Results of Data Documentation Audits to Review V. C. Summer Nuclear Station Unit 2 Geologic Excavation Mapping Report 2091-PR-03 Revision 0 and Revision 1

Results of a Data Documentation Audit Conducted on January 17-18 and 30-31, 2012 to Review the Virgil C. Summer Nuclear Station Unit 2 Geologic Excavation Mapping Report 2091-PR-03, Revision 0

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Introduction

Geologic mapping of safety-related excavations at the Virgil C. Summer Nuclear Station (VCSNS) Unit 2 site was performed by the VCSNS applicant to assure that a geologic mapping License Condition need not be included in the Final Safety Analysis Report (FSAR) specifically for Unit 2. The primary purpose of this data documentation audit, which was conducted by the Office of New Reactors (NRO) Senior Geologist, Dr. Gerry L. Stirewalt, on January 17-18 and 30-31, 2012, was to independently review and evalute Revision 0 of the following report that presents the results of geologic mapping of excavations for safety-related structures, particularly the nuclear island, at the VCSNS Unit 2 site:

> Report 2091-PR-03, Revision 0: "V. C. Summer Unit 2 Excavation Mapping Report," SCE&G, dated December 22, 2011 and prepared by Fugro Consultants, Inc.

The goal of this data documentation audit of Report 2091-PR-03, Revision 0, was to independently verify the accuracy of statements made by the VCSNS applicant in the FSAR regarding the expectation that no potentially detrimental tectonic structures, particularly any of Quaternary age (2.6 million years [Ma] to present), or non-tectonic features occurred in foundation grade level bedrock in the excavations for safety-related structures at the location of VCSNS Unit 2.

The VCSNS applicant prepared Report 2091-PR-03, Revision 0, and made it available to the U.S. Nuclear Regulatory Commission (NRC) for review to document the results of detailed geologic mapping of the Unit 2 nuclear island excavation. The report contained the completed detailed geologic maps, associated data, and final results and conclusions derived from geologic mapping of the VCSNS Unit 2 nuclear island excavation performed by the applicant to address the following regulatory requirements:

- 10 CFR Part 52, which requires that geologic characteristics of a proposed site be described in the FSAR.
- 10 CFR Part 100.23(c), which specifically indicates the need for geologic data related to tectonic and non-tectonic surface deformation.
- 10 CFR Part 100.23(d), which explicitly states that geologic and seismic siting factors related to design must include determination of the potential for tectonic and non-tectonic surface deformation.

By conducting the geologic mapping activities, the VCSNS applicant also considered the guidance provided in the following NRC Regulatory Guides:

- Regulatory Guide 1.132, which indicates that excavations for safety-related structures and other excavations important for verifying subsurface site conditions should be mapped in detail by geologists.

- Regulatory Guide 1.208, which states that faults exposed in site excavations should be mapped and assessed in regard to rupture potential while walls and floors of the excavations are exposed, to include assessment of non-tectonic surface and near-surface deformation.

In addition, the geologic mapping activities satisfied statements presented in the FSAR (Sections 2.5.1.2.4, 2.5.1.2.5, and 2.5.3.1.1) indicating that detailed geologic mapping of the excavations for safety related structures, in particular the nuclear island structures, would be performed to document the presence or absence of minor shear zones such as those reported in bedrock of the Unit 1 excavation, which typically cannot be easily recognized or adequately characterized by surficial geologic mapping or analysis of drill core.

Prior to the review of Report 2091-PR-03, Revision 0, by G. Stirewalt, NRC staff conducted site field audits to directly examine lithologies and geologic features in bedrock exposed in the Unit 2 excavation, including minor shear zones and fractures, for both top of sound rock (i.e., August 2010, reported in the Agencywide Documents Access and Management System (ADAMS) Accession No. ML102380451) and top of foundation grade level bedrock (i.e., April 2011, reported in ADAMS Accession No. ML111505741). An assessment of blast damage was also performed for top of foundation grade level bedrock in the Unit 2 excavation during the April 2011 site audit. The site audits enabled NRC geologists to observe geologic field relationships in bedrock exposed in the Unit 2 excavation and discuss these relationships with the applicant, which greatly facilitated an efficient review of Report 2091-PR-03 by G. Stirewalt.

