Tennessee Valley Authority, 1101 Market Street, BR4A, Chattanooga, Tennessee 37402

August 22, 2012

Mr. Vojin Janjić
Manager, Permit Section
Division of Water Pollution Control
Tennessee Department of Environment
and Conservation
6th Floor, L&C Annex
401 Church Street
Nashville, Tennessee 37243

Dear Mr. Janjić:

TENNESSEE VALLEY AUTHORITY (TVA) – SEQUOYAH NUCLEAR PLANT (SQN) – NPDES PERMIT NO. TN0026450 – REVISED ALTERNATIVE THERMAL LIMIT (ATL) STUDY PLAN

As committed in a letter to the division dated July 19, 2012, enclosed is SQN's revised ATL study plan. The revised plan reflects the previously proposed change to conduct biological monitoring at SQN once per permit cycle during the summer months and annually during the autumn months to assess the aquatic community. TVA believes this approach is the most efficient use of resources and will provide TDEC with the data necessary for continued support of SQN's permitted winter ATL under Section 316(a) of the Clean Water Act.

TVA requests the division's review and comments, if necessary, on the revised study plan that will be followed for the duration of SQN's permit cycle. If you have questions or need additional information, please contact Travis Markum by email at trmarkum@tva.gov or at (423) 751-2795 in Chattanooga.

Sincerely,

Cynthia M. Anderson

Cynthia M. Anderson
Senior Manager
Water and Waste Compliance

Enclosure

C001
NRR

Enclosure
cc: Dr. Richard Urban
Manager, Chattanooga Environmental Field Office
Division of Water Pollution Control
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540 McCallie Avenue
Chattanooga, Tennessee 37402-2013

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555

Study Plan for Evaluation of the TVA Sequoyah Nuclear Plant Discharge in Support of an Alternate Thermal Limit

Soddy Daisy, Hamilton County, Tennessee

Tennessee Valley Authority

June 8, 2011

Revised on August 3, 2012

TABLE OF CONTENTS

LIST OF FIGURES

EXECUTIVE SUMMARY

This document sets forth a revised Study Plan, which the Tennessee Valley Authority (TVA) plans to implement for the purpose of evaluating the Sequoyah Nuclear Plant (SQN) thermal discharge in support of compliance with the National Pollutant Discharge Elimination System (NPDES) permit for the facility and continuance of the associated Alternate Thermal Limit (ATL) for Outfall 101 as authorized under Section 316(a) of Clean Water Act and Tennessee Department of Environment and Conservation rules.

As required by the NPDES permit, the Study Plan was first submitted to the Tennessee Department of Environment and Conservation (TDEC) on December 20, 2010 and subject to review by TDEC and the U. S. Environmental Protection Agency (EPA), Region 4. Comments and suggested revisions were provided to TVA by TDEC in a meeting held on April 7, 2011 and have been incorporated herein.

The Study Plan provides regulatory background for the work; information about SQN operations; a brief description of the receiving waterbody; a summary of previous §316(a) and more recent monitoring studies conducted at the plant; and a detailed Scope of Work proposing the collection of new data to evaluate the potential impact of the Sequoyah Nuclear thermal discharge on the aquatic life and other classified uses of the Tennessee River/Chickamauga Reservoir in the vicinity of the plant. Specifically, studies are proposed to:

1. Collect the temperature data needed to delineate and map the spatial boundaries of the thermal discharge plume;

2. Characterize the aquatic and wildlife habitat in the study area;

3. Sample the fish, macroinvertebrate, and plankton communities;

4. Survey potentially affected wildlife;

5. Evaluate maintenance of a balanced indigenous population (BIP) by performing traditional and multi-metric analyses of collected data, as appropriate; and

6. Evaluate the reasonable potential for impairment of non-aquatic life uses of the receiving waterbody as they relate to the thermal discharge.

Field sampling activities are scheduled to begin in the summer and autumn of 2011. Resultant information will be used to support renewal of the facility's NPDES permit set to expire October 31, 2013.

1.0 INTRODUCTION

This document sets forth a revised Study Plan, which the Tennessee Valley Authority (TVA) plans to implement for the purpose of evaluating the Sequoyah Nuclear Plant (SQN) thermal discharge in support of compliance with the National Pollutant Discharge Elimination System (NPDES) permit for the facility (NPDES Permit No.: TN0026450). The Study Plan includes a review and discussion of applicable regulatory requirements for the thermal discharge and presents specific work elements for the re-verification of the existing Alternate Thermal Limit (ATL) for Outfall 101 in accordance with Clean Water Act (CWA) Section (§) 316(a). As required by the NPDES permit, the Study Plan was first submitted to the Tennessee Department of Environment and Conservation (TDEC) on December 20, 2010 and subject to review by TDEC and the U. S. Environmental Protection Agency (EPA), Region 4. Comments and suggested revisions were provided to TVA by TDEC in a meeting held on April 7, 2011 and have been incorporated herein.

1.1 Facility Information

Unit 1 and 2 were placed in operation in 1981 and 1982, respectively. Both units can produce more than 2,400 megawatts of electricity. SQN is located on the right descending bank of the Tennessee River (Chickamauga Reservoir) near Chattanooga, Tennessee (Figure 1). The facility withdraws cooling water from Chickamauga Reservoir via an intake channel and skimmer wall at river mile (TRM) 484.8. The cooling water intake structure (supporting six circulator pumps) provides the units a nominal flow of 1.11 x 10^6 gallons per minute (gpm) or 1,602 million gallons per day (mgd). The facility employs a once-through (open cycle) condenser cooling water system and can also operate with cooling towers in helper mode. The plant discharges heated effluent to Chickamauga Reservoir via Outfall 101 located at TRM 483.6 as authorized by the NPDES permit (Figure 2).

1.2 Regulatory Basis

1.2.1 Applicable Thermal Criteria

TDEC has specified "use classifications" for the state's surface waters and developed temperature criteria intended to support those uses (TDEC Rule 1200-4-4 and 1200-4-3-.03, respectively). The Tennessee River at the location of SQN has been classified for the following uses: Municipal, Industrial, and Domestic Water Supply, Industrial Water Supply, Fish and Aquatic Life, Recreation, Irrigation, Livestock Watering and Wildlife, and Navigation. Except for Irrigation and Livestock Watering and Wildlife (qualitative criteria), temperature criteria relevant to warm-water conditions of the Tennessee River at SQN specify that:

"The maximum water temperature change shall not exceed 3°C [5.4°F] *relative to an upstream control point. The temperature of the water shall not exceed 30.5°C* [86.9°F] *and the maximum*

rate of change shall not exceed 2°C [3.6°F] *per hour. The temperature of impoundments where stratification occurs will be measured at a depth of 5 feet, or mid-depth whichever is less, and the temperature in flowing streams shall be measured at mid-depth."* [Rule 1200-4-3-.03]

The SQN plant's "once-through" cooling water system design utilizing cooling towers in helper mode provides for the most thermodynamically efficient method of generating electricity and as a result produces a heated discharge. As such, the thermal discharge typically exceeds TDEC's established temperature criteria, therefore, multiport diffusers with mixing zone are used to adequately mix the thermal effluent to meet the state water quality standard at the end of the mixing zone. In such cases, the TDEC rules specific to the Fish and Aquatic Life use classification provide that:

"*A successful demonstration as determined by the state conducted for thermal discharge limitations under Section 316(a) of the Clean Water Act, (33 U.S.C. §1326), shall constitute compliance...* [with the temperature criteria]."

TVA has previously made such successful demonstration for the SQN thermal discharge in support of mixing zone criteria as further discussed below.

