DOMINION VIRGINIA POWER / NORTH CAROLINA POWER

ROANOKE RAPIDS AND GASTON PROJECT

FERC NO. 2009

ARTICLE 411 BYPASSED REACH FLOW RELEASE PLAN

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1. INTRODUCTION

1.1 Project Description

The Roanoke Rapids and Gaston Project is located on the Roanoke River in Virginia and North Carolina downstream of the U.S. Army Corps of Engineers (USACE) Kerr Dam. Kerr, Gaston, and Roanoke Rapids form a continuous chain of reservoirs used for flood control, recreation, water supply, and power generation along the middle portion of the Roanoke River basin.

1.1.1 Roanoke Rapids Development

The Roanoke Rapids development is located 42 miles downstream from the Kerr dam (7.5 miles downstream from the Gaston development) at RM 135. The development's principal, existing features consist of:

1 a concrete gravity dam, measuring 3,050 feet long (includes powerhouse) with a maximum of 72 feet high;
2. a concrete ogee-type spillway, measuring 1,133 feet in length and having 24 spillway bays, each 44 feet wide with steel gates, one 25-foot-wide skimmer bay, and a 48-foot-wide non-overflow section;
3. an 8-mile long impoundment, with a total storage volume of 77,140 AF (20,640 AF useable storage) and surface area of 4,600 acres at a normal water surface elevation of 132 feet msl;
4. intakes integral with the powerhouse, with trash racks having a clear bar spacing of 6 inches;
5. a submerged rockfill weir, located upstream of the intake and surrounding the intake on three sides;
6. a 224-foot-long concrete and masonry powerhouse and an adjacent 182-foot-long service bay;
7. four Kaplan turbines (three fixed-blade propeller and one variable-pitch blade), having a total installed capacity of 104 MW (99 MW dependable) and a maximum hydraulic capacity of 20,000 cfs;
8. a 7,800-foot-long by 80-foot-wide tailrace channel, with variable depth (33 to 50 feet) and a normal water surface elevation of 55 feet msl;
9 four 14.4-kV generators connected to two 110-kV transformers; and
10. appurtenant facilities.

The Roanoke Rapids development was constructed between 1953 and 1955, with commercial operation beginning in September 1955. The development produces an average of 336,408 MWh annually. The Roanoke Rapids development does not occupy any federal lands.

1.2 Project Operation

The Roanoke Rapids and Gaston Project is operated in close coordination with the John H. Kerr Project. The Kerr Project is operated for flood control and power production. Generation of power is accomplished within the limits prescribed for flood control and minimum river flow regulation. The Kerr Project is operated in accordance with a reservoir guide curve and accompanying guidelines. Generally, whenever the reservoir is below the level of the guide curve, the power station is operated to meet the minimum power declaration per the Southeastern Power Administration (SEPA) contracts, which varies monthly. Water stored in the power pool and above the guide curve is generally released as timely as is practical to provide additional capacity for the control of floods.

During a typical week, the energy declaration for Kerr is usually proportioned and scheduled to meet load following system requirements (i.e., “peaking") during the 5 working days (Monday through Friday). Generation from Kerr is normally not scheduled during the weekend days (Saturday and Sunday).

1.2.1 Roanoke Rapids Power Station

The Roanoke Rapids development is normally operated in a peaking (or load following) mode from Monday through Friday. Because of differences in the hydraulic capacity and storage volume (reservoir size) between the Gaston and Roanoke Rapids developments, the normal pool elevation of Roanoke Rapids Lake fluctuates more than that at Gaston, typically 3 feet during day-to-day operations and sometimes as much as 5 feet between elevations 127 and 132 feet msl.

Dominion operates at least one unit at Roanoke Rapids to maintain the required minimum flow. During the weekends when Gaston is not normally operated, the Roanoke Rapids Lake storage capacity is used to maintain the required minimum flow.

1.3 FERC License Article 411, Bypassed Reach Flow Release Plan

Within 270 days of the issuance date of this license, the licensee shall file for Commission approval, a plan for passing water from Roanoke Rapids dam into the Roanoke River bypassed reach. The purpose of the plan is to enhance, maintain, and protect fish and wildlife habitat and biological integrity in the bypassed reach. The licensee shall prepare the plan after consultation with the Cooperative Management Team, as set forth in Article 427 of this license, consisting of the North Carolina Wildlife Resources Commission, the North Carolina Department of Environment and Natural Resources, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and the Regional Partnership of Local Governments as an ex officio member.

The plan at a minimum shall include: (1) provisions for facilitating management of downstream passage and minimizing the escapement of resident fish from Roanoke Rapids Lake, consistent with state and federal fishery management objectives for the Roanoke Rapids Lake and the Roanoke River basin; (2) an evaluation of methods of passing water including, but not limited to, (a) spillway gate valves, (b) siphons, and (c) auxiliary hydropower turbines; (3) provisions for (a) screening, (b) repositioning of intake portals, (c) light barriers, (d) sound barriers, or (e) electrical barriers or something similar to minimize the escapement of resident fish from Roanoke Rapids Lake; (4) the method for measuring minimum flows in the Roanoke River bypassed reach, consistent with the requirements of Article 407; and (5) an implementation schedule.