<u>Materials Reviewed</u>

G. Stirewalt carefully reviewed the full text, appendices, attachments, figures, tables, and plates comprising Report 2091-PR-03 during the data documentation audit. These materials included the following:

Executive Summary

Definitions

1.0 Introduction and Objectives
- 1.1 Introduction
- 1.2 Geologic History
  - 1.2.1 Charlotte Terrane

Attachment I – Report on Petrology and $^{40}Ar/^{39}Ar$ Ages of Lithologies at the V.C. Summer Site
Attachment II – Report on Apatite and Zircon (U-Th)/He Geothermochronologic Analyses

Figures 1.2-1 through V1-2

Tables 2.1-1 through 2.5-3

Plate 1 – Unit 2 Power Block Excavation Plan
Plate 2 – Top of Rock Hillshade
Plate 3 – Nuclear Island Final Foundation Grade Hillshade
Plate 4a – Geologic Map of the Southwest Wall
Plate 4b – Geologic Map of the West Wall
Plate 4c – Geologic Map of the Northwest Wall
Plate 4d – Geologic Map of the North Wall, West Side
Plate 4e – Geologic Map of the North Wall, East Side
Plate 4f – Geologic Map of the Northeast Wall
Plate 4g – Geologic Map of the East Wall
Plate 4h – Geologic Map of the Southeast Wall
Plate 5a – Geologic Map of Top of Rock (TOR), Nuclear Island
Plate 5b – Geologic Map of TOR, Circulating Water System (CWS) Pipe Trench Area
Plate 6a – Geologic Map of Final Foundation Grade, Nuclear Island Excavation
Plate 6b – Geologic Map of Final Foundation Grade, West and South Walls
Plate 6c – Geologic Map of Final Foundation Grade, East and North Walls

Activities implemented by the applicant for geologic mapping as discussed in Report 2091-PR-03, Revision 0, were covered by the following documents produced by Fugro Consultants, Inc. (FCL), "PI" indicates a Project Instruction, and "WI" designates a Work Instruction. These documents were inspected by NRC staff during a Quality Assurance (QA) inspection of the geologic mapping efforts at the VCSNS site conducted in October 2011 (ADAMS Accession No. ML11311A042).

- FCL Project Planning Document 2091-PPD, "Geologic Mapping Services for VCSNS Units 2 and 3," Revision 4, dated May 4, 2011
- FCL 2091-PI-01, "Geologic Mapping Data Collection Plan for VCSNS Units 2 and 3," Revision 3, dated May 4, 2011
- FCL 2091-PI-02, "Laboratory Testing Plan for VCSNS Units 2 and 3," Revision 6, dated June 23, 2011
- FCL 2091-PI-03, "Geoscience Evaluation and Analysis Plan for VCSNS Units 2 and 3," Revision 1, dated May 4, 2011
- FCL 2091-WI-01, "Field Records," Revision 0, dated March 6, 2010
- FCL 2091-WI-02, "Survey Control," Revision 0, dated 6 March 2010
- FCL 2091-WI-03, "Field Mapping Standards," Revision 1, dated May 2, 2011

- FCL 2091-WI-04, "Sampling Protocol, Handling and Storage," Revision 1, dated May 2, 2011
- FCL 2091-WI-05, "Compilation and Verification of Excavation Monitoring and Reconnaissance," Revision 1, dated May 4, 2011
- FCL 2091-WI-06, "Excavation Wall Photography and Mapping for VCSNS Units 2 and 3," Revision 2, dated May 3, 2011
- FCL 2091-WI-07, "GPS Unit Accuracy Verification for VCSNS Units 2 and 3," Revision 1, dated March 6, 2010
- FCL 2091-WI-08, "VCSNS Unit 2 Nuclear Island and CWS Area Preliminary Geologic Mapping," Revision 0, dated August 2, 2010
- FCL 2091-WI-09, "VCSNS Unit 2 Nuclear Island, CWS Area, and Turbine Building Basement Area Final Foundation Geologic Mapping," Revision 0, dated December 16, 2010

Summary Notes and Commentary on Materials Reviewed

1. Section 1.1 ("Introduction") states that the geologic mapping program for VCSNS Unit 2 excavations was designed to examine the distribution and variability of geologic features, including soil profiles, lithologic units and contacts, cross-cutting relationships of geologic structures, mineralogy, faults, shear zones, and other structural elements using a mapping methodology developed from standard practices and approved methods. The geologic mapping methodology was described in Appendix I. Section 1.1 further indicates that geologic mapping of the Unit 2 excavation was conducted to document that geologic characteristics exposed therein were consistent with anticipated conditions as described in the FSAR for Units 2 and 3. Based on observations made during the August 2010 and April 2011 site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, respectively, as well as results of this data documentation audit, which included review of Appendix I ("Mapping Methodology"), G. Stirewalt concludes that both scope and methodology for the geologic mapping program are fully acceptable.