1.2.2 Permitted Conditions

Currently permitted thermal discharge limitations for SQN specify that the daily maximum temperature is not to exceed 30.5°C (86.9°F) at the end of the mixing zone (Page 1 of 28), NPDES permit TN0026450). This mixing zone criteria are based on a previous demonstration by TVA, in accordance with CWA §316(a) and TDEC Rule 1200-4-3-.03 noted above, that a balanced indigenous population (BIP) of fish, shellfish, and wildlife is supported in the Tennessee River potentially affected by the thermal discharge. The mixing zone criteria, as supported by the biological studies, also encompass other components of the TDEC temperature criteria, specifically the change in temperature from ambient/upstream conditions and rate of change in temperature. SQN has maintained a good compliance record with its mixing zone criteria throughout each NPDES permit term since first authorized in the late-1980s; ongoing biological monitoring has consistently demonstrated the mixing zone criteria are protective of aquatic communities in the river near the facility.

1.2.3 Criteria for Alternate Thermal Limits Under §316(a)

The regulatory provisions that implement CWA §316(a) provide limited guidance on precisely what the demonstration study must contain to be considered adequate and do not identify precise criteria against which to measure whether a "*balanced and indigenous*" aquatic community is protected and maintained. Instead, the regulations provide broad guidelines.

Under the broad regulatory guidelines, the discharger must show that the ATL desired, "*considering the cumulative impact of its thermal discharge together with all other significant impacts on the species affected,*" will "*assure the protection and propagation of a balanced, indigenous community of shellfish, fish and wildlife in and on the body of water into which the* *discharge is to be made* (40 CFR §125.73). Critical to the demonstration is the meaning of the term "balanced indigenous community". The rules provide the following definition:

> "The term "*balanced indigenous community*" is synonymous with the term balanced, indigenous population (i.e., BIP) in the Act and means a biotic community typically characterized by diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species and by a lack of domination by pollution tolerant species. Such a community may include historically non-native species introduced in connection with a program of wildlife management and species whose presence or abundance results from substantial, irreversible environmental modifications" (40 CFR §125.73).

Pursuant to this regulatory definition, a successful demonstration must show that under the desired ATL, and in light of the cumulative impact of the thermal discharge together with all other significant impacts on the species affected, the following characteristics, which are indicative of a BIP, will continue to exist: (1) diversity, (2) the capacity of the community to sustain itself through cyclic seasonal changes, (3) presence of necessary food chain species, and (4) a lack of domination by pollution tolerant species.

There are several methodologies a discharger may pursue in making a §316(a) demonstration. Under the regulations, <u>new dischargers</u> must use predictive methods (e.g., laboratory studies, literature surveys, or modeling) to estimate an appropriate ATL that will assure the protection and propagation of a balanced, indigenous community prior to commencing the thermal discharge. However, <u>existing dischargers</u>, such as SQN, need not use predictive methods. For such dischargers, §316(a) demonstrations may be based upon the "*absence of prior appreciable harm*" to a balanced, indigenous community (see 40 CFR §125.73(c)(1)(i) and (ii)). Such demonstrations must show <u>either</u> that:

i) No appreciable harm has resulted from the thermal component of the discharge taking into account the interaction of such thermal component with other pollutants and the additive effect of other thermal sources to a balanced, indigenous community of shellfish, fish, and wildlife in and on the body of water into which the discharge has been made; <u>or</u>

ii) Despite the occurrence of such previous harm, the desired alternative effluent limitations (or appropriate modifications thereof) will nevertheless assure the protection and propagation of a balanced, indigenous community of shellfish, fish, and wildlife in and on the body of water into which the discharge is made.

Furthermore, in determining whether or not prior appreciable harm has occurred, the regulations provide that the permitting agency consider the length of time during which the applicant has been discharging and the nature of the discharge. The regulations do not define "*prior appreciable harm.*" However, using the definition of "balanced, indigenous community," mixing zone criteria are generally granted under either of the following circumstances:

1. When a discharger shows that the characteristics of a BIP (i.e., diversity, the capacity to sustain itself through cyclic seasonal changes, presence of necessary food chain species, and a lack of domination by pollution tolerant species) exist. Stated another way, the existence of such characteristics essentially prove that the aquatic community has not been appreciably harmed; or

2. Despite any evidence of previous harm, the characteristics of a BIP, as stated above, will nevertheless be protected and assured under the alternate limit.

1.2.4 Mixing Zone Requirements in Tennessee Rule 1200-4-3-0.5

As noted above, §316(a) pertains to the Fish and Aquatic Life use classification and provides NPDES-permitted facilities a regulatory compliant means of demonstrating that promulgated temperature criteria may be more stringent than necessary to support a BIP. In such cases, less stringent thermal criteria (i.e., ATLs) are justified. However, other use classifications such as Domestic Water Supply and Recreation must be protected as well. Compliance with TDEC temperature criteria for these uses is typically determined after the discharge has had the opportunity to mix with the receiving water; that is, an allowable mixing zone is determined.

TDEC rules define the mixing zone as:

"*That section of a flowing stream or impounded waters in the immediate vicinity of an outfall where an effluent becomes dispersed and mixed.*" [1200-4-3-.04(8)]

The rules [1200-4-3-.05(2)] further provide that mixing zones are to be restricted in area and length and not:

1. prevent the free passage of fish or cause aquatic life mortality in the receiving waters;
2. contain materials in concentrations that exceed acute criteria beyond the zone immediately surrounding the outfall;
3. result in offensive conditions;
4. produce undesirable aquatic life or result in dominance of a nuisance species;
5. endanger the public health or welfare; or
6. adversely affect the reasonable and necessary uses of the area;
7. create a condition of chronic toxicity beyond the edge of the mixing zone;
8. adversely affect nursery and spawning areas; or
9. adversely affect species with special state or federal status.

While TVA's proposed §316(a) demonstration study plan fully examines the effects of the thermal discharge on the aquatic life components of the mixing zone requirements, the potential effects to other non-aquatic life use classifications (items 3, 5, and 6 above) are generally not evaluated. Therefore, this plan has been revised herein to incorporate and/or collect additional information needed to address the reasonable potential for impairment of other non-aquatic life uses in the Tennessee River near the facility.

1.3 Study Plan Organization

This Study Plan is organized into the following sections:

1. Introductory information, including regulatory basis and rationale for the study;
2. Background information, including a summary of the findings of the previous §316(a) investigation and subsequent biological monitoring; and,
3. The proposed design and implementation schedule for the SQN §316(a) demonstration Study Plan.

2.0 STUDY BACKGROUND

2.1 Sequoyah Nuclear Plant

The SQN facility is operated to produce base-load electric power throughout the year. When operating at design (nameplate) capacity (2,400 MW), the units requires approximately 1,602 million gallons per day of condenser cooling water. Waste heat increases the temperature of the cooling water by approximately 16.4°C (29.5°F) before it is discharged into the river. The actual condenser flow, and hence the ΔT, may vary somewhat with the circulating water pump head and the condenser efficiency.

2.2 Description of the Receiving Waterbody

Sequoyah Nuclear is located on the right descending bank of Chickamauga Reservoir (TRM 484.5) approximately 18 miles northeast of Chattanooga, Tennessee, and 7 miles southwest of Soddy-Daisy, Tennessee (Figure 1). Chickamauga Reservoir was impounded in 1940 and at full pool covers approximately 36,240 acres.

The topography of the reservoir in the vicinity of the discharge outlet consists of a shallow overbank area on the plant side which extends from TRM 484 downstream to TRM 481.8 and varies in depth from 2 to 20 ft and from 500 to 3,100 ft in width. This shallow area is bordered by a main river channel which is about 900 feet (ft) wide and approximately 60 ft deep. Along this reach there are several small, shallow embayments.

