate varies based on the extreme operational values for these five variables. The behaviors of these variables are not mutually exclusive, so it is unrealistic to derive an extreme operational condition merely by concurrently assigning an extreme value to each variable. Under these conditions, the most pragmatic answers to this RAI come from the requirements found in the current NPDES permit and the current operating policy for the Tennessee River System.

Part III.F.1.b and Part III.F.1.c of the current NPDES permit for SQN summarize requirements related to monitoring thermal compliance for the plant diffuser discharge to the Tennessee River. The permit is contained in the file listed in Enclosure 2 as Enclosure_1.c.viii-1.pdf. In these parts of the permit, ranges for the daily average flow past SQN are defined wherein special field surveys are required to verify the adequacy of the measurement for the plant ambient river temperature and the adequacy of the plant diffuser mixing zone. These ranges in flow are given both for river conditions characterized by unsteady flow and river conditions characterized by steady flow. The type of unsteady flow of concern is the type created by strong hydro peaking, sustained day after day with low daily average flows. Similarly, the type of steady flows of concern is the type created by continuous, unvarying hydro operation, again sustained day after day, but at daily average flows lower than those of concern for hydro peaking. The daily average river flows past SQN that trigger the need for these special surveys are as follows:

No units in operation at SQN: No surveys required.

One unit in operation at SQN: Surveys required if the scheduled daily average flow past SQN drops below 3000 cfs in steady operation or below 6500 cfs in unsteady/peaking operation.

Two units in operation at SQN: Surveys required if the scheduled daily average flow past SQN drops below 6000 cfs in steady hydro operation or below 13,000 cfs in unsteady/peaking operation.

These requirements are based on field studies that were carried out in support of the NPDES permit of September 2005). The report summarizing these field studies is contained in the file listed in Enclosure 2 as Enclosure_1.c.viii-2.pdf. The studies included data collected during the warm, drought years of 2007 and 2008, as well as other years. The current TVA strategy for managing these requirements is to schedule the operation of Chickamauga Reservoir in a manner that avoids the need to perform these special surveys. Since the requirements of Part III.F.1.b and Part III.F.1.c have become effective, there has been no need to schedule daily average river flows past SQN at a level below the trigger for steady-related surveys. And thus far, when river flows are scheduled at a level below the trigger for unsteady-related surveys, such has been accomplished by limiting unsteady flow/hydro peaking at Chickamauga Dam and Watts Bar Dam.

In light of the above requirements, the minimum river flow wherein it currently is considered safe to operate the plant, is about 3000 cfs for SQN operating with one unit at full load and about 6000 cfs for SQN operating both units at full load. The nominal condenser flow for each SQN unit is about 1250 cfs. As an extreme operational consideration, this corresponds to a maximum fraction of flow diverted to the plant of about 42 percent. With this, it needs to be emphasized that river flows at these levels would support SQN operation only in the context that the NPDES compliance model says it is safe to do so. Thus far, with the current version of the compliance model (i.e., since June 2007), when the river flow has dropped to levels approaching 6000 cfs, the conditions of the river and plant (providing values for the five variables listed above) have allowed the plant to operate within the NPDES limits for river water temperature.

To address the question concerning the lowest *predicted* river discharge, information regarding allowable minimum flows in the Tennessee River is needed. On a daily average basis, the river flow past SQN is closely tied to the operating objectives for Chickamauga Dam (since the dam is located only 13.5 miles downstream of the plant). The current operating policy for the TVA river system is specified by the Reservoir Operations Study (ROS) of 2004. By the ROS, minimum releases for Chickamauga Dam are summarized in Table 1. For months October through April, TVA must provide a daily average release of at least 3000 cfs from Chickamauga Dam. For months May through September there are no minimum daily release requirements, only weekly or biweekly requirements. In theory, to satisfy the weekly or biweekly requirements, TVA could choose to include some days with no daily releases. However, in practical consideration for general water supply, TVA currently avoids scheduling daily releases from

Chickamauga Dam below 3000 cfs. Actually, due to the NPDES requirements summarized above, TVA currently avoids scheduling daily average releases from Chickamauga Dam below 6000 cfs when both SQN units are in operation, and 3000 cfs when one SQN unit is in operation. In general, 6000 cfs corresponds to about the minimum flow that feasibly can be provided by the operation of one hydro unit at the dam. That is, if a daily average flow of less than 6000 cfs is scheduled for Chickamauga Dam, such operation would by necessity require a period of zero flow from the powerhouse. Or stated differently, steady flow by hydro operations from Chickamauga Dam cannot be provided below a daily release of about 6000 cfs. Steady flows below 6000 cfs can be achieved by spill operations; however, this is highly unfavorable in light of the associated loss in hydro production. As a matter of record, TVA has not provided a daily release from Chickamauga Dam below 6200 cfs since January 2007 (e.g., this includes the drought years of 2007 and 2008).

Table 1. ROS Minimum Flows For Chickamauga Dam

<table>
<tr><td>January</td><td>3000 cfs daily average</td></tr>
<tr><td>February</td><td>3000 cfs daily average</td></tr>
<tr><td>March</td><td>3000 cfs daily average</td></tr>
<tr><td>April</td><td>3000 cfs daily average</td></tr>
<tr><td>May</td><td>7000 cfs biweekly average</td></tr>
<tr><td>June</td><td rowspan="2">13000 cfs to 25000 cfs weekly average, depending on week and amount of water in tributary reservoir storage</td></tr>
<tr><td>July</td></tr>
<tr><td>August+</td><td>25000 cfs to 29000 cfs weekly average, depending on amount of water in tributary reservoir storage (thru Labor Day)</td></tr>
<tr><td>September-</td><td>7000 cfs biweekly average (after Labor Day)</td></tr>
<tr><td>October</td><td>3000 cfs daily average</td></tr>
<tr><td>November</td><td>3000 cfs daily average</td></tr>
<tr><td>December</td><td>3000 cfs daily average</td></tr>
</table>

With the above, and in light of current TVA guidelines for scheduling the operation of Chickamauga Dam, the *predicted* river flow past SQN could be as low as 3000 cfs. With this, and with both units operating at full load, the flow diverted by SQN would represent 84 percent of the river flow. It needs to be emphasized that unless such an operating condition were spawned by an unexpected "emergency" event, allowing SQN to operate at a daily average river flow as low as 3000 cfs with both units at full load would first need to be evaluated for safe operation by the compliance model, and then also would need to be accompanied by special field surveys to confirm the adequacy of the plant ambient river temperature and the adequacy of the plant diffuser mixing zone (i.e., as summarized above). In general, the provisions in the NPDES permit for special field surveys (i.e., Part III.F.1.b and Part III.F.1.c) are given to assure the proper assessment, and if need be, recalibration of the SQN compliance model for safe operation of at lower river flows.

The following documents are listed in Enclosure 2 as available for NRC review:

1.c.viii.1 Enclosure_1.c.viii-1.pdf NPDES Permit No. TN0026450, TVA—SQN, Soddy Daisy, Hamilton County, TN, effective March 1, 2011, TN Department of Environment and Conservation, issuance date January 31, 2011.

1.c.viii.2 Enclosure_1.c.viii-2.pdf Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from SQN as Required by NPDES Permit No. TN0026450 of September 2005.

NRC RAI 1.d.i

d. Ambient Water Resources Considerations

i. If available, provide a summary of ambient river water quality monitoring data for sites(s) nearest SQN outfall 001 (covering the last 5 years).

<u>TVA Response</u>

A summary of ambient river water quality monitoring data for sites(s) nearest SQN outfall 001 (covering the last 5 years) is contained in the file listed in Enclosure 2 as 1.d.i Chickamauga TRM 490.5 Physical-Chemical Water Quality Results and Summary 2000-2011.

NRC RAI 1.d.ii

ii. Provide a description of operational and maintenance activities (or projects) anticipated to be undertaken during the license renewal term (as possible, identify expected timeframe, location(s) affected, acres disturbed, and activity/project duration).

<u>TVA Response</u>

TVA currently has no plans for specific projects or changes to operational or maintenance activities during the license renewal term (during the PEO). See also the TVA response to **RAI 5.b.i**

NRC RAI 1.e.i

e. References Requested for Docketing

i. Submit the last 5-years of surface water withdrawal/discharge reports (i.e., Water Withdrawal Registration forms) submitted to the Tennessee Department of Environment and Conservation (TDEC).

<u>TVA Response</u>

See the files listed in the TVA response to **RAI 1.e.iii**.

NRC RAI 1.e.ii

ii. SQN's Section 26a permit (as referenced in the ER).

<u>TVA Response</u>

TVA is not required to issue itself Section 26a permits and accordingly a 26a permit for water withdrawal at SQN does not exist.

NRC RAI 1.e.iii

iii. Submit copies of agency correspondence relating to Notices of Violation (NOVs) to TVA SQN, including nonconformance notifications, or related infractions received from regulatory agencies associated with NPDES permitted discharges, sewage systems, groundwater or soil contamination, including spills, leaks, and other inadvertent releases of fuel solvents, chemicals, or radionuclides (covering past 5 years).

TVA Response

The following documents are listed in Enclosure 2 as available for NRC review:

1.e.iii.2.1 SQN Annual Water Withdrawal Updates for 2008, Jan to June, 193p

1.e.iii.2.1.a SQN Annual Water Withdrawal Updates for 2008, July to Dec, 187p

1.e.iii.2.2 SQN Annual Water Withdrawal Updates for 2009, Jan to June, 299p

1.e.iii.2.3 SQN Annual Water Withdrawal Updates for 2009, July to Dec, 202p

1.e.iii.2.4 SQN Annual Water Withdrawal Updates for 2010, Jan to June, 226p

1.e.iii.2.5 SQN Annual Water Withdrawal Updates for 2010, July to Dec, 204p

1.e.iii.2.6 SQN Annual Water Withdrawal Updates for 2011, Jan to June, 175p

1.e.iii.2.7 SQN Annual Water Withdrawal Updates for 2011, July to Dec, 176p

1.e.iii.2.8 SQN Annual Water Withdrawal Updates for 2012, Jan to June, 176p

1.e.iii.2.9 SQN Annual Water Withdrawal Updates for 2012, July to Dec, 164p

1.e.iii.2.10 SQN Annual Water Withdrawal Updates for 2013, Jan to Feb, 20p

1.e.iii.3 May 21, 2009 letter from SQN to TDEC documenting Required Actions from the March 30, 2009 Division of Solid Waste Management Compliance Evaluation Inspection

NRC RAI 2.a

2. Hydrology - Ground Water Resources

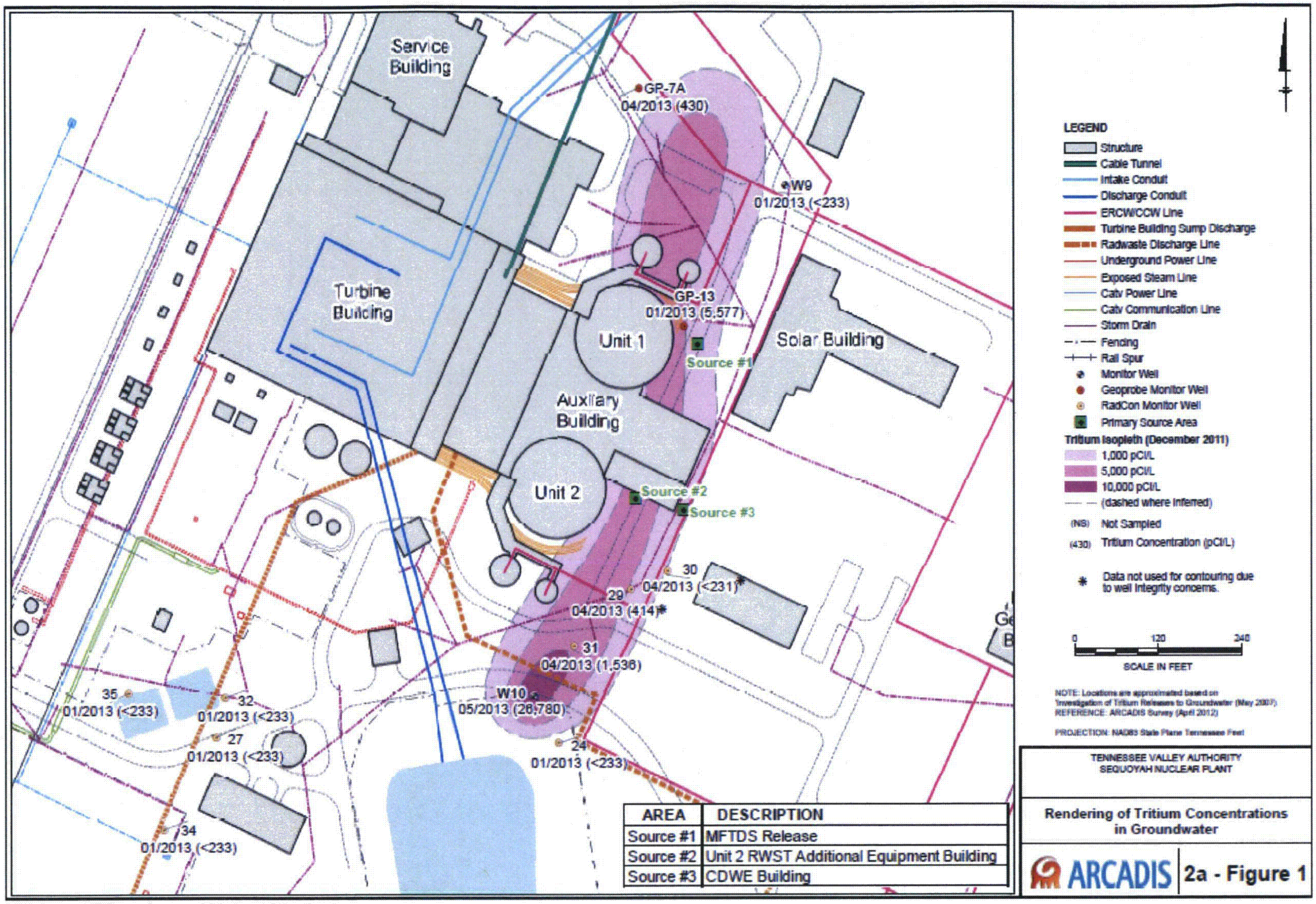
Provide the following information in order to allow for a thorough review and evaluation of the impacts of license renewal on ground water resources.

a. Provide a map showing the extent and concentration of tritium contamination in the groundwater.

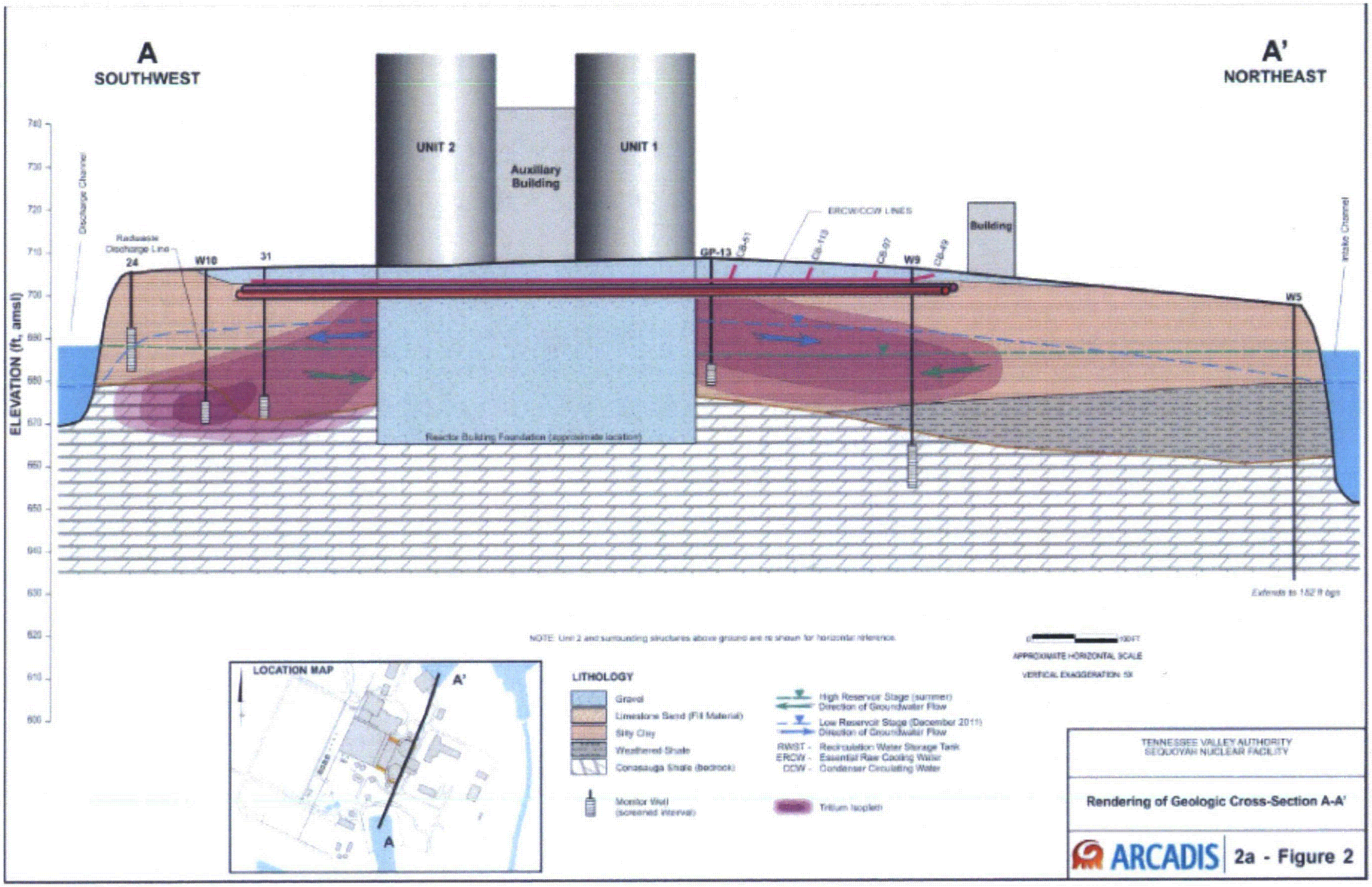
TVA Response

The extent and concentration of tritium contamination in the groundwater are displayed in two maps on the next two pages.