With respect to the plan required by this article, the licensee shall submit to the Commission documentation of its consultation, as set forth in Article 427. The Commission reserves the right to require changes to the plan. Upon Commission approval, the licensee shall implement the plan, including any changes required by the Commission.

1.4 Objective

The objective of the Bypassed Reach Flow Release Plan (Plan) is to ensure attainment of the minimum flows required in Article 407 of the FERC license. The Plan addresses the specific requirements of the Comprehensive Settlement Agreement (Settlement) Article FL1 Section 3.1, 4.2 – 4.9.

1.5 Current Bypassed Reach Flow Operation

1.5.1 Temporary Flow Operation

Per Article 407 (Roanoke River Bypassed Reach Flows), temporary flows to the bypassed reach have been continuous since May 11, 2004.

1.5.2 Flow Management

Per License Article 412 (Project Operation and Flow Monitoring Plan), Dominion has taken measures to ensure the flows to the bypassed reach are managed per the requirements of Articles 407, 411 and 412. These temporary measures are described in Section 3.3 of Dominion's Project Operation and Flow Monitoring Plan filed with the Commission on June 27, 2005. Though the Project Operation and Flow Monitoring Plan required inclusion of the bypassed reach flow and operation in the plan for Article 412, that was not possible since the permanent means of flow to the bypassed reach had not been developed. The portion of the Project Operation and Flow Monitoring Plan addressing the bypassed reach flow is quoted below:

"3.3 Bypass Flows (Articles 407 and 411)

> *3.3.1 Temporary bypass flows are maintained by cracking open two floodgates (e.g., gates 1 and 17). The temporary arrangement will be maintained until the permanent bypassed reach flow plan, approved by the Commission, is implemented.*

3.3.2 Temporary bypass flows are maintained by manually observing the gate openings of a gate at the north end of the dam and one at the south end of the dam.

3.3.3 Flows through the gate at a median Roanoke Rapids Lake level of 129.5 feet msl with a one foot opening are approximate 1000 cfs.

3.3.4 Each of two gates is opened approximately two inches in order to maintain 325 cfs continuously.

3.3.5 When freshet flows are required (total of 500 cfs), one of the electric motor operated gates is opened an additional two inches.

3.3.6 Monitoring equipment for bypassed flows shall be automated upon Bypassed Flow Plan (Article 411) approval by the Commission (due to the Commission on September 30, 2005).

3.3.7 Station operators will utilize station procedure number RR-0-L-1 Flows In Bypassed Reach to assist in maintaining license compliance."

2.0 PLAN DEVELOPMENT

Discussions regarding possible re-watering of the bypassed reach downstream of the Roanoke Rapids Dam began in 1995 during initial consultation meetings. Dominion and its consultants conducted studies in the bypass. Discussions and evaluations relating to the studies occurred in the Fisheries Technical Work Group. The Fisheries Technical Work Group met many times between 1998 and 2003 to craft an operation and flow proposal that would be sensitive to the needs of resident aquatic ecosystems, anadromous fish and project operation. Ultimately, the bypassed reach flow enhancements were incorporated into final license negotiations for the comprehensive settlement agreement signed in 2003, and amended in early 2005.

Settlement Article FL1 and License Articles 407, 408 and 413 reflect the consensus goals for obtaining targeted flows in the bypassed reach. Flow studies were conducted during relicensing that guided the Fisheries Work Group in designing the settlement bypass flow article. Consideration was given as well to anadromous fish habitat needs during the spring spawning season with general methods described to determine appropriate flows. Specific study plans have also been developed (Article 413 Roanoke River Bypassed Reach Biological Monitoring Plan) to address resident aquatic species and mollusks (submitted to the Commission on September 30, 2005).

2.1 Consultation

This plan was developed in consultation with the US Fish and Wildlife Service (USFWS), the National Marine Fisheries Service (NMFS), the North Carolina Wildlife Resources Commission (NCWRC), the North Carolina Department of Environment and Natural Resources (NCDENR), and the Regional Partnership of Local Governments in an ex officio capacity. Much of the consultation on the Plan occurred prior to Dominion's submission of the Comprehensive Settlement Agreement (SA) to the Commission on July 15, 2003. The relicensing Fisheries Technical Work Group developed Article FL1 of the SA and the SA was signed by each of the parties listed above.

In order to address numerous implementation requirements in the cooperative manner designed into the license and SA, Dominion along with the agencies have developed several committees to manage the license implementation in a cooperative manner. There were originally two separate teams designated by the license and SA to address diadromous fish restoration in the Roanoke River (Diadromous Fish Restoration Technical Advisory Team – DFRTAC) and habitat enhancement in the bypassed reach (Bypassed Reach Cooperative Management Team – Bypass CMT). The teams began meeting in early 2004, even before the license was issued. It soon became apparent that the two teams were composed of the same agencies with the same agency representatives on both teams. Therefore, during the consultation for development of several of the required plans, including this Plan, the consultation meetings were concurrent.

