**DEQ/DWR**

**FACT SHEET FOR NPDES PERMIT DEVELOPMENT**

NPDES No. NC0004987

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| --- | --- | --- | --- |
|  | **Facility Information** | | |
| Applicant/Facility Name: | Duke Energy – Marshall Steam Station | | |
| Applicant Address: | Water Management, Duke Energy, P.O. Box 1006, Charlotte, NC 28201 | | |
| Facility Address: | 8320 E. NC Highway 150, Terrell, NC 28682 | | |
| Permitted Flow | Not Limited | | |
| Type of Waste: | 100% Industrial | | |
| Facility/Permit Status: | Renewal | | |
| County: | Catawba | | |
|  | **Miscellaneous** | | |
| Receiving Stream: | Lake Norman | Regional Office: | Mooresville |
| Stream Classification: | WS-IV & B CA | USGS Topo Quad: | Lake Norman North |
| 303(d) Listed?: | No | Permit Writer: | Sergei Chernikov, Ph.D. |
| Subbasin: | 03-08-32 | Date: | October 4, 2021 |
| Drainage Area (mi2): | NA |  | |
| Summer 7Q10 (cfs) | Release (60 cfs) |
| Winter 7Q10 (cfs): | NA |
| 1Q10 (cfs): |  |
| IWC (%): | 18 |

# SUMMARY

This is a renewal for the Marshall Steam Station. Duke Energy operates Marshall Steam Station in Catawba County. Currently, the facility is still conducting the ash pond dewatering. This step is necessary to excavate the ash from the ash pond. The Station operates ten outfalls. The permitted outfalls are summarized below:

* Outfall 001 – Condenser Cooling Water (CCW) Units 1 – 4.

The CCW system is a once-through, non-contact cooling water system, which condenses steam from the condensers and other selected heat exchangers. When the station is operating at full power, it has a design capacity to pump 1463 MGD (1.016 MGPM) of cooling water through the network of tubes that runs through the condenser and selected heat exchangers. The raw cooling water is returned to the lake. No biocides or other chemicals are used in the condenser cooling water. Units 1 and 2 operate two CCW pumps each while units 3 and 4 operate three pumps.

* Outfall 002 – Ash Basin.

The station ash basin accommodates flows from two yard-drain sumps, an ash removal system, low volume wastes and non-point source stormwater. Low volume waste sources include, but are not limited to: wastewater from wet scrubber air pollution control systems, ion exchange water treatment system, water treatment evaporator blowdown, laboratory and sampling streams, boiler blowdown, floor drains, and recirculating house service water systems. A sanitary waste treatment system consists of an aerated basin that provides treatment with a 30 – day retention time and has a total volume of 587,000 gallons. Effluent from the aerated basin is polished further through additional residence time in the ash basin. The new sanitary waste treatment system is designed for 6100 gpd (normal) and 13500 gpd (outage).

* Outfall 002a – Sump #1 Overflow.

This outfall discharges very infrequent overflows of yard sump number 1.

* Outfall 002b – Sump #2 Overflow.

This outfall discharges very infrequent overflows of yard sump number 2.

* Outfall 001/001A (internal outfall). Yard sump (wastewater from the yard sump 2, the yard sump 3, the fly ash silo yard sump, and stormwater) discharging to the retention basin.

* Outfall 003 (internal outfall) – Unit 4 ID Fan Control House Cooling Water discharge into the intake for CCW: Once-through, non-contact cooling water is supplied to the Unit 4 induced draft (ID) fan motor control-house equipment to remove excess heat. No chemicals are added to the once-through raw lake water

* Outfall 005. The lined retention basin accepts wastes from holding basin (coal pile runoff), ash transport water, various sumps, stormwater runoff, Flue-Gas Desulfurization (FGD) wastewater, and various low volume wastes such as boiler blowdown, oily waste treatment, wastes/backwash from the water treatment processes, plant area wash down water, equipment heat exchanger water, landfill leachate, and ash transport water. All waste streams previously discharged to ash basin, have been re-routed to the new retention basin. During the transition period, wastewater from the ash pond can also be discharged (Outfall 002).

* Outfall 006 (internal outfall) - FGD system discharge into the new lined retention basin. In association with Clean Smokestacks legislation, Duke Energy installed a flue-gas desulfurization (FGD) wet scrubber. This scrubber generates a wastewater needing treatment prior to discharge. An internal outfall (006) has been established for the effluent from the FGD treatment system. FGD treatment system includes physical/chemical and biological treatment. Internal outfall 006 discharges to the new retention basin, which is currently permitted as outfall 005.

* Outfall 007. The emergency spillway of the Ash Pond. The spillway is designed for a flood greater than 100-year event. Sampling of this spillway is waived due to unsafe conditions associated with sampling during overflow event.

* Outfall 010 (internal outfall). Holding Basin accepts coal pile runoff, and storm water; discharges to the retention basin.

The summer 7Q10 flow (60 cfs) is based on the minimum release from the dam that regulates the receiving water body.

# ASH POND DAMS

Seepage through earthen dams is common and is an expected consequence of impounding water with an earthen embankment. Even the tightest, best-compacted clays cannot prevent some water from seeping through them. Seepage is not necessarily an indication that a dam has structural problems, but should be kept in check through various engineering controls and regularly monitored for changes in quantity or quality which, over time, may result in dam failure.

REASONABLE POTENTIAL ANALYSIS (RPA)-OUTFALL 002 DEWATERING.

The Division conducted EPA-recommended analyses to determine the reasonable potential for toxicants to be discharged at levels exceeding water quality standards/EPA criteria by this facility **from outfall 002 dewatering (Ash Pond).** For the purposes of the RPA, the background concentrations for all parameters were assumed to be below detection level. The RPA uses 95% probability level and 95% confidence basis in accordance with the EPA

Guidance entitled “Technical Support Document for Water Quality-based Toxics Control.” The RPA included evaluation of dissolved metals’ standards, utilizing a default hardness value of 25 mg/L CaCO3 for hardness-dependent metals.

Calculations included: As, Be, Cd, Total Phenolic Compounds, Cr, Cu, CN, Pb, Hg, Mo, Ni, Se, Ag, Zn, Ba, Sulfate, Tl, Sb, and B (please see attached). The permit limit of 3.0 MGD was used in the RPA. The analysis indicates no reasonable potential to violate the surface water quality standards or EPA criteria. The water-quality based limits for Selenium were removed from the permit (Outfall 002) based on the results of Reasonable Potential Analysis.

The Division also considered data for other parameters of concern in the EPA Form 2C that the facility submitted for the renewal. The vast majority of the parameters were not detected in the discharge. The remaining parameters have no associated state water quality standards.

The proposed permit requires that EPA methods 200.7 or 200.8 (or the most current versions) shall be used for analyses of all metals except for total mercury.

REASONABLE POTENTIAL ANALYSIS(RPA)-OUTFALL 005 RETETNION BASIN.

The Division conducted EPA-recommended analyses to determine the reasonable potential for toxicants to be discharged at levels exceeding water quality standards/EPA criteria by this facility **from outfall 005 (Retention Basin).** For the purposes of the RPA, the background concentrations for all parameters were assumed to be below detection level. The RPA uses 95% probability level and 95% confidence basis in accordance with the EPA Guidance entitled “Technical Support Document for Water Quality-Based Toxics Control.” The RPA included evaluation of dissolved metals’ standards, utilizing a default hardness value of 25 mg/L CaCO3 for hardness-dependent metals.

Calculations included: Calculations included: As, Be, Cd, Total Phenolic Compounds, Cr, Cu, CN, Pb, Hg, Mo, Ni, Se, Ag, Zn, Ba, Sulfate, Tl, Sb, and B (please see attached). The renewal application listed 5.1 MGD as the highest reported flow during the last permit cycle. This flow was used in the RPA The analysis indicates no reasonable potential to violate the surface water quality standards or EPA criteria. The water-quality based limits for Copper were removed from the permit (Outfall 005) based on the results of Reasonable Potential Analysis.

The Division also considered data for other parameters of concern in the EPA Form 2C that the facility submitted for the renewal. The vast majority of the parameters were not detected in the discharge. The remaining parameters have no associated state water quality standards.

The proposed permit requires that EPA methods 200.7 or 200.8 (or the most current versions) shall be used for analyses of all metals except for total mercury.

# FGD TECHNOLOGY BASED EFFLUENT LIMITS (TBELS)-INTERNAL OUTFALL 006

The federal 40 CFR 423 Technology Based Effluent Limits (TBELs) have been implemented in the permit:

Total Arsenic – 8.0 µg/L (Monthly Average); 18.0 µg/L (Daily Maximum)

Total Selenium – 29.0 µg/L (Monthly Average); 70.0 µg/L (Daily Maximum)

Total Mercury – 34.0 ng/L (Monthly Average); 103.0 ng/L (Daily Maximum)

Nitrate/nitrite as N – 3.0 mg/L (Monthly Average); 4.0 mg/L (Daily Maximum)

# CWA SECTION 316(a) TEMPERATURE VARIANCE – OUTFALL 001

The facility has a temperature variance. In order to maintain the variance the facility has to conduct annual biological and chemical monitoring of the receiving stream to demonstrate that it has a balanced and indigenous macroinvertebrate and fish community. The latest BIP (balanced and indigenous population) report was submitted to DWR in April 2021. The DWR has reviewed the report and concluded that Lake Norman near Marshall Steam Station has a balanced and indigenous macroinvertebrate and fish community.

# CWA SECTION 316(b)

The permittee submitted documentation to comply with the Cooling Water Intake Structure Rule per 40 CFR 125.95. The following is an excerpt from the Duke Executive Summary submittal that summarizes their request. The complete text of the submittal is very voluminous and consists of 1,130 pages. It can be downloaded from the following link - [https://edocs.deq.nc.gov/WaterResources/DocView.aspx?id=1959570&dbid=0&repo=Wate rResources](https://edocs.deq.nc.gov/WaterResources/DocView.aspx?id=1959570&dbid=0&repo=WaterResources)

# Introduction

In accordance with Section 316(b) of the Clean Water Act (CWA), Final Regulations (FR) to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities (79 FR 48299) and 40 Code of Federal Regulations (CFR) §122 and § 125, Duke Energy Carolinas, LLC (Duke Energy) submits the enclosed CWA §316(b) rule for existing facilities (Rule) study reports and supporting information for the Marshall Steam Station (Marshall). This Executive Summary provides an overview of the §122.21 (r)(2) through (r)(13) study reports included in Sections 2 through 13 of the main Compliance Submittal.

