CONCEPTUAL DESIGN REPORT

PROGRESS ENERGY CAROLINAS

230kV SWITCHYARD CONCEPTUAL DESIGN REPORT

HARRIS ADVANCED REACTORS UNITS 2 AND 3

NOT NUCLEAR SAFETY-RELATED

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ISSUE SUMMARY PAGE

NOT NUCLEAR SAFETY-RELATED

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Prepared by: Mark J. Zar Date: 08-08-2007

Reviewed by: Frank C. Shainauskas Date: 8/14/07

Approved by: AK Singh Date: 8/14/07

Note: This is a conceptual report prepared to support the Harris Unit 2 and Unit 3 COL application only. A Professional Engineer's Seal is not required.

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1 PURPOSE/SCOPE

The purpose of the Conceptual Design Report is to support COL application for Progress Energy Harris Advanced Reactors (HAR) Unit 2 and 3. This Conceptual Design Report summarizes the HAR Units 2 and 3 230kV Switchyard design parameters.

2 CODES, STANDARDS AND REFERENCES

2.1 Codes and Standards: Work will be in accordance with the prevailing standards of skill and care of each trade and shall be per the latest codes and applicable laws and ordinances at the time of permit approval unless noted otherwise below. The following are the codes that the project shall be based on:

- ACI – American Concrete Institute
- ADC – Air Diffusion Council
- AISC – American Institute of Steel Construction
- AMCA – Air Movement Control Association
- ANSI – American National Standards Institute, Inc.
- ARI – American Refrigeration Institute
- ASCE – American Society of Civil Engineers
- ASHRAE – American Society of Heating, Refrigeration and Air Conditioning Engineers
- ASTM – American Society for Testing and Materials
- AWS – American Welding Society
- ICEA – Insulated Cable Engineers Association
- IEEE – Institute of Electrical and Electronics Engineers
- NEBB – National Environmental Balancing Bureau
- NEC – National Electrical Code
- NEMA – National Electrical Manufacturers Association
- NESC – National Electrical Safety Code
- NFPA – National Fire Protection Association
- NRC – Nuclear Regulatory Commission
- SMACNA – Sheet Metal and Air Conditioning Contractors National Association
- IBC – International Building Code

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2.2 References: The following information is referenced in this conceptual design report document.

2.2.1 Sketches:

- The applicable sketches for HAR Unit 2 are under Attachment A, Pages A1 – A5 as listed below:

  A-1 – SK-HAR-008 Rev. 2, HNP and HAR Unit 2 – 230kV Switchyard One Line Diagram
  A-2 – SK-HAR-009 Rev. 2, 230kV Switchyard Modified Single Line Diagram
  A-3 – SK-HAR-010 Rev. 2, 230kV Switchyard Expansion Proposed Single Line Diagram
  A-4 – SK-HAR-011 Rev. 2, 230kV Switchyard Modified Plan
  A-5 – SK-HAR-012 Rev. 2, 230kV Switchyard Expansion Proposed Plan

- The applicable sketches for HAR Unit 3 are under Attachment B, Pages B1 – B4 as listed below:

  B-1 – SK-HAR-013 Rev. 2, New 230kV Switchyard One Line Diagram
  B-2 – SK-HAR-014 Rev. 2, New 230kV Switchyard Single Line Diagram
  B-3 – SK-HAR-015 Rev. 2, New 230kV Switchyard Plan

- The applicable sketches for both HAR Unit 2 and Unit 3 are under Attachment C, Pages C1 – C2 as listed below:

  C-1 – SK-HAR-016 Rev. 2; HNP, HAR Unit 2, & HAR Unit 3 Transmission Line Routing
  C-2 – SK-HAR-017 Rev. 2; MPT, RAT, & Transmission Line Conceptual Layout

2.2.2 Reports and Data:

- For Unit 2 and Unit 3, soil boring data and resistivity readings will be required during the detailed design phase.

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3 PROJECT DESCRIPTION AND EVALUATION

3.1 The expansion of the existing Harris 230kV Switchyard for HAR Unit 2 and the new 230kV Switchyard for HAR Unit 3 are to be built on the site of the existing Harris Nuclear Plant (HNP) in New Hill, North Carolina. The existing Switchyard is approximately 631 feet long by 473 feet wide. It will be expanded to approximately 1,302 feet long by 473 feet wide to accommodate HAR Unit 2. A new switchyard will be built for HAR Unit 3 that is approximately 445 feet long by 370 feet wide.