The Tennessee River flow in the vicinity of SQN is controlled by releases from Watts Bar and Chickamauga Dams, and to a lesser extent Hiwassee River. SQN is situated on Chickamauga Reservoir approximately 54.5 river miles downstream from Watts Bar Dam and 13.5 river miles upstream from Chickamauga Dam.

2.3 Previous §316(a) Demonstration Study

TVA conducted comprehensive §316(a) demonstration-related studies of the SQN thermal effluent in the mid-1980s to support establishment of the current mixing zone criteria for the plant discharge (TVA, 1989). The minimum average daily flow for the Tennessee River near SQN at the time of the early studies was 6,000 cfs.

The mid-1980s studies included extensive sampling of the aquatic community including:

- Phytoplankton,
- Periphyton,
- Aquatic macrophytes,
- Zooplankton,
- Benthic macroinvertebrates; and
- Fish populations.

Hydrothermal, water quality and other parameters also were evaluated.

Major findings of these studies included:

- Average dissolved concentration in the water column was similar immediately upstream and downstream of SQN.

- Analysis of the data indicate that the assemblages of phytoplankton, zooplankton, and macroinvertebrates were diverse and, in general, relatively abundant.

- Dominance of blue-green algae was similar upstream and downstream of SQN.

- The phytoplankton and zooplankton communities were found to be similar, or if different, not impacted by SQN operation, at all stations during 20 of the 27 survey months when the plant was in operation.

- Species richness in the benthic macroinvertebrate communities during pre-operational and operational monitoring was similar.

- No changes were documented in the aquatic macrophyte community that reflected effects of the thermal effluent.

- Fish species occurrence and abundance data indicated insignificant impacts. Avoidances of the plume could not be detected for any species of fish. One study found that sauger (*Sander canadensis*) were not concentrated in the thermal plume during winter months nor inhibited from movement past SQN. Results of gonadal inspections indicate that the heated discharge did not adversely affect fish reproduction.

- Other fisheries studies indicated that the thermal discharge resulted in no discernible increase in parasitism.

- No mortalities of threadfin shad due to cold shock following shutdown of SQN were observed or reported, and none are anticipated to occur in the future.

2.4 Contemporary Studies

Monitoring of the thermal effects of the SQN discharge on the aquatic community of the receiving waterbody has been more recently conducted by TVA after an agreement was reached with TDEC in 2001. TVA's "Vital Signs" monitoring program also provides useful information for evaluating reservoir-wide effects. Monitoring has included sampling of the fish and macroinvertebrate communities and associated collection of temperature and other water quality parameters. Results of the permit monitoring work and TVA's ongoing Vital Signs monitoring (TVA, 2011) have consistently demonstrated that fish and macroinvertebrate assemblages of Chickamauga Reservoir within and downstream of the SQN thermal discharge are similar to those of upstream locations, as well as to established mainstem reservoir reference conditions for the area.

Results of the above studies notwithstanding, TVA plans to implement this Study Plan for the purpose of further evaluating the SQN thermal discharge to support continuance of the ATL for the facility discharge in accordance with CWA §316(a) and TDEC Rule 1200-4-3-.03(e).

3.0 STUDY PLAN

This §316(a) demonstration Study Plan is informed by communications with TDEC and EPA, the study design of the previous demonstration study, and TVA's ongoing river/reservoir biological monitoring programs.

3.1 Study Timing

As reasonably practicable, TVA sampling crews will coordinate with SQN facility operations staff to schedule field studies to coincide with representative conditions of maximum generation for the time period to be sampled as dictated by seasonal power demand. The additional field studies will be conducted during the period of critical environmental (thermal) conditions in summer (mid-July – August) when plant operations and ambient reservoir temperatures are at expected seasonal maximums. Summer monitoring will be conducted once during the SQN permit cycle. Data collection during this period will focus on characterization/delineation of the thermal plume and biological field investigations inclusive of thermally affected and unaffected areas. TVA will also conduct monitoring in autumn (October – mid-December) annually as has been occurring in previous study years.

3.2 Study Scope

The following tasks will be conducted for the SQN §316(a) demonstration Study:

Task 1 – Evaluate Plant Operating Conditions

During the course of the study, SQN operational data will be recorded, compiled, and analyzed to assist in the interpretation of thermal plume characteristics and biological community information. Available historical operational data will also be compiled and analyzed to evaluate and identify any material changes in SQN operations over the most recent 5-year period that might affect the thermal plume characteristics. Parameters to be recorded during the proposed study and evaluated historically include, but are not limited to:

- Cooling water intake flow and water temperature;
- Discharge flow and water temperature; and
- Power generation statistics.

The data will be presented in tabular and graphical formats to describe SQN operational conditions during the current study.

Task 2 – Thermal Plume Monitoring and Mapping

Physical measurements will be taken to characterize and map the SQN thermal plume concurrent with biological field sampling during the sampling events. In this manner, it is expected that the plume will be characterized under representative thermal maxima and seasonally-expected low flow conditions. Measurements will be collected during periods of high power production from SQN, as reasonably practicable, to capture maximum extent of the thermal plume under existing river flow/reservoir elevation conditions. This effort will allow general delineation of the "Primary Study Area" per the EPA (1977) draft guidance defined as the: "*entire geographic area bounded annually by the locus of the 2°C above ambient surface isotherms as these isotherms are distributed throughout an annual period*"); ensure placement of the biological sampling locations within thermally influenced areas; and inform the evaluation of potential impacts on recreation and water supply uses.

However, it is important to emphasize that the ≥2°C isopleth boundary is not a bright line; it is dynamic, changing geometrically in response to changes in ambient river flows and temperatures and SQN operations. As such, samples collected outside of, but generally proximate to the Primary Study Area boundary should not be discounted as non-thermally influenced. Every effort will be made to collect biological samples in thermally affected areas as guided by the Primary Study Area definition.

Field activities will include measurement of surface to bottom temperature profiles along transects across the plume. One transect will be located proximate to the thermal discharge point; subsequent downstream transects will be concentrated in the near field area of the plume where the change in plume temperature is expected to be most rapid. The distance between transects in the remainder of the Primary Study Area will increase with distance downstream or away from the discharge point. The farthest downstream transect will be just outside of the Primary Study Area. A transect upstream of the discharge that is not affected by the thermal plume will be included for determining ambient temperature conditions. The total number of transects needed to fully characterize and delineate the plume will be determined in the field.

Temperature profile measurement (surface to bottom) points along a given transect will begin at or near the shoreline from which the discharge originates and continue across the plume until ambient background temperature conditions (based on surface (0.1 meters (m)/0.3 ft depth) measurements) or the far shore is reached. The number of measurement points along transects will generally be proportional to the width of the plume and the magnitude of the temperature change across a given transect. The distances between transects and measurement points will depend on the size of the discharge plume.

The temperature measurement instrument (Hydrolab® or equivalent) will be calibrated to a thermometer whose calibration is traceable to the National Institute of Standards and Technology.

Temperature data will be compiled and analyzed to present the horizontal and vertical dimensions of the SQN thermal plume using spatial analysis techniques to yield plume cross-sections, which can be used to demonstrate the existence of a zone of passage under and/or around the plume.

Task 3 – Establishment of Biological Sampling Stations

Water temperature data from Task 2 will define the relationships between the biological sampling zone and thermally affected areas as informed by the EPA (1977) draft guidance, which identifies the Primary Study Area as having water temperatures of >2°C (3.6°F) above ambient temperature. The thermally affected sampling location will be referred to as the "downstream zone;" the non-thermally-affected sampling location will be referred to as the "upstream zone." If it is determined, based on the plume temperature measurements/mapping that the currently used biological sampling zone downstream of SQN is not fully within the EPA guidance-defined Primary Study Area, that sampling zone will be re-established within the EPA Primary Study Area.