Based on the filed Integrated Resource Plan (IRP) (Duke Energy 2019), Duke Energy currently anticipates retiring Marshall's four existing units in 2034; therefore, the year 2034 was used to estimate the potential social costs and social benefits of candidate compliance technologies, as detailed in Sections 10 through 12 of the compliance document and summarized in the following sections of this Executive Summary. However, Duke Energy has recently proposed updated retirement dates as detailed in the 2020 IRP (Duke Energy 2020a), which anticipates that all units could retire as soon as 2028 depending on the scenario approved by North Carolina Utilities Commission. Assuming the same technology implementation dates but earlier retirement dates (i.e. 2028), a hypothetical comparison of the social costs to social benefits for the candidate compliance technologies would yield net negative benefits that are greater than what is presented in Sections 10 through 12 of this document. Under this scenario, the net social benefits for a 2028 retirement (versus a 2034 retirement) would result in a 1-year (versus 7-year) accrual period for the hypothetical mechanical draft cooling tower (MDCT) scenario and a 3-year (versus 9-year) accrual period for the hypothetical fine mesh screen (FMS) scenario.

Based on the existing design, operational data, low impingement rates demonstrated in historical monitoring data, and results of the comparative evaluation of impingement mortality (IM) reduction options, and with consideration of the anticipated end of useful life of the operating units at Marshall, Duke Energy's chosen method of complying with the IM reduction standard is IM best technology available (BTA) compliance Option 6 (system of technologies). Additional supporting information is provided below:

# Curtain Wall

• The primary purpose of the curtain wall located at the entrance to the intake cove is to facilitate the withdrawal of cooler water from the bottom of the reservoir, which is conveyed to the cooling water intake structure (CWIS) to improve the station's thermal efficiency. The curtain wall also functions as a physical barrier to entrainable ichthyoplankton by blocking passage of early life stages (i.e., eggs, yolk-sac larvae) drifting passively in the water column or those life stages (i.e., post yolk-sac larvae, young-of-year) with underdeveloped swimming ability that may otherwise be pulled into the intake cove. Studies (Jirka 1979; Adams and Schweickart 1987; Davies and Jensen 1975; Savitz et al. 1998) have demonstrated significant reductions in ichthyoplankton entrainment and IM when water is withdrawn from the lower stratum or near-bottom waters at depths sufficient to create stratification of temperature, salinity, or dissolved oxygen.

 Historical (Davies and Jensen 1975; Olmsted and Adair 1981) and recent (HDR 2017; see Section 7.1.1) efficacy studies performed at Marshall concluded that the curtain wall is effective at reducing ichthyoplankton passage; with the recent study demonstrating a 95 percent reduction in ichthyoplankton abundance from the lake side to the intake side of the curtain wall. Further, based on the species composition and abundance of ichthyoplankton documented in the 2016-2017 entrainment study (HDR 2019; see Section 9), the 95 percent reduction in ichthyoplankton on the intake side of the curtain wall extends to the Marshall CWIS.

# Operational Measures/Seasonal Reductions in Withdrawal

* Marshall has a design intake flow (DIF) of 1,463 MGD based on the design capacity of the circulating water pumps. However, the actual intake flow (AIF) at Marshall based on the 5-year period of record (POR) from July 1, 2014 through June 30, 2019 was 914 MGD, which represents a 37.5 percent reduction in cooling water withdrawals. During the colder winter months, one circulating water pump per unit is typically operated (resulting in a 795 MGD total cooling water flow (a reduction of approximately 46 percent from DIF). Flow reductions have been shown to result in commensurate reductions in impingement mortality, and facilities can take credit for reductions in cooling water withdrawals at the CWIS.

Historical impingement monitoring data provide evidence that impingement is low at the Marshall CWIS

* An impingement study and assessment of environmental impact performed at the Marshall CWIS between 2006 and 2007 concluded that IM was dominated (over 93 percent of total abundance) by fragile clupeid species (Alewife and Threadfin Shad) and represented a very small percentage of the estimated fish population densities in Lake Norman (EPRI 2009). When excluding these fragile fish species from annual IM, the impingement rate at Marshall is approximately 37 fish per day. Clupeids are highly prolific spawners with high growth rates and short life spans, considered to be fragile per the Rule, and thus are capable of compensating for at Marshall without long-term population effects. Furthermore, Alewife are an introduced species in Lake Norman, whose presence have had negative effects on the fishery (Duke Energy 2018a).

* The EPRI study (2009) indicated that when excluding fragile species (i.e., clupeids), Blue Catfish and White Perch dominated (78 percent) the total annual impingement losses. Blue Catfish and White Perch are highly mobile and move extensively throughout Lake Norman, and, like Alewife, are introduced species. When excluding fragile and introduced species from annual IM, the impingement rate at Marshall is approximately seven fish per day. The densities of other species impinged at Marshall represented a very small percentage of their respective estimated population densities in Lake Norman and suggests that the curtain wall may be restricting passage of some species of impingeablesized fish from the lake side to the intake side of the curtain wall.

Further, no IM reduction technology alternative is justified based on the following:

* While the existing design through screen velocity (TSV) at the CWIS is slightly greater than 0.5 feet per second (fps), the 0.5 fps velocity contour (Section 3.5.2.3, Figure 3-7), does not extend beyond the face of the CWIS, thus providing IM reduction benefits.

* Operations at Marshall (detailed in Section 5) and the diversity and abundance of the fish community in Lake Norman (detailed in Section 4.2) have remained consistent since the 2006-2007 impingement study (EPRI 2009), thus these data are valid and representative of current conditions.

* The estimated potential IM reduction benefit of adding an additional technology at Marshall was estimated under IM BTA Option 5 (modified-Ristroph traveling screens with an aquatic organism return system) using 2006-2007 impingement data and actual water withdrawals in 2016 and 2017. The annual impingement losses estimated based on 2016 and 2017 withdrawals would equate to between 7,601 (384 pounds [lbs]) and 7,617 (382 lbs) equivalent adults, between 5,169 and 5,294 lbs of forage biomass, and between 3,103 and 3,110 lbs of harvestable biomass (Section 11.5.1.3).

* The social costs of designating the existing system of technologies at Marshall as BTA for

IM reduction (see Section 6 of compliance document) are the forgone incremental impingement benefits ($0.02 million [M]) of the next least-cost impingement compliance alternative which was estimated based on IM BTA Option 5 (modified traveling water screens with an organism return system), resulting in a net benefit of -$0 02M.

Duke Enerqy also requests a determination that the existing plant configuration and operation (system of technologies) is BTA for reducing entrainment at Marshall. The request for an entrainment BTA determination is based on the following:

# Curtain Wall

• Historical (Davies and Jensen 1975; Olmsted and Adair 1981) and recent (HDR 2017; see Section 7.1.1) efficacy studies performed at Marshall concluded that the existing curtain wall reduces ichthyoplankton passage; with the recent study demonstrating a 95 percent reduction in ichthyoplankton abundance from the lake side to the intake side of the curtain wall. Further, based on the species composition and abundance of ichthyoplankton documented in the 2-year Entrainment Characterization Study (Study) (HDR 2019; see Section 9), the 95 percent reduction in ichthyoplankton on the intake side of the curtain wall extends to the Marshall CWIS.

## Operational Measures/Seasonal Reductions in Withdrawal

* Based on actual water withdrawals during the Study, annual entrainment in 2016 (24.1 million) and 2017 (31.6 million) represented a 40.2 percent and 47.6 percent reduction from annual estimates based on DIF (40.4 and 60.2 million, respectively).
* Further, the Study performed at the CWIS during 2016 and 2017 (HDR 2019) demonstrated that entrainment at Marshall is dominated by clupeid species (Alewife, Gizzard Shad, and Threadfin Shad), followed by White Perch. The composition and abundance of ichthyoplankton collected during the Study at Marshall indicates that the reproductive strategies of these taxa increase their susceptibility to entrainment at the CWIS (high fecundity, broadcast spawning in the pelagic zone). However, the continued abundance of these taxa in Lake Norman demonstrated in ongoing monitoring studies (Duke Energy 2014a, 2015, 2016a, 2016b, 2017) indicates that the reproductive strategy of these taxa is able to compensate for losses that occur at the Marshall CWIS. As such, the Study concluded that it is unlikely that entrainment at Marshall has a significant influence on the Lake Norman fishery.

As required by the Rule, two potential entrainment reduction technologies were evaluated:

* Installation of mechanical draft cooling towers (MDCTs) would result in social benefits of $0.02M compared to social costs of $586.43M; resulting in total net benefits of - $586.41M; and
* A retrofit to 0.75-millimeter (mm) FMS in the existing CWIS including construction of an aquatic organism return system would result in social benefits of $0.03M compared to social costs of $45.92M; resulting in total net benefits of -$45.89M.

Using the anticipated unit retirement date of 2034, a comparison of social costs to social benefits (Section 11) associated with each of the entrainment technologies indicated that:

* The existing or baseline configuration at Marshall consists of a system of technologies that is considered BTA for meeting the site-specific entrainment requirements. The cost to install any new technology would be wholly disproportionate to the potential benefits. For the MDCT installation scenario, the cost benefit ratio is approximately 29,322: 1 (i.e. $586.43M/$0.02M). Retrofitting the existing CWIS with 0.75-mm FMS and aquatic organism return system would result in a cost benefit ratio of approximately 1,531: 1 (i.e. $45.92M/$0.03M). Per 40 CFR 125.98(f)(4), an available technology may be rejected as BTA "if the social costs are not justified by the social benefits".

# Station Description

Marshall withdraws cooling water from Lake Norman in Catawba County near Sherrils Ford, North Carolina. Lake Norman was expressly constructed to function as a cooling impoundment in support of electrical generation at the Marshall Steam Station and nearby McGuire Nuclear Station. Water is withdrawn through a CWIS at the end of 0.5-mile long intake canal situated on the southwestern end of an intake cove on Lake Norman and the station's discharge to Lake Norman is approved through the North Carolina Department of Environmental Quality NPDES Permit NC0004987. Marshall's cooling water intake system consists of a curtain wall at the entrance of the intake cove and a CWIS at the downstream end of the intake canal. The curtain wall effectively blocks the upper portion of the water column such that only water in the bottom 10 ft of the water column can flow into the intake cove via a 270-ft-wide opening. The total flow distance from the curtain wall through the intake cove and intake canal is approximately 1.3 miles. The CWIS includes bar racks, fixed panel mesh screens, and circulating water pumps.