3.2 The expansion of the existing Harris Nuclear Plant Switchyard will consist of seven new 230kV circuit breakers, and associated disconnect switches, bus work, and equipment aligned to the East of the existing 230kV air-insulated, composite breaker-and-a-half / double breaker scheme. This expansion will provide for connections to the HAR Unit 2 generator step-up transformer, the HAR Unit 2 Reserve Auxiliary Transformers (RAT A and RAT B), and a new 230kV Line to RTP. The North and South buses will be extended to the East to connect to the new buswork and equipment. Based on a preliminary assessment, adequate space and expansion capabilities exist in the existing Harris Unit 1 Control Building to accommodate equipment and panels required for Unit 2. Refer to Attachment A, Page A-5.

- The existing switchyard fence will be extended to encompass the expansion. New roadways and gates will be provided for equipment maintenance and removal.
- The existing ground grid will be expanded as appropriate.
- The connections to the HAR Unit 2 generator step-up transformer and reserve auxiliary transformers will all exit the switchyard overhead and to the North.
- The switchyard has the capability to accommodate two RAT's per unit.

3.3 The new switchyard for Harris Advanced Reactor Unit 3 will consist of a 230kV air insulated, five bay, composite breaker-and-a-half / double breaker scheme with twelve new 230kV circuit breakers and associated disconnect switches, bus work, and equipment. This switchyard will provide for connections to the HAR Unit 3 generator step-up transformer, the HAR Unit 3 Reserve Auxiliary Transformers A and B, and 230kV transmission lines to Wake, Erwin, and Fort Bragg. Space is also included for a future line position. A new Control Building will be located along the west side of the Switchyard. Refer to Attachment B, Page B-3.

- The exterior design of the new Control Building will be similar to that of the existing Control Building for the Harris Nuclear Plant.

- A switchyard fence will be provided to encompass the new switchyard. The fence will be a similar design to the existing HNP switchyard fence. New roadways and gates will be provided for equipment maintenance and removal.

- The connections to the HAR Unit 3 generator step-up transformer and HAR Unit 3 Reserve Auxiliary Transformers will exit the switchyard to the South. The 230kV lines to Wake, Erwin, and Fort Bragg will all exit the switchyard to the North.

3.4 Fiber optic cable will be installed as necessary for the protection schemes.

3.5 Telephone Requirements: Progress Energy will provide and install required telephone service.

3.6 Remote Terminal Work: Work at remote terminals of each of the affected transmission lines will be identified as the detailed design work proceeds.

4 ELECTRICAL DESIGN PARAMETERS AND INPUTS

4.1 One Line Arrangement:

4.1.1 The arrangement of the 230kV switchyard for HNP and HAR Unit 2 will consist of eight, 230kV overhead transmission lines, one connection to each of the HNP and HAR Unit 2 main generator step up transformers, one connection to each of the HAR Unit 2 Reserve Auxiliary Transformers, and two connections to the HNP reserve auxiliary transformers. The 230kV switchyard will be arranged in a composite breaker-and-a-half / double breaker configuration. Manually operated disconnect switches are provided for isolation of equipment for maintenance. Refer to Attachment A, Page A-1.

4.1.2 The arrangement of the 230kV switchyard for HAR Unit 3 will consist of three, 230kV overhead transmission lines, one connection to the HAR Unit 3 main generator step up transformer, and connections to each of the two HAR Unit 3 Reserve Auxiliary Transformers. The 230kV switchyard will be arranged in a composite breaker and a half / double breaker configuration. Manually operated disconnect switches will be provided for isolation of equipment for maintenance. Refer to Attachment B, Page B-1.

4.2 230kV Electrical Criteria

4.2.1 The new 230kV dead tank, SF_6, puffer type circuit breakers will be rated at 3000 Amperes continuous and will be capable of interrupting 63 kA (REF. RFI-077). The new circuit breakers will have dual trip coils. Trip coil 1 and the close coil will be on the same 125 VDC circuit. Trip coil 2 will be on a separate 125 VDC circuit. Loss of AC and DC alarm relays will be required.