Figure 3 depicts the downstream biological sampling zone; Figure 4 includes the location of the ambient biological sampling zone upstream of SQN.

Task 4 – Shoreline and River Bottom Habitat Characterization

Informed by the results of Tasks 2 and 3, habitat characterization will be conducted at each selected sampling location to evaluate potential for bias in the results due to habitat differences between the thermally affected area and the ambient sampling locations, and to support interpretation of the biological data. Eight line-of-sight transects will be established across the width of Chickamauga Reservoir downstream and upstream of SQN to assess the quality of shoreline habitat (Figure 5). An integrative multi-metric index (Shoreline Aquatic Habitat Index or SAHI), including several habitat parameters important to resident fish species, will be used to measure the existing fish habitat quality. Using the SAHI, individual metrics are scored through comparison of observed conditions with reference conditions and assigned a corresponding value.

River bottom habitat characterization for both the upstream and downstream study zones will consist of eight transects each collected perpendicular to the shoreline. Each transect will evaluate substrate by collecting 10 equally spaced Ponar® dredge samples across the width of the reservoir. Each sample will be visually estimated to define substrate and then sieved to define percent makeup of substrate. At each sample location, depth, and sediment type encountered will be recorded. Sediment categories include bedrock, boulder, cobble, gravel, sand, fines, and detritus. Each site will be assigned one of three habitat categories to reduce the amount of assessment variability. Habitat categories are as follows: A) areas with presence of large substrates such as cobble and boulders, B) areas dominated by sand or fine substrates and C) areas with a presence of a mixture of both A and B (small and large) habitat types.

Task 5 – Supporting Water Quality Measurements

In addition to the thermal plume measurements, additional water quality profiles will be collected as necessary in conjunction with the field studies to: (i) support interpretation of the biological data; and (ii) evaluate potential impacts to water supply and recreational uses. Using a Hydrolab®, or equivalent unit, three water column profiles at one-meter increments will be collected near the left descending bank, right descending bank and mid-channel at the upstream and downstream ends of each sample zone, and other areas as needed (e.g., at water supply intakes). Each profile collected will include temperature, dissolved oxygen concentration, pH, and conductivity.

Task 6 – Biological Evaluations

The biological evaluations will focus on major representative species of the aquatic and wildlife community that could potentially be affected by the SQN thermal discharge. Sampling will be conducted during the summer months (mid-July – August) once during the SQN permit cycle to evaluate "worst case" conditions. Autumn monitoring (October – mid-December) will be conducted annually as a measure of potential manifested effects to the aquatic community from summer-long exposure to the thermal discharge and other stressors (basis for existing multi-metric assessments).

The biological communities to be sampled and collection methodologies are provided in the following sections.

Reservoir Fish Community Monitoring

Informed by the habitat characterization and temperature measurements, the fish community will be sampled during sample events at two locations: downstream within the thermal influence of the power plant (Figure 3); and upstream and beyond thermal influence of SQN (centered at TRM 489.5) (Figure 4). Sampling will be conducted by boat electrofishing and gill netting (Hubert 1996; Reynolds, 1996).

The electrofishing methodology is based on existing monitoring programs and consists of 15 shoreline-oriented boat electrofishing runs in the upstream sampling zone and 15 shoreline runs in the downstream zone. Each run is 300 m (984 ft) long and electrofishing is conducted for a duration of approximately 15 minutes each. The total near-shore linear area sampled will be approximately 4,500 m (15,000 ft) per zone (Jennings, et al., 1995; Hickman and McDonough, 1996; McDonough and Hickman, 1999). Should the size of the SQN thermal plume (i.e., Primary Study Area) be too small to allow collection of all replicate electrofishing runs, the needed remaining replicate runs will be conducted as close as practicable to the Primary Study Area and be identified in the data analyses. As indicated previously, the $\geq 2^{o}C$ isopleth boundary that defines the Primary Study Area is not a rigid boundary; rather, its geometry changes in response to ambient river flows and temperatures and SQN operations (discharge flow). As such, samples collected outside of, but generally proximate to the Primary Study Area boundary should not be discounted as non-thermally influenced.

Experimental gill nets (so called because of their use for research as opposed to commercial fishing) are used as an additional gear type to collect fish from deeper habitats not effectively sampled by electrofishing. Each experimental gill net consists of five-6.1 m (20 ft) panels for a total length of 30.5 m (100 ft). The distinguishing characteristic of experimental gill nets is mesh size that varies between panels. For this application, each net has panels with mesh sizes of 2.5 (1 inch (in)), 5.1 (2 in), 7.6 (3 in), 10.2 (4 in), and 12.7 (5 in) centimeters (cm). Experimental gill nets are typically set perpendicular to river flow extending from near-shore to the main channel of the reservoir. Ten overnight experimental gill net sets will be used at each area.

Fish collected will be identified by species, counted, and examined for anomalies (such as disease, deformities, or hybridization).

Reservoir Benthic Macroinvertebrate Community Monitoring

Benthic macroinvertebrates will be sampled with benthic grab samplers at ten equally-spaced points along the upstream (ambient) and downstream (mid-plume) sampling zones (Figures 3 and 4). A Ponar® sampler (area per sample 0.06 m^2) will be used for most samples. When heavier substrates are encountered, a Peterson sampler (area per sample 0.11 m^2) will be used. Bottom sediments will be washed on a 533 micron (μ) screen; organisms will be picked from the screen and from any remaining substrate. Organisms will be sent to an independent laboratory for identification to the lowest practicable taxonomic level.

Reservoir Plankton Community Monitoring

At the request of TDEC, phytoplankton samples will be obtained from a photic zone[1] composite water sample collected at two locations each in the main channel area of the downstream sampling zone (Primary Study Area: mid-plume and plume downstream boundary; see Figure 3) and the upstream zone (Figure 4). This will be accomplished by lowering the intake end of a peristaltic pump sample tube to the bottom of the photic zone; and with the pump activated, slowly retrieving the sample tubing at a constant rate until the reservoir surface is reached. The phytoplankton data will be used to compare potential algal community response to thermal influence based on high-level taxonomy (i.e., Chrysophyta, Chlorophyta, Cyanophyta).

Zooplankton samples will be collected with a plankton net (300 millimeter (1 ft) diameter with 153 μ mesh) towed at two locations each in the main channel area of the downstream sampling zone (Primary Study Area: mid-plume and plume downstream boundary) and the upstream zone (Figures 3 and 4). Tows will consist of a vertical pull (tow) of the entire water column from 2 m off the bottom to the surface of the reservoir. Comparative analysis of zooplankton data from the two locations will be used to evaluate potential thermal influence on community structure.

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[1] For the purposes of this study, the photic zone is defined as twice the Secchi disk transparency depth or 4 meters, whichever is greater.

Plankton sampling will be conducted once during the sampling events utilizing established TVA procedures. Among other criteria, these procedures specify replicate sampling, proper sample preservation, and data processing requirements.

Wildlife Community Evaluation

The wildlife community will be evaluated via implementation of visual encounter (observational) wildlife survey methodology and supported through review of the available literature, and communications with natural resource agency contacts. The effort will focus on the more water dependent species of the herpetofaunal, avian, and mammalian communities. These activities will assist in identifying the wildlife species expected for the ecoregion, establish the presence/absence of a BIP of wildlife in the study area, and support evaluation of potential direct effects of temperature on sensitive life stages and any indirect effects such as increased predation.

A review of available resources to identify any threatened or endangered species potentially occurring in the study area will also be conducted.