The CWIS is divided into four sections, one for each of Units 1, 2, 3, and 4, and has sixteen

11.2-ftwide intake bays (three intake bays each for Units 1 and 2, and five intake bays each for

Units 3 and 4). Intake bays are equipped with steel vertical bar racks with 2.5-inch spacing (three bar racks each for Units 1 and 2, five bar racks each for Units 3 and 4, and 16 bar racks total), that prevent large debris from entering the CWIS (Duke Power Company 1965c, 1969), and fixed panel mesh screens (three each for Units 1 and 2, five each for Units 3 and 4, a total of 16 fixed screens) that filter smaller debris (Duke Power Company 1965a, 1966a). The fixed panel mesh screens are equipped with 3/8-inch coarse mesh with 0.121 -inch wire diameter and are 10.85-ft wide (Duke Power Company 1965b, 1966b). There are two 18.04-ft tall screen panels stacked vertically in each bay.

Each intake bay has two fixed screen slots, the empty slot is used during screen cleaning. Electronic water level sensors are utilized at the screens to indicate the timing and frequency of manual screen cleanings (Duke Energy 2018b). When screen cleaning is required, a clean fixed screen is dropped into the empty screen slot in an intake bay before the dirty fixed screen is pulled from the intake bay via an overhead gantry crane. This prevents debris from reaching the pumps during screen cleaning. The dirty screen is placed into a wash bay where it is sprayed clean. Solids removed from the screen collect in a pan in the wash bay and are decanted before disposal off-site. Larger debris (e.g., logs and tree limbs) are collected manually from the bar racks periodically, typically three to four times per year (Duke Energy 2018b, 2014b).

The Marshall CWIS contains 10 vertical, wet-pit type circulating water pumps (two pumps each for Units 1 and 2, three pumps each for Units 3 and 4). The design capacity for each of the Unit 1 and 2 circulating water pumps is 126,000 gallons per minute (gpm) (181.4 MGD) (or 252,000 gpm total for each unit), and the design rating for each of the Unit 3 and 4 circulating water pumps is 150,000 gpm (216 MGD) (or 450,000 gpm total for each unit), for a total pumping capacity of 1,404,000 gpm (2,021.8 MGD). However, there is a piping restriction in the condenser cooling water (CCW) system which limits the capacity of Units 1 and 2 to 190,000 gpm each (273.6 MGD), and Units 3 and 4 to 318,000 gpm each (457.9 MGD) (Duke Energy 2014c). This results in a total station DIF of 1,016,000 gpm (1,463 MGD). The service water system at Marshall consists of a low-pressure system and high pressure system, both of which draw suction from the condenser inlet piping for each unit downstream of the CWlS. The low-pressure service water system includes six pumps (with one common spare pump), each with a design capacity of approximately 1,690 gpm (Duke Energy 2020c). The high-pressure service water system includes six pumps, each with a design capacity of 2,770 gpm (Duke Energy 2020c).

The actual intake flow (AIF) based on daily pump operation data for Marshall from July 1, 2014 through June 30, 2019 is presented in Table 3-3. Marshall's AIF during this 5-year period was 914 MGD, or approximately 62 percent of the station DIF. Average withdrawal rates for this period for each unit were 164 MGD for Unit 1,143 MGD for Unit 2, 307 MGD for Unit 3, and 301 MGD for Unit 4 (Duke Energy 2019c). See Table 5-1 in Section 5.1.2 for number of days per year and month when Marshall circulating water pumps operated.

# Regulatory Nexus

On August 15, 2014, the U.S. Environmental Protection Agency (USEPA) published in the Federal Register the NPDES — Final Regulations to Establish Requirements for Cooling Water Intake Structures at Existing Facilities and Amend Requirements at Phase I Facilities, referred to as the Final Rule (Rule) (USEPA 2014). The Rule establishes requirements under §316(b) of the CWA to ensure that the location, design, construction, and capacity of a CWIS reflect the BTA for minimizing impingement and entrainment at the CWIS. The Rule applies to existing facilities that withdraw more than 2 MGD from waters of the United States, use at least 25 percent of that water exclusively for cooling purposes, and have an NPDES permit.

The Rule is applicable to Marshall for the following reasons:

* Marshall withdraws raw water from Lake Norman, the source waterbody, through a shoreline-situated CWIS located at the end of a 0.5-mile-long intake canal for use in a once-through cooling water system. The intake canal is situated in a cove that is separated from the main body of the lake via a curtain wall.

* Marshall meets the minimum 2 MGD withdrawal rate criteria for AIF and DIF. The design capacity for each of the Unit 1 and 2 circulating water pumps is 126,000 gallons per minute (gpm) (181.4 MGD) (or 252,000 gpm total for each unit), and the design rating for each of the Unit 3 and 4 circulating water pumps is 150,000 gpm (216 MGD) (or 450,000 gpm total for each unit), for a total pumping capacity of 1,404,000 gpm (2,021.8 MGD). However, there is a piping restriction in the CCW system which limits the capacity of Units 1 and 2 to 190,000 gpm each (273.6 MGD), and Units 3 and 4 to 318,000 gpm each (457.9 MGD) (Duke Energy 2014c). This results in a total station DIF of 1,016,000 gpm (1,463 MGD). The calculated AIF based on daily pump operation data for Marshall from July 1, 2014 through June 30, 2019 was 914 MGD, or approximately 62 percent of the station DIF.

• On a design basis, approximately 95 percent (1,394 MGD) of Marshall's DIF (1,463 MGD) is used in the CCW system (Baldwin-Lima-Hamilton Corp. 1968; C.H. Wheeler MFG. Co. 1964). The remaining 5 percent (69 MGD) is used for service water and other station uses. Marshall does not use cooling water for process units (see Section 8.3) or contact-cooling purposes.

Because Marshall is subject to the Rule, Duke Energy has prepared technical information required under CFR §122.21(r)(2) through (r) (13) for submittal to the Director to facilitate the determination of BTA for Marshall.

Under the Rule, the owner or operator of a facility must choose from one of seven compliance options for IM reduction or an alternate exemption, as provided by the Rule. The facility must also provide results from site-specific entrainment studies and information identified at §122.21 (r)(2) through (r)(13) and §125.98 to the permitting authority to aid in the determination of whether site specific controls would be required to reduce entrainment.

At §125.98, the Rule identifies specific information that the Director Must (§125.98 (f)(2)) consider and information that the Director May (§125.98 (f)(3)) consider in a site-specific entrainment BTA determination. This Executive Summary describes the evaluation of these compliance options and the Must and May factors for the Director to consider, as they relate to Marshall.

# Impingement Mortality Compliance

## Impingement Mortality Characterization

In the impingement survey performed at Marshall between April 2006—March 2007, a total of 6,219 fish (66 pounds [lbs] biomass) consisting of 10 species and 4 families were collected (EPRI 2009). Impingement densities for all species combined were lower during spring (April-June) and highest in late summer through early fall (August-October) and February. These patterns reflect the typical seasonality of impingement for specific species. Threadfin Shad accounted for 80.8 percent of impingement, followed by Alewife (12.6 percent). Of these two dominant species, Alewife were primarily impinged during late summer months, while Threadfin Shad were impinged throughout the fall and winter months (September - March). Fluctuations in water temperature, lake water levels, DO concentrations, and other environmental conditions are known stressors that may lead to deleterious behaviors (i.e., impaired swimming capabilities) or even mortality. Peak impingement occurred in February 2007, when water temperatures and the lake's surface elevation were near minimum levels (EPRI 2009), which is expected as decreased temperatures (below 100C) cause stress and lead to impaired swimming ability, especially for shad (Loar et al. 1978; EPRI 2008).

The total annual impingement at Marshall was estimated using the results from the 2006-2007 study (EPRI 2009) and actual water withdrawals at the station in 2016 and 2017. The total number of fish impinged at Marshall under "normal operations" (i.e., not at design capacity) was estimated at 188,419 fish weighing 2,284 lbs. Threadfin Shad and Alewife accounted for 92.0 percent of the annual number impinged and 79.4 percent of the estimated total biomass.

Threadfin Shad was also the most commonly impinged species during the 1974-1975 impingement monitoring effort (Edwards et al. 1976). These results are similar to those obtained during a two-year impingement study at the main cooling water intake of the McGuire Nuclear Station located on the southern end of Lake Norman from 2000-2002, in which Threadfin Shad were more abundant in winter samples while Alewife, White Perch, and Bluegill were frequently collected in impingement samples in summer and fall (Duke Power Company 2003).

The continued dominance of Threadfin Shad in impingement samples since the 1970s indicates that Threadfin Shad populations in Lake Norman remain abundant, stable, and unaffected by impingement losses at the Marshall CWIS. Based on the life history characteristics and intolerance of the Threadfin Shad and Alewife to fluctuations in environmental conditions, the results of the impingement studies at Marshall indicate that these pelagic species are more vulnerable to impingement than littoral species. As discussed in Section 4.11, they are also considered fragile species.

## Impingement Compliance Technology Evaluation

Per §122.21 (r)(6), the owner of a facility must identify the chosen method of compliance with the IM standard for the entire facility, or for each CWIS. Facilities may select one of seven 1M BTA Options provided in §125.94(c) paragraphs (1) through (7) unless pursuing compliance under paragraphs (c)(11) *de minimis* rate of impingement or (c)(12) low capacity utilization power generating units. The facility must also provide sufficient information and justification to support the selected alternative compliance approach. Methods used to assess the compliance options for addressing the requirements of §122.21(r)(6) are provided in Section 6.

Duke Energy performed a screening-level evaluation of IM reduction technologies and alternative operational measures for the CWIS to identify feasible options that could be implemented to reduce impingement at Marshall. Alternatives that were not considered feasible were removed from further consideration. The remaining (i.e., short-listed) options were evaluated in greater detail and the findings, which are presented in Section 6, identify the technology or technologies that could result in the greatest benefit while minimizing implementation, maintenance, and operational costs.

The compliance options were evaluated using the following step-wise process.

1. Determine if Marshall is currently compliant with BTA for impingement under 1M Options 1, 2, or 3, based on existing design and operational data.
2. Evaluate existing impingement data to determine if impingement rates support a de minimis rate of impingement determination by the Director.
3. Determine if the 3-year average (based on most recent data) capacity utilization rate (CUR) is below the Rule-defined threshold of 8 percent.
4. Assess the potential efficacy, technical feasibility, and relative costs of 1M reduction technologies and operational measures applicable to open-cycle cooling systems (1M Options 4, 5, and 6).
5. Evaluate the potential efficacy, technical feasibility, and relative costs of ceasing operations.