4.2.2 The 230 kV open air substation will be designed for the following ratings:

• Maximum Voltage	242 kV
• BIL Level	900 kV
• Bus Continuous Current Rating	3000A
Clearances:	
• Minimum Phase-to-Phase (metal to metal)	89 inches
• Minimum Phase-to-Ground	71 inches
• Rigid Bus Spacing (center to center)	16 feet
• Minimum Clearance Live Parts to Grade for Personnel Safety	165 inches

4.3 Design Input

- Harris FSAR
- Progress Energy response (8/7/06) to RFI-063 – Expected changes for HAR Unit 2 Switchyard One-Line
- Progress Energy response (8/7/06) to RFI-064 – Drawings and Documents for Existing Harris Unit 1 Switchyard
- Progress Energy response (9/27/06) to RFI-077 – Review of working draft FSAR Section 8.2 – HAR Unit 2 and HAR Unit 3
- Progress Energy response (11/1/06) to RFI-108 – Harris Switchyard Native Files
- Progress Energy response (11/6/06) to RFI-116 – 230kV Conceptual Design
- Progress Energy Harris Training Section, System Description for the Off-Site Power System, SD-157, Revision 8, dated 11/19/03
- Progress Energy response to RFI-079 & 080 – Progress Energy Carolinas Transmission System Analysis for Harris Nuclear Units 2 & 3, dated 6/11/07.
- Layout of the AP1000 Transformer Area – Westinghouse Engineering Sketch SK: KB070531 Revision 0 (Transmittal #DCP/NUS0540, 6/14/07).
- Progress Energy response to RFI-212 – Progress Energy Review of transmission line conceptual layout, SK-HAR-017, dated 6/04/07.

5 ELECTRICAL EQUIPMENT/MATERIALS

5.1 230kV Air Insulated HNP/HAR Unit 2 and HAR Unit 3 Switchyards

5.1.1 The expanded HNP/HAR Unit 2 Switchyard and the HAR Unit 3 Switchyard will both be in composite breaker-and-a-half / double breaker arrangements that will operate on a 230kV, 3-phase, 60 Hertz, effectively grounded neutral transmission system.

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5.1.2 The Switchyards will consist of: circuit breakers, manually gang-operated disconnect switches, capacitance voltage transformers (CVT's), current transformers (CT's), rigid aluminum bus, insulators, supporting structures for the buswork and equipment, and protective relaying and controls.

5.1.3 Ratings

Component	Rating
Substation:	
Nominal Voltage (kV)	230
Rated Voltage (kV)	242
Rated Basic Impulse Level (BIL) (kV)	900
Rated Continuous Current Busbar (Amps)	3000
Buses	Rigid Aluminum Tube on Porcelain Insulators
Aux. voltage (control, alarm, motor)	125VDC (+10%,-15%)
Circuit Breakers:	
Rated Voltage (kV)	230
Rated Frequency (Hz)	60
Short circuit breaking current (kA)	63
Rated current (A)	3000
Rated interrupting time (cycles)	2
Operating mechanism	3-phase independent pole-operated
Manually Operated Disconnect Switches	
Rated voltage (kV)	230
Maximum Voltage (phase to phase kV)	242
Basic Impulse Level (BIL)	900
Rated frequency (Hz)	60
Rated short time withstand current (kA)	63
Rated current (A)	3000
Current Transformer Ratios	3000:5 multi

Component	Rating
Capacitance Voltage Transformers (CVT's):	
Capacitance Voltage Transformer (CVT) Ratios	3000/1/1

5.2 AC Station Service

5.2.1 The AC Station service to the expanded HNP/HAR Unit 2 Switchyard will be from Station Service Transformers 1-4A4 and 1-4B4, which will supply ac service for the switchyard loads. These are 300kVA, 6900/480/277V, 3 phase transformers. These transformers will be assessed during the detailed design phase for loading with the new configuration and they will be replaced if necessary. The AC Station service to the new HAR Unit 3 Switchyard will be a similar design.