For the visual encounter surveys, two permanent transects will be established both upstream and downstream of the SQN thermal effluent. The midpoint of the upstream transect will be positioned at TRM 489.5 and span a distance of 2,100 m within this transect. The downstream transect will be located in the field based on sampling event and likewise span a distance 2,100 m. The beginning and ending point of each transect will be marked with GPS for relocation. Transects will be positioned approximately 30 m offshore and parallel to the shoreline occurring on both right and left descending banks. Basic inventories will be conducted to provide a representative sampling of wildlife present during summer (mid-July – August) and late autumn-early winter (October – December).

Each transect will be surveyed by steadily traversing the length by boat and simultaneously recording observations of wildlife. Sampling frame of each transect will generally follow the strip or belt transect concept with all individuals enumerated that crossed the center-line of each transect landward to an area that included the shoreline and riparian zone (i.e., belt width generally averages 60 m where vision is not obscured). Information recorded will include wildlife identification (to the lowest taxonomic trophic level) that is observed visually and/or audibly and a direct count of individuals observed per trophic level. If flocks of a species or mixed flock of a group of species are observed, an estimate of the number of individuals present will be generated. Time will be recorded at the starting and ending point of each transect to provide a general measure of effort expended. However, times may vary among transects primarily due to the difficulty in approaching some wildlife species without inadvertently flushing them from basking or perching sites. To compensate for the variation of effort expended per transect, observations will be standardized to numbers per minute or numbers per hectare in preparation for analysis.

The principal objective and purpose behind the wildlife surveys are to provide a preliminary set of observations to verify trophic levels of birds, mammals, amphibians and reptiles present that might be affected by thermal effects of the power plant (i.e., the ATL). If trophic levels are not represented, further investigation will be used to target specific species and/or species groups (guilds) that will determine the cause.

Task 7 –Water Supply and Recreational Use Support Evaluation

Water temperature data collected as part of the thermal mapping (Task 2) and collection of supporting water quality information (Task 5) will be used to evaluate potential thermal impacts to water supply and recreational uses in the vicinity of SQN. Locations of any public water supply intakes and/or established public recreational areas will be determined and their position(s) mapped relative to the SQN thermal plume. We are aware of one domestic water supply intake located within approximately 10 river miles downstream of the SQN thermal discharge (Figure 1). The existence of any relevant water temperature data collected by the owners of these water supply intake(s) will be determined; and if available, requested to augment the field-collected data. As necessary (limited or no available owner-supplied temperature data), direct measurements of water temperature may also be conducted specifically at these locations to evaluate potential thermal effects of the SQN discharge.

3.3 Data Contribution to the Analysis/Demonstration

The analysis of fish, macroinvertebrate, and plankton community data will include traditional analyses whereby community attributes for the thermally affected areas will be compared to the non-thermally affected ambient location. For the purposes of the demonstration (within river/reservoir comparisons), the composition of fish and macroinvertebrate assemblages collected at the upstream station, uninfluenced by the SQN thermal discharge, is expected to set the baseline for evaluating the presence of a BIP in the downstream thermally influenced area. In that regard, a BIP is the expected determination for the thermally uninfluenced area.

3.3.1 Traditional Analyses

As applicable, biological community data will be compiled into tables providing a listing of species collected and their status with regard to expected occurrence in the ecoregion. Reference materials such as: "*The Fishes of Tennessee*" (Etnier and Starnes, 1993); similarly applicable publications; and best professional judgment by experienced aquatic biologists will be used for this determination. The dataset will be further evaluated with regard to the following:

- Life stages represented,
- Food chain species present (e.g., predator and prey species),
- Thermally-tolerant or -sensitive species present (based on Yoder et al., 2006),
- Representative Important Species (commercially and/or recreationally); and
- Other community attributes (fish and macroinvertebrates)

To evaluate similarity with the downstream thermally influenced area, traditional species diversity indices will be used. Diversity indices provide important information about community composition and take the relative abundances of different species into account as well as species richness (i.e., number of individual species). Two diversity indices will be calculated for each sample location; such as: the Shannon-Weiner diversity index (H') (Levinton, 1982) and Simpson's Index of Diversity (D_s) (Simpson, 1949). Of the many biological diversity indices, these two indices are the most commonly reported in the scientific literature and will be evaluated for use in determining if community structure is similar between the thermally influenced and non-thermally influenced sampling locations. Other methods/indices for evaluating similarity between sampling sites will also be considered.

Based on the BIP baseline for the thermally uninfluenced ambient (upstream) location, comparative statistical analysis of the diversity indices and/or other measures of biological community status such as: species richness, relative abundance, pollution tolerance, trophic guilds, indigenousness, and thermal sensitivity (each pending sufficient sample size) will be used to confirm the presence/absence of a BIP in the thermally influenced study area.

3.3.2 Supporting Multi-metric Bioassessment

Upon review of the species listings and establishment that the fish and macroinvertebrate populations are appropriate to the aquatic systems of the ecoregion, sample data also will be analyzed using TVA's Reservoir Fish Assemblage Index (RFAI) methodology (McDonough and Hickman 1999) and Reservoir Benthic Index to further evaluate if the SQN thermal discharge has materially changed ecological conditions in the receiving water body (Tennessee River – Chickamauga Reservoir).

<u>Reservoir Fish Assemblage Index</u>

The RFAI uses 12 fish assemblage metrics from four general categories: Species Richness and Composition (8 metrics); Trophic Composition (two metrics); Abundance (one metric); and Fish Health (absence of anomalies) (one metric). Individual species can be utilized for more than one metric.

Each metric is assigned a score based on "expected" fish assemblage characteristics in the absence of human-induced impacts other than impoundment of the reservoir. Individual metric scores for a sampling area (i.e., upstream or downstream) will be summed to obtain the RFAI score for each sample location and comparatively analyzed. The maximum RFAI score is 60. Ecological health ratings (12-21 ["Very Poor"], 22-31 ["Poor"], 32-40 ["Fair"], 41-50 ["Good"], or 51-60 ["Excellent"]) are then applied to scores.

Based on statistical analysis of multiple RFAI datasets, RFAI scores between sites (e.g., downstream vs. upstream) will need to differ by 6 points or more to be considered to have different fish assemblages based on documented variability in the sampling methodology.

Regardless of the scores, a metric-by-metric examination will be conducted; this review will be helpful in evaluating potential metric-specific impacts that may be thermally related.

Reservoir Benthic Macroinvertebrate Index

The RBI is similarly calculated as the RFAI except that it uses seven metrics specific to the macroinvertebrate assemblage. Each metric is assigned a score based on reference conditions and then summed to produce an overall RBI score for each sample site. The maximum RBI score is 35. Ecological health ratings (7-12 "Very Poor", 13-18 "Poor", 19-23 "Fair", 24-29 "Good", or 30-35 "Excellent") will then be applied to scores.

Based on statistical analysis of multiple RBI datasets, RBI scores between sites (e.g., downstream vs. upstream) that differ by 4 points or more will be considered to have different macroinvertebrate assemblages. A metric-by-metric examination will also be conducted, regardless of the scores, to evaluate potential thermally-related impacts on specific metrics.

3.3.4 Reasonable Potential Evaluation

Based on existing information and temperature data collected/obtained during the study, the reasonable potential for the thermal discharge to impair current and future water supply and recreational (water contact) uses will be evaluated. The measured temperatures at the water supply intake location and location of any named recreational areas or areas where recreational users are known to congregate within the thermally influenced area (if any), will form the basis for determining reasonable potential for use impairment. Should reasonable potential be indicated, TVA will discuss with TDEC; and as necessary, submit a revised scope of work (study design) for this task (Task 7) proposing additional data collections and/or analysis to focus the evaluation.