2. Section 1.2 ("Geologic Setting") describes regional geologic setting of VCSNS Units 2 and 3. This section states that rock units comprising the Charlotte Terrane were initially formed, deformed, and subjected to regional metamorphism during Late Proterozoic to Early Cambrian time (> 506 Ma), and then intruded by igneous rock masses making up the Winnsboro Plutonic Complex at 309 +/- 1 Ma (Late Paleozoic). The Winnsboro Complex comprises foundation bedrock in the Unit 2 excavation. Section 1.2 also discusses regional Mesozoic (mainly Triassic-Jurassic, 251-145.5 Ma) effects marked by reactivation of older Paleozoic (> 251 Ma) faults, intrusion of basaltic igneous dikes, hydrothermal activity, and development of silicified microbreccia along brittle fault zones. This section indicates that latest Mesozoic fracturing in the Piedmont occurred at near-surface crustal levels during the Cretaceous (145.5-65.5 Ma), and that structures of Tertiary age as young as Miocene (23-5.3 Ma) have been reported in the site region. Based on observations made during the August 2010 and April 2011 site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, respectively, as well as independent review of references cited in both the

FSAR and Report 2091-PR-03, Revision 0, G. Stirewalt concludes that geologic setting of the VCSNS site is accurately described.

3. Section 2.0 specifically discusses Unit 2 excavation geology. Section 2.1 ("Introduction") states that diorite and quartz monzonite are the primary rock types making up the Winnsboro Plutonic Complex, although the Complex does contain zenoliths (i.e., inclusions) of Charlotte Terrane country rock and partially melted country rock (i.e., migmatite), and that saprolite overlying sound bedrock is up to 21.3 m (70 ft) thick at the location of Unit 2. Section 2.1 also indicates that fracturing and minor faulting are present in the Winnsboro Complex, and that field relationships suggest these structures were developed during intrusion of the two plutonic rock masses (i.e., first the diorite and then the quartz monzonite, with both intrusions around 309 Ma) and subjected to later hydrothermal alteration during Triassic time (251-201.6 Ma). Based on observations made during the August 2010 and April 2011 site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, respectively, G. Stirewalt concludes that the statements provided in Section 2.1 regarding ages of intrusions, fracturing, minor faulting, and subsequent hydrothermal alteration are accurate.

4. Section 2.2 ("Lithology") states that there is no penetrative deformation fabric in rocks comprising the Winnsboro Plutonic Complex, as is observed in deformed Charlotte Terrane rock units. Based on observations made during the site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, G. Stirewalt concludes that this statement provided in Section 2.2 about a lack of penetrative deformation fabric in rock units of the Winnsboro Plutonic Complex is accurate.

5. Section 2.3 ("Structure") defines the following three categories of geologic structures found in the Unit 2 excavation, and describes the specific fracture/shear zones found in that excavation:

   - Category 1 – Small-scale shear zones characterized by closely-spaced fractures; weakly-developed striations (i.e., slickensides) indicative of at least minor slip on fracture surfaces; occasional offsets; and metasomatic/hydrothermal pink alteration of rock materials adjacent to the zones. Hornblende and biotite are commonly replaced by chlorite in the shear zones, and fractures in the zones are commonly filled with epidote, clay, feldspar fragments, and Fe-Ti oxides.

   - Category 2 – Fractures filled with green-colored greenschist metamorphic facies minerals (i.e., very weakly deformed to undeformed chlorite and epidote) and soft white or grey material, generally without striations. This metamorphic facies mineral assemblage is commonly interpreted to correspond to temperatures in the range of 300-500 ^{0}C.

   - Category 3 – Fractures filled with black amorphous material, commonly striated, in saprolite and partially weathered rock. Because the striations are either poorly developed or absent in less-weathered rock materials, the report indicates that they are non-tectonic in origin and resulted from differential movement during weathering.

(a) Based on a stereonet plot of poles to 889 fracture planes measured in the Unit 2 excavation (Report Figure 2.3-4), four populations of fractures exist: 345-350^0 (i.e., N 10-15^0 W), 80^{0}SE; 295-305^0 (N 55-65^0 W), 85^{0}NE; 020-030^0 (N 20-30^0 E), 85^{0}SE; 220-260^0 (N 40-80^0 E), and 40-70^{0}NW. A stereonet plot of poles to 229 fractures exhibiting striations or displacement (Report Figure 2.3-5) showed similar strike directions, but shallower dips. Only 9 of the 229 fractures with striations or displacement were measured at final foundation grade level in the Unit 2 excavation.