5.2.2 AC panelboards shall be provided with bolt-in type, molded case circuit breakers.

5.3 DC Station Service

5.3.1 The DC auxiliary power systems for the HNP/HAR Unit 2 and Unit 3 Switchyards each will consist of two (2), flooded, lead calcium batteries and two (2), mag-amp type, ripple-free, battery chargers all located within the respective control buildings. The DC systems will be ungrounded. The sizes of the batteries and chargers will be determined during detailed design.

5.3.2 The batteries will be sized per IEEE 485 and will be equipped with flame arresters. The battery banks will be arranged on two-step racks. The battery room floor, walls up to a height of six feet, and any exposed steel structures will receive an acid resistant finish. A portable eye wash station shall be provided in the battery room(s).

5.3.3 The battery leads from the battery terminals to the main switch and fuses will be welding cable routed in separate aluminum conduits. The leads from the main switch and fuses to the DC Panelboards will be EPR cable and will be routed together in rigid galvanized conduits.

5.3.4 The DC panelboards will consist of 2-pole, bolt-in type, molded-case circuit breakers.

5.4 Protection and Control

5.4.1 The switchyard protection schemes will include the following:

- Line Protection – Two Independent High Speed Schemes with
  - Impedance Backup Non-Pilot Schemes
  - Directional Comparison Blocking Schemes with (as necessary) Permissive over Reach Transfer Trip Schemes
- Breaker Failure Schemes
- Transformer Protection – Two Independent High Speed Schemes
- Bus Fault Protection – Two Independent High Speed Schemes

5.4.2 On relay and control panels, the test switches will be arranged such that the test switch jaws are towards the relay or other device to be tested (so the test lead clips can be securely fastened), and the test switch jaws will be cold (dead) while the test switch blade will be hot (live) via DC positive, DC negative or AC potential. The nameplates on the relay panels will be dull black background with white letters.

5.4.3 The existing annunciator in the HNP / HAR 2 control building will be modified to include new alarms and status for the switchyard additions. An annunciator will be provided in the new control building for HAR 3. The annunciator will be provided with repeat contacts for connection to the Progress Energy SCADA system. The annunciator will be used for major alarms and alarming of "abnormal" occurrences (e.g. lockout relay operation, 230kV circuit breaker local-remote switches in the remote position, etc.).

5.4.4 The existing mimic board in the HNP / HAR 2 control building will be extended to include the new additions to the switchyard. A new mimic board will be provided in the HAR 3 control building.

5.5 Cables (Specific Progress Energy Carolinas' cable specifications to be added later)

5.5.1 Control cable will be 600 Volt, multi-conductor, copper cable with FREPR or FRXLPE insulation and a Hypalon jacket.

5.5.2 Instrumentation cable shall be 600 Volt, single or multi-pair, copper cable with individual shielded pairs and an overall cable shield, FREP or FRXLPE insulation and a Hypalon jacket.

5.5.3 Wiring for lighting and receptacle circuits in AWG sizes # 12 through # 8 shall be type THHN.

5.5.4 Fiber optic cable, where needed, will be as required for its intended purpose.

5.6 Raceway

5.6.1 Cabling for primary and secondary protection relaying and breaker trip coils will be separated to the extent practical.

5.6.2 Cable trench will be used to route cables from the switchyard equipment to the control building.

5.7 Conduits

5.7.1 Conduit used for lighting and receptacle circuits within the control building will be electrical metallic tubing (EMT).

5.7.2 Conduit run outdoors, above grade within the switchyard property, will be galvanized, rigid metal conduit.

5.8 Lighting

5.8.1 Lighting in the new control building will be provided via fluorescent fixtures.

5.8.2 Lighting in the outdoor maintenance areas will be provided via high pressure sodium fixtures.

5.8.3 Exit lighting/exit signs will be provided in the new control building.

5.8.4 Self contained, battery powered emergency lights will be provided for emergency egress from the new control building.

5.8.5 Outdoor, high pressure sodium vapor fixtures will be provided above each personnel door of the control building.

5.9 Grounding

5.9.1 The grounding system for the expansion of the existing Harris 230kV Switchyard for HAR Unit 2 will be an extension of the existing grounding system.

6 STRUCTURAL DESIGN PARAMETERS

6.1 General Description:

6.1.1 New Control Building: The new control building will be a one story building. The type of building construction will be determined during the detailed design phase. The approximate size of the building will be 60' x 30'.