The meeting notes from seven joint DFRTAC – Bypass CMT meetings are attached as Appendix 1 to this plan (February 4, 2004; March 13, 2004; September 13, 2004; January 7, 2005; May 16, 2005; July 21, 2005; and November 15, 2005). (Also included in Appendix 1 are the notes from two telephone conference calls with USFWS and NMFS engineers.) At each of the meetings a time was set on the agenda to discuss the re-watering of the bypassed reach and issues related to the final plan. During the meetings/conference calls specific decisions were made related to the bypassed reach final flow design criteria. They are:

January 7, 2005: Methods for evaluating spawning and nursery habitat for anadromous fish;

May 16, 2005: The fish screening to be openings not to exceed 2 inches, vertical or horizontal bars appropriate;

May 16, 2005: Approach velocity for the fish screening to be 2 feet per second or less;

May 16, 2005: Approval of concept for passing flow into south end of bypassed reach through the skimmer gate;

August 22, 2005 Conference Call: Utilization of the skimmer gate appropriate for future downstream American shad passage consideration;

September 8, 2005 Conference Call: Approval of concept for passing flow into north end of bypassed reach through existing radial gate with measured opening;

September 8, 2005 Conference Call: Approval of conceptual screening design for the radial gate opening and the skimmer gate opening. At this time Dominion was requested to provide flow calculations to NMFS and USFWS engineers, provide actual velocity measurements in front of open gates to physically verify calculations and to provide assurance that required flows would be met in the bypassed reach. The calculations were provided as requested. The final flow determination has been addressed in this Plan and reviewed by CMT members.

During Dominion's development of the scope of work for the engineering design, the draft scope of work was distributed to the CMT members for comment. One comment received and added that was not in the SA was for the design to consider future downstream passage for American shad and American eel.

During the SA negotiations, it was agreed that the baseline flow would be 325 cfs. However, this flow was acceptable to the fish and wildlife agencies only if it was distributed from two points of the dam, one near the northern portion of the dam and one near the southern portion of the dam. Due to the geometry of the bypassed reach and as indicated during the relicensing studies, in order to obtain the agency-desired distribution of flow within the bypass reach, either a higher flow (greater than 400 cfs) needed to be discharged from one point or a lower flow (325 cfs) needed to be discharged from two points (one discharge point towards the north end of the dam and one towards the south end of the dam).

Dominion distributed this draft plan with the final engineering package (Appendix 2) on November 2, 2005. The draft Plan was discussed during the November 15th meeting of the CMT. All comments received were addressed satisfactorily (see Appendix 1).

2.2 Reporting

Bypass flows at the time of submission of this plan are documented manually using calculated gate openings assuming an average Roanoke Rapids Lake level of 129.5 ft. msl. (See Section 4.3 of the Project Operation and Flow Monitoring Plan filed with the Commission on June 27, 2005.) Upon approval of this plan, Dominion will utilize the station Electronic Monitoring System (EMS) to record Roanoke Rapids Lake water level, radial and spillway gate openings, and the associated flow. Manual staff gage readings will be taken daily on both the north and south sides of the bypass reach as a check that minimum flow requirements are met (see Section 3.5 of this plan). Dominion will develop an annual summary report that will document daily bypass water levels, minimum daily flows, freshet flows, spring spawning flows and any other unusual flow event. This report will be submitted by March 31 to the Commission and members of the CMT.

2.3 Evaluation

The evaluation of passing water into the bypassed reach occurred in three phases. The first phase was a feasibility study to determine the most cost effective method of flow. This phase was completed in 1999 by Harza Engineering. Numerous methods were considered but the most economic and operable was determined to be placement of gate valves in two radial gates. During the relicensing consultations, the fish and wildlife agencies were clear that at the lower required flows it is essential to have a release point at two or more places on the dam, one towards the north side and one towards the south side. This distribution would facilitate a more even distribution throughout the bypass reach and help connect potential isolated pools within the reach. This feasibility study was the basis for the contract with Montgomery Watson Harza Engineering (MWH) to develop the engineering scope of work for this Plan.

In the 1999 feasibility study Dominion also considered pumps that would take suction in the tailrace and distribute water into the bypass. Two significant hindrances to this method were the capital cost and screening. The high capital cost to provide the required 325 to 500 cfs made the alternative a less economical choice. In addition, screening requirements to minimize entrainment of diadromous fish during annual migrations were a significant design consideration.

Considered during the 1999 feasibility study and later when the final design plan scope of work was being performed, auxiliary hydropower turbines were evaluated. Design hurdles that significantly impacted the costs of this engineering solution were penetration through the existing dam (emergency spillway section), placement of the turbines and associated civil works, ancillary equipment, and screening. Given special consideration in the evaluation were Dominion's market in the northeast region of the US and potential "green power" incentives as well as the Energy Policy Act of 2005. However, even with these considerations, this was not an economical alternative for Dominion.