2.a - Figures 1 and **2** (extent and concentration of tritium contamination at SQN Units 1 and 2)



Service Building
Turbine Building
Auxiliary Building
Unit 1
Unit 2
Solar Building
GP-7A
04/2013 (430)
W9
01/2013 (<233)
GP-13
01/2013 (5,577)
Source #1
Source #2
Source #3
30
04/2013 (<231)*
29
04/2013 (414)*
31
04/2013 (1,536)
W10
05/2013 (26,780)
24
01/2013 (<233)
35
01/2013 (<233)
32
01/2013 (<233)
27
01/2013 (<233)
34
01/2013 (<233)
LEGEND
Structure
Cable Tunnel
Intake Conduit
Discharge Conduit
ERCW/CCW Line
Turbine Building Sump Discharge
Radwaste Discharge Line
Underground Power Line
Exposed Steam Line
Catv Power Line
Catv Communication Line
Storm Drain
Fencing
Rail Spur
Monitor Well
Geoprobe Monitor Well
RadCon Monitor Well
Primary Source Area
Tritium Isopleth (December 2011)
1,000 pCi/L
5,000 pCi/L
10,000 pCi/L
(dashed where inferred)
(NS) Not Sampled
(430) Tritium Concentration (pCi/L)
* Data not used for contouring due to well integrity concerns.
0 120 240
SCALE IN FEET
AREA | DESCRIPTION
Source #1 | MFTDS Release
Source #2 | Unit 2 RWST Additional Equipment Building
Source #3 | CDWE Building
TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR PLANT
Rendering of Tritium Concentrations in Groundwater
ARCADIS
2a - Figure 1



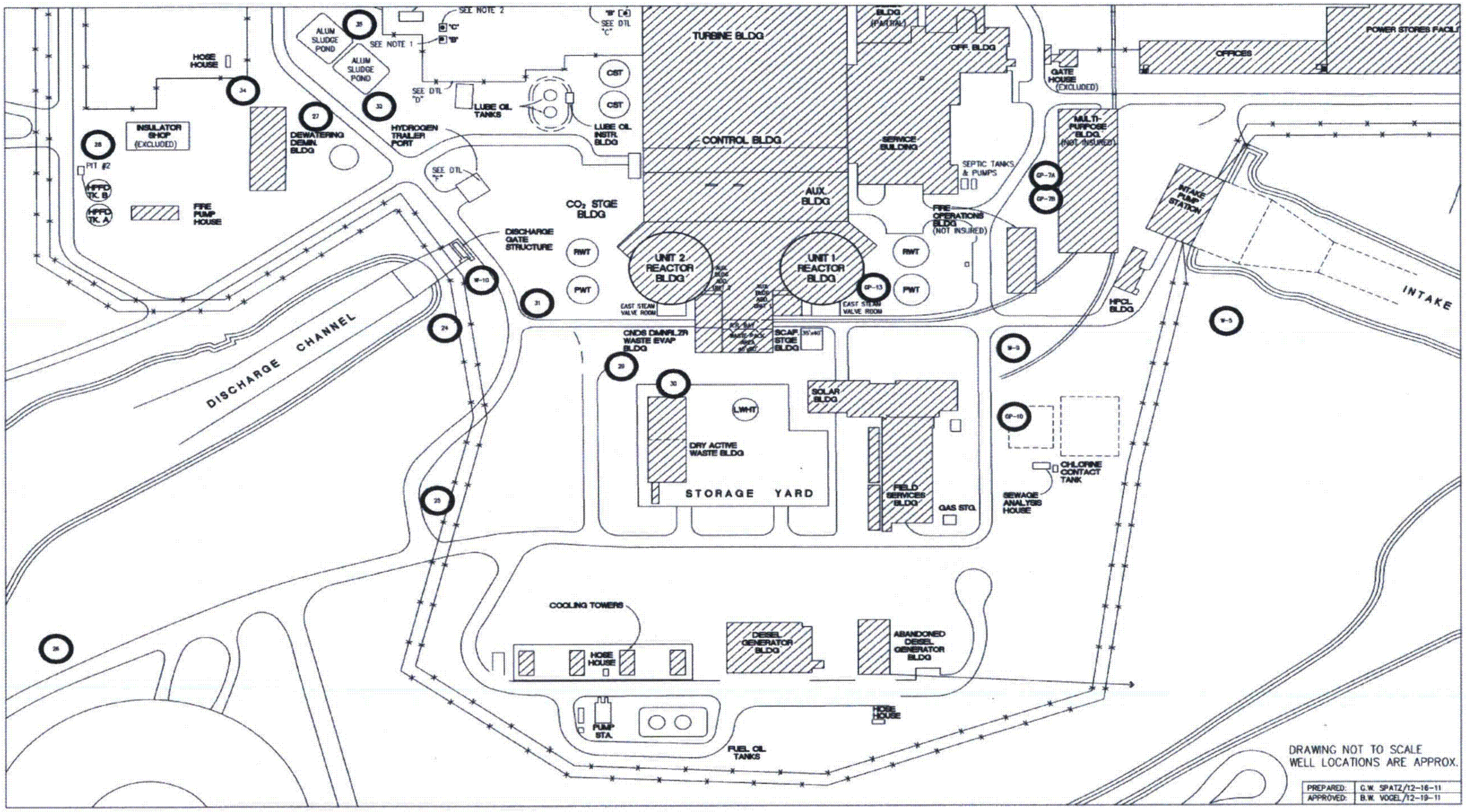
A
SOUTHWEST
A'
NORTHEAST
UNIT 2
Auxiliary Building
UNIT 1
Building
ERCW/CCW LINES
ELEVATION (ft, amsl)
Discharge Channel
Intake Channel
Radwaste Discharge Line
24
W10
31
GP-13
W9
W5
Reactor Building Foundation (approximate location)
Extends to 152 ft bgs
NOTE: Unit 2 and surrounding structures above ground are shown for horizontal reference.
APPROXIMATE HORIZONTAL SCALE
VERTICAL EXAGGERATION: 5X
LOCATION MAP
LITHOLOGY
Gravel
Limestone Sand (Fill Material)
Silty Clay
Weathered Shale
Conasauga Shale (bedrock)
Monitor Well (screened interval)
High Reservoir Stage (summer) Direction of Groundwater Flow
Low Reservoir Stage (December 2011) Direction of Groundwater Flow
RWST - Recirculation Water Storage Tank
ERCW - Essential Raw Cooling Water
CCW - Condenser Circulating Water
Tritium Isopleth
TENNESSEE VALLEY AUTHORITY
SEQUOYAH NUCLEAR FACILITY
Rendering of Geologic Cross-Section A-A'
ARCADIS
2a - Figure 2

NRC RAI 2.b

b. Provide a map that shows the locations of those wells that have been sampled for tritium.

__TVA Response__

2.b - Map 3, SQN wells location This map shows the locations of those wells that have been sampled for tritium.



NRC RAI 2.c

c. Provide a table that contains the names of wells that have been sampled for tritium and identifies for each well, the geologic material that it monitors i.e., (a) soil/structural fill, (b) bedrock or (c) both.

<u>TVA Response</u>

SQN Monitor Wells Used for Tritium Monitoring

Well ID #	Geologic Material Monitored
W-6*	Bedrock
W-9	Bedrock
W-10	Bedrock
Well-24	Soil
Well-25	Soil
Well-26	Soil
Well-27	Soil
Well-28	Soil
Well-29	Soil
Well-30	Soil
Well-31	Soil
Well-32	Soil
Well-34	Soil
Well-35	Soil
GP-7A	Soil
GP-10	Soil
GP-13	Soil

* Note: W-6 is not in the Ground Water Protection Program (GWPP), but is monitored under the Radiological Environmental Monitoring Program (REMP).

NRC RAI 2.d

d. *Provide a table of well names, date sampled, and tritium concentrations for all of 2012 and up to the present.*

TVA Response

SQN Well Results from 2012 to Current (in pCi/L)

Well ID #	1/1/12	2/1/12	3/28/12	4/1/12	5/1/12	6/1/12	7/1/12	8/26/12	10/9/12	1/1/13	3/1/13	4/1/13	5/1/13
24				<219			<236		<236	<233			
25				<219			<230		<236	<233			
26				<219			<230		<236	<233			
27				<219			<230		<236	<233			
28				<219			340		<236	<233			
29				407		745	covered		covered	covered	418	414	
30									<236	<233		<231	
31				6840		5677	covered		covered	covered	537	1536	
32				<230			<230		<236	<233			
34				<230			<230		<236	<233			
35				<230			<230		<236	<233			
GP-7A							493		351	304	<219	430	
GP-10											<219		
GP-13				4540			4163		5325	5577			
W-9				<218			<230		<236	<233			
W-10	21,035	22,272	20,368	14,704	17,848	18,170	18,437	19,312	19,489	22,606	27,959	*27,160 29,630	26,780

(*) 2 Samples for April 1, 2013

***NRC RAI* 2.e**

e. *Provide the results of tritium age dating that has been completed for groundwater samples. Also provide the name of the well sampled and the date when the sample was obtained.*

TVA Response

In December 2011, SQN asked Multi Industrial Services (MIS) to age determinate activity identified at two onsite wells. MIS used He-3 to perform tritium age dating for wells W-10 and W-3.

The ages of the samples are 14 years old, $\pm$ 6 years. The wide variability is due to a limited sample population. SQN legacy spills are the likely source of tritium contamination.

This activity, again based on a limited sample population, will migrate to the discharge canal in about 5 $\pm$ 2 years. The 5 $\pm$ 2 years calculation is based on long-term ground water migration patterns and does not account for discrete groundwater transport.

NRC RAI 2.f

f. For the proposed period of licensed activities, provide a description of where tritium contamination in the groundwater is predicted to move in the future and the rate of movement.

TVA Response

SQN hydrogeologic properties and existing tritium plume distribution have been estimated from site investigation and testing studies. In order to determine plume migration and velocity, a number of considerations were taken into account. Tritium plume migration occurs through the mechanisms of advection (primary), dispersion, and diffusion, and is also governed by sorption and radioactive decay (half-life 12.3 years). These mechanisms and the hydraulic characteristics of the saturated zone (effective porosity, hydraulic conductivity and gradient) govern tritium plume velocity.

The first source release is the Modularized Fluidized Transfer Demineralized System Release to the Turbine Building Railroad Bay in 1997 [15 years (5475 days)]. Given the release date and a plume length of 480 feet (ft.), the average groundwater velocity in the overburden is estimated to be 0.088 feet/day. Similar calculations can be made for the second source release that was the Unit 2 Refueling Water Storage Tank Additional Equipment Building release in the mid-1980s. Assuming a plume length of 380 ft. and an elapsed time of 9,855 days (i.e., 27 years), average groundwater velocity in the southern portion of SQN overburden is 0.039 ft. per day.

Uncertainties in these estimates include: seasonal changes in hydraulic gradients (governed largely by river/reservoir levels); discreet transport (via bedrock fractures) and interfaces/bedding associated with subsurface appurtenances (e.g., pipelines, cable tunnels); and subsurface heterogeneity that could retard or accelerate the plume migration. Additionally, high river/reservoir stages (i.e., summer pool) reduce mean hydraulic gradients and may slow tritium migration toward the Intake and Discharge Channels.

Additional data collection in the form of wells/borings, groundwater quality sampling, and hydraulic characterization are planned to supplement existing data and interpretations.

NRC RAI 2.g

g. NRC Regulations (10 CFR 51, Subpart A, Table B-1) require the staff to conduct additional analysis of groundwater use conflicts for those plants who use greater than 100 gpm (24 hours/day, 7 days/week) of groundwater for service water, potable water, and dewatering activities. Provide an estimate of the total rate of groundwater withdrawal by sump pumps (i.e., dewatering activities) located throughout the facility.

TVA Response

SQN's bounding estimate of groundwater inleakage is 17 gpm.

NRC RAI 3.a.i

3. ***Cultural Resources***

Provide the following information in order to allow for a thorough review and evaluation of the impacts of license renewal on cultural resources.

a. *Section 106 requirements of the National Historic Preservation Act - All of the following were discussed during the site audit. This information is being requested formally as it is essential to NRC staff for describing the procedures the applicant has in place regarding cultural resources as well as to describe the cultural affected environment at SQN. This information will assist the staff in fulfilling Section 106 requirements of the National Historic Preservation Act. Docketing should follow guidelines from NRC regarding sensitive cultural resources location information. When submitting cultural resources information, do not include maps or coordinates of site location information.*

i. *Provide a description of the process or procedures TVA uses to ensure cultural resources are considered in project planning or ground-disturbing activities during normal operation of SQN. Include a description of the process or procedures that TVA implements upon inadvertent discovery of cultural resources during ground-disturbing activities.*

TVA Response

The process TVA uses to ensure cultural resources are considered in project planning or ground disturbing activities during normal operation of SQN is the same process used throughout the TVA power properties. SQN environmental staff review proposed projects to identify environmental issues that need to be addressed. Any such issues that affect cultural resources are sent to TVA Cultural Compliance (CC) staff for review. The review request normally includes a written description of the project, maps showing the project location, and a due date for the input.

For larger projects that have the potential to affect historic properties, TVA routinely follows the Section 106 process for site identification, identification of effects, evaluation of project effects, and resolution of adverse effects in the context of NEPA reviews of cultural resources. This includes consultation with State Historic Preservation Officers (SHPOs), federally recognized Indian tribes, and any other interested parties. For smaller projects, or projects in which the review leads CC staff to conclude that there is no potential for effects to historic properties, CC staff may not carry out consultation. TVA's findings and determinations, and the outcomes of any Section 106 consultation, are shared with plant environmental staff so that these findings, determinations, and consultation outcomes can be incorporated into project planning, and so that any required changes in project design can be made.

When a project is reviewed by CC staff, they determine the nature of the potential effects, e.g., archaeology and historic architecture, and review those potential effects accordingly. CC staff consult the datasets that TVA maintains on previous cultural resources surveys, archaeological sites, and cemeteries. The purpose of consulting these data is to determine whether the proposed project or ground disturbing activities would affect any previously recorded archaeological site, historic architectural property, cemetery, or property listed in the National Register of Historic Places (NHRP). For SQN, these data have been obtained from the sources listed in Table 1.

Table 1: Sources of data on cultural resources at SQN and vicinity.

Data type	Source
Archaeological sites	Phase I cultural resources surveys of Chickamauga Reservoir (Elliot 1993)
	Phase I cultural resources survey within SQN property boundary (Calabrese et al. 1973, Jones and Karpynec 2009; McKee et al. 2010)
	Site forms for sites within SQN reservation and immediate vicinity, from TN Division of Archaeology (TDOA) site files
	Phase I archaeological surveys carried out previously on transmission lines originating at SQN (Schroedl and Wallace 1975).
	Information obtained from TDOA on National Register listings and archaeological sites within a 6-mile radius of the plant reservation in connection with the SQN license renewal application
Cemeteries	TVA's cemetery records database
	Notes on the Igou and McGill cemeteries, made by civil surveyors prior to the construction of SQN
Historic architecture	Phase I cultural resources survey within SQN property boundary (Jones and Karpynec 2009, McKee et al. 2010)
	Information obtained from TDOA on National Register listings and historic architectural properties within a 10-mile radius of the plant reservation in connection with the SQN license renewal application

In some cases, CC staff is asked to review projects that include areas that have not been included in any previous Phase I cultural resources survey. For example, surveys have not been conducted in all of the transmission line rights-of-way associated with SQN because some of the lines were constructed before the Advisory Council on Historic Properties issued regulations implementing Section 106. For these reviews, CC staff examines topographic maps and satellite images of the project site, along with all the relevant data on cultural resources, to identify conditions that suggest high potential for historic properties. Such conditions include deep soils, low slopes (< 10%), proximity of major water sources, and lack of modern disturbance. When areas with high potential for historic properties are identified during the environmental review, TVA contracts with a private consulting firm to perform a Phase I identification survey and follows the Section 106 process. In some cases (when the high potential areas are small and avoidance is feasible), those areas are flagged in a GIS database and conditions for avoidance are placed on the proposed work. The flagged areas are provided to the work crews so that the conditions are followed when the work is performed.