Results of the screening-level evaluation of IM reduction technologies and operational measures that could be implemented at Marshall to comply with the IM reduction requirements of the Rule are discussed below.

Marshall is an open-cycle system withdrawing more than 125 MGD of raw water for cooling purposes and the existing design and operation of the CWIS results in TSV estimates of greater than 0.5 fps; therefore, it does not comply with IM BTA Options 1, 2, or 3. Additionally, based on existing conditions, Marshall does not currently comply with IM BTA Option 4 (typically applies to facilities in coastal environments or the Great Lakes), IM BTA Option 5 (currently has fixed screens and no fish return system), or IM BTA Option 7 (not applicable as the most recent impingement study performed did not include an assessment of latent mortality). Further, Marshall does not meet the low capacity utilization rate (CUR) compliance option, as the current 24-month capacity utilization is greater than 8 percent.

The location of the CWIS (at the end of the intake canal and downstream of the curtain wall) provides IM reduction benefits, and since the 0.5 fps velocity contour does not extend beyond the face of the CWIS, the impingement AOI at full pond and maximum drawdown lake elevation would be contained within the CWIS.



Additionally, the AIF withdrawn at the CWIS (from July 1, 2014 through June 30, 2019), represents a 37.5 percent annual flow reduction and a 46 percent maximum seasonal flow reduction from DIF for the station; providing further IM reduction benefits.

Given the existing level of IM reduction benefits, and results of the social cost and social benefit evaluation, installation of additional IM reduction technologies at Marshall is not practical or warranted.

## Summary of Selected Impingement Mortality Compliance Options

Based on the information presented above, estimated annual impingement at Marshall based on actual water withdrawals from 2016 and 2017 was 181,696 and 176,963 fish and shellfish, of which, approximately 92 percent were fragile species(i.e., Threadfin Shad and Alewife). Excluding fragile species from the analysis reduces the annualized IM estimates to 13,604 and 13,774 fish for 2016 and 2017, respectively, or around 37 to 38 non-fragile fish per day. Excluding fragile and introduced species from the analysis reduces the annualized IM estimates to 2,528 and 2,665 fish for 2016 and 2017, respectively, or around 7 non-fragile, native fish per day. Given the efficacy of the existing curtain wall at reducing entrainment and its potential for minimizing passage of impingeable size fish (thus potentially reducing densities of fish susceptible to impingement at the CWIS), the existing curtain wall, in combination with the estimated 37.5 percent impingement reduction achieved through reductions in cooling water withdrawals (based on the 5-year AIF), would comply with IM BTA Option 6 under the Rule

# Analyses Performed in Support of an Entrainment BTA Determination

This section summarizes the analyses required by the Rule for submission to the Director in support of a site-specific best professional judgment (BPJ) review and entrainment BTA determination. Although information presented under the requirements of §122.21 (r)(2) through (r)(8) of the Rule (i.e., Sections 2—8 of the compliance document) provides useful perspective on the location, design, and operation of the existing facility, this section focuses on reports prepared under §122.21 (r)(9) through (r)(13) of the Rule (i.e., Sections 9—13), which offer perspective on entrainment BTA. The process and results for evaluating the social costs, social benefits, and other environmental impacts related to entrainment BTA, as prepared under §122.21 through (r)(12), are outlined along with a description of and results from the peer review process in §122.21(r)(13).

## Entrainment Characterization Study — § 122.21(r)(9)

An entrainment study was performed at Marshall from March 1 — August 27, 1976 (Olmstead and Adair 1981). One unidentified egg and 19 larvae were collected during the historical entrainment study. Yellow Perch (*Perca flavescens*) were the dominant species entrained (47 percent). Unidentified shad species, White Catfish (*Ameiurus catus*), Channel Catfish (*Ictalurus punctatus*), and crappie species were also entrained during the study. Larvae were collected during the entrainment study from March 4 to August 2, with the single unidentified egg collected in April.

To supplement data from the 1976 Entrainment Study (Olmsted and Adair 1981), a two-year Study was performed at Marshall from 2016 to 2017 (see Section 9 and Appendix 9-A). A total of 490 organisms representing 8 distinct taxa from 5 families were collected in ichthyoplankton samples during the two-year Study. The entrainment samples were dominated by species in the Clupeidae family (Alewife, Threadfin Shad, and Gizzard Shad; 70.6 percent across the two years) and White Perch (14.5 percent across both years). Monthly average ichthyoplankton densities for all taxa and life stages were reviewed for temporal (seasonal and diel) trends. In general, the two years of sampling exhibited similar seasonal trends with the highest ichthyoplankton densities coinciding with peak spawning of Clupeidae and White Perch during the spring. Considering a combined sample data set for 2016 and 2017, peak ichthyoplankton densities occurred in the months of April (15.7 organisms/100 m3), May (28.5 organisms/100 m3), and June (12.2 organisms/100 m 3).

Samples collected in 2016 predominantly consisted of post-yolk-sac larvae (39.7 percent), unidentified larval stages (29.6 percent), and eggs (23.6 percent). Few yolk-sac larvae and no young-of-year or older were collected in 2016. Post-yolk-sac larvae accounted for majority (72.5 percent) of 2017 ichthyoplankton totals, followed by eggs (11.3 percent), unidentified larval stages (9.3 percent), and yolk-sac larvae (6.9 percent). No young-of-year or older were collected in 2017. Ichthyoplankton densities within diel periods were variable. Ichthyoplankton density was lowest during the daytime hours and highest during the morning period during both 2016 and 2017.

## Comprehensive Technical Feasibility and Cost Evaluation Study - §122.21 (r)(10)

The Rule requires an evaluation of feasibility and costs for alternative entrainment control measures to support an entrainment BTA determination by the Director. This includes quantification of the potential social costs of alternative entrainment control measures be estimated and compared to potential social benefits. Due to the diversity in organism biology, habitat requirements, and different body sizes of entrainable organisms, the available technologies and measures expected to be reasonably effective at reducing entrainment are relatively limited. An evaluation of potential entrainment reduction technologies for Marshall was performed to identify those that are feasible and practical to address requirements listed at §122.21 (r)(10).

The process for developing this information for Marshall included.

* Evaluating potential siting locations to identify options posing minimal impact on station operations and the surrounding community;

* Assessing potential for overcoming operational problems (e.g., no negative impacts to intake velocities or flows, does not exceed pressure specifications of condensers);

* Evaluating potential for impacting operational reliability;

* Evaluating facility-level Operation and Maintenance (O&M) costs associated with each technology; and

* As required by the Rule, considering the feasibility and costs of three potential technologies that could reduce rates of entrainment at Marshall, which include:

* 1. Retrofit to closed-cycle cooling;

* 1. Installation and operation of FMS with an aquatic organism return system (includes fine-slot wedgewire screens and/or dual-flow screens) at the CWIS; and

* 1. Use of alternate water sources to replace all or some of the water used in the once-through cooling system.

Assessment of Compliance Technology Feasibility

An assessment of multiple entrainment reduction compliance technologies was performed to evaluate potential feasibility at Marshall, with analyses of conversion to closed-cycle cooling towers, including MDCTs, natural draft cooling towers (NDCTs), plume-abated MDCTs, and dry cooling systems, installation of 0.75-mm fine-slot wedgewire screens; installation of 0.75-mm FMS under several different modification scenarios, and water reuse or alternate sources of water.

The evaluation determined that existing water reuse strategies and alternate water sources are unavailable or unable to provide the amount of water needed to replace the volume of cooling water required by Marshall, and thus were excluded from further consideration. Results of the assessment indicated that all but two of the evaluated compliance technologies were infeasible and/or impractical at Marshall; therefore, they were excluded from further consideration. The two entrainment reduction technologies determined to be technically feasible for potential implementation at Marshall are 1) installation of closed-cycle MDCTs and 2) retrofit of the existing CWIS with 0.75-mm FMS and an aquatic organism return system. These two technologies were retained for further evaluation.

For the two potentially feasible technologies, a conceptual design, including location of infrastructure, capital costs associated with technology implementation, project scheduling, permitting requirements, and O&M costs through the remaining life of the station1 were developed. The net present value (NPV) of the social costs of each technology was then developed based on the estimated start of operations for each technology and estimated retirement dates for the station's generating units. It should be noted that the installation of MDCTs would be very challenging due to the limited available space which would result in likely relocation of transmission lines and constructing infrastructure underneath a state highway. Thus, while MDCTs are feasible from an engineering perspective, they are impractical based on construction challenges, significant capital costs, and unit retirement dates. Furthermore, there are uncertainties and challenges associated with a retrofit of FMS traveling screens to replace the existing fixed screens. The complete process and results of the evaluations are provided in Section 10. A summary of the results is presented below.

Social Costs of Compliance Technologies

Social costs were used to determine whether the potential entrainment reduction technology costs would result in the station becoming economically infeasible to operate. Since a premature shutdown of Marshall would result in social costs (i.e., lost jobs, income, and tax base; increased generation costs as power plants lower in the dispatch order would be called upon to make up the lost generation; and increased pollutant air emissions of replacement generation), installing entrainment reducing technologies at Marshall to comply with the Rule represents additional operational costs that would most likely be passed onto Duke Energy's electric customers in the form of higher rates. Thus, the social costs were determined assuming that Duke Energy would incur these additional costs and pass them on to electric customers.

The engineering costs of installing entrainment reduction technologies are estimated by determining the total capital and annual O&M costs, including permitting costs borne by the station for each of the evaluated technologies. The social costs associated with each entrainment reduction technology are estimated by determining the electricity price increases resulting from compliance (i.e., technology installation) and power systemcosts, externality costs, and government regulatory costs.

The analysis discounts the future stream of each of these social costs at the relevant discount rate and sums them over the years they are specified to occur to develop the total social cost estimate presented in the next to last column in the table; annual social costs for each technology are presented in the last column.

## Benefits Valuation Study — §122.21 (r)(11)

The goal of the Benefits Valuation Study is to demonstrate the estimated social benefits that would result from impingement and entrainment reductions based on implementation of one or more technologies at Marshall.

Losses from Entrainment and Impingement Mortality under Technology Scenarios

Impingement and entrainment losses under actual withdrawal volumes for each Reduced- Entrainment scenario (i.e., Post-IM BTA [for impingement], FMS, and MDCT) were converted to net benefits, defined as the potential reduction in entrainment or impingement from the baseline or With-Entrainment scenario. For comparison purposes, an additional scenario (Without-Entrainment) was added to represent the total benefit that would occur to the fishery with the complete elimination of entrainment at Marshall, and assumes a 100 percent elimination of baseline entrainment losses estimated under actual water withdrawal volumes recorded at Marshall over the 2-year Study.