In March of 2005, Dominion contracted with MWH to develop the engineering design and plans needed to file this Plan with the Commission. The contract utilized the 1999 feasibility study as the basis for the scope of work. However, during the final relicensing consultation and consultation with the fish and wildlife agencies in developing the engineering scope of work, several additional requirements were added to the bypassed reach flow method that were not addressed in the 1999 feasibility study. Among them was the requirement for screening to prevent/deter resident lake fish escapement. In consulting with the agencies in development of the contract for MWH an added requirement was to "consider" provisions for future downstream American shad passage. The addition of these two items caused Dominion and MWH to perform an additional feasibility study.

The "future consideration" of downstream American shad passage directed Dominion to evaluate the use of the skimmer gate for the southern portion of the flow to the bypass. The skimmer gate opens in a manner (opens by lowering) that releases water over the gate. Since juvenile shad tend to move near the surface, and the skimmer gate ogee provides a reasonable method for safe and effective downstream fish passage, it was agreed to use the skimmer gate for the south end flow. The agencies did raise a concern that the area below the ogee may need to be engineered to receive the fish to reduce impact effects as they enter into the bypass. However, it was also agreed that this would be deferred until American shad are passed downstream.

Downstream American eel passage was also considered. Although not a lot is known about the eels outmigration at this time, fisheries biologists know they tend to move along the bottom of the river channel following flow and are most active at night. There is potential to use the skimmer gate for downstream passage in conjunction with devices that would discourage the eel movement into the intake bays of an operating hydro unit. This issue will be addressed thoroughly as Dominion progresses with the eel restoration measures described in the requirements of license Article 401 and NMFS's prescription which is Appendix A to the license.

Although the feasibility study indicated the best method for passing water into the bypass was to design and install control valves in one or two of the radial gates (flood gates), the additional fish screening requirement indicated that the screens would reduce flow enough to require installation of more than two gates in order to obtain the required flow. Since the impact of this option was a significant increase in cost of construction, Dominion directed MWH to evaluate use of siphon pipes. Though this method did not require any modification to the radial gates, it required six pipes with multiple valves and a priming system. The cost analysis indicated it too was not a desirable choice.

MWH and Dominion then settled upon utilization of a small "permanent" opening of a radial gate to provide the north side flow. The requirements needed for this flow solution were modification of the gate bottom seal (from a rubber seal to a hard seal) and installation of a screening system. MWH developed a design concept for the screens that was reviewed with the USFWS and NMFS engineers during the September 8, 2005 teleconference. The design has been reviewed by the CMT members and their engineers and is presented as part of the engineering design package included in this plan as Appendix 2.

Dominion preliminarily considered the repositioning of intake portals, light barriers, sound barriers and electric barriers to minimize the escapement of resident fish from Roanoke Rapids Lake. These options were rejected as the placement of fish screens was considered a more effective measure for minimizing resident fish escapement.

3.0 PLAN

3.1 General Flow Plan

The flow released from the Roanoke Rapids Dam will meet the requirements described in license Article 407 and SA Article FL1 Sections 4.2 – 4.6.

Dominion will provide a baseline flow (325 cfs) roughly evenly divided between the skimmer gate on the south side and radial (spillway) gate number 2 on the north side of the dam.

Spillway gate no. 2, operated by a fixed dedicated gate hoist, will be opened 2 inches to release 160 cfs at a reservoir level of 129.5 feet. The release will vary from 150 to 170 cfs for reservoir levels from elevation 127 to 132 feet (per license Article 406). The gate will be kept at a 2-inch opening until a freshet a flow of 500 cfs is required (see Section 3.2 below).

In order to maintain the 325 cfs, the remaining flow will be passed through the skimmer bay. Flow will be regulated by partial opening of the skimmer gate. The existing 15-foot wide skimmer gate is a slide gate/bulkhead that is lowered in a recessed slot to allow water to pass over the gate. The skimmer gate is operated by a twin-screw stem hoist (one stem on each side of the gate width) located on the spillway deck. The skimmer gate position will be manually adjusted on an hourly basis to maintain the required minimum flow from the skimmer gate (i.e., 175 to 155 cfs for a total of 325 cfs). Table 1 defines the required gate openings at various lake levels and flow scenarios at each dam. Since it is a spreadsheet and contains the formulae that will be used to calculate the skimmer gate opening as described in Section 3.5 below, it is included as an attachment at the end of the Plan.

Water released from the skimmer gate will flow over the gate, down the ogee, through the energy dissipater and into the bypass. The flow will then be directed northward by the geometry of the bypass in combination with an existing concrete wall in the bypass reach just north of the skimmer gate release point. Flow measurement and control are discussed in Section 3.5 below.

3.2 Freshet Flows

3.2.1 Intent and Frequency

Freshet flows are intended as periodic pulses of additional flow to mimic naturally occurring events such as rainfall. The desire of the fish and wildlife agencies is to ensure connectivity of pools within the bypassed reach that may become isolated with the long-term 325 cfs flow. The magnitude of the freshet flows is based on observations made during flow studies that occurred during relicensing. The freshet flows are to occur approximately once every three weeks when the base flow is 325 cfs, or approximately 17 times per year. However, when the base flow is increased to 500 cfs for 90 days during the study cycles (Section 3.6 below), the freshet flows will continue on an approximate once every three week schedule or 13 times during the remaining 9 months of the year.