Once CC staff has determined whether cultural resources have been identified in the project area of potential effects (APE), CC staff determines whether the project has potential to affect any of the known cultural resources, based on the project description, the nature of the resource, and the staff's experience with various kinds of projects. When the project does have such potential, the CC staff then evaluates whether the resource is listed in, eligible for listing in, or potentially eligible for listing in the NRHP. The two recent Phase I surveys (Jones and Karpynec 2009; McKee et al. 2010) were carried out in fulfillment of Section 106 of the National Historic Preservation Act and included evaluations of the NRHP status of the identified resources. TVA bases its determinations concerning the NRHP eligibility status of cultural resources on these studies, and conducts consultation with the appropriate SHPO, seeking agreement with those determinations. These determinations are relied upon during project planning and when evaluating potential effects from normal maintenance and operation of SQN.

If there has been no evaluation of a cultural resource's NRHP eligibility, TVA CC staff may make such a determination during the project review, and would conduct consultation with the SHPO before completing the environmental review. For example, 40HA22 was thought to have been destroyed based on two earlier surveys (Calabrese et al. 1973; McKee et al. 2010), but TVA recently discovered that there is an extant site remnant that TVA believes is eligible for the NRHP (but is also outside the SQN property boundary). TVA consults with the TN SHPO, pursuant to 36 CFR 800.4, to correct the error in the earlier survey reports, seeks SHPO agreement on the eligibility of the site, and seeks comments on TVA's evaluation of effects to the site from plant operation and reservoir operations and on TVA's plans for site preservation. TVA carries out consultation with the interested federally recognized Indian tribes, and seeks their comments.

TVA CC staff have evaluated prior ground disturbance at SQN and have carried out Phase I cultural resources surveys on those areas within the site boundary that appear to contain intact or relatively undisturbed soils and sediments. Because of this, TVA has no plans for additional Phase I identification surveys at SQN. However, if the plant boundaries were expanded in the future, or if future projects are proposed by TVA that would affect land outside the plant boundary (such as soil borrow areas), TVA CC staff would evaluate the need for Phase I identification surveys of those areas and then proceed as described above.

Based on all available information, TVA has identified only one extant cultural resource within the SQN property boundary that requires preservation measures (the Igou Cemetery). Although this cemetery is ineligible for listing in the NRHP, TVA has the responsibility to regularly maintain the Igou Cemetery and avoid all ground disturbing activities. TVA continues to take steps to uphold this responsibility.

TVA's process complies with cultural resource laws and regulations. TVA CC staff regularly reviews SQN activities that have the potential to affect these resources, and follows the Section 106 process for identifying, evaluating, and resolving adverse effects.

NRC RAI 3.a.ii

ii. Provide a description of cultural resource training for TVA staff. The e-mail to Steve Cole regarding this subject, discussed in the cultural resources during the site audit, would be sufficient.

TVA Response

The following description is adapted from the subject e-mail discussed during the Cultural Resources Site Audit Meeting:

In general, SQN employees do not receive specific cultural resource training. However, this issue is addressed in National Environmental Policy Act (NEPA) reviews, i.e., any time land is disturbed, a NEPA review is performed. More than 80% of SQN site staff have completed the NEPA Overview and Categorical Exclusion training, and 100% of the environmental personnel working at SQN have completed this training. If a project is taking place inside the power block area or other area that has already been assessed for cultural resources, then SQN environmental staff would complete the Categorical Exclusion Checklist for the affected land site. However, if a project plan includes disturbing land in an area that is questionable or that has not been assessed, SQN environmental staff contacts the TVA CC staff to ensure that excavation is not allowed without the TVA CC staff review.

NRC RAI 3.a.iii

iii. Provide ongoing updates on the status of proposed stabilization and consultation activities for site 40HA22.
Provide an update prior to the issuance of the draft supplemental environmental impact statement (SEIS) and an update prior to the publication of the final SEIS (FSEIS).

TVA Response

Site 40HA22 was thought to have been destroyed based on two earlier surveys (Calabrese et al. 1973; McKee et al. 2010), and TVA had obtained agreement with SHPO on the findings and determinations based on the 2010 survey.

However, during the SQN site audit it was discovered that site 40HA22 is at least partially intact. Based on field observations and on subsequent examination of TVA's records concerning the property boundary of SQN, site 40HA22 is outside the SQN property boundary.

Site 40HA22 is within TVA reservoir lands and therefore TVA has the responsibility, under Section 110 of the National Historic Preservation Act, to address site preservation and possible effects to the site from TVA actions such as reservoir operations.

Based on the discussion above, Site 40HA22 is not germane to the SQN License Renewal Application.

NRC RAI 4.a.i

4. ***Protected Species and Habitats***

Provide the following information in order to allow for a thorough review and evaluation of the impacts of license renewal on protected species and habitats.

a. *Because the Commission approved the NRC staff's proposal to publish a final rule revising 10 CFR 51 on December 6, 2012 (ML12341A250), the NRC staff is addressing the new and revised issues in its National Environmental Policy Act (NEPA) reviews effective immediately. In its environmental review, the NRC will consider transmission lines as defined in Table B–1 of 10 CFR 51, Subpart A, Appendix B, under the revised final rule, which states that in-scope transmission lines are those lines that "connect the nuclear power plant to the substation where electricity is fed into the regional power distribution system and transmission lines that supply power to the nuclear plant from the grid" (see footnote 4 in the revised Table B–1, which starts on page 123 of the Federal Register notice associated with SECY-12-0063 (ML110760045)).*

    i. *Clarify where the substation is located that connects the transmission lines to the regional grid and which portions of the 12 lines described in Section 3.2.10.1 of the ER are in scope for the license renewal review according to this revised definition.*

TVA Response

TVA has reviewed the transmission line configuration at SQN to determine which lines or portions of lines (1) connect the nuclear power plant to the substation where electricity is fed into the regional power distribution system and (2) supply power to the nuclear plant from the grid. For SQN, the 500-kV and 161-kV switchyards adjacent to the plant serve both of these functions, i.e., connecting the plant to the regional distribution system via five 500-kV lines and eight 161-kV lines, and supplying power to the nuclear plant from the grid as needed. Both switchyards and all the high-voltage lines would remain in service if the plant was decommissioned, and there are no other lines which connect to the grid or other outside sources of power.

NRC RAI 4.b.i

b. Sections 9.1.1 and 9.1.3.16 of the ER points the reader to TVA's June 2011 FSEIS for documentation of Endangered Species Act Section 7 consultation and TVA's assessment of impacts to Federally-listed species. Pages 3-69 of TVA's FSEIS states that TVA completed a Natural Heritage Database query for a 6-mile radius around SQN in March 2010, which is documented in FSEIS Table 3-15.

i. Because this database query is now 3 years old, confirm that this table remains accurate and that each of the species in the table remains relevant to the review according to the revision definition of in-scope transmission lines in Table B–1 of 10 CFR 51, Subpart A, Appendix B, in the 2012 revised final rule.

TVA Response

TVA confirms that this table remains accurate and that each of the species in the table remains relevant to the NRC Environmental Review.

NRC RAI 4.b.ii

> *ii. Provide any new protected species occurrence data, if applicable, or confirm that new data does not exist.*

<u>TVA Response</u>

TVA confirms that new data does not exist.

NRC RAI 4.c

c. Provide records from the TVA Natural Heritage Database of all the protected resource records which were identified in the ER (all records within a 6-mile radius of SQN and a few selected records which lie just outside that radius within 1/4 mile that have a high potential to occur within 6 miles of SQN). During the site audit, TVA staff referred to this as an "EO Dump Report."

TVA Response

The TVA Regional Natural Heritage database was queried on April 10, 2013, producing the report listed in Enclosure 2 as 4.c TVA Regional Natural Heritage database Element Occurrence Report. This report was made available to NRC staff during the April 9 - 11, 2013 SQN NRC site environmental audit.

From these results, no new federally or state-listed species have been reported from the vicinity of SQN since the June 2011 report.

No updates to the ER are needed for the listed species. Under the revised definition of in-scope transmission lines (i.e., ending at the on-site substation/switchyard), there are no federally or state-listed species at SQN.

NRC RAI 4.d

d. Section 2.5.1 of the ER states that suitable habitat for the large-flowered skullcap and pink mucket mussels may occur along some portions of the in-scope transmission lines.

Do these statements remain true under the revised definition of in-scope transmission lines in Table B–1 of 10 CFR 51, Subpart A, Appendix B, in the 2012 revised final rule?

TVA Response

Under the revised definition of in-scope transmission lines (i.e., ending at the on-site substation/switchyard) discussed during the April 9 – 11, 2013, NRC SQN environmental audit, no suitable habitat for large-flowered skullcap (Scutellaria montana) or pink mucket mussels (Lampsilis abrupta) occurs along in-scope transmission lines.

NRC RAI 4.e

e. *Section 2.5.1 of the ER states that one dromedary pearlymussel individual was identified in the late 1970s approximately 3 miles from SQN.*
However, during the ecology discussion at the environmental site audit, TVA staff indicated that this statement was not accurate.
Provide an updated statement regarding the occurrence of the dromedary pearlymussel to resolve this discrepancy.

TVA Response

In the January 10, 2013, SQN ER Section 2.5.1, the third paragraph of page 2-94, the sentence "One individual was identified in **the late 1970s** approximately 3 miles from SQN." is inaccurate.

The phrase *"the late 1970s"* will be replaced with *"1918"* in the update of the SQN ER before NRC issues the Final SEIS.

This record was from a 1918 publication {Ortmann, A.E. 1918. The nayades (freshwater mussels) of the upper TN drainage, with notes on synonymy and distribution. Proceedings of the American Philosophical Society 57:521-626}. The date of collection is unknown. While historically present in the TN River prior to the impoundment of Chickamauga Reservoir, this species is no longer considered to be present in Chickamauga Reservoir.

NRC RAI 4.f

f. Section 2.5.1 of the ER states that pink mucket mussels were identified in the early 1960s approximately 5.5 miles from SQN. Provide more information on this record of occurrence as well as a reference to the study under which the mussels were identified, if available.

TVA Response

From the April 10, 2013, database query, the reference cited is: {Stansbery, D.H. 1972. Mussel records from Chickamauga Reservoir. Unpublished List. Specimens collected by Stein and Lightner. Ohio State University Museum of Zoology No. 7616}. The survey site is identified as the TN River at Houseboat Cove of Harrison Bay State Park, River Miles 477 to 483, plotted near the mouth of Wolftever Creek.

NRC RAI 4.g

g. Docket the following documents:

i. Dinkins, G. R. 2008. Survey for Federally Protected Mussels in the Tennessee River Adjacent to Proposed Clifton Fuels Terminal Project, Decatur County, Tennessee. Prepared for Natural Resource Group, LLC.

ii. LEC (Lewis Environmental Consulting, LLC). 2008. Baseline Mussel Monitoring Survey at Calvert City Terminal, Tennessee River Mile 14.0 - 14.4 R, 14.2 - 14.5 L, 14.6 - 15.0 R, Livingston and Marshall Counties, Kentucky. Prepared for Calvert City Terminal, LLC.

iii. MCD (Mainstream Commercial Divers, Inc.). 2006. Mussel Survey of Snake Creek Mile 0.00–0.15 and Tennessee River Mile 197.0–197.7 in Hardin County, Tennessee. Prepared for Santana Dredging Corporation.

iv. Third Rock (Third Rock Consultants, LLC). 2010a. Mollusk Survey of the Tennessee River Near Watts Bar Nuclear Plant (Rhea County, Tennessee). Prepared for Tennessee Valley Authority.

v. Third Rock. 2010b. Draft Report: Mollusk and Habitat Survey of the Tennessee River Near Sequoyah Nuclear Power Plant (Hamilton County, TN). Prepared for Tennessee Valley Authority—accepted by TVA as the final report.

vi. Third Rock. 2010c. Phase 1A and 1B Mussel Survey Results—Johnsonville Fossil Plant, Humphreys County, Tennessee. Prepared for Tennessee Valley Authority.

vii. *TVA. 1979. Recent Mollusk Investigations on the Tennessee River. Prepared by Tennessee Valley Authority, Division of Environmental Planning, Water* Quality and Ecology Branch.

TVA Response

The following documents are listed in Enclosure 2 as available for NRC review:

4.g.i Dinkins, G. R. 2008. Survey for Federally Protected Mussels

4.g.ii LEC (Lewis Environmental Consulting, LLC). 2008. Baseline Mussel Monitoring

4.g.iii MCD (Mainstream Commercial Divers, Inc.). 2006. Mussel Survey

4.g.iv Third Rock (Third Rock Consultants, LLC). 2010a. Mollusk Survey

4.g.v Third Rock. 2010b. Draft Report: Mollusk and Habitat Survey

4.g.vi Third Rock. 2010c. Phase 1A and 1B Mussel Survey Results

4.g.vii TVA. 1979. Recent Mollusk Investigations on the TN River

NRC RAI 5.a.i

5. ***Terrestrial Ecology***

Provide the following information in order to allow for a thorough review and evaluation of the impacts of license renewal on terrestrial ecology.

a. *Section 2.4 of the ER, and portions of the TVA (2011) SQN final EIS and the TVA (2009) steam generator environmental assessment (EA), describe various terrestrial resources on the SEQ [sic, SQN] site, including herbaceous vegetation, invasive species, wetlands, common wildlife, and heron rookeries.*

   i. *If available, provide any additional reports, field notes, or updated surveys for these terrestrial resources, other than the ER, TVA (2011) SQN final EIS, or the TVA (2009) steam generator EA.*

TVA Response

Although TVA Environmental Permitting and Compliance (EP&C) staff did not participate in the 2010 walk down that identified a heron colony near the intake, EP&C staff conducted a site visit on March 27, 2013, and determined that no colony is currently present at the intake structure at SQN. This was determined by taking a boat up to the intake structure and surveying the intake structure and surrounding area. Also, there is no record of a wading bird colony at this site in the TVA Natural Heritage Database. A description of the TVA Natural Heritage Database is included at the end of this RAI #5 response.

A survey of nest sites within six miles of SQN was conducted on March 27, 2013. Aerial and topographical maps resulting from this survey indicate which nest sites had been previously recorded (yellow) and which were currently active as of March 27 (orange, although the title indicates these are in pink). These maps are listed with this response (Record of Terrestrial Zoology Resources and Active Nests Identified March 27, 2013 within 6 Miles of SQN; aerial and topographical views).

Beyond the statement above, no additional terrestrial ecology field surveys were conducted, and no additional reports were generated.

The following document is listed in Enclosure 2 as available for NRC review:

5.a.i Record of Terrestrial Zoology Resources and Active Nests Identified March 27, 2013 Within 6 Miles of SQN; aerial and topographical views

TVA's Natural Heritage Database:

TVA's Power Service Area (PSA) falls within one of the most biologically diverse geographic areas in the United States, one which also contains one of the highest proportions of rare species (particularly aquatic animals) in the country. Any project proposed by TVA has a relatively high potential to affect one or more rare species protected by federal legislation such as the Endangered Species Act.

TVA's Endangered Species Act (ESA) Compliance business unit utilizes an application known as Biotics 4 as its data management system. Biotics 4 includes both a spatial component (i.e., Geographic Information System software) and a relational database (i.e., Oracle).

NatureServe, a non-profit environmental conservation organization, designed this software package and provides support services, ensuring consistency in the use of conservation data among its international network of member natural heritage programs.

TVA's database records include federal and state-listed plant and animal species, formally managed natural areas, ecologically significant sites, wading bird colonies, some geologic features (e.g., caves and waterfalls), and rare plant communities. Records are added to or updated in the database throughout the year using the results of TVA's endangered species monitoring, field surveys for environmental review projects, unpublished and published scientific literature, data from museums and herbaria, information from personal contacts in other agencies or academia, data from formal exchanges with natural heritage programs in the seven states overlapped by TVA's PSA, and data from formal exchanges with five United States Fish and Wildlife Service (USFWS) offices with regulatory authority in TVA's PSA. The TVA ESA Compliance business unit currently maintains the largest natural heritage database in the TN Valley, containing approximately 33,000 records, and one of the largest natural heritage databases held by a single member of the NatureServe network in the United States.

NRC RAI 5.a.ii

ii. In addition, provide a description of the methodology used to conduct the desktop or field surveys.

TVA Response

The potential presence of common wildlife species is based on the suitable habitat types known to the region.

Assessment of habitat present in areas outside of and surrounding TVA property and/or actions is typically based on desktop review of aerial photography and topographic maps.

Specific proposed actions, either along a TVA transmission line right-of-way or within a project site, involve on-the-ground site assessments when warranted (i.e., when the assessment cannot be made via desktop review).