Reductions in entrainment and impingement were estimated with the following assumptions:

* Baseline scenario — Losses based on existing design and operations under actual water withdrawal volumes from 2016 and 2017;
* MDCT scenario — Based on estimated reduction in percent water withdrawal anticipated under the preliminary design assumptions (Section 10); and
* FMS scenario — Based on exclusion efficacy of 0.75-mm FMS (Section 10), on-screen survival (Appendix 11-A), and assumes a 100 percent effective organism return system.

The detailed methodology for developing species and life-stage specific estimates of the potential incremental reductions in entrainment or impingement among compliance technology scenarios is detailed in Section 11. The entrainment and impingement loss reductions estimated for each technology are provided in Appendix 11-A.

Estimated Changes in Stock Size or Harvest Levels

The potential benefits to the fishery, due to changes in stock size or harvest levels, of the estimated entrainment reductions were estimated using commonly applied population and harvest models (EPRI 2004, 2012) that use numeric- and mass-based data in the Production Foregone, Equivalent Adult, and Equivalent Yield models. These three models were used to determine the potential entrainment reduction benefits (for both “use” and “nonuse” scenarios) on recreational harvest (as harvest forgone). Parameters used in population modeling were derived from literature (EPRI 2004; USEPA 2006) and also reflect site specific information on the Lake Norman fishery (when available) and data specific to the recreational uses of the fishery.

The models estimate a maximum benefit of 42 to 954 equivalent adults with a biomass between 16 and 375 lbs and a maximum 18 lbs of recreational yield that would be returned to the fishery under the baseline or Without-Entrainment scenario. The degree of interannual variation in equivalent adults, production foregone, and harvest foregone estimates demonstrate the potential annual variation in benefits that can be anticipated for fishery stocks in Lake Norman near the Marshall CWIS under an entrainment reduction technology. Furthermore, it is important to consider how non-operational factors (e.g., year class strength, annual precipitation and flow changes, annual temperature patterns and fluctuations) can influence fishery stocks and annual entrainment estimates. Therefore, it is important to note that annual entrainment estimates and potential entrainment reduction benefits are intended to be generally representative of potential conditions at Marshall and are not intended to represent minimum or maximum scenarios.

Uncertainty is an inherent aspect of model-based estimation techniques (i.e., equivalent adult and production foregone models) due to the complexities of economics and natural biological systems. The equivalent adult (recreational species) and production foregone (forage or non-game species) estimates for Marshall were used to determine the benefits achievable under each candidate entrainment reduction technology scenario. Although unlikely to substantially change the results of the benefits analysis performed for Marshall, the BPJ decisions and assumptions made in the development of equivalent adult and production foregone models cumulatively have the potential to affect the monetization of benefits. Therefore, a qualitative evaluation was performed on the primary sources of uncertainty associated with this analysis (Appendix 11-F). While efforts were made to control uncertainty to the maximum extent practicable, the models used are "ecologically simplistic and ignore important ecological processes that affect the growth and survival of fish" (EPRI 2004). For example, the equivalent adult and production foregone models do not incorporate density dependance, nor do they assume that entrained and impinged fish are returned to the waterbody (which is often the case, where they can support future primary and secondary production).

However, as a means to present the maximum benefits possible with entrainment or impingement-reducing technologies, input parameters used in the Benefits Valuation Study were based on the most conservative data from literature, and therefore overestimate the potential benefits that would likely occur in the fishery of Lake Norman.

Monetization of Benefits

The benefits of reductions in entrainment and impingement losses of early life stage fish are best evaluated by translating losses to an ecological or human-use context, and assessing differences in total losses among compliance technology scenarios discussed in Section 10. The estimation of social benefits was based on use benefits derived from potential changes in recreational fish stocks (e.g., equivalent adults, forage production foregone, and equivalent yield) and their associated economic effects annualized over the remaining useful plant life.

Another benefit category, nonuse benefits, results from changes in values that people may hold for a resource, independent of their use of the resource. Given the precepts of nonuse values and consideration of estimated entrainment reduction costs and benefits, and the absence of federal or state listed species in entrainment (Section 9), impingement (Section 4 and Section 6), and source waterbody assessments (Section 4), and with entrainment reduction costs that are hundreds to thousands of times the level of benefits, correctly measured nonuse benefits would not influence a BTA determination that considers benefits and costs based on historically applied criteria. A detailed discussion of the typical methods used to evaluate nonuse benefits and the justification for not applying those at Marshall is provided in Appendix 11-E.

Given the annual entrainment loss estimates documented at Marshall for 2016 and 2017, the potential entrainment reduction benefits are modest under each of the scenarios and validate the efficacy of the existing installed curtain wall. Regardless of technology, year of estimated loss, or discount rate assumptions, the present value of reductions in entrainment were estimated to range between $9 (FMS with 2016 entrainment data) and $3, 192 (MDCT with 2017 entrainment data). The annual benefit value was estimated to range between $1 (FMS with 2016 entrainment data) and $456 (MDCT with 2017 entrainment data).

Barnthouse (2013) notes that the available peer-reviewed literature does not support a conclusion that entrainment reductions will produce measurable improvements in recreational or commercial fish populations. The potential social benefits estimated for Marshall based on entrainment reduction scenarios are minimal and thus are consistent with this position.

Other Benefits

Other benefits from reducing entrainment can include ecosystem effects such as population resilience and support, nutrient cycling, natural species assemblages, and ecosystem health and integrity (79 FR 158, 48371). The fisheries benefits study (summarized in Section 11) does not quantify other effects on the fish community, such as density-dependent influences including increased competition, predation, or increased abundance of introduced or nonnative species populations. Further, potential non-use values or effects which many occur in the absence of entrainment or impingement are expected to be minimal and thus, were addressed qualitatively for Marshall.

Based on the relatively low number of annual entrainment losses documented at Marshall (Section 9), regardless of specific entrainment reduction technology, the potential reduction benefits were estimated to be an additional 19,531 lbs of forage biomass added to the fishery, with an equivalent annual recreational yield of 18 lbs. As such, the reduction of entrainment at Marshall is not expected to yield measurable ecological benefits. Further, source water monitoring data demonstrate a balanced fishery continues to exist in Lake Norman with the ongoing operation of the Marshall CWIS.

## Non-Water Quality Environmental and Other Impacts Study - §122.21(r)(12)

The Rule at §122.21(r)(12) requires an assessment of other non-water quality environmental impacts, including estimates of the level of impact, for each technology or operational measure considered under §12.21 (r)(10). It also requires a discussion of reasonable efforts to mitigate the impacts; this information is presented in Section 12. The evaluation must address, if relevant to the alternative technology being assessed, the following items.

* Estimates of changes to energy consumption, including but not limited to, auxiliary power consumption and turbine backpressure energy penalty;

* Estimates of increases in air pollutant emissions;

* Estimates of changes in noise generation;

* A discussion of potential impacts to safety;

* A discussion of facility reliability;

* Estimation of changes in water consumption; and

* Discussion of efforts to mitigate these adverse impacts

The conceptual approach to each technology (e.g., location and design of the cooling towers), as defined in Section 10, has an important effect on the level of impacts discussed in Section 12. The quantitative engineering and costing analyses presented in Section 10 includes an evaluation of potential impacts and incorporates reasonable estimates of impact mitigation and associated costs, thus concepts and approaches presented in Section 10 and 12 are related.

Impact information presented in Section 12 of the compliance document are summarized and discussed below in the sections addressing the "Must" and "May" factors.

## Peer Review - §122.21 (r)(13)

As required by the Rule at §122.21(r)(13), the reports prepared under §122.21(r)(10)-(r)(12) were subjected to an external peer review by subject matter experts. The independent peer review process is summarized in Section 13 of this document. Four expert peer reviewers were selected in fields relevant to the material presented in the submittal package (i.e., power plant engineering, aquatic biology, and resource economics). Section 13 of this document provides a summary of the peer reviewer qualifications (Appendix 13-A), a log of written/electronic/phone communication with peer reviewers (Appendix 13-B), documentation of formal peer review comments and responses to those comments (Appendix 13-C and 13-D), and includes confirmation from reviewers of their satisfaction with responses to comments and recommended revisions.

# Entrainment BTA Factors that Must Be Considered

The Rule requires that the Director consider several factors in the written explanation of the proposed entrainment BTA determination. The following Must factors to be considered for entrainment BTA (§125.98(f)(2)) are:

* Numbers and types of organisms entrained, including federally listed, threatened and endangered species, and designated critical habitat (e.g., prey base, glochidial host species);

* Impact of changes in particulate emissions or other pollutants associated with entrainment technologies;

* Land availability as it relates to the feasibility of entrainment technology;

* Remaining useful plant life; and

* Quantitative and qualitative social benefits and costs of available entrainment technologies.

While each of the Must factors is considered separately in Section 10 for the potential technologies considered (i.e., MDCT and FMS with an aquatic organism return), a brief summary of findings for each factor is presented below along with references to the relevant section(s) of the report.

## Numbers and Types of Organisms Entrained

Sections 9 and 11 present the number and types of organisms entrained based on the 2-year

Study at Marshall (HDR 2019); these data were annualized and adjusted for station flows (maximum and actual intake flows) to estimate total annual entrainment losses. The annual estimates are presented separately for 2016 and 2017 based on the rates of entrainment documented during the 2016-2017 Study and demonstrate the range of interannual variation in entrainment losses that can occur at the Marshall CWIS.

An estimated total of 490 ichthyoplankton representing 8 distinct taxa from 5 families were collected during the two-year Study. The ichthyoplankton samples were dominated by species in the Clupeidae family (Alewife, Gizzard Shad, and Threadfin Shad), followed by White Perch. No endangered or threatened species are known to exist in Lake Norman and none were collected during the two-year Study. At the maximum potential cooling water intake withdrawal volumes (based on design pump capacities), the estimated total annual entrainment varied from 40.4 million ichthyoplankton in 2016 to 60.2 million ichthyoplankton in 2017. The annual entrainment estimates based on 2016 and 2017 AIF volumes, varied from 24.1 million ichthyoplankton in 2016 to 31.6 million ichthyoplankton in 2017.