3.2.2 Schedule

Dominion will program its Environmental Tracking System (ETS) to notify the Station Services Coordinator to contact the NCWRC annually in mid-October to set the freshet flow schedule for the following year. If the NCWRC dose not provide the next year's schedule by November 30, the Station Services coordinator shall determine the next year's freshet flow schedule and Dominion will notify the NCWRC of the schedule. The freshet flow schedule will be loaded into the ETS to notify the Manager Station Operations and Maintenance two to three days prior to the next scheduled freshet flow. The operator will log the gate opening in the station electronic logs (per station procedure RR-0-L-02)

3.2.3 Actual Flow Release and Documentation

The station operator shall raise spillway gate no. 2 to an opening of 3.5 inches, corresponding to a flow of 280 cfs at a lake elevation of 129.5 feet, on the scheduled day to ensure 24 hours of the freshet flow occurs (see Table 2 for gate discharge at various lake levels). The skimmer gate shall then be operated to provide the required total flow (Table 2). Opening and closing of the gates shall be documented on the station Flood Gate Operating Log. The operator shall ensure the flow is at least 500 cfs utilizing bypass flow measurement instruments (Section 3.5 below) and document in the station electronic logs.

3.3 Gate Modifications

3.3.1 Radial Gates

Radial gate no. 2 will undergo only minor modification. Currently the sides and bottom of the gate have a rubber j-type seal that is designed to prevent leakage around the sides or when the gate is closed. The bottom rubber seal will be replaced with a stainless steel seal bolted to the bottom of the gate skinplate. The concrete ogee will be ground to ensure a positive seal or low spots epoxied (or as deemed appropriate by the engineer supervising construction).

3.3.2 Skimmer Gate

The skimmer gate will remain unchanged. Prior to the addition of the fish screen and the control system, the gate opening/closing system will be overhauled to ensure proper operation. The gate opening/closing system will be accomplished on an hourly basis to ensure appropriate bypass flows are maintained. The gate opening will be varied automatically as the lake level changes to ensure a constant minimum 325 cfs flow to the bypassed reach (see Section 3.5 below). The current boat safety rack will be modified at time of construction as required to ensure it does not interfere with the fish screening device.

3.4 Fish Screens

In consultation that occurred during the development of the SA, the NCWRC asked for fish screening devices (fish racks) on the lake side of the bypass flow devices. The desire of the NCWRC was to discourage large resident game fish from moving downstream. Two components of the design for the screens were emphasized during development of the fish racks contained in Appendix 2. The first was Dominion's desire to have the openings large enough to be unlikely to foul during normal operations. The second is the consulting agencies desire to have the fish racks designed and installed in such a way that the flow velocity through the fish racks is 2 feet per second or less.

3.4.1 Spillway Fish Rack

The radial gate fish rack (screen) will be a permanent non removable structure located on the concrete section of the radial gate structure approximately four feet upstream of the radial gate sealing surface (see design detail in Appendix 2). The screen will be carbon steel, with vertical bars spaced so that the opening between the bars does not exceed two inches. Further the opening between the screen and the gate will also not exceed two inches. The location of the screen is at a sufficient distance away from the gate opening as to have a velocity of less than 2 feet per second. The calculations for flow velocity are included in this plan as Appendix 3. The screen will be fastened in place per the engineering specifications in Appendix 2.

Once the screen is placed in operation, Dominion operators will regularly check the screen for blockage. It is anticipated that because of the depth and design of this screen, the likelihood for debris build up is small, necessitating only periodic inspections. However, frequency of inspection will be determined after the screen is put into service. The design of the screen is such that if blockage occurs, the gate will be opened resulting in an increased volume of water and an associated higher velocity that will allow the screen to be "self cleaning". If the blockage were to persist, the caisson would be put into place and the screen would be cleaned manually by Dominion maintenance personnel.

3.4.2 Skimmer Gate Fish Rack

The skimmer gate fish rack will be constructed with high-density polyethylene (HDPE) vertical bars with a maximum 2-inch clearance between bars. The HDPE bars will be supported with a carbon steel frame designed to withstand hydrostatic pressures that would potentially be created if the fish rack were fully clogged and to withstand boat impact load. The fish rack will be attached to an electric hoist to allow complete removal from the water to facilitate cleaning and passing of debris downstream (current purpose of the skimmer gate). The skimmer fish rack will be located about 4 feet upstream of the gate and when in place will sit on the front shelf of the dam at elevation 120 feet. Design criteria for the gate are contained in Appendix 2. The calculations for flow velocity are included in this plan as Appendix 3.

Even though the fish rack is designed to withstand forces in a fully blocked condition, Dominion operators will regularly check the fish rack for debris. It is anticipated that occasional raising of the fish rack will cause most of the fouling debris to drop off. However it can be raised to the deck level for a more thorough debris removal.