The specific methodologies used in conducting desktop reviews and field surveys for

(1) Botany,

(2) Terrestrial zoology,

(3) Wetlands, and

(4) Natural areas are as follows:

(1) Botany: Description of the Methodology used to Conduct Desktop Reviews or Field Surveys

General Protocol for Initial Desktop Reviews for Categorical Exclusion (CE) /

Environmental Assessment (EA)

- Once the project has been assigned and the description has been read, a desktop review is initiated by accessing the TVA Natural Heritage Database either via Arc-Map or EMap. Both of these applications contain information concerning Threatened and Endangered (T&E) organisms within the TVA power service area.
- For botanical projects, T&E plants are identified within a five mile radius of the project area and a table is created listing those species that have the potential to be affected by the action alternative(s).
- Satellite images and photos provided of the project area are then reviewed to determine if habitat is present for the listed species.
- The NatureServe Website (http://www.natureserve.org/explorer/servlet/NatureServe) is also consulted to determine if any rare or uncommon terrestrial plant communities are found in or adjacent to the project area.
- Previous field work conducted within the general vicinity of the proposed project is also reviewed for the presence of T&E plants or unusual plant communities.

Protocols for Desktop Review for EAs

This review includes discussion of existing conditions for the botanical component of Terrestrial Ecology, Invasive Plants, and Threatened & Endangered Plant Species.

A. Terrestrial Ecology (Plants)

- If the proposed action has the potential to affect vegetation, an introductory statement is included concerning applicable ecological regions and vegetation known to occur within these regions based on information found in the following EPA website: http://www.epa.gov/wed/pages/ecoregions/level_iv.htm
- A list of plant communities within the project area is summarized in a tabular format describing the community types and percentage of project area covered by each type. The table is omitted if three or fewer different plant communities are present. The description of the forested classes/subclasses includes a description of the age/size class of the stands present and any old growth attributes present, as well as a discussion of the dominant and/or characteristic species present
- Rare community types are designated using the NatureServe Community Classification (G1, G2, G3) where, G1=critically imperiled globally, G2=imperiled globally, and G3=globally rare or uncommon,

B. Invasive or Exotic Species (Plants)

- A list of invasive or exotic plant species present within the project area is created, or if a desktop review is provided, the distribution of invasive plants known to occur within the county is reviewed. These data can be obtained from the following EDDMapS website: http://www.eddmaps.org/tools/choosecounty.cfm. The plant list is reviewed to determine which species are high priority for control (or are most likely to become a serious problem) at TVA facilities.

  For example, the following website has the list of invasive species known to occur in Hamilton County: http://www.eddmaps.org/tools/countyplants.cfm?id=us_tn_47065N
- If there is a large number of invasive species found within the project area, a table is constructed using the same format as used with T& E species.

C. Threatened and Endangered Species (Plants)

- Based on data from the TVA heritage database and other sources, a table of the state- and federally-listed T&E plant species is compiled that lists the common name, scientific name, federal status, and state status/rank of plant species recorded within five miles of the proposed action. Two asterisks ("**") are used to identify species that are discussed in greater detail in the text. All federally-listed plants recorded in the county are included in the table.
- If the environmental review is an EA/EIS, a description of the plants that are most likely to be affected by the project is provided. An example of the description is as follows:

- Branching whitlow grass, a member of the mustard family, is a mat-forming perennial recorded from one population in the upper Watts Bar Reservoir (WBR). It is typically found in dry areas.

- If a Designated Critical Habitat (DCH) is present, a discussion including a description of the primary constituent elements is provided. If a DCH is not present, it is mentioned that there is no CH present within the project area.

General Protocols for Field Reviews: Botany EA/EIS Input

A. Prior to Field Visit:

- Coordinate with all other disciplines to schedule site visit.
- Coordinate with project control contractor for loading GPS/GIS project related data onto ArcPad/ArcMap/Trimble Unit.
- Conduct desktop review to determine what plants or plant communities could be present within and around the project area.
- Print any necessary field maps.

B. During Field Visit:

- Prior to walking the site, conduct a Pre-Job Safety Briefing for field surveys. (Typically this is performed jointly with the other disciplines.)
- For all projects, record common plant species present within the project area for canopy, subcanopy, shrub layer, and herb layer species.
- Make notes on uncommon plant communities if present.
- If rare plants or rare plant communities are found, photograph and take GPS coordinates of the plant communities.
- Collect specimens if needed for verification.
- Fill out data sheets.

(2) Terrestrial Zoology: Description of the Methodology used to Conduct Desktop Reviews or Field Surveys

General Protocol for Initial Desktop Reviews for CE/EA

- Once the project has been assigned and the description has been reviewed, a desktop review is initiated by accessing the TVA Natural Heritage Database either via Arc-Map or EMap. Both of these applications contain information concerning T&E organisms within the TVA power service area.
- For terrestrial zoology projects, T&E terrestrial animal species are identified within a three mile radius of the project area. The federally-listed T&E terrestrial animal species are also identified in the county where the proposed actions are to take place. The U.S. Fish and Wildlife Service (USFWS) website (http://ecos.fws.gov/ecos/indexPublic.do) is

consulted if previously unknown records for a federally-listed species are thought to exist in the county. A table is created listing all identified species.

- TVA then reviews satellite images and photos provided of the project area to determine if habitat is present for the listed species.
- The NatureServe website (http://www.natureserve.org/explorer/servlet/NatureServe) is also consulted to determine if any other rare species have ranges that may overlap the project area.
- Any previous field work conducted within the general vicinity of the proposed project is reviewed. See 'General Protocol for Field Reviews for CE/EA' below for discussion of field work procedures.

General Protocol for Field Work for CE/EA

- The field survey uses the list of T&E terrestrial animal species recorded within a three mile radius of the project area and federally-listed T&E terrestrial animal species recorded in the county where the proposed actions are to take place (created above).
- Prior to walking the project site, a Pre-Job Safety Briefing is conducted for field surveys.
- The entire project site is traversed and a visual assessment is made of the habitat utilized by the listed species (as well as for the presence of the species themselves). Visual and aural encounters are used to create species occurrence lists. Notes are recorded in a bound field notebook.
- Terrestrial animal species observed within the proposed project site and in the surrounding area are recorded.
- Any specific locations that provide suitable habitat for the listed T&E terrestrial animal species, observations of listed species themselves, caves, heronries, or other unique terrestrial features are either mapped using a GPS with sub-meter accuracy, and/or described in the field notes taken of the site.
- Locations that warrant restrictions on the proposed actions are added to the "heritage polygon" layer within the heritage geodatabase associated with the projects ArcMap file format mxd. Within the attribute table for these shapefiles, restrictions are described.

  For example: "Suitable summer roosting habitat for the Indiana bat exists here. Consultation with USFWS is required prior to clearing trees."

- Responsible parties are informed of restrictive polygons placed on the mxd and this information is included in the Threatened and Endangered Species (Wildlife) portion of the Categorical Exclusion Checklist or EA input when the effects on suitable habitat are discussed.

(3) <u>Wetlands</u>: Description of the Methodology used to Conduct Desktop Reviews or Field Surveys

Protocols for Desktop Review

- The project footprint and associated aspects (i.e., something outside the footprint that might be affected) are uploaded into the ArcInfo/ArcMap Geographic Information System (GIS).
- The presence/absence of wetlands is assessed using National Wetland Inventory (NWI) maps, aerial photography, land use/land cover data, and soil survey data.
- If wetlands are present, field surveys are requested/recommended as needed.

Protocols for Field Surveys

A. Prior to field visit:

- Coordinate with the GIS technician for loading GIS project related data onto field global positioning (GPS) equipment for wetland mapping.
- Conduct desktop review (see above) and print any necessary field maps.

B. Field Visit:

- Prior to walking the project site, conduct a Job Safety Briefing for field surveys
- The entire project site footprint is surveyed via foot
- Any wetlands are identified and delineated in accordance with the following:
  - (a) Environmental Laboratory. 1987. U.S. Army Corps of Engineers (USACE) Wetland Delineation Manual, Tech Report Y-87-1. U.S. Army Corps of Engineers Waterways Experiment Station, Vicksburg, Mississippi.
  - (b) Cowardin, L.M., V. Carter, F.C. Golet, and E.T. LaRoe. 1979. Classification of Wetland and Deepwater Habitats of the US. Washington, D.C.: U.S. Fish and Wildlife Publication FWS/OBS-79/31.
  - (c) Executive Order 11990. Protection of Wetlands. May 24, 1977; 42 FR 26961.
- Wetland boundaries are mapped using available field equipment (Trimble ProXH GPS); sub-meter accuracy is desired, depending on field conditions.

C. ArcMap/Flagging Edits:

- Field data is uploaded by a GIS technician.
- Wetland boundaries for the project are entered into ArcMap, using the Editor as follows:
  - (a) Create a polygon (for each delineated OR desktop-indicated-potential wetland area)

(b) Edit the polygon attributes data to include:

- Project number
- Field ID
- Sequence number (starting with 001 and following order of existing poles or ordered as customer requests)
- Resource (=Wetland)
- TVARAM Category
- Type (Palustrine Forrested, Palustrine Scrub-Shrub, Palustrine Emergent, etc.)
- Field Notes (if any, the more information included the better)
- Special Instructions (if any, the more information included the better)
- Photo numbers
- Date of site visit

D. Prepare U.S. Army Corps of Engineers wetland data sheets,

- TVA Rapid Assessment Method (TVA RAM) data sheets using field notes.

(4) Natural Areas: Description of the Methodology used to Conduct Desktop Reviews or Field Surveys

General Protocol for Initial Desktop Reviews for CE/EA

- Once the project has been assigned and the description has been read, a desktop review is initiated by accessing the TVA Natural Heritage Database via Arc-Map. This application contains information concerning managed areas or ecologically significant sites within the TVA power service area. Additionally, Nationwide Rivers Inventory (NRI) streams and Wild and Scenic Rivers layers are added to Arc-Map for initial review.
- The natural areas located within a 3 to 5-mile radius of the project area are identified. For CE level reviews, the natural areas within 0.5 miles of the project area are described and the natural areas within 0.5 to 3.0 miles of the project area are listed. For EA level reviews, the natural areas within three miles of the project area are described and natural areas within 3-5 miles of the project area are listed. The natural areas that are within the proposed project area or have the potential to be affected by a project are

  "flagged" via a flagging project which involves obtaining Global Positioning System coordinates of resources identified in the field and uploading them into an ArcMap file. Contact information is provided for the natural areas management personnel via database tables in Arc-Map. Areas that would not be affected are recorded in a draft CE or EA but not flagged.

Protocols for Desktop Review for EA

The following protocols apply to natural areas, NRI Streams, and Wild and Scenic Rivers.

Natural Areas

- The natural areas within three miles of the proposed project area are identified and described. This description includes acreage and land use.

  Example: Peabody State Wildlife Management Area (WMA), a 46,000 acre WMA, is mostly forested, but has large expanses of open land, wetland, and open water. It also offers birding, fishing, and horseback riding opportunities. Peabody WMA is a rough terrain of reclaimed coal-mined land with numerous excavated ridges and water-filled strip mine pits. Waterfowl and small and big game frequent swamplands, high ridges, and deep pits. Fishing and hunting opportunities are excellent. Hunts are administered by the Kentucky Department of Fisheries and Wildlife Resources. Primitive camping is allowed on all WMA land. The Peabody WMAs are well known birding locales. Bald eagle, golden eagle, osprey, and snow goose have been noted at Goose Lake, just southwest of Paradise Fossil Plant. Summertime brings Bell's vireo, willow flycatcher and Henslow's sparrow to the WMA. In the winter, shorebirds and a large raptor population, including northern harriers and short-eared owls, visit the area for its abundance of small mammals.

- If the proposed action has the potential to affect a natural area, the potential effects are described in Chapter 3 of the EA and any mitigation that would need to be completed.

NRI Streams

- The NRI Streams that are within three miles of the proposed project are identified, as well as any NRI streams that are crossed by the proposed project. For new construction, The National Park Service Rivers, Trails and Conservation Assistance Program is contacted to determine potential effects of the proposed project. For maintenance and demolition projects, NRI Streams in the area are noted, but the National Park Service is not contacted.

  Example: A segment of the Gasper River in Warren County, from river mile 0, the confluence with Barren River to river mile 35, the headwaters northwest of Auburn, is recognized by the National Park Service for its outstanding scenic, recreational, geologic, fish, and wildlife values.

Wild and Scenic Rivers

- The National Wild and Scenic Rivers that are within three miles of a proposed project area are identified, as well as any Wild and Scenic Rivers that are crossed by a proposed project area. For new construction, the USFWS would be contacted to determine potential effects of the proposed project. For maintenance and demolition projects, Wild and Scenic Rivers in the area are noted, but the USFWS would not be contacted.

Field Review Protocols: Natural Areas

- ArcGIS database files - gathered from multiple federal, state, and local agencies - are used to delineate natural areas boundaries. These files represent the most accurate natural area boundaries available. Because many of these boundaries are not marked in the field, field reviews for natural areas are rarely feasible. If effects are anticipated to occur on a natural area, the project managers and natural areas coordinator work with a representative of that natural area to minimize effects. This representative has a thorough knowledge of the area and a site visit is rarely, if ever necessary to complete a CE/EA natural areas review.
- If a field survey is deemed necessary, a Pre-Job Safety Briefing is conducted prior to walking the site.

NRC RAI 5.b.i

b. Section 4.9.5 of the ER states that TVA has not planned to conduct construction activities during the period of extended operations in undisturbed areas.

i. Describe typical construction activities that may occur in previously disturbed areas during the period of extended operations.

ii. If available, provide any environmental evaluations related to such activities.

TVA Response

The construction or modification projects currently planned or anticipated at SQN are expected to be completed prior to the renewed license period.

Currently, TVA does not have any planned construction for SQN during the PEO. However, based on past experience, there will likely be future projects during the PEO.

The following are some of the types of future projects during PEO:

- Reliability or efficiency improvements, such as elimination of repetitive failures to instruments and controls;
- Upgrades resulting from evolving regulatory requirements, such as mandated changes to safety-related plant hardware, security barriers, or environmental protection equipment;
- Replacement of obsolete equipment or equipment no longer supported by the original vendor, such as outdated electrical switchgear with a lack of spare parts;
- Modifications to eliminate operator impacts or excessive maintenance, such as replacing corroded buried pipe;
- Site overall appearance and employee convenience upgrades, such as demolishing deteriorated buildings or parking lot improvements; and
- Modifications in response to Industry Operating Experience.

In areas proposed for any construction activities, TVA personnel would conduct a NEPA review of the proposed activity at the appropriate level (i.e., Categorical Exclusion Checklist, EA, and Environmental Impact Statement) that includes input from applicable subject matter experts to ensure compliance with environmental regulations. For example, wetland biologists would conduct an initial desktop review of the site footprint. This would consist of a review of aerial photography, NWI maps, and site-specific photographs. If there is a potential for the presence of wetlands, a field survey would be conducted, utilizing current U.S. Army Corps of Engineers (USACE) wetland delineation methodology. Existing wetlands would be mapped, a site report prepared, and environmental review conducted. Wetlands would be avoided to the extent practicable; where effects are unavoidable, mitigation as per state and federal regulations would be undertaken to offset those effects.

NRC RAI 5.c

c. *Docket the following documents:*

   i. *Tennessee Valley Authority Division of FFWD. Forestry Bulletin 143, June 1969. (Note that this document is reference #7 from Section 1.2 in the TVA 1974 Final Environmental Statement).*

   ii. *Henry, T. H. 2011a. Results of the Tennessee River Valley Shorebird Initiative. Final Report. December 2011.*

   iii. *TVA. 1974a. Final Environmental Statement Sequoyah Nuclear Plant Units 1 and 2. February 13, 1974.*

   iv. *TVA. 1974b. Cooling Tower Contract M02712_0044459421, Invitation, Bid and Acceptance, Guaranteed Data, Performance Under Specified Design Conditions. TVA Reference No. 74C53-83659.*

TVA Response

The following documents are listed in Enclosure 2 as available for NRC review:

5.c.i Tennessee Valley Authority Division of FFWD. Forestry Bulletin 143, 24p

5.c.ii Henry, T. H. 2011a. Results of the Tennessee River Valley Shorebird Initiative, 150p

5.c.iii TVA. 1974a. Final Environmental Statement, previously docketed, ~1100p

5.c.iv TVA. 1974b. Cooling Tower Contract M02712_0044459421, 9p

NRC RAI 6.a.i

6. ***Meteorology, Air Quality, and Noise***

Provide the following information in order to evaluate the impacts of license renewal on air quality meteorology, air quality, and noise.

a. *Meteorology and Air Quality*

i. *Provide a summary of SQN, Units 1 and 2, annual greenhouse gas emissions (GHG) for the most recent five years.*

Identify sources and provide GHG amount emitted ($CO_{2equivalent}$) for each source and calculations.

Include GHG emissions such as carbon dioxide (CO_2), sulfur hexafluoride (SF_6), hydroflurocarbons (HFC), perflurocarbons (PFC).

Include stationary combustion source emissions, mobile combustion source emissions, refrigerant leakage emissions, emissions from switchyard, and other sources.

<u>TVA Response</u>

The following documents are listed in Enclosure 2 as available for NRC review:

6.a.i.1 SQN GHG Summary.xlsx This document is a summary of GHG emissions at the SQN location.