3.4 Reporting

A final Project Report will be prepared providing a description of the study design, data collection methods, SQN operational data, thermal plume mapping results, water quality monitoring data, and aquatic and wildlife community information. Raw data and associated field collection parameters will be appended to the report.

Results and conclusions regarding the §316(a) demonstration (maintenance of a BIP) and support of other use classifications (recreation and water supply) will be presented.

3.5 Study Schedule Summary

Field sampling will be conducted during summer (mid-July – August) once during the SQN permit cycle and autumn annually (October – mid-December); each event will include sampling of the Primary Study Area/downstream zone and upstream/ambient zone.

TVA will provide TDEC with an interim progress report of the summer 2011 sampling results in spring of 2012. Final report will be completed and submitted with the SQN NPDES permit renewal package.

4.0 LITERATURE CITED

EPA 1977. Draft Interagency 316(a) technical guidance manual and guide for thermal effects sections of nuclear facilities environmental impact statements. U.S. Environmental Protection Agency and U.S. Nuclear Regulatory Commission. U.S. Environmental Protection Agency, Office of Water Enforcement, Permits Division, Industrial Permits Branch, Washington, D.C.

Etnier, D.A. & Starnes, W.C. 1993. *The Fishes of Tennessee*. University of Tennessee Press, Knoxville, TN, 681 pp.

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.

Hubert, W. A. 1996. Passive capture techniques, entanglement gears. Pages 160-165 in B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Jennings, M. J., L. S. Fore, and J. R. Karr. 1995. Biological monitoring of fish assemblages in Tennessee Valley reservoirs, *Regulated Rivers: Research and Management,* Vol. 11, pages 263-274.

Levinton, J.S. 1982. *Marine Ecology*. Prentice-Hall, Inc. Englewood Cliffs, NJ

McDonough, T.A. and G.D. Hickman. 1999. Reservoir Fish Assemblage Index development: A tool for assessing ecological health in Tennessee Valley Authority impoundments. *In*: Assessing the sustainability and biological integrity of water resources using fish communities. Simon, T. (Ed.) CRC Press, Boca Raton, FL. pp 523-540.

Reynolds, J.B. 1996. Electrofishing. Pages 221-251 in B. R. Murphy and D. W. Willis, editors. Fisheries techniques, 2nd edition. American Fisheries Society, Bethesda, MD.

Simpson, E.H. (1949) Measurement of diversity. *Nature* 163:688 see http://www.wku.edu/~smithch/biogeog/SIMP1949.htm

TVA 2011. Biological Monitoring of the Tennessee River Near Sequoyah Nuclear Plant Discharge Autumn 2010. Tennessee Valley Authority, Knoxville, TN.

TVA 1989. A Predictive 316(a) Demonstration for an Alternative Winter Thermal Discharge Limit for Sequoyah Nuclear Plant, Chickamauga Reservoir, Tennessee. Tennessee Valley Authority, Chattanooga, TN

Yoder, C.O., B.J. Armitage, and E.T. Rankin. 2006. Re-evaluation of the technical justification for existing Ohio River mainstem temperature criteria. Midwest Biodiversity Institute, Columbus, OH.

FIGURES

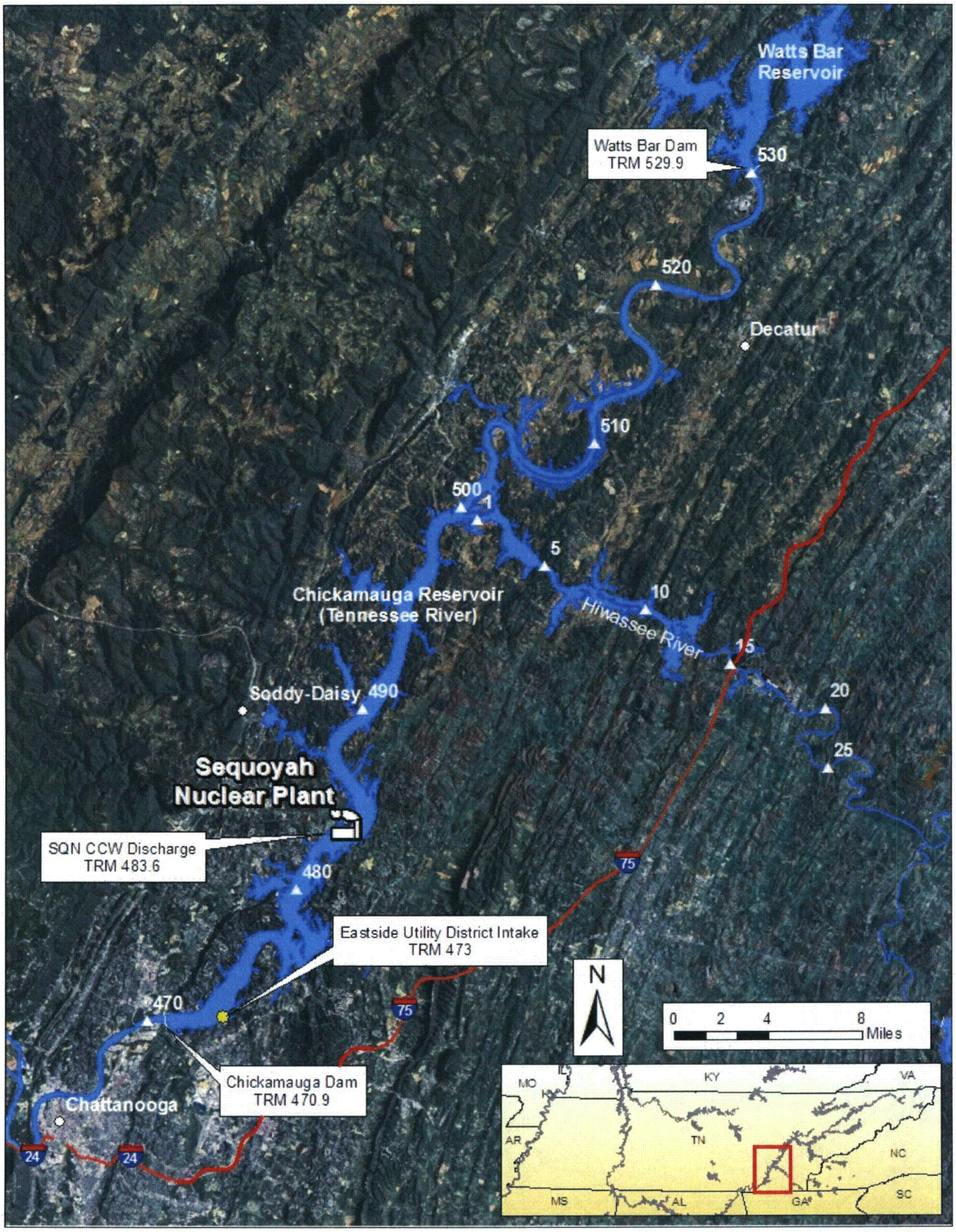

Figure 1. Vicinity map for Sequoyah Nuclear plant depicting Chickamauga and Watts Bar Dam locations and water supply intakes downstream of the plant thermal discharge