3.4.3 Velocity Measurement and Verification

As discussed in Sections 3.4.1 and 3.4.2, one of the design criteria incorporated was to ensure a flow velocity < 2.0 ft./sec. at the face of the fish racks. The calculations utilized in the design are contained in Appendix 3. During consultation, the agency representatives requested physical measurements to verify the Appendix 3 calculations. On November 15 and 16, 2005 the USGS Raleigh Field Office performed field measurements of velocity and flow at the skimmer and radial gates. The velocity measurements at the radial gate were at the approximate location of the proposed fish rack. (The data and discussion is contained in Appendix 4.)

The USGS velocity measurements indicated that velocities at the fish racks were less than 2 feet per second. However, as noted in detail in the report, there was significant error velocity. Accordingly Dominion considers these velocity measurements as indicators only. Since there is excellent agreement between the measured and calculated discharges, Dominion used the discharge measurements as a check that the velocities at the fish racks are less than 2 feet per second, as described below.

Dominion determined the velocity at the fish racks using the continuity equation, the measured discharge values, and the cross-sectional area of the fish racks. For both the radial and skimmer gates, the higher velocities will occur at the higher flow case (500 cfs). The highest velocity case for the skimmer gate fish rack occurs when the lake level is at 127 feet and a total of 500 cfs is being discharged. (This occurs because less flow is coming from the radial gate with a lower lake level and the skimmer gate needs to be opened more to attain the 500 cfs.) The highest velocity at the radial gate fish racks occurs at a flow of 500 cfs when the lake is at 132 feet (the highest head) because the gate opening is maintained at 3.5 inches when flow is at 500 cfs.

The radial gate fish rack has dimensions of 4 feet (high) by 38 feet (wide) and will be installed almost perpendicular to the flow lines. Therefore, for the 500-cfs case and a reservoir elevation of 127 feet, the velocity at the upstream face of the fish rack is 1.7 feet per second (i.e., 260 cfs/38 ft width/4 ft height). Under the worst case condition, the flow through the radial gate will be about 300 cfs at a reservoir level of 132 feet. This translates to a velocity of 2.0 feet per second (1.7 ft/sec x 300 cfs/260 cfs). Under the more normal bypass reach flow of 325 cfs, velocities will be closer to 1 foot per second.

Velocities at the skimmer gate itself would be about 6.2 feet per second (240 cfs/15 feet width/2.6 ft height from top of skimmer gate to water surface). However, the fish rack is a little more than 4 feet upstream of the skimmer gate and is 17 feet wide at that point. The bottom of the fish rack will be at elevation 120 feet. Thus the average velocity through the fish rack at a skimmer gate flow of 240 cfs and lake level of 127 feet is 2.0 feet per second (240 cfs/17 ft wide/7 ft depth). Since the flow lines are not perpendicular to the fish rack, there may be some local velocities that are higher, particularly nearer the surface and others that are lower such as near the bottom. However, since there is leakage from the bottom of the skimmer gate when it is in a partially open condition, there would be more flow through the bottom of the fish rack. This would tend to even out differences in the velocity distribution and have velocities closer to 2 foot per second throughout the entire water column at the fish rack.

At typical operating levels of between 129 and 132 feet, the required skimmer gate flows would be lower and be between 224 and 200 cfs depending upon lake level. Further the flow area through the fish rack would increase because of the greater depth, resulting in a decrease in velocity. For example, at a lake level of 129 feet, the average velocity through the fish rack would be 1.5 feet per second (224 cfs/17 ft width/9 ft depth). At higher lake levels the velocity would be even lower.

The combination of a flow of 500 cfs and lake level of 127 feet is likely to be a very rare occurrence. However, even if this situation were to occur, the average velocity at the fish rack would meet the agency design criteria. At more typical operating conditions, the velocities at the upstream face of the fish rack would be well within the design criteria. Accordingly, Dominion concludes that the fish rack design meets or exceeds the agency velocity criteria of less than 2 feet per second.

3.5 Flow Measurement and Control

The combination of bypassed reach geometry, potential fish rack blockage and dam safety made accurate flow measurement a difficult engineering consideration. The utilization of a sharp crested skimmer gate with an ogee spillway and a rectangular radial gate opening with an ogee spillway allows for accurate flow calculations in a free-flowing, known head scenario. Because of the known flow characteristics over ogee and sharp crested weirs, discharge equations have been developed for these design conditions. In fact, these equations can be more accurate than flow measurements. However, with typical lake level fluctuations of three feet and periodic fluctuations of up to five feet and the potential for some blockage of the fish racks, a verification technique was required to ensure that minimum required flows are attained.

As described in Section 3.4, the USGS attempted to measure discharges at different lake levels and different skimmer gate/radial gate openings to verify the velocities and flows that were calculated based on weir and gate equations. The measured flows agreed well with the calculated flows. However, the discharge measurements were done without the fish racks in place and not all desired conditions were measured. Once the fish racks are installed, the USGS will measure discharge at the skimmer and radial gates at flows of 325 and 500 cfs, and at lake levels of 127 and 132 feet to verify the calculated flows. As appropriate, the weir/gate equations used to determine the radial and skimmer gate flows will be adjusted to reflect the measured flow values. The results of the USGS flow measurements will be filed with the Commission, along with any revisions to the flow plan. In the mean time, the tables attached in Appendix 3 provide the basis for the control technique described here.