6.a.i.2 TVA – SQN – Annual GHG Data Report v3-2 – Final – 04-02-13.xlsx This document is SQN's portion of TVA's FY2012 GHG Inventory. It has detailed GHG emissions and the sources that make up the total. Both documents 1 and 2 show CO2 equivalents.

6.a.i.3 Refrigerant Sources.pdf This document lists potential sources of GHG emissions due to refrigerant leaks; the sources listed are those that contain over 50 pounds of Class I or II ozone depleting substances.

NRC RAI 6.a.ii

ii. Provide the associated annual air emissions (air pollutant and amount) for the most recent 5 years of operation for air permitted emissions sources at SQN. Identify sources and provide amount emitted (include particulate matter (PM), PM_{10}, $PM_{2.5}$, carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), lead (Pb), volatile organic compounds (VOCs), hazardous air pollutants (HAPs), and CO_2 equivalent (CO_{2e}) emissions) and calculations.

TVA Response

TVA provides an annual list of the hours of operation of the SQN auxiliary boilers and diesel generators to the Chattanooga-Hamilton County Air Pollution Control Bureau. The Bureau then calculates the resulting air emission quantities for particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, volatile organic compounds, and carbon dioxide equivalent.

The Bureau uses the methodology in AP-42, the U.S. Environmental Protection Agency (EPA) Office of Air Quality Planning and Standards Compilation of Air Pollutant Emission Factors, as the basis of their calculations except for CO2 equivalent (which utilizes §98.33 of 40 CFR Part 98, Subpart C). A summary table of the annual hours of operation of the auxiliary boilers and diesel generators has been compiled for the most recent five years and is listed in Enclosure 2.

A summary table of SQN Annual Air Emissions data has also been compiled from the most recent five years of Chattanooga-Hamilton County Air Pollution Control Bureau Annual Air Inspection Reports and is listed in Enclosure 2. The Bureau typically performs the inspection in July of each year, so the 2012 data is not available until August of 2013. Note that Volatile Organic Compounds were not included until the 2008 report, and the Carbon Dioxide Equivalent was not included until the 2009 report.

The Toxic Release Inventory (TRI) Reports for hazardous air pollutants (hydrazine and lead) are not due until July 1 of the following year; the 2012 data is currently being prepared for submittal to the EPA and is not available until August of 2013.

Lead is present at SQN mainly from the use of ammunition at the on-site security gun range; a small fraction of the lead from the ammunition becomes airborne and is released. SQN plant emissions from the firing of ammunition at the onsite firing range are calculated using the total weight of ammunition fired and the AP-42 emission factor. The weight of ammunition fired is calculated from daily firing range use records. These records include the quantity, types and weights of ammunition fired. The EPA default emission factor for estimating lead emissions is 1.2 pounds of lead per ton of ammunition fired [(AP-42 Chapter 13.3 Explosives Detonation (2/1980)]. The fugitive or non-point lead air emissions reported in the 2007 through 2011 TRI reports are 0.11, 0.36, 0.37, 0.8 and 0.7 pounds/year, respectively; the annual amounts can vary depending on the type and quantity of ammunition used in a given year.

Hydrazine usage and releases to the environment are evaluated annually as part of the TRI. Hydrazine is managed in a closed process; it is mixed with water to form a weak aqueous solution. When this aqueous solution is converted to steam, a very small amount could be emitted to the atmosphere. However, hydrazine is not likely to volatilize, and any airborne portion would be converted to ammonia (in the ppb range). Therefore, emissions are too small to quantify and are reported as zero on the TRI Report.

The following documents are listed in Enclosure 2 as available for NRC review:

6.a.ii.2a SQN Air Emissions 5-Year Summary

6.a.ii.2b SQN Air Emissions 5-Year Summary, HAP emissions from permitted engines

6.a.ii.3 SQN Air Quality Permit, Expire on.7-17-2017.pdf

6.a.ii.4 SQN Annual Air Inspection Report 2007.pdf

6.a.ii.5 SQN Annual Air Inspection Report 2008.pdf

6.a.ii.6 SQN Annual Air Inspection Report 2009.pdf

6.a.ii.7 SQN Annual Air Inspection Report 2010 .pdf

6.a.ii.8 SQN Annual Air Inspection Report 2011 .pdf

6.a.ii.9 SQN Hours of Operation Annual Air Report 2007.pdf

6.a.ii.10 SQN Hours of Operation Annual Air Report 2008.pdf

6.a.ii.11 SQN Hours of Operation Annual Air Report 2009.pdf

6.a.ii.12 SQN Hours of Operation Annual Air Report 2010.pdf

6.a.ii.13 SQN Hours of Operation Annual Air Report 2011.pdf

6.a.ii.14 SQN Hours of Operation Annual Air Report 2012.pdf

6.a.ii.15 SQN 2007 TRI Report.pdf

6.a.ii.16 SQN 2008 TRI Report.pdf

6.a.ii.17 SQN 2009 TRI Report.pdf

6.a.ii.18 SQN 2010 TRI Report.pdf

6.a.ii.19 SQN 2011 TRI Report.pdf

6.a.ii.20 SQN CY11 TRI Releases.pdf

NRC RAI 6.a.iii

iii. Identify any expected upgrade/replacement activities for equipment/operation (e.g., diesel generators, diesel pumps) that could increase air emissions over the license renewal period.
Provide fuel consumption, estimated use, expected annual air emissions (air pollutant and amount), and expected date(s) of installation.

TVA Response

The only expected equipment/operation changes that could increase air emissions over the license renewal period are those associated with modifications made in response to the Fukushima incident. Expected date of the Fukushima Diesel Generator installation at SQN is December 2016.

The following documents are listed in Enclosure 2 as available for NRC review:

6.a.iii.1 SQN Fukushima Diesel Generator Air Emissions.xlsx

6.a.iii.1.a SQN Fukushima DG, diesel pumps/tow truck list

6.a.iii.2 Fukushima EA.pdf The pertinent sections of the Fukushima Environmental Assessment are: (1) 2.1.2 Action Alternative, particularly Station Blackout Regulatory Actions; (2) 3.1 Air Quality and Greenhouse Gases – Affected Environment

6.a.iii.2 See section 4.1 Air Quality and Greenhouse Gases – Environmental Consequences

NRC RAI 6.a.iv

iv. *Provide the following meteorological information from the data recorded at SQN's meteorological facility. The meteorological data should include the most recent 5 years for which data is available.*
Provide the following information:

1. *mean monthly and annual temperatures;*
2. *mean monthly precipitation and annual precipitation; and*

TVA Response

The following meteorology documents are listed in Enclosure 2 as available for NRC review:

6.a.iv.1 Mean Temps 2008-2012.pdf

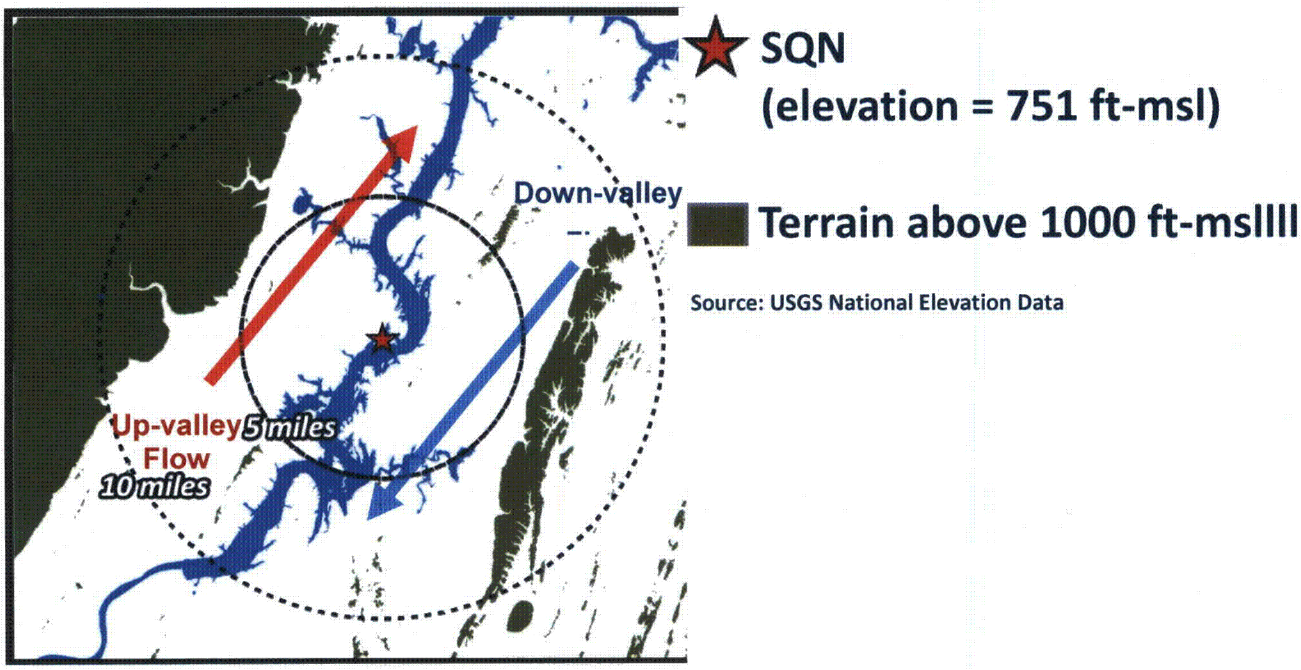
6.a.iv.2 Mean Precip 2008-2012.pdf

NRC RAI 6.a.iv.3

3. *provide seasonal and annual summary wind statistics in the form of wind direction and speed frequency distribution tables and wind roses. Discuss predominant wind direction and speed by season and annual average, local terrain features affecting wind direction and speed, and provide a value for annual average wind speed and peak wind gust.*

<u>TVA Response</u>

SQN is located in the Tennessee River Great Valley of southeast Tennessee (about 14 miles from the NWS station at the Chattanooga airport). The Cumberland Plateau to the northwest, and the Appalachian Mountains to the southeast, create a valley orientation that results in a distinct southwest-northeast windflow pattern at SQN.



Typical regional-scale weather conditions enhance the flow along the valley axis. During high pressure, which affects SQN about 52% of the time, regional winds are generally too light to overcome the normal diurnal pattern (night-time down-valley flow from the northeast, daytime up-valley flow from the southwest). Migratory low pressure systems are the only other major influence on SQN regional winds. Pre-warm front flow tends to drift down-valley, while pre-cold front flow streams up-valley. Only during post-cold frontal conditions (about 5% of the time) is windflow distinctly across the valley axis.

Wind Direction

The southwest-northeast flow characteristics are illustrated in wind roses, based on wind measurements from the SQN meteorological tower (10-meter level) during 2008-2012. The very strong bimodal pattern is clearly evident as the up-valley/down-valley flow accounts for about 74% of all wind directions (36% from S-SSW-SW and 38% from N-NNE-NE). The cross-valley winds (8% from the eastern arc and 18% from the western arc) result from migratory low pressure systems and transitions between up-valley and down-valley conditions.

There is little seasonal variation from the up-valley/down-valley flow pattern. During the second quarter (when migratory storm systems are more frequent), the up-valley flow is more pronounced than the other three quarters (when the down-valley flow is most frequent). For all quarters, the bimodal flow pattern consistently accounts for about 3/4 of the winds.

Percent Up-Valley Flow (from S-SSW-SW) | **Percent Down-Valley Flow (from N-NNE-NE)**

Quarter				Annual		Quarter				Annual
1st	2nd	3rd	4th		Year	1st	2nd	3rd	4th	
40.3	46.2	30.0	30.2	**36.6**	2008	31.0	28.3	44.4	41.9	**36.4**
40.9	41.0	31.9	28.6	**35.5**	2009	35.3	30.0	41.2	45.9	**38.2**
22.6	43.2	33.7	23.3	**30.7**	2010	43.7	30.2	43.7	49.9	**41.9**
36.8	48.9	38.8	37.7	**40.5**	2011	39.5	28.4	34.6	37.1	**34.9**
43.0	39.7	41.0	31.2	**38.7**	2012	33.6	38.3	34.3	44.7	**37.7**
36.7	43.8	35.1	30.2	**36.4**	5-year	36.6	31.0	39.6	43.9	**37.8**

Wind Speed

Winds at SQN are light with an average annual wind speed of 3.81 mph.

Winds are strongest in the winter season (first and fourth quarters) and lightest in the summer season (second and third quarters). However, because the overall annual wind speed is so light, the 1.35 mph difference in quarterly averages is not significant.

Average 10-meter Wind Speed (mph)

	Quarter				
Year	1st	2nd	3rd	4th	Annual
2008	4.72	3.84	3.19	3.74	**3.87**
2009	4.57	3.65	3.16	3.76	**3.78**
2010	4.50	3.38	3.21	3.91	**3.75**
2011	4.65	3.87	3.42	3.87	**3.95**
2012	4.39	3.54	3.06	3.85	**3.71**
5-year	4.56	3.66	3.21	3.83	**3.81**

During 2008-2012, maximum hourly average wind speeds were 16.0 mph at 10 meters elevation and 34.8 mph at 91 meters elevation. Wind gust information is not measured by the SQN meteorological tower. However, during 2008-2012 the maximum wind gust (i.e., 3-second wind speed) reported by the Chattanooga NWS was 69 mph.

The following documents are listed in Enclosure 2 as available for NRC review:

6.a.iv.3.1 SQN-winds.docx

6.a.iv.3.2 SQN-Wind_Summary.xlsx

6.a.iv.3.3 SQN_2008-2012_5yr(q).docx

6.a.iv.3.4 SQN_2008-2012_5yr(q).pdf

6.a.iv.3.5 SQN_2008.docx and SQN_2008.pdf

6.a.iv.3.6 SQN_2009.docx and SQN_2009.pdf

6.a.iv.3.7 SQN_2010.docx and SQN_2010.pdf

6.a.iv.3.8 SQN_2011.docx and SQN_2011.pdf

6.a.iv.3.9 SQN_2012.docx and SQN_2012/pdf

6.a.iv.3.10 SQN_TERRAIN.pptx

In addition, SQN Meteorology Tower Data from 2008 through 2012 is contained in the Excel file listed in Enclosure 2 as 6.a.iv.3.11 SQN_Met_2008-2012.xlsx.

NRC RAI 6.a.v

v. References Requested for Docketing:

1. *SQN. 2007g. Hours of Operation Annual Report, S58 070503 800—Air Correspondence. May 3, 2007.*
2. *SQN. 2008e. Hours of Operation Annual Report, S58 080501 800—Air Correspondence. May 1, 2008.*
3. *SQN. 2009h. Hours of Operation Annual Report, S58 090507 801—Air Correspondence. May 7, 2009.*
4. *SQN. 2011h. Hours of Operation Annual Report. May 12, 2011.*
5. *SQN. 2012e. Hours of Operation Annual Report. May 10, 2012.*
6. *SQN. 2010e. Hours of Operation Annual Report, S58 100513 801—Air Correspondence. May 13, 2010.*
7. *SQN. 2007c. Sequoyah Nuclear Plant Air Quality Permits. 2007.*

TVA Response

The following documents are listed in Enclosure 2 as available for NRC review:

6.a.ii.9 SQN Hours of Operation Annual Air Report 2007.pdf

6.a.ii.10 SQN Hours of Operation Annual Air Report 2008.pdf

6.a.ii.11 SQN Hours of Operation Annual Air Report 2009.pdf

6.a.ii.12 SQN Hours of Operation Annual Air Report 2010.pdf

6.a.ii.13 SQN Hours of Operation Annual Air Report 2011.pdf

6.a.ii.14 SQN Hours of Operation Annual Air Report 2012.pdf

6.a.ii.3 SQN Air Quality Permit, Expire on.7-17-2017.pdf

NRC RAI 6.b.i

b. Noise

i. Identify noise sources at SQN, Units 1 and 2, and in the vicinity of SQN.

TVA Response

SQN is located in a rural area along the Tennessee River in Hamilton County, Tennessee.

There is scattered residential development in the area around the plant site. The nearest resident lives approximately 0.5 miles in the north-northwest direction from the reactor units' centerpoint. There is a subdivision approximately 1 mile north of the plant site and another within a mile to the west along Hixson Pike, the State Route (SR) 319. This subdivision is separated from the main part of the SQN site by an embayment that has a border of trees on both sides. There are residences located on the eastern shoreline of Chickamauga Reservoir within 1 mile of the plant site.

Noise sources in the vicinity of the SQN site include river and lake traffic, road traffic, dogs barking, insects, plant equipment at SQN: fans, turbine generators, transformers, cooling towers, compressors, emergency diesels, main steam-safety relief valves (MS-SRVs), and emergency sirens.

The MS-SRVs occasionally produce a loud noise and visible steam and are therefore easily noticed by residents in the vicinity. The release of steam and noise would only be expected for a few hours when these valves are used. The MS-SRVs use is rare (fewer than 5 days per year).

Under some atmospheric conditions, a light humming may be noticed directly under 500-kV lines, but this noise is rarely heard off the transmission line right-of-ways.