The period of peak entrainment at the Marshall CWIS is primarily from April to June, followed by a decline in entrainment beginning in July. No organisms were entrained in October of 2016 or August through October of 2017. The two-to-three-month spring period of entrainment observed in Lake Norman is typical of reservoirs in the southeastern U.S. (EPRI 2011). The results of this Study are also consistent with results documented in the 2016 Marshall Curtain Wall Study (HDR 2017), which demonstrated that the curtain wall reduced ichthyoplankton abundance from the lake side to the intake side of the wall by 98 percent and that reductions extend from the intake side of the curtain wall to the CWIS (see Section 7.1.1).

It is unlikely that entrainment at Marshall has a significant influence on clupeid population stability in Lake Norman due to their life history characteristics. Clupeids are prolific, broadcast spawners producing demersal and adhesive eggs that sink to the bottom of the water column where they attach to substrates, plants, or other objects (Etnier and Starnes 1993; Hendrickson and Cohen 2015), thus reducing their susceptibility to entrainment at the CWIS. Once hatched, the pelagic larvae may be drawn into the CWIS where they are susceptible to entrainment. Clupeids are pelagic species with relatively high abundance and fecundity in Lake Norman. Additionally, clupeids exhibit a wide-spread distribution in Lake Norman so entrainment losses are replenished by cohorts spawned from other locations. Multiple years of monitoring data via purse seines and hydroacoustics (see Section 4.2.2) along with data from the Study demonstrate that clupeids continue to maintain self-sustaining populations. Therefore, it is unlikely that the operations at Marshall have a measurable impact on the clupeid populations in Lake Norman.

White Perch also dominated sample collections during the Study. Similar to clupeids, White Perch are prolific broadcast spawners with demersal eggs. White Perch may spawn 20,000 to 150,000 adhesive eggs, which hatch within 30 hours to 6 days (SCDNR 2013; Rohde et al. 2009). Given the prolific reproductive capabilities of the White Perch (SCDNR 2013; USFWS 2014), widespread distribution, continued abundance evidenced by monitoring data, and densities observed during the current Study, it is unlikely that operations at Marshall has a significant influence on White Perch population stability in Lake Norman.

It is important to place the rates of entrainment at Marshall into the context of the trends documented for Lake Norman, the source waterbody (see Section 4);

* Duke Energy performs annual monitoring of the Lake Norman fishery, with results that continue to demonstrate a stable and balanced, self-sustaining population with a robust forage fish base supportive of predatory species (Section 4);

* With a littoral zone community dominated by centrarchids and a pelagic community dominated by clupeids, Lake Norman supports a typical southeastern U.S. Piedmont fishery. The species composition of the Lake Norman fish community has demonstrated variability in species composition and dominance, a result of non-native species introductions (e.g., Alewife, White Perch, Alabama Bass, Green Sunfish, Blue Catfish, and Flathead Catfish). Regardless of the evolving species composition, abundant littoral zone and pelagic forage fish species (Threadfin and Alewife) continue to provide a regular and diverse prey base for predators. Annual lake monitoring studies indicate that Lake Norman continues to support a balanced fish community; and

* The direct and indirect effects of the small loss of organisms at Marshall, as demonstrated through modeling (specifically designed to overestimate effects), does not result in a negative impact to the recreational fishery (see Section 11).

These findings are interrelated and driven by the same factors: (1) Marshall entrainment consisted of early life stages of highly fecund, fragile, and invasive species, many of which exhibit high natural mortality, and (2) entrainment losses represent a small portion of the available Lake Norman resources, a result of the effectiveness of the curtain wall at reducing entrainment at the Marshall CWIS. Based on the estimated annual losses under existing conditions, the total annual harvest foregone was estimated to be 1 lbs in 2016 and 18 lbs in 2017. Harvest foregone represents the total annual biomass lost from the recreational fishery due to entrainment at Marshall. Given the low annual entrainment loss estimates documented at Marshall for 2016 and 2017, the losses resulting from entrainment are not expected to impact the Lake Norman fishery.

The incremental reductions in estimated entrainment losses, and their effect on the fishery as represented by production foregone, equivalent adults, and harvest foregone, were modeled for each of the potential compliance scenarios described in Section 11 of the compliance document. Although already markedly reduced due to the curtain wall efficacy, entrainment was estimated to be further reduced by approximately 98 percent under a closed-cycle cooling (MDCT) retrofit, based on the anticipated water withdrawal volumes. The potential percent reductions estimated under the 0.75-mm FMS retrofit scenario (i.e., the product of the rate of exclusion and post-exclusion onscreen survival) were less than 7 percent for equivalent adult numbers and biomass, between 4.5 and 22.4 percent in lbs of biomass production foregone, and between zero and 8.3 percent in lbs of harvest foregone. The entrainment losses at Marshall in 2016 and 2017 were dominated by fragile forage species and introduced recreational species. Interannual variation in the composition and abundance of species and life stages within entrainment samples, along with the dominance of fragile species, resulted in minimal percent reductions in equivalent adult, production foregone, and harvest foregone estimates under the FMS retrofit scenario.

Given the low number and types of organisms entrained at Marshall (highly fecund or invasive species and absence of protected species) do not provide a compelling basis under the Rule to evaluate additional entrainment measures. The low entrainment rates at Marshall do not negatively affect the Lake Norman fishery, which continues to reflect a balanced and indigenous community.

## Impacts of Changes in Air Emissions of Particulates and Other Pollutants

The assessment of entrainment technologies for BTA considers changes in pollutant air emissions in Section 12. The increase in emissions is associated with two factors: (1) on-site particulate matter (PM) emissions from the cooling towers associated with the concentration of total dissolved solids (TDS) and total suspended solids (TSS) in the cooling water, and (2) loss of generation capacity associated with parasitic loads and loss of efficiency based on the entrainment technology operating requirements.

Emissions associated with the replacement of lost generation at Marshall would include minor increases in carbon dioxide, sulfur dioxide, and nitrogen oxides. These increased emissions are based on assumptions and results of Duke Energy's Power System Simulation Model (PROSYM). For all modeled years, the PROSYM results indicate the net difference in carbon dioxide, sulfur dioxide, and nitrogen oxides air emissions is less than 0.5 percent when compared to the base case air emissions for both the MDCT and FMS technology retrofit scenarios. No attempt was made to monetize the social costs of the increased emissions.

## Land Availability Related to Technology Retrofit Options

Land availability for infrastructure associated with the retrofit of potential entrainment technologies was considered in the assessment of entrainment BTA for Marshall. While land is technically available at Marshall to facilitate a closed-cycle cooling tower retrofit, there are substantial site constraints that would impact the placement, required infrastructure, and associated costs.

Two hypothetical MDCT locations were selected (see Figure 10-11). The conceptual design for hypothetical MDCT Location A includes placing four linear back-to-back MDCTs, one for each unit, to the northeast of the station in an undeveloped wooded area. This hypothetical location avoids station infrastructure, overhead transmission lines, and the 100-year floodplain, but poses construction constraints including steep topography, pipe crossing(s) of North Carolina State Highway 150 and the station entrance access road, and the potential for roadway icing from cooling tower plumes. At Location A, the cooling towers would be within 400 ft of the closest property boundary, excluding public roadways. The building that is on the closest adjacent property is located approximately 300 ft from the closest hypothetical cooling tower at Location A and is a commercial facility (non-residential). Noise mitigation studies would potentially be required prior to design or construction of cooling towers at this hypothetical location. While Location A is not ideal for the construction or operation of hypothetical closed-cycle cooling towers at Marshall, other potential locations considered were less suitable, as discussed in Section 10.

The conceptual design for hypothetical cooling tower Location B includes placing four linear back-to-back MDCTs, one for each unit, to the south of Marshall's generating units. This hypothetical location avoids the 100-year floodplain, overhead transmission lines, and station infrastructure, but poses construction constraints including steep topography, pipe crossing(s) of North Carolina State Highway 150 and other local roadways, and the potential for roadway icing from cooling tower plumes. In addition, this location is partially outside of Duke Energy's property boundary. Location B, while closer to the existing generation units at Marshall, is less suitable for the construction and operation of hypothetical closed-cycle cooling towers at Marshall due to roadway crossings and property right-of-way and acquisition requirements.

For both hypothetical MDCT locations, new piping would be installed under North Carolina State Highway 150 and potentially other roadways, which would require significant permitting and construction. There are future plans to expand the existing North Carolina State Highway 150 south of the station, and the hypothetical cooling towers at this location could potentially impact traffic safety on this expanded highway due to icing and fogging, as discussed in Section 12.

## Remaining Useful Station Life

The remaining life of each generating unit and each technology impacts O&M costs, potential future technology replacement costs (if the life of a generating unit is longer than the anticipated life of a technology), and the associated social benefits. If the hypothetical entrainment reduction technology is in good operating order at that time, it is assumed that the technology would be retired at that time (no salvage value has been included). This evaluation assumes that Marshall Units 1, 2, 3 and 4 will operate through 2034 (Duke Energy 2019). The expected lifespan of the technologies evaluated are longer than the assumed lifespan of the generating units, therefore, technology replacement costs are assumed to be zero.

## Quantitative & Qualitative Social Benefits and Costs of Available Entrainment Technologies

The social costs and social benefits for each compliance technology option evaluated for Marshall are summarized in Section 10 and provides the present value estimates discounted at 3 and 7 percent based on the estimated annual losses for entrainment and impingement for 2016 and 2017. The social benefits include both the impingement and entrainment benefits estimated for each compliance option. The methodology and results for estimating the entrainment benefits are presented in the Entrainment Reduction Benefits Study (Appendix 11-E). The methods and results for estimating the social costs are presented in the Social Costs of Purchasing and Installing Entrainment Reduction Technologies Study (Appendix 10-H).

Quantitative Cost to Benefit Comparison

The Rule has two separate regulatory components:

* A command and control component in which the facility must implement one of seven impingement compliance alternatives (S 125.94(c)) if not currently installed, or demonstrate that its rate of impingement is *de minimis* (§ 125.94(c)(11)); and

* A site-specific best technology available evaluation to determine the maximum entrainment reduction warranted based, in part, on the social costs and social benefits of each technology.

By comparing the entrainment reduction options to the impingement option, the evaluation provides context for what is warranted for entrainment versus what is required for impingement.

The impingement compliance option (as identified in Section 6), represents the current configuration and has net benefits of -$0.02M. By comparison, the entrainment compliance options of FMS and MDCT have net benefits of -$45.89M and -$586.41M, respectively.