The control system will be designed so that at average head, the calculated flow will be equally divided between the north and south gates (approximately 160 cfs through the radial gate and 165 cfs through the skimmer gate) at a lake level of 129.5 feet. A programmable logic controller (PLC) will be incorporated into the system. Based upon flow information obtained from the hydro units operation control system and lake level information obtained from the environmental monitoring system (EMS), the skimmer gate opening will be controlled to ensure a minimum flow of 325 cfs is maintained as lake level (head) fluctuates (Table 1 tab 1 for 325 cfs). Similarly the PLC will be designed for maintaining a minimum of 500 cfs when freshet or anadromous flows are required (Table 2 tab 2 for 500 cfs).

The PLC will work as follows:

1. The generation at the top of the hour for Gaston and Roanoke Rapids Power Stations will be converted to equivalent flows for the next hour.
2. The Roanoke Rapids powerhouse discharge and bypass flow release will be subtracted from the Gaston powerhouse flow to determine net inflow for the next hour.
3. The net inflow will be converted to a storage increase or storage decrease, depending upon the relative flows at Gaston and Roanoke Rapids. The storage change will be based on the following equation: net change (feet) = net flow (cfs hours)/24 hours/day x 1.98 acre-feet/cfs day/4600 acres/foot change.
4. The change in water level will be added to the existing Roanoke Rapids Lake level to estimate the lake level at the end of the hour (see calculation in Table 1, 325 cfs tab).
5. The lower lake level will be used as the basis for the skimmer gate setting for the next hour to ensure that the minimum required flow is maintained. That is, if the reservoir level is decreasing the projected level at the end of the next hour will be used as the basis for the skimmer gate setting. If the reservoir level is increasing, the reservoir level at the beginning of the hour will be used.
6. The PLC will use the flows and calculations presented in Table 1 to determine the appropriate gate setting (Table 1, 500 cfs tab will be used when freshet flows are required.)
7. The PLC will then direct the skimmer gate control system to adjust the gate to the appropriate setting.
8. The calculated flow set point will be automatically logged in the EMS.
9. This sequence will be repeated each hour.

The above procedure will generally result in slightly higher flows than the minimum required flow. For example with a reservoir level of 129.5 feet, a Roanoke Rapids discharge of 6,000 cfs, a bypass flow of 325 cfs and no discharge at Gaston Power station, the gate will be set at an opening of 1.86 feet for the end-of-hour reservoir level of 129.4 feet (see Table 1 example). At the beginning of the hour, flow through the radial gate will be 160 cfs and the gate opening will be 1.96 feet (instead of the 1.86 feet at the end of the hour) for a flow of 169 cfs, and a total flow of 329 cfs. Thus the average flow for the hour will be 327 cfs.

The procedure will also apply in unusual circumstances when generation is significantly adjusted during the hour. The more typical case for this will be a relative increase in power generation at Gaston because of its 44,000 cfs capacity relative to Roanoke Rapids which has a maximum capacity of 20,000 cfs. This will provide more flow rather than less in the bypass. If the Gaston power station tripped for some reason and shut down when it was projected to operate at 44,000 cfs, the worst case situation would be Roanoke Rapids operating at 20,000 cfs for one hour. Since the more conservative reservoir level would have been used for the calculation (i.e., the reservoir level at the beginning of the hour), the instantaneous flow at the beginning of the hour would be 325 cfs. Since the reservoir would drop by 0.4 feet in that hour, the instantaneous flow at the end of the hour would decrease from 325 to 307 cfs with an average of 316 cfs for the hour. This situation would be corrected to provide at least 325 cfs the following hour at the next scheduled gate adjustment. The resulting average daily flow would likely be greater than 325 cfs because of the conservative nature of the procedure (see above example) and the fact that lower flows will persist for less than one hour. Because of the extreme rareness of this event, Dominion proposes only to report the flow exception in its annual summary report to the Commission, provided that the average daily flow is maintained at or above 325 cfs.

The focus of control for this method is on the skimmer gate. It will be moved hourly as described above with the radial gate remaining open a constant amount dependent only upon the need for a 325 cfs or 500 cfs total flow. However, to ensure the opening is established at the correct position, an electronic sensor will be installed to provide guidance to the operator in setting the opening and feedback (alarm) should the gate deviate from the desired opening distance.

Since there is the potential for fish rack blockage or materials to be trapped in the radial gate opening between operator inspections, water levels will be monitored in the bypassed reach. Since the bypassed reach is open to outdoor sportsmen, temporary testing materials and equipment have often been vandalized. The remoteness of the area also makes security of flow measuring equipment difficult. Therefore, Dominion has determined that operator monitoring of permanent staff gages will be the most effective means to verify that minimum flows are maintained. Staff gages will be placed at two locations in the bypassed reach (see Figure 1 [attached drawing] for proposed location). The gages will be viewed through video cameras located on the dam. During daylight hours, Dominion operators will log the staff gage level during their top of the hour operator log entries. The staff gages will be correlated to flow based on the discharge measurements to be conducted by the USGS after the fish racks are installed.