Emergency sirens are deliberately very loud and easily heard in the community. These sirens provide a warning to area residents as part of the local community emergency plans for various emergencies, such as a tornado warning, as well as serving as a warning for an SQN radiological emergency.

The average noise levels in rural areas are typically about 40 dBA during the day. SQN is an industrial facility in which average noise levels can approach approximately 65 – 75 dBA onsite, although this is not based on actual measurements at SQN. However, from the experience of site workers in recent years, the noise levels at SQN boundary are generally consistent with those of a rural residential area.

NRC RAI 6.b.ii

ii. *Provide information about any noise complaints for the most recent 5 years resulting from plant operation.*

TVA Response

SQN has not received any noise complaints from plant operations during the last five years. New sirens were installed in the 10-mile emergency planning zone this year and calls were received concerning the sirens sounding on a day that was not the usual monthly test time (first Wednesday of the month at noon), but this was part of siren installation testing and not related to plant operation or plant noise.

Note: RAI No. 7 (SAMA) follows the TVA's response to the Aquatic Ecology RAI.

Aquatic Ecology NRC RAI a

a. *Intake velocities at four locations*

Background - Section 2.6 (page 2.6-15) of the 1974 TVA final environmental statement (FES) stated that

> *Estimated velocities at four locations in the intake system under full plant load conditions are:*
>
> *(1) 0.5 ft/s under the skimmer wall,*
>
> *(2) 2.7 ft/s in the intake channel,*
>
> *(3) 1.2 ft/s in the intake bays and*
>
> *(4) 2.2 ft/s through the 3/8 inch-square mesh traveling screen.*

Section 3.2.2.1 of the environmental report (ER) indicates, "[Closed cooling water (CCW)] flows into the intake structure through trash racks designed to catch larger trash such as driftwood, plastic containers, etc. The flow then passes through six traveling screens at an intake velocity of approximately 1.7 feet per second (fps), three screens for each unit (Figure 3.2-1)." This value is also provided in Section 4.3.5.1 of the ER - "Flow [cooling water intake system] passes through six traveling screens at a velocity of approximately 1.7 fps, three for each unit." [Rather than the 2.2 ft/s specified in the 1974 FES]. Further, the 2007 impingement report "Sequoyah Nuclear Plant NPDES 316(b) Monitoring Program – Fish Impingement at Sequoyah Nuclear Plant During 2005 to 2007" states that "Velocity at the traveling screens averaged 37 cm/sec (1.2 fps)". (Page 1).

<u>Request</u>:

Provide a verification (or update) of the velocities given under the skimmer wall, in the intake channel and bays and through the traveling screens. If necessary, provide an explanation for the difference in the through-screen velocity during the fish impingement study (2005 to 2007) and the velocity reported in the ER.

<u>TVA Response</u>

The Condenser Circulating Water traveling screens at SQN have been replaced as of February 2013. The design drawing data for the new screens specify a through-screen flow velocity of 2.08 fps at a pump flow rate of 189,000 gpm (approximately 420 cfs using a 450 gpm per cfs conversion) at a minimum water depth of 28 feet (i.e., elev. 675 feet). This is calculated from: Velocity = (flow in cfs)/(Basket Width x Water Depth x Basket Efficiency). With a Basket Efficiency of 51.44%, which takes into account the percent open area of the screen mesh and basket frame (and assuming no fouling), this yields an approximate through-screen flow velocity of (420)/(14' x 28' x 0.5144) = 2.08 fps.

The design configuration for the skimmer wall, intake channel and intake bays has not changed significantly since the 1974 SQN FES; therefore, the estimated flow velocities for these three locations are still valid. The original SQN design in 1974 located the ERCW pumps in the CCW pumping station and both systems utilized common traveling screens. As noted in the 1974 FES, the estimated velocity through the screens was 2.2 fps; this slightly higher flow velocity through the screens may have been based on the total flow of all the CCW and ERCW pumps.

The 2007 impingement report stated a velocity at the traveling screens of 1.2 fps (not through the screens); to be more clear, the report should have stated the average flow velocity value is 1.2 fps in the intake bays just before the traveling screens.

The 1.7 fps through-screen velocity stated in Sections 3.2.2.1 and 4.3.5.1 of the ER was taken from a 2004 calculation of intake flows and velocities for TVA fossil and nuclear units. The documentation stated that this value was the intake velocity through the screen; however, it has been determined that this velocity is actually the velocity through the initial rough screens (i.e., "trash racks") that are located just upstream of the traveling screens.

SQN ER will be revised at the update before NRC issues the Final SEIS to reflect the current traveling screen installation velocity of 2.08 fps.

NRC RAI b

b. Intake channel velocity compared to through-screen velocity

<u>Background</u>:

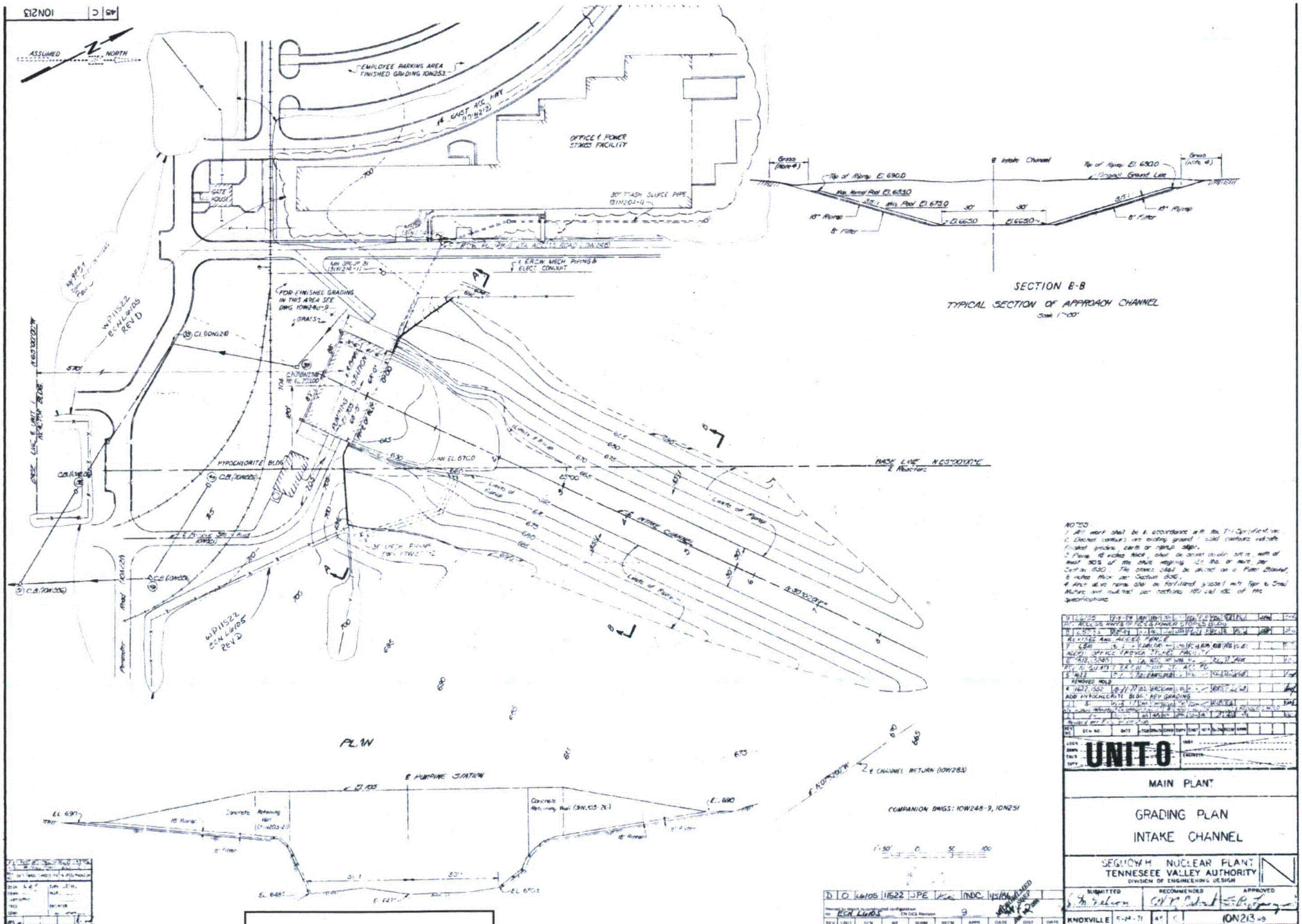
The velocity reported for the intake channel in final safety analysis report (FSAR) Amendment 23 is 2.7 fps. This is larger than the velocity cited in Section 3.2.2.1 or 4.3.5.1 of the ER (1.7 ft/s), although the maps showing the intake structure (Figure 3.2-2 for example) show an intake channel that is wider than the CCW intake structure.

<u>Request</u>:

Provide a description of the intake channel that would account for a higher velocity in the channel (2.7 ft/s) as reported in the FSAR Amendment 23, Section 2.4.8.1 (page 2.4-31), than the velocity measured through the traveling screens of the intake structure as described in the previous RAI. If available and germane to this description, provide a legible copy of FSAR Figure 2.4.5-1 or similar illustration showing the grading plan for the intake channel.

<u>TVA Response</u>

The intake channel grading plan drawing no. 10N213 (from which FSAR figure 2.4.5-1 was taken) is shown below. From Section B-B, the bottom elevation of the intake channel is 665 feet. Using a minimum pool elevation of 675 feet, the calculated cross-sectional flow area is approximately 950 square feet (trapezoidal cross section with a 60 foot base and 3.5/1 slope wall). At the design flow of 2526 cfs (189,000 gpm per CCW pump) the average flow velocity is approximately 2.7 fps. As noted in the previous RAI, the correct flow velocity through the traveling screens is 2.08 fps (rather than the 1.7 fps value listed). The flow area at the screens is much larger than at the Section B-B intake channel cross section because the intake bays, and thus the bottom of the traveling screens, are located at elevation 647 feet (i.e., a depth of 28 feet at a pool elevation of 675 feet) and the combined width of the traveling screens is wider (84 feet vs. 60 foot base). With a screen basket efficiency of 51.44% (again, assuming no fouling), this yields a cross-sectional flow area of approximately 1210 square feet (vs. 950 square feet for the intake channel).



FSAR Figure 2.4.5-1

NRC RAI c

c. Entrainment of freshwater drum eggs and larvae

Background:

ER page 4-20 states "The 1986 assessment of operational monitoring (TVA 1986) noted that cove rotenone studies indicated a decline in numbers and biomass of young and intermediate-size freshwater drum... As a result of the assessment, TVA conducted a focused study on freshwater drum in 1986 to assess the impact of the higher entrainment rates on this species. The study involved collecting samples of adult fish and age analysis of the collected freshwater drum."

No reference was provided for the "focused study" other than TVA 1986. The following text in TVA 1986 appears to refer to a continued study (not reported in TVA 1986) and a potential future study:

> *However, because high entrainment rates of freshwater drum were noted at SQN (see section 5.1.2) TVA has initiated investigations to determine if entrainment losses provide an explanation of reduced numbers of young and intermediate size freshwater drum. EPA was informed of TVA's plans to conduct these studies in a letter dated February 14, 1986. Investigations are planned in two phases: (1) length frequency and age structure of the adult population to determine if recruitment to adult size may be restricted and (2) fish egg and larvae collections at SQN and downstream to determine if significant reproduction occurs beyond the influence of the plant's intake such that eggs and larvae would not be subjected to entrainment. The first phase of the study is being conducted in 1986, while the second phase is not planned until SQN resumes operation. (From Section 5.2.3; page 227)*

Request:

Provide a copy of any additional reports generated as a result of the continued studies or new studies related to freshwater drum entrainment losses.

TVA Response

The following report was specifically written to respond to the **Aquatic RAI c**.

Trend Analysis of Freshwater Drum in Chickamauga Reservoir

The purpose of this document is to examine historical and contemporary trends in the freshwater drum population of Chickamauga Reservoir to determine if entrainment of drum eggs and larvae by the SQN cooling water intake has had a significant effect on long-term sustainability of this population.

The 1985 larval fish studies at SQN provided basically the same results as larval fish studies in previous years: low entrainment rates for all species except freshwater drum (TVA 1986). Due to these results, TVA evaluated the effects of the high entrainment rates of eggs and larvae on the juvenile and adult freshwater drum population in Chickamauga Reservoir in 1986 (TVA 1987). The results of this study indicated that that the freshwater drum population of Chickamauga Reservoir had not been adversely affected by the operation of SQN (TVA 1987). Conversely, cove rotenone surveys during this time indicated decreasing trends of young and intermediate stocks of freshwater drum.

Methods

To further examine trends in the freshwater drum population in Chickamauga reservoir, rotenone data collected from 1971 to 1997 from representative zones of Chickamauga Reservoir were analyzed. Mainstem Tennessee River reservoirs are typically characterized by three distinct zones: inflow, transition, and forebay. The inflow zone is within the upper reaches of the reservoir and is riverine in nature; the transition zone or mid-reservoir is the area where water velocity decreases due to increased cross-sectional area; and the forebay is the lacustrine area near the dam. Three coves located within each reservoir zone were selected for analysis: Tennessee River Mile (TRM) 478 (forebay), TRM 495 (transition), and TRM 508 (inflow). For reference, the SQN intake is located at ~ TRM 484.8. Since rotenone sampling was only conducted until 1997, additional analysis was conducted on gill net and electrofishing samples collected from 1993 to 2011. In addition to the three aforementioned reservoir zones, sampling was also conducted in the Hiwassee River embayment of the Chickamauga Reservoir. The Hiwassee River is a large tributary to Chickamauga Reservoir and its lower reaches are impounded, creating a large embayment. Gill net data were analyzed from the TRM 472 (forebay zone), 482 (forebay zone), 490 (transition zone), and Hiwassee River Mile 8 (embayment). Electrofishing data were analyzed from the four aforementioned sites and from TRM 529 (inflow zone). Gill nets were not used at TRM 529 because inflow areas are not suitable for gill netting due to higher water velocities, which render the nets ineffective.

Results and Discussion

Cove rotenone

Only the three datasets – Tennessee River Mile (TRM) 478 (forebay), TRM 495 (transition), and TRM 508 (inflow) – were used in the current analysis because they spanned from 1971 to 1997. Cove rotenone data collected from other locations were collected more sporadically and did not contain enough temporal data for this analysis. Therefore, the results in the current analysis vary from conclusions made in the TVA (1987) report where other datasets were utilized. In the 1987 report, it was stated that linear regression analyses of cove rotenone data, collected from 1970 through 1986, revealed no significant increasing or decreasing trends in adult stocks; however, similar analysis revealed that both the numbers and the biomass of young and intermediate size freshwater drum had declined in Chickamauga Reservoir (TVA 1987). Analysis using the three coves from representative zones of Chickamauga Reservoir, reported here, present different results. Freshwater drum were most abundant in these coves during 1985 than in any other year, except 1972 and 1973 (Figure 1). Furthermore, adult freshwater drum were most abundant from 1980 to 1987 (Figure 2). The high entrainment rate of eggs and larvae may have been due to the high density of reproductively mature freshwater drum during this time period. The peaks in intermediate-sized freshwater drum seem to correspond with peaks in adult drum in subsequent years, but the trends in young drum do not correspond with later life stages (Figure 2). This may indicate that cove rotenone sampling is not an adequate sampling technique for documenting recruitment of freshwater drum. Juvenile drum appear to be strongly influenced by light, staying in darker water most of the time. In the Tennessee River, large drum juveniles were typically collected only at night, predominantly from deep water samples (Wallus 2006). Because of this presumed habitat preference, a representative sample of juvenile drum may not be possible with cove rotenone sampling. With the exception of juveniles, freshwater drum sampled from these three coves do not demonstrate a decreasing trend over time (Figures 1 and 2).

Fish populations exhibit natural variability over time. This variability comes from various sources, including annual variations in air temperature and stream flow; variations in pollutant loadings from nonpoint sources; changes in habitat, such as the extent and density of aquatic vegetation; natural population cycles and movements of the species being measured (TWRC 2006). Another source of variability arises from the fact that nearly any practical measurement of a biological community is a sample rather than a measurement of the entire population. As noted in TVA (1987), reduced stock estimates of young and intermediate sizes of freshwater drum may have been related to the significant increases of aquatic macrophytes in the reservoir since the mid-1970s. From 1976 through 1983, there was a seven-fold increase in the acreage affected by rooted aquatic vegetation in Chickamauga Reservoir. Unlike many of the centrarchids, young and intermediate sizes of freshwater drum seem to prefer open-water areas and avoid coves with dense aquatic vegetation.