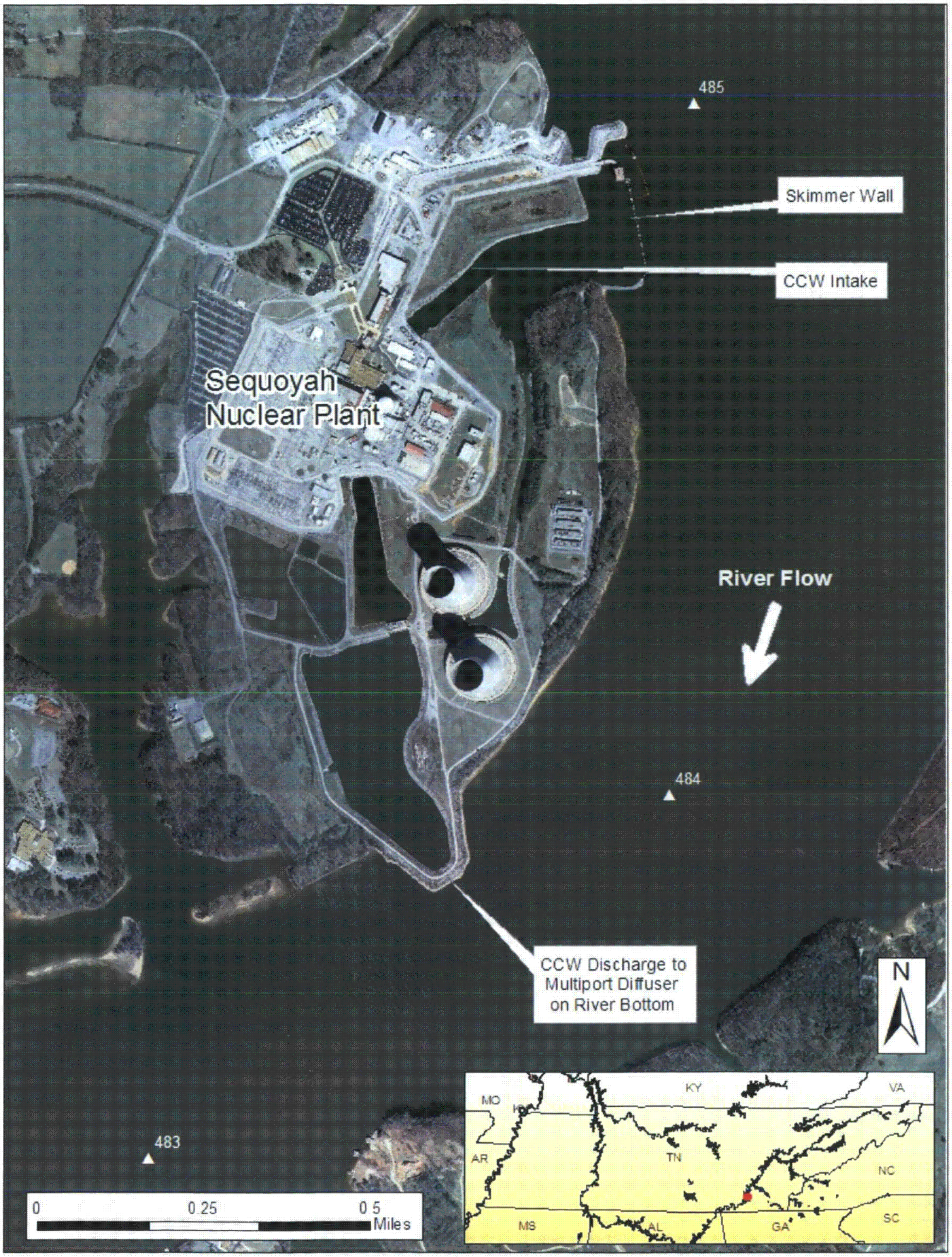

Figure 2. Site map for Sequoyah Nuclear plant showing condenser cooling water intake structure, skimmer wall, and NPDES-permitted discharge Outfall No. 101