3.6 Five-Year Anadromous Fish Flow Monitoring Cycles

A monitoring cycle will consist of five-year periods beginning in January of 2005. There will potentially be four cycles lasting a total of 20 years or until such time as the CMT determines that further monitoring is not necessary. Prior to the first year of each monitoring cycle, the Licensee will report to the Commission planned flows and duration of the next cycle. If the CMT so determines, the monitoring cycle may be extended or shortened in whole year increments.

License Article 407 and SA Article FL1 Sections 4.3 – 4.6 require flow adjustments to determine if increased bypassed reach flows augment anadromous fish habitat. Article 407 contains a general plan the relicensing Fishery Technical Work Group developed that would meet fish and wildlife agency fish restoration goals while minimizing the impacts of lost generation for the water released into the bypass.

The flow requirements of the Article 407 are clear and precise. In the third year, Dominion will provide a minimum flow of 500 cfs for a 30-day period between March 1 and June 15. The CMT agreed that 2005 is considered year one. The Dominion ETS will be programmed to alert the Station Services Coordinator and Dominion's Senior Fisheries Biologist for the project in January of 2007, 2008 and 2009 of the required 30 days of 500-cfs flow to the bypass. The Senior Fisheries Biologist will then consult with the CMT members to determine the desired 30 days of the 500-cfs flow. Dominion operators will release the 500-cfs flow according to the CMT developed schedule. Years 2005 – 2009 will constitute the first study cycle.

The ETS will be programmed for similar alerts for years 2010 – 2014 (second study cycle). The flow for the anadromous fish season will again be for 500 cfs but the time frame will be increased to 90 days. Per consultation with the CMT, Dominion operators will release the 500 cfs flow according to the schedule developed by the CMT.

The 90-day period for spawning flow in the bypassed reach was selected by the Fisheries Technical Work Group during relicensing as a period of time likely to cover spring spawning for the majority of anadromous species in the Roanoke River. The CMT may reduce the duration from 90 days to something shorter if study results or observation of the species of interest indicate a shorter high flow duration will meet agency objectives. If such a determination is made, the Commission shall be notified 30 days prior to implementing the shorter flow period.

Beginning in 2004, Dominion consulted with other CMT members to determine appropriate study techniques that will quantify anadromous fish utilization of the bypassed reach during the spring spawning season. Initial steps taken included videography for habitat mapping and egg densities studies being directed by the US Geological Survey (USGS) Wildlife Research Unit. As the results of these studies are documented, the CMT will decide if this will provide sufficient information to make the flow determination decision required in 2014 for the required 2015 bypassed reach anadromous fish spawning flows (2015 – 2019, third study cycle). Results or progress of studies will be submitted to CMT members and to the Commission annually by January 31 as required in license Article 407.

The decision required of the CMT in 2014 will be to determine if additional flow to the bypass is needed for an additional study cycle at 750 cfs. Again the ETS will be programmed to alert the Station Services Coordinator and the Senior Fisheries Biologist for the project to alert them of the license requirement. The basis of the decision shall be data analysis and evaluation to determine if agency objectives have been met. If the CMT determines that the fourth study cycle is needed, in the year 2019 a decision by the CMT will be made to determine if a 1000 cfs (or 900 cfs per NMFS prescription in license Appendix A) flow is needed for this study cycle. Because of the uncertainty of fish passage and providing the 750 and 900/1000 cfs flows, Dominion has deferred any further design changes for providing the higher flows until at least 2012.

3.7 Final Flow Determination

In 2024 (or as adjusted by lengthening or shortening study cycles by whole year increments), a final flow determination will be needed. The consensus decision will be to provide guidance to the Commission on the recommended bypass flow from the year the determination is made until 2034. The final flow decision may be made earlier if so determined by the CMT as described in Article 407 (after the second or third study cycle).

3.8 Adjustments after 30 Years

The Dominion ETS will be programmed to alert the Station Services Coordinator and the Senior Fisheries Biologist for the project to alert them in 2034 of this license requirement (Article 407). Determination for further anadromous fish spawning flows in the bypassed reach will be made according to license Article 407.

4.0 SCHEDULE

Dominion shall complete construction of facilities described in Appendix 2 of this Plan within one year of receiving final Commission approval of the plan. During construction the temporary means of providing minimum flows shall be maintained. The general schedule shall be as follows:

4.1 Commission Comments

If the Commission staff has comments to the plan that require modification to Appendix 2, Dominion will address the comments and change the plan accordingly and resubmit to the Commission within the timeframe allowed by the Commission.

4.2 Construction Bid Package

Upon receiving final Commission approval of this plan, Dominion will issue a bid package, select a contractor and complete final contract negotiations within 4 months.

4.3 Construction

Construction will be completed within one year of receiving Commission approval of the plan. Dominion shall notify the Commission within 30 days of the completion and initial operation of the facilities described in Appendix 2.