Electrofishing and gill netting

Beginning in 1993, TVA initiated a reservoir fish monitoring program to assess the condition of fish communities in the reservoirs of the Tennessee River system (Hickman and McDonough, 1996). Monitoring stations were sampled in the inflow, transition, forebay, and embayment zones of Chickamauga Reservoir. Sampling effort consisted of 15 daytime electrofishing transects per station, each of which was 300 meters. Samples were collected during autumn each sample year, and each electrofishing run was conducted at the same location. In addition to electrofishing, 10 experimental gill nets were set overnight in all sampling zones except the inflow. This methodology was developed to assess the overall composition of fish communities, but was not designed to assess changes in overall density of a particular species such as freshwater drum. Drum have been shown to be more susceptible to capture along shoreline areas during night (e.g. Sanders 1992; Rypel and Mitchell 2007), therefore shoreline electrofishing during daylight hours may not be a very accurate method for assessing the status of freshwater drum populations. Gill nets are used to sample deeper water habitats than electrofishing, thus it would be assumed that gill nets would be more effective for capturing freshwater drum. It should be noted that freshwater drum were more abundant in cove rotenone samples in upstream reaches of Chickamauga Reservoir (TVA 1987), where gill nets were not used in sampling from 1993 to 2011.

A decreasing linear trend, although not significant, was seen in catch rates of freshwater drum in gill net samples from 1993 to 2011; while an increasing trend was seen, also not significant, in electrofishing samples (Figures 3 and 4). Overall, these sampling methods displayed a similar cyclic pattern in abundance that was seen in cove rotenone samples.

Cumulatively, 40 years of data presented here do not demonstrate an overall increasing or decreasing temporal trend in abundance. Freshwater drum are extremely fecund- a typical mature female produces 40,000 to 60,000 ova per year (Swedberg and Walburg 1970). Because of this high reproductive potential, years where the reproductive population is comprised of a large number of individuals would undoubtedly result in entrainment of large numbers of eggs and larvae, as was seen during the early 1980s. In summary, all data presented do not indicate that the freshwater drum population of Chickamauga Reservoir is impaired or that entrainment of eggs or larvae has had a significant effect on overall population stability.

Literature Cited

Hickman, G. D. and T. A. McDonough. 1996. Assessing the Reservoir Fish Assemblage Index- A potential measure of reservoir quality. *In*: D. DeVries (Ed.) Reservoir symposium- Multidimensional approaches to reservoir fisheries management. Reservoir Committee, Southern Division, American Fisheries Society, Bethesda, MD. Pp 85-97.

Rypel, A.L. and J.B. Mitchell. 2007. Summer nocturnal patterns in freshwater drum (*Aplodinotus grunniens*). American Midland Naturalist 157:230-234.

Sanders, R.E. 1992. Day versus night electrofishing catches from near-shore waters of the Ohio and Muskingum rivers. Ohio Journal of Science 92:51-59.

Swedberg, D.V. and C.H. Walburg. 1970. Spawning and early life history of the freshwater drum in Lewis and Clark Lake, Missouri River. Transactions of the American Fisheries Society 99:560-570.

TVA. 1986. Aquatic environmental conditions in Chickamauga Reservoir during operation of SQN, fifth annual report (1985). TVA/ONRED/WRF-86/5a

TVA. 1987. Aquatic environmental conditions in Chickamauga Reservoir during operation of SQN, sixth annual report (1986). TVA/ONRED/WRF-87/7

Tennessee Wildlife Resources Commission (TWRC). 2006. Strategic Plan, 2006-2012. Nashville, TN. March 2006. pp 124-125. http://tennessee.gov/twra/pdfs/StratPlan06-12.pdf

Wallus, R. 2006. Reproductive biology and life history account for Freshwater Drum, p. 281-300. *In*: Reproductive biology and early life history of fishes in the Ohio River drainage, Volume 5: Aphredoderidae through Cottidae, Moronidae, and Sciaenidae. R. Wallus, and T.P. Simon (eds.). CRC Press, Boca Raton, Florida.

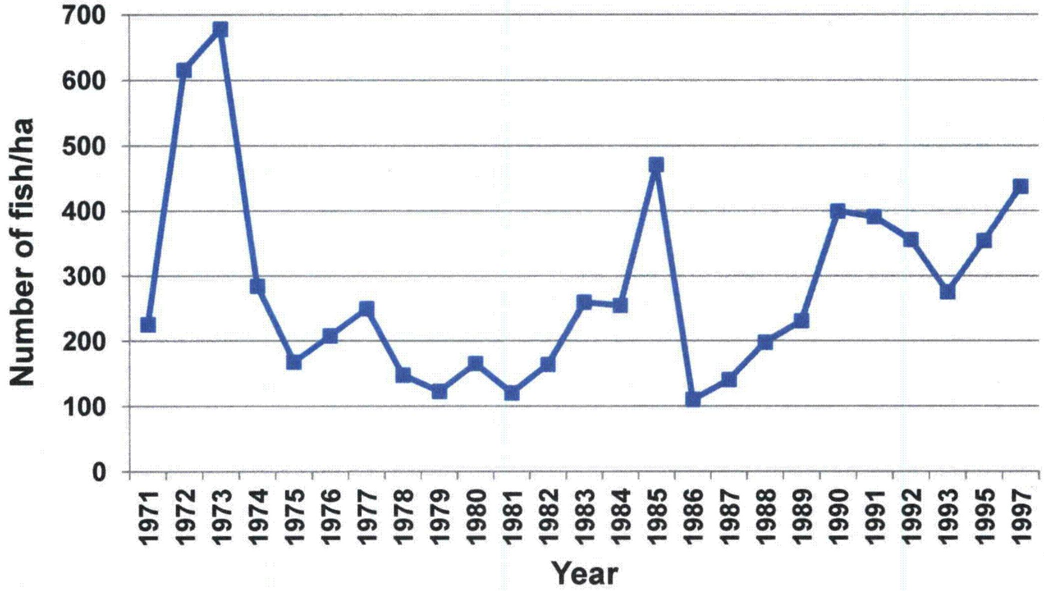


Figure 1. Mean number of freshwater drum per hectare collected in cove rotenone samples from three coves on Chickamauga Reservoir, 1971 to 1997. Coves were located at Tennessee River Miles 478 (forebay zone), 495 (transition zone), and 508 (inflow zone).

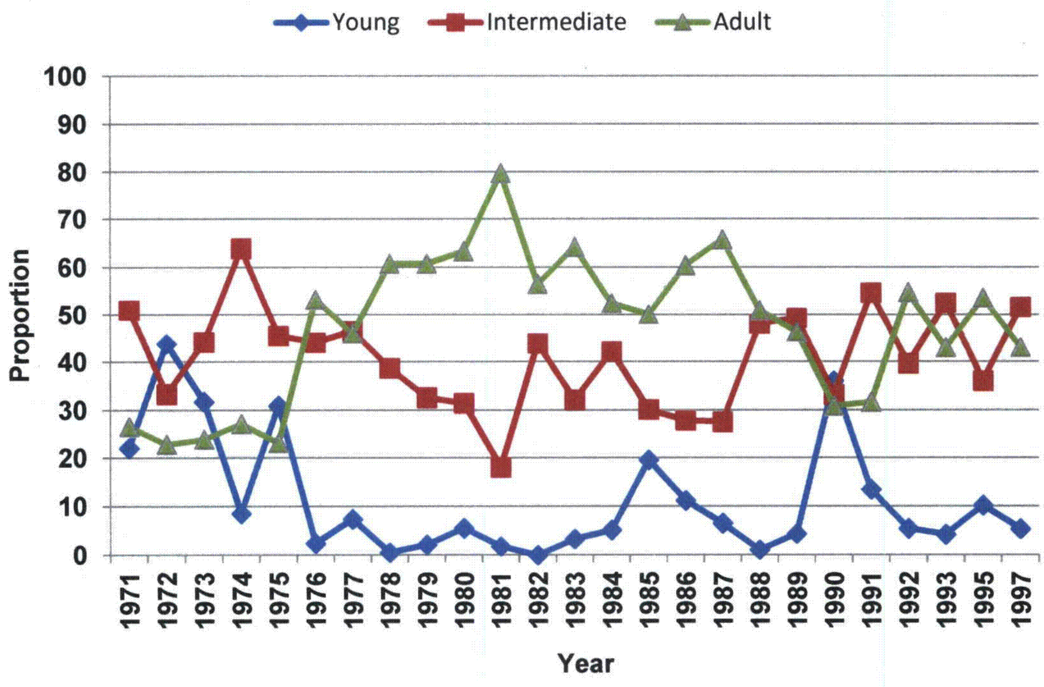


Figure 2. Mean proportion of young, intermediate, and adult freshwater drum per hectare collected in cove rotenone samples from three coves on Chickamauga Reservoir, 1971 to 1997. Coves were located at Tennessee River Miles 478 (forebay zone), 495 (transition zone), and 508 (inflow zone).

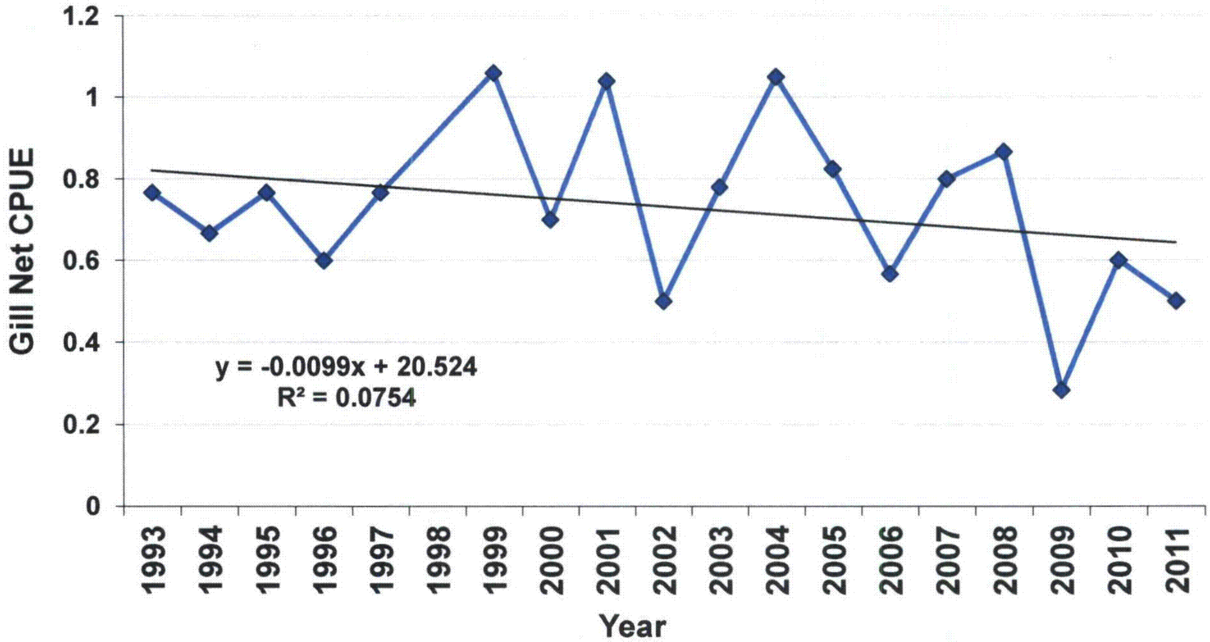


Figure 3. Mean freshwater drum catch per unit effort (CPUE) in gill net samples (n=190) from Chickamauga Reservoir, 1993 to 2011. Data included were from Tennessee River Miles 472 (forebay zone), 482 (forebay zone), 490 (transition zone), and Hiwassee River Mile 8 (embayment). CPUE represents the number of freshwater drum collected per gill net set (10 nets set overnight per site/year).

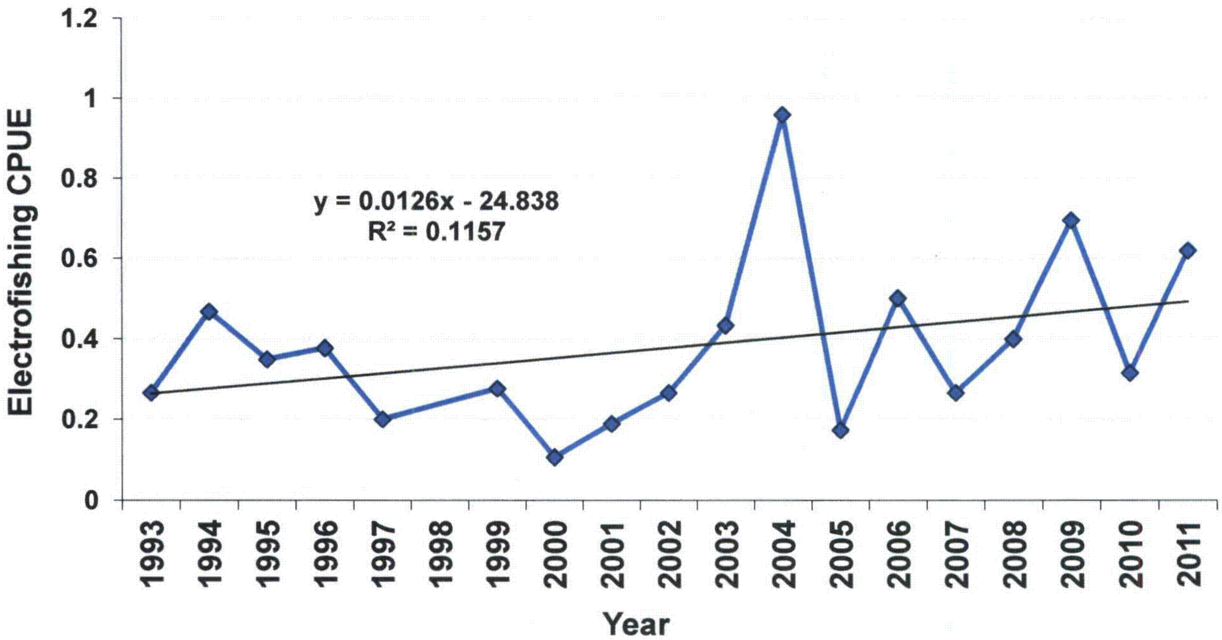


Figure 4. Mean freshwater drum catch per unit effort (CPUE) in electrofishing samples (n=285) from Chickamauga Reservoir, 1993 to 2011. Data included were from Tennessee River Miles 472 (forebay zone), 482 (forebay zone), 490 (transition zone), 529 (inflow zone) and Hiwassee River Mile 8 (embayment). CPUE represents the number of freshwater drum collected per 300 m shoreline electrofishing run (15 electrofishing runs per site/year).

NRC RAI d

d. Clarification of Site Audit Notes

Page 51 of 131 on the Site Audit notes "Closed by Inspector 3 11 13" the question "Why isn't the ERCW included in the entrainment analysis" was answered in part with "Provided email from Mike Stiefel to Chuck Wilson about this on thumb drive". We did not find this email on our copy of the documents on the iron key thumb-drive. Provide a copy of the email.

TVA Response

The following is the requested email.

From: Stiefel, Michael B
Sent: Thursday, April 04, 2013 11:43 AM
To: Wilson, Charles L
Cc: Markum, Travis R; Baxter, Dennis Scott; Nida, Diedre B; Love, Bradley Michael; Cheek, Terence Edward; Barnes, Stephen E
Subject: APPLICABILITY OF 316(b) REGULATIONS TO THE SQN ERCW & CCW INTAKES

Chuck:

This is to document our conversation concerning the applicability of the pending 316(b) regulations for existing facilities to SQN.

Under the 2004 rulemaking (subsequently suspended), **SQN was not required to meet the standard for Entrainment Mortality (EM) for either intake because the water source met the definition of a reservoir.** The draft version of the revised regulations (to be issued final this summer) did not include a waterbody exclusion for meeting the EM standard and the assumption should be that it will apply to both intakes at SQN.

Also, under the 2004 regulations, an intake with a through-screen velocity of 0.5 fps or less was deemed to meet the impingement mortality (IM) standard. Based on the recent draft regulations, it is likely that some requirements (e.g., velocity monitoring and fish friendly screens with fish return) will be required for all intakes, even those with a velocity of less than 0.5 fps. The assumption should be that IM requirements will apply to both intakes at SQN.

Please note that EPA may make revisions the final rule in response comments from industry and others that could reduce the impacts to SQN. However, at this point, we must assume that the final regulations will apply to both intakes.

Mike Stiefel, P.E.
TVA
Water Permits and Compliance
1101 Market Street, BR 4A
Chattanooga, TN 37402-2801
Tel: 423.751.6844 Fax: 423.751.7011 Cell: 423.595.6923

ENCLOSURE 2

Tennessee Valley Authority

Sequoyah Nuclear Plant, Units 1 and 2 License Renewal

Environmental RAI References List

Many of the responses to the NRC Requests for Additional Information in Enclosure 1 contain references to supporting TVA documents. These documents are available for NRC review and will be placed on the Sequoyah Nuclear Plant (SQN) docket, if requested.