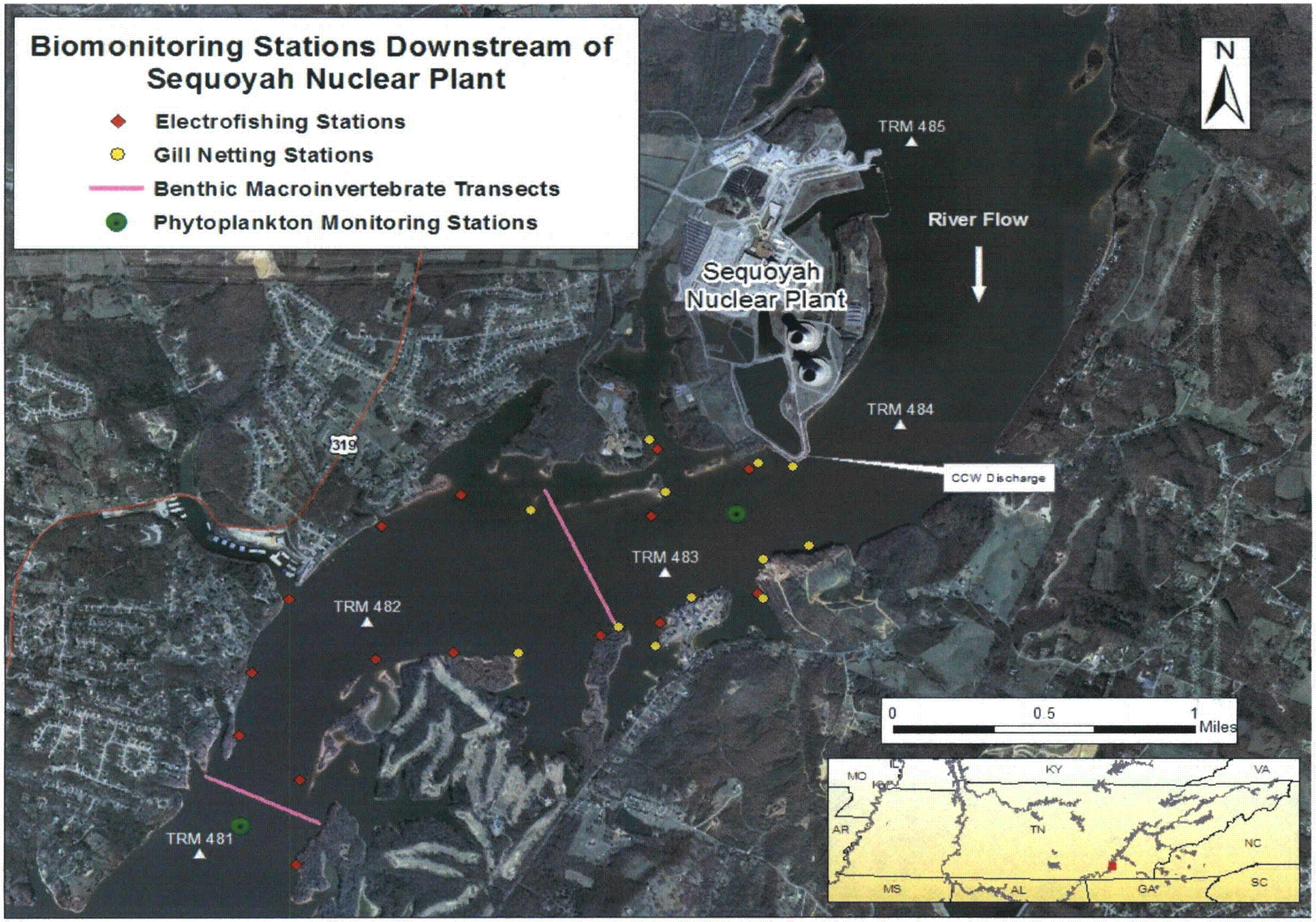

Figure 3. Biological monitoring zone downstream of Sequoyah Nuclear plant

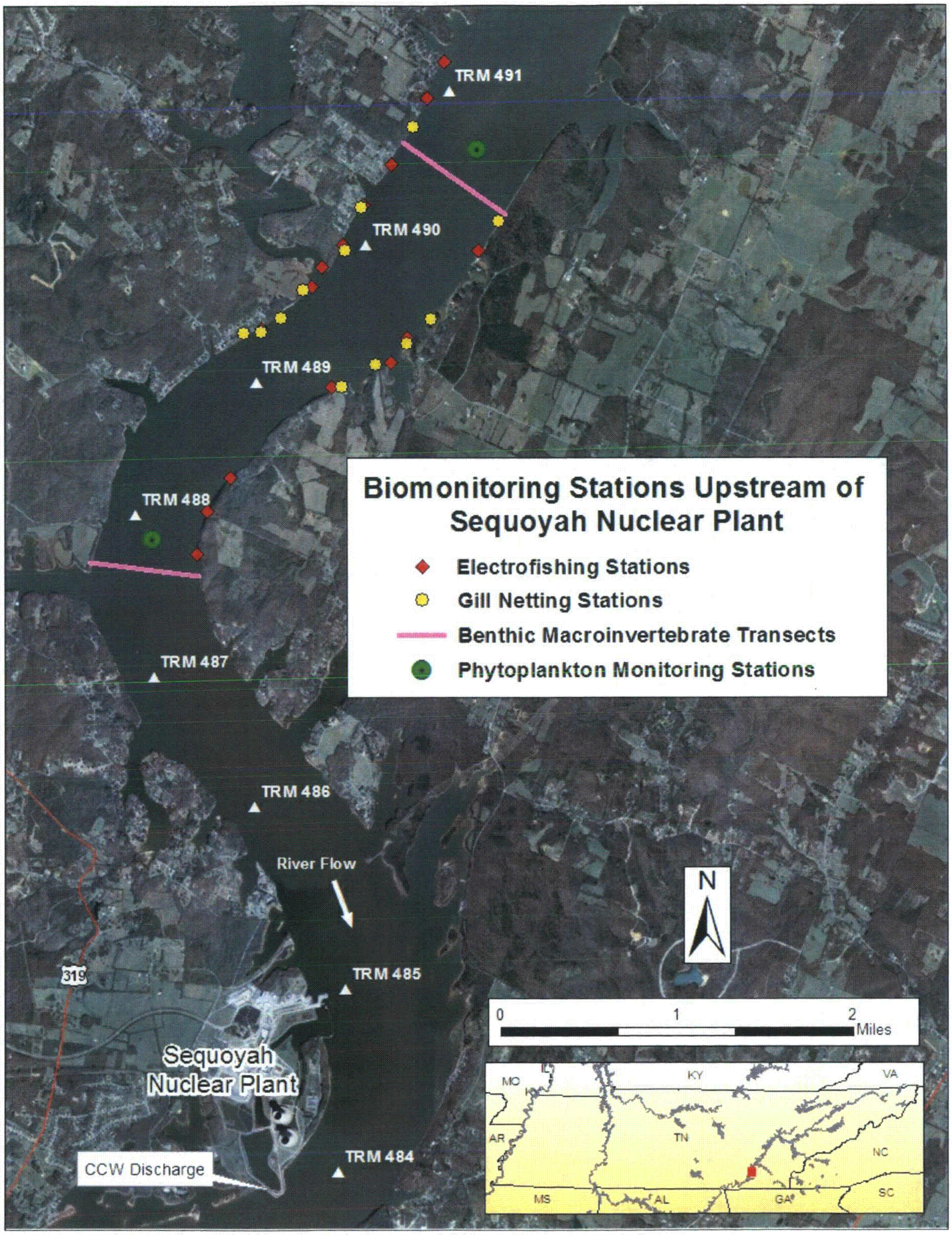

Figure 4. Biological monitoring zone upstream of Sequoyah Nuclear plant thermal discharge

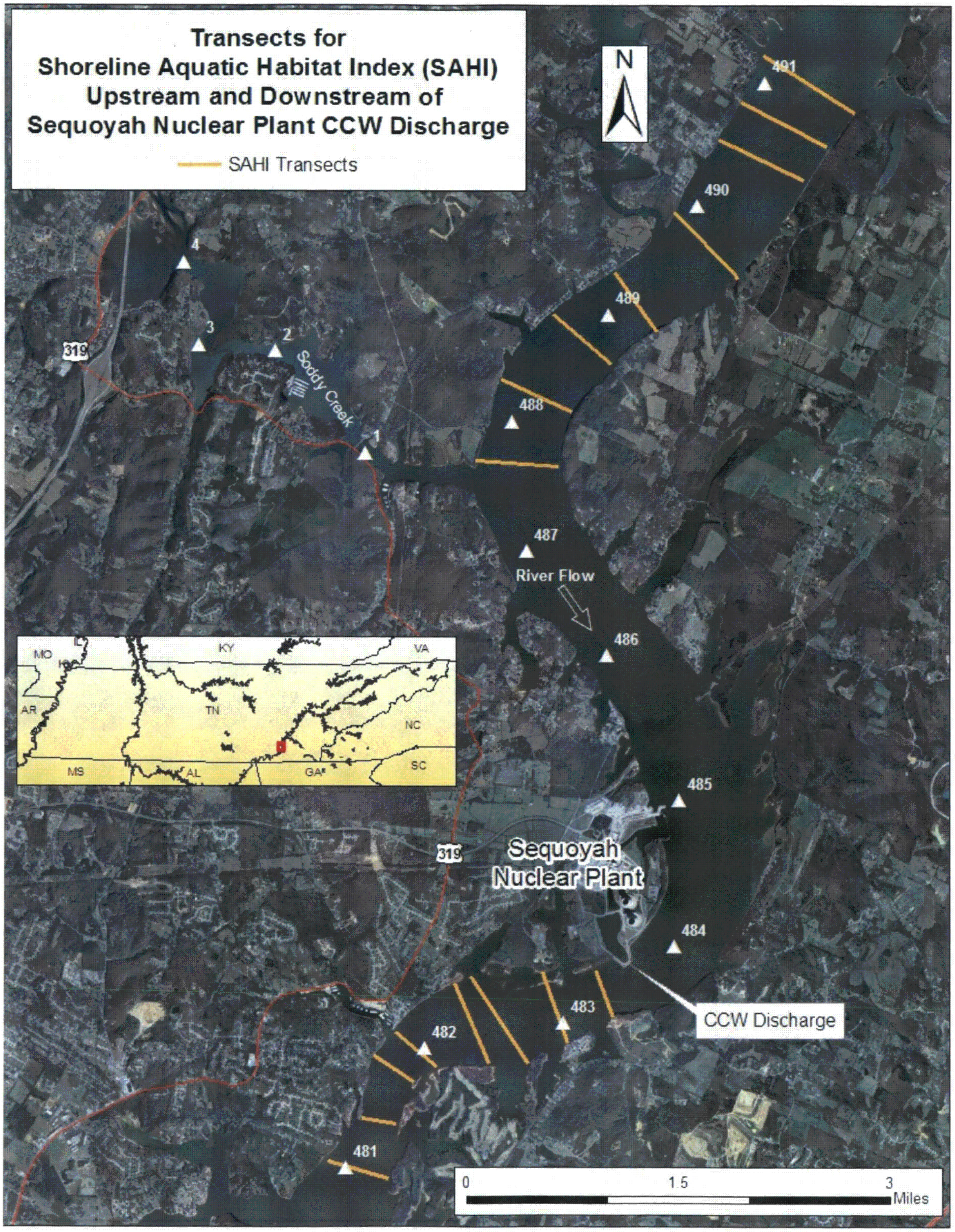

Figure 5. Anticipated transects to be established for conduct of the integrative multi-metric aquatic shoreline habitat assessment