Entrainment BTA determinations require consideration of both benefits and costs. Under the criterion that governs benefit-cost-based determinations, only technologies that have social benefits that exceed their social costs are justified (Boardman et al. 2018; Freeman et al. 2014). As noted in the Rule, "[i]f all technologies considered have social costs not justified by the social benefits... the Director may determine that no additional control requirements are necessary beyond what the facility is already doing. The Director may reject an otherwise available technology as a BTA standard for entrainment if the social costs are not justified by the social benefits (§ 125.980(4)).”

Given that the net benefits are negative for each of the alternatives, the social costs are not justified by the potential social benefits. Therefore, neither the FMS nor MDCT entrainment compliance option is justified as the BTA under the Rule's site-specific entrainment compliance requirements. Additionally, the 2016-2017 entrainment monitoring data clearly demonstrate that the existing system of technologies (curtain wall and flow reduction) substantially reduce entrainment at the CWIS

Qualitative Cost to Benefit Comparison

The qualitative costs and benefits of reducing entrainment and IM are difficult to evaluate and quantify and therefore are not included in the benefits valuation presented in Section 11. These qualitative effects, however, may result in ecosystem benefits such as increased population resilience and support, nutrient cycling, and overall health and integrity of the ecosystem (79 FR 158, 48371). The reduction in entrainment losses could also result in qualitative costs to the fish community due to density-dependent influences such as increased competition, predation, or increased populations of introduced species.

Heated water discharged into Lake Norman from Marshall creates favorable habitat conditions during colder winter months by forming a warm water refuge in the vicinity of Marshall and supporting a winter fishery for recreational anglers. The elimination of warm water discharges at Marshall is a potential outcome under closed-cycle cooling (MDCT) scenario (see Section 11), which could lead to social costs or social benefits. Estimating the impacts of the loss of Marshall's winter fishery requires assessing the relationship between the thermal discharge, fishery changes, and the impact that fishery changes have on people. For recreational values, this includes understanding how Marshall's thermal discharge affects recreational fishing catch rates and how changes in catch rates affect angler well-being

A Recreational Angling Demand Model was used to link fishery-specific catch and effort rates, thus forming a bio-economic equilibrium for the Lake Norman fishery expected to be affected by the loss of Marshall's thermal discharge (Veritas 2020). The integrated partial equilibrium model simulates conditions under With Thermal Discharge (baseline) and Without Thermal Discharge conditions, and the monetized welfare differences between these two conditions determine the impacts of the loss of Marshall's thermal discharge. As described in USEPA's Guidelines for Preparing Economic Analysis (USEPA 2016), equilibrium modeling using the With- and Without-impact approach is central to all sound benefit estimation processes and regulatory impact analyses.

Within the model, winter catch estimates were modified to represent recreational catch rates and values if the thermal discharge was eliminated. The Recreational Angling Demand Model considered potential impacts to anglers located in ZIP codes within a 50-mile radius of affected sites in Lake Norman. The model was applied from 2028 (the year the MDCTs would be operational, thus eliminating the heated discharge) to 2034 (the assumed retirement of Marshall). Over this 7-year period, the present value estimate of the social cost ranges from a loss of approximately $163 (7 percent discount rate) to approximately $245 (3 percent discount rate) (see Appendix 10-H).

The fish species composition found in the vicinity of the discharge may also change in response to reduced warm water discharges. Depending on the species, this may be seen as either a cost or a benefit. An example of a species which may use the thermal discharge as refuge in Lake Norman is the Threadfin Shad, which even as a non-native species still provides an important forage base for recreational predator species (Duke Energy 2014 a,b,c; 2015; 2016 a, b; 2017; 2018 a). The elimination of warm water discharges into Lake Norman would result in cooler water temperatures immediately downstream from the Marshall discharge canal; however, since ongoing monitoring activities continue to demonstrate a balanced and indigenous community near Marshall, the potential for the fish community to benefit from elimination of warm water discharges is expected to be minimal. Despite the fragile nature of Threadfin Shad and temperature-induced seasonal die-offs, the continued presence of robust and balanced Threadfin Shad populations in maintenance monitoring studies of Lake Norman indicates that the Marshall CWIS is not having an adverse effect on their populations. Furthermore, due to their low tolerance of cool temperatures, the long term success of this species in Lake Norman may be owed, in part, to the thermal influence of McGuire's, and to a lesser extent Marshall's thermal discharge creating a winter fishery during low temperature

# Entrainment BTA Factors that May Be Considered

The May factors to be considered for entrainment BTA (§125.98(f)(3)) are:

* Entrainment impacts on the waterbody;

* Thermal discharge impacts;

* Credit for reductions in flow associated with the retirement of units occurring within the ten years preceding October 14, 2014;

* Impacts on the reliability of energy delivery within the immediate area;

* Impacts on water consumption; and

* Availability of process water, grey water, wastewater, reclaimed water, or other waters of appropriate quantity and quality for reuse as cooling water.

The information from this list is included or addressed in detail in the study reports and supporting documentation provided in Sections 2 through 12 of the compliance submittal document. The findings of the entrainment BTA assessment relative to the factors that NCDEQ may consider are provided below.

## Entrainment Impacts on the Waterbody

The degree of susceptibility of aquatic organisms to entrainment can be quite variable depending on their size, swimming ability, wind speed and direction, bathymetry of the lake and intake canal, and the rate and variability of flows withdrawn at the Marshall CWIS. Due to the variability associated with these factors, an entrainment AOI at Marshall was not quantified, but is discussed qualitatively. Most entrainable-sized organisms are unable to swim and, thus float within the water column or at the water surface where they are subject to ambient flows and currents within Lake Norman and the Marshall intake cove and canal.

The potential exists for entrainment of aquatic organisms within the intake canal at Marshall, and the likelihood of entrainment would increase as an organism's proximity to the Marshall CWIS increases. However, a curtain wall located at the entrance of the intake cove, which facilitates water withdrawal from the lower portion of the water column, was shown to be effective at reducing the number of ichthyoplankton (see Section 7.1.1) passing from Lake Norman into the Marshall intake canal by greater than 95 percent (HDR 2017). The documented reduction extends to the Marshall CWIS, as evidenced by the relatively low ichthyoplankton densities documented in the entrainment characterization study, as presented in Section 9.

Based on the information presented above and in Sections 2 through 12 of the compliance document, entrainment at Marshall does not result in substantial or adverse impacts to Lake Norman, with no observable or measurable impacts occurring based on the stability of the fishery and presence of a balanced indigenous community (Sections 4 and 9). This position is further supported by the results of the quantitative modeling of the effects of entrainment, using recent monitoring data collected at Marshall in 2016 and 2017 (Section 9), including direct losses of recreational species as well as indirect losses from trophic transfer of forage species to consumers or predators (see Section 11).

## Credit for Flow Reductions

No unit retirements have occurred within the preceding 10-year period and none are planned in the next 5-year period. Marshall's DIF is 1,463 MGD. The station employs seasonal flow reductions (i.e., typically, one pump per unit is operated during the colder winter months when intake temperatures are lower) which resulted in a 37.5 percent reduction in water withdrawals over the 5-year POR, compared to operating at full pumping capacity. It is assumed that reductions in cooling water withdrawal are commensurate with reductions in impingement and entrainment.

## Impacts on the Reliability of Energy Delivery

Marshall is a large generating asset that supports the reliable supply of electricity to Duke Energy's customers. Maintaining safe and reliable energy delivery is imperative to Duke Energy, their customers, and their shareholders, and has been considered in this entrainment BTA assessment in the following manner:

* During the conceptual design phase for potential entrainment reduction technologies, consideration was given to the location, configuration, operational requirements, and other design specifics for each potential technology to maintain generation reliability. This information was incorporated into capital and social costs estimated for each potential retrofit option; and
* System modeling (i.e., PROSYM) was performed by Duke Energy to evaluate the extent and impact (system-wide) of loss of generation capacity associated with potential technology retrofit options to ensure reliable energy delivery and to estimate the social costs of securing it.

Under the MDCT retrofit scenario, the station would potentially be required to operate at reduced power during the warmest and most humid periods of a typical year due to the inability of the cooling towers to provide an acceptable cold water discharge temperature during these periods. The power reduction is anticipated to result in reliability impacts due to increased condenser and turbine backpressures. Additionally, during periods of peak demand in winter, there would be the potential for icing on Marshall's transmission lines due to cooling tower plume formation, which could impact station reliability.

Under the 0.75-mm FMS retrofit scenario, there would be significant increases to TSV and headloss across the screens, especially during high debris loading (i.e., clogging) events, which could impact the performance of the existing CCW pumps or result in pump cavitation, damage, or failure. This situation would significantly impact station reliability at Marshall. It is noted that retrofitting an active power station presents different challenges than constructing a new facility, as maintaining safe station operating conditions is paramount during a retrofit.

## Availability of Alternate Water Sources for Use as Cooling Water

Alternate water sources, such as groundwater and grey water sources, were evaluated for potential use to supplement the current water needs at Marshall. These sources were evaluated by first comparing the distance and available flow of the potential alternate water source to the location of the station, and then by determining its practicability as a source of cooling water for the station. Due to permitting challenges such as stream and wetlands crossings, numerous rights-of-way required over private properties, and prohibitive construction costs, alternate water sources more than 5 miles from the station are not considered feasible. Groundwater and grey water sources within 5 miles of Marshall were determined to be of insufficient quantity to support the station's cooling water requirements. In addition, the only potentially reusable existing onsite water source would be service water, which would have treatment requirements prior to reuse, and is not considered a viable option.

# Conclusions

Based on the current design (location and depth) and operations of the Marshall CWIS and the prevalence of fragile and introduced species in entrainment and IM losses, and with consideration of the anticipated 2034 facility retirement, a determination that the existing configuration, which includes a system of technologies, is requested as the IM BTA Option for the Marshall CWIS. The data presented in Section 6 and summarized in this Executive Summary demonstrate that the current design and operations at Marshall result in IM primarily composed of fragile clupeids and that the social costs of implementing additional impingement reduction technology for the Marshall CWIS do not justify the potential social benefits.

As outlined in the Rule, the requirements of the NPDES Director include the following (40 CFR §125.98(f), Site-specific Entrainment Requirements):

(4) *If all technologies considered have social costs not justified by the social benefits, or have unacceptable adverse impacts that cannot be mitigated, the Director may determine that no additional control requirements are necessary beyond what the facility is already doing. The Director may reject an otherwise available technology as a BTA standard for entrainment if the social costs are not justified by the social benefits.*

Model-based estimates of the direct and indirect effects of the loss of organisms at Marshall, based on conservative assumptions and BPJ decisions, indicated that losses do not have a negative impact on the recreational fishery of Lake Norman. The existing Marshall CWIS incorporates entrainment reduction technologies, such as a curtain wall that facilitates water withdrawals from the lower portion of Lake Norman, and operational flow reductions of approximately 37.5 percent from DIF based on the most recent 5-year POR.