6.1.2 Perimeter Fencing: The existing fence for the HNP switchyard will be extended for the expansion to include HAR Unit 2. A chain link fence shall be provided for the perimeter of the new HAR Unit 3 Switchyard and will consist of 6 feet of fence fabric and an extension utilizing three or more strands of barbed wire to achieve a fence height of not less than 7 feet.

6.1.3 Miscellaneous Yard Equipment Pads: Cast-in-place mats on grade and drilled pier foundations.

6.2 Materials:

Concrete Foundations	$f'c$ = 4000 psi (in accordance with ACI 301)
Steel	ASTM A36 or A572
Reinforcing Bars	ASTM 615, Grade 60
Welded Fabric	ASTM A185
Anchor Bolts	ASTM F1554
Nuts	ASTM A194, Grade 1, ANSI B18.2 or equal
Connections – Bolted	ASTM A325
Connections – Welded	AWS D1.1:2000
Exterior Louvers	ASTM A653
Roof	1-1/2" metal roof deck with permanent, fully adhered membrane roofing systems and roof insulation, with proper flashing and metal coping parapets.
Yard Stone Material	CA-6 or CA-10.

6.3 Loading:

Dead Load	As calculated
Snow	Per ASCE 7
Wind	Per ASCE 7
Floor Loads	250 psf + superimposed dead load.
Seismic Load	Per ASCE 7

6.4 Codes:

Concrete	ACI 318-02
Steel	ANSI/AISC 360
Building	Applicable Local Building Code

7 ARCHITECTURAL DESIGN PARAMETERS

7.1 Sealant will be provided for all interior and exterior assembly joints.

7.2 Metal steel doors, steel door frames, UL fire-rated door and frame assemblies will be utilized. Exterior doors and frames will be galvanized and shop primed.

7.3 If the new control building is to have a service overhead rollup door, a concrete slab will be installed at grade directly underneath the overhead door to facilitate the loading and unloading of equipment. Doors will be fully weather stripped and equipped with safety edges. Personnel doors will be provided with automatic door closers.

7.4 The new control building will have weatherproof formed-metal louvers (if required). Intake louvers will be provided with bird screens.

8 MECHANICAL DESIGN PARAMETERS

8.1 The new control building will be provided with heating, ventilating, and air conditioning (HVAC).

8.2 Control Building

8.2.1 The control building HVAC system will be designed to maintain a minimum temperature of 60° F in the winter and a maximum of 75°F in the summer.

8.2.2 The two battery rooms located in the new control building will each be provided with redundant exhaust fans. These fans will maintain negative pressure within the room by exhausting air and gases that are generated during battery discharge from the battery room directly to the outdoors. Ventilation air for the battery room will be drawn from the rest of the building. Each battery room will also be provided with a unit heater to ensure that a minimum temperature of 55° F is maintained.

8.2.3 Sequence of Operation for the Battery Room Exhaust Fans

Each of the two battery rooms will have two (2) – 100% capacity exhaust fan systems. Operation of one out of two of the exhaust fans will be initiated by charging circuitry in the battery charger. When operating, the fan will maintain a negative pressure in the room. The fans will be automatically alternated on a weekly basis to ensure that both fans remain functional. Each fan operation will be sensed and controlled electrically at the motor starter. If one of the fans were to fail, a current monitoring device will sense this failure and start the alternate fan. If a fan should fail (stop running) or fail to start a signal will be sent to SCADA system to alert a malfunction.

8.3 The HVAC systems will be designed based on the conditions listed below:

Table 8-1 ENVIRONMENTAL DESIGN CONDITIONS

Room Designation	HVAC System			Indoor Conditions		Pressure Relative to:		Exhaust to Atmosphere
	No.	Type	Configuration	Summer, Max °F_{db}	Winter, Min.°F_{db}	Adjacent	Outside	
Control Building								
Control Panel Area	1	HVAC	1-100%	75	60	P	N/A	N/A
Battery Room	2	Exhaust	2 - 100%	75	60	N	N	Yes

Legend:

- HVAC = Heating, Ventilating, and Air Conditioning
- °Fdb = Fahrenheit dry bulb
- P = Positive
- N = Negative
- N/A = Not Critical

9 FIRE DETECTION SYSTEM DESIGN PARAMETERS (NEW CONTROL BUILDING)

9.1 CO_2 and Dry Chemical (ABC multi-purpose) handheld portable fire extinguishers will be located in the new control building in accordance with NFPA 10.