The following documents are referenced in Enclosure 1:

1. 1.a.i, SQN NPDES Permit renewal application, dated May 2, 2013

2. 1.b Enclosure_1.b.i-1, TVA. 2013. "Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from Sequoyah Nuclear Plant as Required by NPDES Permit No. TN0026450 of March 2011," WR2013-1-45-152, dated April 2013
3. 1.b Enclosure_1.b.i-2, TVA. 2013. "Estimation of River Flow at Sequoyah Nuclear Plant for NPDES Thermal Compliance". TVA white paper prepared in support of RAI 1.b.i, dated May 2013

4. 1.b.ii.1 Enclosure 1.b.ii-1, Sensitivity of the TVA Reservoir and Power Supply Systems to Extreme Meteorology," Report No. WR28-1-680-111, TVA Engineering Laboratory, Norris, Tennessee, June 1993
5. 1.b.ii.2 Enclosure_1.b.ii-2, River temp, 2007-2013 Excel file containing the SQN daily maximum, 24-hour average upstream ambient river temperature for the from June 2007 through May 2013
6. 1.b.ii.3 Enclosure_1.b.ii-3, SQN NPDES Permit No. TN0026450, expire on 10/31/13 "NPDES Permit No. TN0026450, Authorization to discharge under the NPDES." Tennessee Department of Environment and Conservation, Division of Water Pollution Control, Nashville, Tennessee. January 31, 2011
7. 1.b.ii.4 Enclosure_1.b.ii-4, Potential Impact of Climate Change on Natural Resources in the TVA Region EPRI (2009). "Potential Impact of Climate Change on Natural Resources in the TVA Region." Electric Power Research Institute, Palo Alto, California. November 2009

8. 1.b.iii Enclosure_1.b.iii.xlsx

9. 1.c.i.1 Enclosure_1.c.i-1.pdf, 29p additional information related to the re-entrainment of diffuser effluent
10. 1.c.i.2 Enclosure_1.c.i_2007.xlsx Thermal Discharges data
11. 1.c.i.3 Enclosure_1.c.i_2008.xlsx Thermal Discharges data
12. 1.c.i.4 Enclosure_1.c.i_2009.xlsx Thermal Discharges data
13. 1.c.i.5 Enclosure_1.c.i_2010.xlsx Thermal Discharges data
14. 1.c.i.6 Enclosure_1.c.i_2011.xlsx Thermal Discharges data
15. 1.c.i.7 Enclosure_1.c.i_2012.xlsx Thermal Discharges data
16. 1.c.i.8 Enclosure_1.c.i_2013.xlsx Thermal Discharges data

17. 1.c.ii Enclosure_1.c.ii.xlsx CTLP data

18. 1.c.iii Enclosure_1.c.iii.xlsx CTLP data

19. 1.c.iv.1 Enclosure_1.c.iv_Flow&Stage_2007.xlsx, river flow and reservoir stage
20. 1.c.iv.2 Enclosure_1.c.iv_Flow&Stage_2008.xlsx, river flow and reservoir stage
21. 1.c.iv.3 Enclosure_1.c.iv_Flow&Stage_2009.xlsx, river flow and reservoir stage
22. 1.c.iv.4 Enclosure_1.c.iv_Flow&Stage_2010.xlsx, river flow and reservoir stage
23. 1.c.iv.5 Enclosure_1.c.iv_Flow&Stage_2011.xlsx, river flow and reservoir stage
24. 1.c.iv.6 Enclosure_1.c.iv_Flow&Stage_2012.xlsx, river flow and reservoir stage
25. 1.c.iv.7 Enclosure_1.c.iv_Flow&Stage_2013.xlsx. river flow and reservoir stage
26. 1.c.iv.8 Enclosure_1.c.iv_Temps_2007.xlsx, river temperature
27. 1.c.iv.9 Enclosure_1.c.iv_Temps_2008.xlsx, river temperature
28. 1.c.iv.10 Enclosure_1.c.iv_Temps_2009.xlsx, river temperature
29. 1.c.iv.11 Enclosure_1.c.iv_Temps_2010.xlsx, river temperature
30. 1.c.iv.12 Enclosure_1.c.iv_Temps_2011.xlsx, river temperature
31. 1.c.iv.13 Enclosure_1.c.iv_Temps_2012.xlsx, river temperature
32. 1.c.iv.14 Enclosure_1.c.iv_Temps_2013.xlsx. river temperature

33. 1.c.v.1 Enclosure_1.c.v-1.pdf TVA (2009), "Ambient Temperature and Mixing Zone Studies for SQN as Required by NPDES Permit No. TN0026450 of September 2005," Report No.WR2009-1-45-151, TVA, River Operations, January 2009
34. 1.c.v.2 Enclosure_1.c.v-2.pdf TVA (1990), "The Effect Of SQN On Dissolved Oxygen In Chickamauga Reservoir", Report No. TVA/WR/WQ--90/10, TVA, Resource Development, River Basin Operations, Water Resources, September 1990
35. 1.c.v.3 Enclosure_1.c.v-3.xlsx Excel file containing hourly 10-meter average wind speed and wind direction data from the SQN Environmental Data Station for the period of record from January 2000 through May 2013

36. 1.c.vi Enclosure_1.c.vi-1.pdf TVA. 2009. "Ambient Temperature and Mixing Zone Studies for SQN as Required by NPDES Permit No. TN0026450 of September 2005," WR2009-1-45-151. January 2009

37. 1.c.vii.1 Enclosure_1.c.vii-1_WR28-1-45-100.pdf TVA (1978), "The Natural Thermal Regime of Chickamauga Reservoir in the Vicinity of SQN" Report No. WR28-1-45-100, TVA, Division of Water Management, Water Systems Development Branch, February 1978.
38. 1.c.vii.2 Enclosure_1.c.vii-2_WR28-1-45-101.pdf TVA (1978), "Effect of SQN Discharges on Chickamauga Lake Water Temperatures" Report No. WR28-1-45-101, TVA, Division of Water Management, Water Systems Development Branch, April 1978
39. 1.c.vii.3 Enclosure_1.c.vii-3_WR28-1-45-103.pdf TVA (1979), "Model Study and Analysis of SQN Submerged Multiport Diffuser," Report No. WR28-1-45-103, TVA, Division of Water Management, Water Systems Development Branch, March 1979
40. 1.c.vii.4 Enclosure_1.c.vii-4_WR28-1-45-110.pdf TVA (1982), "A Field Verification of SQN Diffuser Performance Model: One-Unit Operation," Report No. WR28-1-45-110, TVA, Office of Natural Resources, Division of Air and Water Resources, Water Systems Development Branch, October 1982
41. 1.c.vii.5 Enclosure_1.c.vii-5_WR28-1-45-115.pdf TVA (1983), "Validation of Computerized Thermal Compliance and Plume Development at SQN," Report No.WR28-1-45-115, TVA, Office of Natural Resources, Division of Air and Water Resources, Water Systems Development Branch, August 1983
42. 1.c.vii.6 Enclosure_1.c.vii-6_WR28-4-45-125.pdf TVA (1986), "Hydrothermal Aspects Of Chickamauga Reservoir," Report No.WR28-4-45-125, TVA, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Engineering Laboratory, November 1986
43. 1.c.vii.7 Enclosure_1.c.vii-7_WR28-1-45-128.pdf TVA (1987), "SQN Historical Thermal Evaluation," Report No. WR28-1-45-128, TVA, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Engineering Laboratory, March 1983
44. 1.c.vii.8 Enclosure_1.c.vii-8_WR28-3-45-134.pdf TVA (1987), "Quality Program For Verification Of SQN Thermal Computed Compliance System," Report No. WR28-3-45-134, TVA, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Engineering Laboratory, September 1987
45. 1.c.vii.9 Enclosure_1.c.vii-9_WR28-2-45-135.pdf TVA (1987), "SQN," Report No. WR28-2-45-135, TVA, Office of Natural Resources and Economic Development, Division of Air and Water Resources, Engineering Laboratory, September 1987
46. 1.c.vii.10 Enclosure_1.c.vii-10_WR28-1-45-136.pdf TVA (1988), "The Effect of SQN on Temperature and Dissolved Oxygen in Chickamauga Reservoir During Summer 1988," Report No. WR28-1-45-136, TVA, Engineering Laboratory, October 1987
47. 1.c.vii.11 Enclosure_1.c.vii-11_TVA-WR-AB--89-11.pdf TVA (1989), "A Predictive Section 316(a) Demonstration for an Alternative Winter Thermal Discharge Limit for SQN, Chickamauga Reservoir, Tennessee," Report No. TVA/WR/AB--89/11, TVA, Resource Development, Nuclear Power, August 1989
48. 1.c.vii.12 Enclosure_1.c.vii-12_TVA-WR-WQ--980-10.pdf TVA (1990), "The Effect of SQN on Dissolved Oxygen in Chickamauga Reservoir," Report No. TVA/WR/WQ--980/10, TVA, Resource Development, River Basins Operations, September 1990

49. 1.c.vii.13 Enclosure_1.c.vii-13_WR96-1-45-145.pdf TVA (1996), "A Supplemental 316(a) Demonstration For Alternative Thermal Discharge Limits For SQN, Chickamauga Reservoir, Tennessee," Report No. WR96-1-45-145, TVA, Resource Group, Engineering Services, Engineering Laboratory, December 1996
50. 1.c.vii.14 Enclosure_1.c.vii-14_WR2003-1-45-149.pdf TVA (2003), "Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from SQN as Required by NPDES Permit No. TN0026450 of August 2001 (DRAFT)," TVA, River Systems Operations & Environment, River Operations, June 2003
51. 1.c.vii.15 Enclosure_1.c.vii-15_WR2009-1-45-150.pdf TVA (2009), "Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from SQN as Required by NPDES Permit No. TN0026450 of September 2005" Report No. WR2009-1-45-150, TVA, River Operations, January 2009
52. 1.c.vii.16 Enclosure_1.c.vii-16_WR2009-1-45-151.pdf TVA (2009), "Ambient Temperature and Mixing Zone Studies for SQN as Required by NPDES Permit No. TN0026450 of September 2005," Report No. WR2009-1-45-151, TVA, River Operations, January 2009. *(Same as Enclosure_1.c.vi-1.pdf provided in TVA response to RAI 1.c.vi)*
53. 1.c.vii.17 Enclosure_1.c.vii-17_WR2009-1-45-152.pdf TVA (2013), "Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from SQN as Required by NPDES Permit No. TN0026450 of September 2011," Report No. WR2009-1-45-152, TVA, River Operations, April 2013. *(Same as Enclosure_1.b.i-1.pdf provided in TVA response to RAI 1.b.i)*
54. 1.c.vii.18 Enclosure_1.c.vii-18.xlsx Excel file containing velocity measurements recorded at nine locations on July 30-31, 2003

55. 1.c.viii.1 Enclosure_1.c.viii-1.pdf TDEC (2011), NPDES Permit No. TN0026450, TVA—Sequoyah Nuclear Plant, Soddy Daisy, Hamilton County, Tennessee, effective March 1, 2011, Tennessee Department of Environment and Conservation, issuance date January 31, 2011.
56. 1.c.viii.2 Enclosure_1.c.viii-2.pdf Study to Confirm the Calibration of the Numerical Model for the Thermal Discharge from Sequoyah Nuclear Plant as Required by NPDES Permit No. TN0026450 of September 2005.

57. 1.d.i Chickamauga TRM 490.5 Physical-Chemical Water Quality Results and Summary 2000-2011

58. 1.e.iii.2.1 SQN Annual Water Withdrawal Updates for 2008, Jan to June, 193p
59. 1.e.iii.2.1.a SQN Annual Water Withdrawal Updates for 2008, July to Dec, 187p
60. 1.e.iii.2.2 SQN Annual Water Withdrawal Updates for 2009, Jan to June, 299p
61. 1.e.iii.2.3 SQN Annual Water Withdrawal Updates for 2009, July to Dec, 202p
62. 1.e.iii.2.4 SQN Annual Water Withdrawal Updates for 2010, Jan to June, 226p
63. 1.e.iii.2.5 SQN Annual Water Withdrawal Updates for 2010, July to Dec, 204p
64. 1.e.iii.2.6 SQN Annual Water Withdrawal Updates for 2011, Jan to June, 175p

65. 1.e.iii.2.7 SQN Annual Water Withdrawal Updates for 2011, July to Dec, 176p
66. 1.e.iii.2.8 SQN Annual Water Withdrawal Updates for 2012, Jan to June, 176p
67. 1.e.iii.2.9 SQN Annual Water Withdrawal Updates for 2012, July to Dec, 164p
68. 1.e.iii.2.10 SQN Annual Water Withdrawal Updates for 2013, Jan to Feb, 20p

69. 1.e.iii.3 May 21, 2009 letter from SQN to TDEC documenting Required Actions from the March 30, 2009 Division of Solid Waste Management Compliance Evaluation Inspection

70. 4.c TVA Regional Natural Heritage database Element Occurrence Report, April 10, 2013, 176p [Environmentally Sensitive]

71. 4.g.i Dinkins, G. R. 2008. Survey for Federally Protected Mussels
72. 4.g.ii LEC (Lewis Environmental Consulting, LLC). 2008. Baseline Mussel Monitoring
73. 4.g.iii MCD (Mainstream Commercial Divers, Inc.). 2006. Mussel Survey
74. 4.g.iv Third Rock (Third Rock Consultants, LLC). 2010a. Mollusk Survey
75. 4.g.v Third Rock. 2010b. Draft Report: Mollusk and Habitat Survey
76. 4.g.vi Third Rock. 2010c. Phase 1A and 1B Mussel Survey Results
77. 4.g.vii TVA. 1979. Recent Mollusk Investigations on the Tennessee River

78. 5.a.i. Record of Terrestrial Zoology Resources and Active Nests Identified March 27, 2013 Within 6 Miles of SQN; aerial and topographical views

79. 5.c.i Tennessee Valley Authority Division of FFWD. Forestry Bulletin 143, 24p
80. 5.c.ii Henry, T. H. 2011a. Results of the Tennessee River Valley Shorebird Initiative, 150p
81. 5.c.iii TVA. 1974a. Final Environmental Statement, previously docketed, 764p
82. 5.c.iv TVA. 1974b. Cooling Tower Contract M02712_0044459421, 9p

83. 6.a.i.1 SQN GHG Summary.xlsx, a summary of GHG emissions at the SQN location
84. 6.a.i.2 TVA – SQN – Annual GHG Data Report v3-2 – Final – 04-02-13.xlsx, detailed GHG emissions and the sources
85. 6.a.i.3 Refrigerant Sources.pdf, lists potential sources of GHG emissions due to refrigerant leaks.

86. 6.a.ii.2a SQN Air Emissions 5-Year Summary, 4p
87. 6.a.ii.2b SQN Air Emissions 5-Year Summary, HAP emissions from permitted engines, 4p
88. 6.a.ii.3 SQN Air Quality Permit, Expire on.7-17-2017.pdf, 36p
89. 6.a.ii.4 SQN Annual Air Inspection Report 2007.pdf, 35p
90. 6.a.ii.5 SQN Annual Air Inspection Report 2008.pdf, 35p
91. 6.a.ii.6 SQN Annual Air Inspection Report 2009.pdf
92. 6.a.ii.7 SQN Annual Air Inspection Report 2010 .pdf

93. 6.a.ii.8 SQN Annual Air Inspection Report 2011 .pdf
94. 6.a.ii.9 SQN Hours of Operation Annual Air Report 2007.pdf
95. 6.a.ii.10 SQN Hours of Operation Annual Air Report 2008.pdf
96. 6.a.ii.11 SQN Hours of Operation Annual Air Report 2009.pdf
97. 6.a.ii.12 SQN Hours of Operation Annual Air Report 2010.pdf
98. 6.a.ii.13 SQN Hours of Operation Annual Air Report 2011.pdf
99. 6.a.ii.14 SQN Hours of Operation Annual Air Report 2012.pdf, 5p
100. 6.a.ii.15 SQN 2007 TRI Report.pdf, 23p
101. 6.a.ii.16 SQN 2008 TRI Report.pdf, 12p
102. 6.a.ii.17 SQN 2009 TRI Report.pdf, 12p
103. 6.a.ii.18 SQN 2010 TRI Report.pdf, 9p
104. 6.a.ii.19 SQN 2011 TRI Report.pdf, 9p
105. 6.a.ii.20 SQN CY11 TRI Releases.pdf, 9p

106. 6.a.iii.1 SQN Fukushima Diesel Generator Air Emissions.xlsx
107. 6.a.iii.1.a SQN Fukushima DG, diesel pumps/tow truck list, docketed letter, 6p
108. 6.a.iii.2 Fukushima EA.pdf, 63p

109. 6.a.iv.1 Mean Temps 2008-2012.pdf, mean monthly and annual temperatures
110. 6.a.iv.2 Mean Precip 2008-2012.pdf, mean monthly precipitation and annual precipitation
111. 6.a.iv.3.1 SQN-winds.docx
112. 6.a.iv.3.2 SQN-Wind_Summary.xlsx
113. 6.a.iv.3.3 SQN_2008-2012_5yr(q).docx
114. 6.a.iv.3.4 SQN_2008-2012_5yr(q).pdf
115. 6.a.iv.3.5 SQN_2008.docx and SQN_2008.pdf
116. 6.a.iv.3.6 SQN_2009.docx and SQN_2009.pdf
117. 6.a.iv.3.7 SQN_2010.docx and SQN_2010.pdf
118. 6.a.iv.3.8 SQN_2011.docx and SQN_2011.pdf
119. 6.a.iv.3.9 SQN_2012.docx and SQN_2012/pdf
120. 6.a.iv.3.10 SQN_TERRAIN.pptx
121. 6.a.iv.3.11 SQN_Met_2008-2012.xlsx