The model-based estimates of entrainment losses were used to assess the social costs and social benefits of potential entrainment reduction technologies, including: (1) installation of MDCT and (2) the installation of FMS at the existing CWIS with an organism return system. Monetized social costs and social benefits were estimated for both technologies to provide a common basis for comparison, which is consistent with the goals and requirements of the Rule. The estimates were based on conservative assumptions (e.g., all entrained organisms were

considered to affect recreational fisheries either directly as equivalent adults or indirectly through trophic transfer of production foregone biomass) and include evaluations of uncertainty at multiple stages of the development process. The social cost to social benefit comparison yielded substantial net-negative benefits for the modeled entrainment reduction technologies, and unavoidable adverse effects were identified for both evaluated technologies. A potential MDCT retrofit would result in increased air emissions, increased noise, and potential impacts to station reliability. A 0.75-mm FMS retrofit would result in increased TSV and headloss across the screens, which could negatively impact existing CCW pump operation, station reliability, and availability of cooling flow.

Based on historical and periodic biological monitoring data, historical impingement and entrainment monitoring, and results of the 2016-2017 entrainment Study presented in Section 9, Lake Norman supports a diverse and balanced community in the presence of ongoing operations at Marshall. No federal or state threatened or endangered species are known to occur in Lake Norman near Marshall, none were collected in the recent or historical impingement and entrainment studies, and none were collected during the entrainment sampling activities or the 2017 curtain wall study. These data, combined with the evaluations described in Sections 10 through 12, demonstrate that the additional entrainment reduction technologies that were identified as feasible in Section 10 (MDCT and FMS) are not justified as BTA for entrainment at Marshall as they would result in adverse effects (described above and in more detail in Section 10) and the estimated social costs would be wholly disproportionate compared to the potential social benefits.

The NPDES Director must consider the social costs and benefits of each evaluated entrainment compliance option when determining the maximum entrainment reduction warranted; however, from a practical standpoint, any modifications to the existing intake structure or station operations would provide minimal biological benefits. For the purposes of the current compliance submittal, all units at Marshall are expected to retire in 2034.

For the MDCT installation scenario, the cost benefit ratio is estimated at approximately 29,322:1 (i.e., $586.43M/$0.02M). Retrofitting the existing CWIS with 0.75-mm FMS and aquatic organism return system would result in an estimated cost benefit ratio of approximately 1,531:1 (i.e., $45.92M/$0.03M). Per 40 CFR §125.98(f)(4), an available technology may be rejected as BTA “if the social costs are not justified by the social benefits”. Based on the evaluation of social costs and benefits of each technology, the existing (i.e., baseline) configuration at Marshall represents BTA for meeting the entrainment requirements of the Rule.

Furthermore, per §122.21(r)(6), the owner of a facility must identify the chosen method of compliance with the IM standard for the entire facility and provide sufficient information and justification to support the selected alternative compliance approach. Based on the current IM reduction benefits at the station (i.e., location of the CWIS, reduction in AF relative to DIF) and the results of the social cost and social benefit evaluation, installation of additional IM reduction technologies at Marshall is not practical or warranted.

**Based upon a review of the information provided by both Duke and independent consultant the Division agrees with the conclusion of the Duke report that “the current design and operations at Marshall result in IM primarily composed of fragile clupeids and that the social costs of implementing additional impingement-reduction technology for the Marshall CWIS do not justify the potential social benefits” and “based on the evaluation of social costs and benefits of each technology, the existing (i.e., baseline) configuration at Marshall represents BTA for meeting the entrainment requirements of the Rule.”**

**These conclusions are supported by the four independent peer reviewers retained by Duke and by the DWR environmental scientists. It is also important to emphasize that the Marshall station operated since 1965 and maintained Balanced and Indigenous Population in Lake Norman, which supports conclusion of the report. Furthermore, the station is scheduled to retire in 2034 and any additional technologies installed will have a very short lifespan (7-year accrual period for MDCT and 9-year accrual period for FMS) that is unlikely to have any measurable impact on the aquatic community.**

## INSTREAM MONITORING-OUTFALL 002

The permit required monthly upstream and downstream monitoring near the ash pond discharge. The upstream site (Station 15.9) is approximately 1 mile upstream of the discharge and downstream location (Station 14) is approximately 1 mile downstream of the discharge. These monitoring stations have been established through the BIP monitoring program, which was required to maintain the 316(a) temperature variance. The monitored parameters are: As, Cd, Cr, Cu, Hg, Pb, Se, Zn, Br, Total Hardness as CaCO3) and Total Dissolved Solids (TDS). The concentrations of the measured parameters downstream are either below detection level (As, Cd, Pb, Se, Zn) or below water quality standards. Bromide does not have a water quality standard or EPA criterion and it is not possible to evaluate the obtained results.

It is required that the monitoring of the instream stations will continue during the next permit cycle. It is also required that the facility uses low level method 1631E for all Hg analysis.

## FISH TISSUE MONITORING-NEAR OUTFALL 002

The permit required fish tissue monitoring for As, Se, and Hg near the ash pond discharge. Samples were taken at one upstream location and two downstream locations. Sunfish and Black Bass tissues were analyzed for these trace elements. All results were below action levels for Se and Hg (10.0 µg/g – Se, 0.40 µg/g – Hg, NC) and screening value for As (1.20 – µg/g, EPA). These results are consistent with the previous monitoring results. The only exception was an individual Alabama Bass collected at the upstream location with a Hg concentration of 0.57 µg/g, which exceeds Hg screening value. Since this fish was collected upstream of the discharge, this result is unlikely to be caused by the effluent from the Marshall station.

## TOXICITY TESTING-OUTFALL 002 AND OUTFALL 005

Current Requirement: Outfall 002 – Chronic P/F @ 23% using Ceriodaphnia

Recommended Requirement: Outfall 002 – Chronic P/F @ 7.2% using Ceriodaphnia

This facility has passed all toxicity tests during the previous permit cycle, please see attached.

Current Requirement: Outfall 005 – Chronic P/F @ 11.6% using Ceriodaphnia

Recommended Requirement: Outfall 005 – Chronic P/F @ 11.6% using Ceriodaphnia

This facility has passed all toxicity tests (except 1) during the previous permit cycle, please see attached.

For the purposes of the permitting, the highest monthly average flow reported during the last 3 years in conjunction with the 7Q10 summer flow was used to calculate the percent effluent concentration to be used for WET.

## COMPLIANCE SUMMARY

Based on the monitoring required under the current version of the permit there was one violation of the TSS limit resulting in the Notice of Violation during the last permit cycle.

## PERMIT LIMITS DEVELOPMENT

* The temperature limits (Outfall 001) are based on the North Carolina water quality standards (15A NCAC 2B .0200) and 316(a) Thermal Variance. Summer and winter thermal limits have been established in support of the 316(A) temperature variance issued by EPA in May of 1975.
* Free Available Chlorine Limits (Outfall 001 and Outfall 003) were established in accordance with 40 CFR 423.
* The limits for Oil and Grease and Total Suspended Solids (Outfall 002) are based on Best Professional Judgment and are more stringent than prescribed in the 40 CFR 423.
* The pH limits (Outfall 002, 002A, 002B, 003, and 005) in the permit are based on the North Carolina water quality standards (15A NCAC 2B .0200).
* The limits for Total Copper and Total Iron (Outfall 005) were established in accordance with 40 CFR 423.
* The limits for Oil and Grease and Total Suspended Solids (Outfalls 002A, 002B, and 005)) were established in accordance with 40 CFR 423.
* The turbidity limit in the permit (Outfall 002) is based on the North Carolina water quality standards (15A NCAC 2B .0200).
* The Technology Based Effluent Limits for Total Arsenic, Total Mercury, Total Selenium, and Nitrate/nitrite as N (Outfall 006) are based on the requirements of 40 CFR 423.
* The Whole Effluent Toxicity limit (Outfalls 002 and 005) is based on the requirements of 15A NCAC 2B .0500.

## PROPOSED CHANGES

* The Effluent Page for the decanting (Outfall 002) was removed from the permit since the facility transitioned to the dewatering process.
* Limits for Total Arsenic have been removed from the permit based on the results of the Reasonable Potential Analysis (Outfall 002).
* The monitoring frequency for the Total Copper, Total Selenium, Total Iron, and Total Mercury was reduced from Weekly to Monthly based on the results of the Reasonable Potential Analysis (Outfall 002).
* Limits for Total Copper have been converted from Water-Quality Based Limits to Technology Based Limits based on the results of the Reasonable Potential Analysis (Outfall 005).
* The Instream Waste Concentrations for the Whole Effluent Toxicity Test was changed based on the highest reported flow data (Outfall 002 and Outfall 005).
* Limits for Total Iron and Total Copper and Total Iron have been removed from Outfall 002 since ash basin no longer receives any wastewater.
* The Outfall 003 status was changed from internal to external to reflect the current conditions at the facility.
* The monitoring for the Total Cadmium, Total Chromium, Total Iron, Total Lead, Total Nickel, Total Silver, and Total Zinc have been removed from the permit based on the results of the Reasonable Potential Analysis (Outfall 005).
* The monitoring frequency for the Sulfates, Chloride, Bromide, TDS, and Total Hardness was reduced from Monthly to Quarterly based on the results of the Reasonable Potential Analysis and review of the effluent data (Outfall 005).
* The Chronic Toxicity monitoring frequency was reduced from Monthly to Quarterly to be consistent with other major industrial permits (Outfall 005).
* The Section A. (19.) entitled Ash Settling Basin was removed from the permit since wastewater is no longer discharged to the Ash Basin.
* The Section A. (20.) entitled Chemical Metal Cleaning Waste was removed from the permit since wastewater is no longer discharged to the Ash Basin.
* The instream monitoring frequency was reduced from Monthly to Quarterly based on the review of the instream data that demonstrated a lack of noticeable impact from the facility on the receiving stream.

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| PROPOSED SCHEDULE |  |
| Draft Permit to Public Notice: | December 28, 2021 |
| Permit Scheduled to Issue: | February 25, 2022 |

## STATE CONTACT

If you have any questions on any of the above information or on the attached permit, please contact Sergei Chernikov at (919) 707-3606 or sergei.chernikov@ncdenr.gov.