9.2 Fire Detection, Alarm and Notification System

9.2.1 The features of fire detection, alarm and notification system for the new control building are as follows:

- A multiplex fire detection and alarm panel will be provided for the new control building. The fire alarm control panel will be equipped with relaying to shut down the ventilation in the event the system goes into alarm. A bypass will be provided so that responding fire service personnel can restore building ventilation while the system is still in alarm. The control panel will:

  - Receive alarm and supervisory signals.
  - Annunciate signals.
  - Supervise detection and alarm circuits.
  - Have an interface connection to a UL approved central station monitoring service.

9.2.2 Smoke detectors will be included in the control building.

9.2.3 Manual pull stations will be provided.

9.2.4 Combination fire alarm horn strobe units will be provided.

9.2.5 Exit signs will be provided.

9.2.6 Portable fire extinguishers will be mounted on the wall and have locator signs.

10 PLUMBING AND DRAINAGE SYSTEM REQUIREMENTS (NEW CONTROL BUILDING)

10.1 Roof Drainage: The new control building roof will drain by gravity.

10.2 Surface water will be conveyed from the site in accordance with local storm water management system requirements.

10.3 Grading: Finish surfaces of the switchyard will be graded with a slope of 3/4 %. Large flat areas will be avoided and terraces will not be utilized. The top of concrete foundations will be a least 6 inches above grade and no more than 21" above grade.

10.4 Road layout: The minimum width will be 20'-0" and the minimum horizontal turning radius will be 50'-0" (measured to the inside edge of the roadway) where possible. Road construction onsite will be constructed of crushed stone to a minimum of 12" thickness consisting of two 6" thick layers.

10.5 Switchyard Surfacing: Crushed stone a minimum of 6" thick will be used throughout the substation area.

11 COMMUNICATIONS / SCADA (NEW CONTROL BUILDING)

11.1 SCADA/RTU

11.2 A SCADA RTU system will be installed for control and status indication of the 230kV circuit breakers.

11.3 The following inputs will be required for the SCADA/RTU:

Service	**Control**	**Status**	**Indication (Analog Value)**
230kV Breakers	X	X	X
230kV Line Relay Alarms	N/A	N/A	N/A
Fire Alarms		X	
Battery Room Fan Failure		X	
230kV Line Volts			X
230kV Line Amps			X
230kV Line Watts			X
230kV Line Vars			X

11.4 Communications

Communication between Switchyard Control Buildings, Unit Control rooms, and remote location will be determined during detailed design phase.

12 SECURITY

12.1 Perimeter Security

12.1.1 A number of steps will be included in the design of the new switchyard to ensure public safety and site security. A perimeter fence will surround the switchyard to provide security. The entrances to the switchyard will be through locked metal gates.

12.1.3 Placement of hinges or supports will be on the inside of gates so as not to create steps for climbing the gate.

12.1.4 Building Perimeter Doors: Doors will be designed of solid steel construction with anti-pick plates to prevent attempts to defeat the lock with a screwdriver etc. All doors will be of the solid core type.

12.1.5 Security Alarms: Door contacts will be provided and connected such that a door contact will trigger an alarm if a door is forced open or access is made with a key.

13 METERING

13.1 Metering requirements will be determined during detailed design phase.

14 LIMITATIONS

- The Conceptual Design is prepared to support the COL application.
- This conceptual design report is prepared to support the COL application and shall provide the basis for the detailed design prior to construction.
- The design inputs, assumptions, and limitations included in this report shall be verified during detail design.
- The circuit breakers identified with 50kA interrupting ratings are to be replaced with circuit breakers having interrupting ratings of 63kA prior to HAR Unit 2 startup (REF. Response to RFI 079 & 080).
- The Layout of the AP1000 Transformer Area (Westinghouse Engineering Sketch SK: KB070531 Revision 0) is preliminary and shall be verified prior to proceeding with the final design.

15 ASSUMPTIONS

Assumptions are included in the text of the report.

16 CONCLUSIONS AND RECOMMENDATIONS

None.

17 ATTACHMENTS

For attachments, please refer to Section 2.2.1.