(b) Four relatively prominent shear zones occur in foundation grade level bedrock in the Unit 2 excavation, with BSZ1 near the southern extent of the excavation being the most prominent. BSZ1 fits into the 295-305^0 (N 55-65^0 W) fracture set. The shear zones contain closely-spaced fractures, chlorite and epidote mineralization, and quartz veins. Shear zones BSZ1, BSZ2 (essentially parallel to BSZ1), BSZ3 (made up of fracture sets trending about N 10^0 E and N 25^0 W), and BSZ5 (with fracture sets trending about N 10-15^0 W and N 55-65^0 W) are clearly shown in Plate 6a, the geologic map of final foundation grade for the Unit 2 nuclear island excavation, which was examined to estimate strike orientations of the shear zones. BSZ4 is shown in Plate 5a, the geologic map of top of (sound) rock (TOR) for the Unit 2 nuclear island, but this shear zone did not extend vertically downward to final foundation grade level. The strike of BSZ4 was generally parallel to that of BSZ1.

(c) Some igneous dikes cut across shear zone BSZ1 without offset, while others appear to show lateral shear displacement. Pods of vein quartz in the shear zone may support the interpretation of dilation in the zone. The largest apparent offset along BSZ1 is a right-lateral separation of 25 cm (9.8 in) near the southeastern corner of the Unit 2 excavation, and striations in the shear zone also show mainly strike-slip movement.

(d) An unlabeled minor shear zone is mapped at the top of rock in the southeastern part of the CWS pipe trench area excavation (Plate 5b). This shear zone, which generally parallels the N 55-65^0 W strike direction of BSZ1 as mapped in the nuclear island excavation, is not discussed in the report. However, during a conference call with the applicant on February 16, 2012, the applicant's geologic mapping contractor with Fugro Consultants, Inc., Dr. R. Cumbest, clarified that this structure can be continuously traced from the nuclear island excavation into the CWS pipe trench area excavation as shear zone BSZ1, which is well documented in regard to geometry and age in the report. The applicant may expand the discussion of BSZ1 in a future revision of Report 2091-PR-03 to clearly document that shear zone BSZ1 extends continuously from the nuclear island excavation into the CWS pipe trench area excavation and that all shear zones in the Unit 2 excavation have been mapped and characterized. This change, if implemented, would further support the conclusion that no capable tectonic structures occur in the Unit 2 excavation.

(e) The report cites regional studies that postulate at least 9 different Mesozoic (251-65.5 Ma) fracture populations. The northwest-striking Wateree Creek Fault, located about 3 km (2 mi) south of the VCSNS site, is interpreted from field relationships to be a tectonic feature of Mesozoic age. An exposure of this fault was directly examined in the field by G. Stirewalt, who concludes that field data support a Mesozoic age for the fault.

(f) The report states that diorite is more strongly fractured than quartz monzonite, suggesting that fractures and shear zones developed during a late phase of the Late Paleozoic (309 Ma) intrusion of the Winnsboro Plutonic Complex. Field relationships observed by G. Stirewalt during the August 2010 (ADAMS Accession No. ML102380451) and April 2011 (ADAMS Accession No. ML111505741) audits document that fractures in the diorite controlled intrusion of some quartz monzonite veinlets in the Unit 2 excavation.

(g) The two most prominent fracture/shear zone orientations in the Unit 2 excavation are 295^0 (N 55^0 W) and 345^0 (N 15^0 W). The prominent zones that show pink metasomatic/hydrothermal alteration are interpreted to be related to Mesozoic reactivation of fracture sets initially developed during the Late Paleozoic (309 Ma) intrusion of the Winnsboro Plutonic Complex. The orientations of fracture/shear zones in the Unit 2 excavation roughly correspond to orientations of shear zones identified in the site region and in the Unit 1 excavation.

Based on observations made during the August 2010 and April 2011 site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, respectively, as well as independent review of references cited in both the FSAR and Report 2091-PR-03, Revision 0, G. Stirewalt concludes that the descriptions of fractures and shear zones found in the Unit 2 excavation are accurate.

6. Section 2.4 (“Weathering Profile”) states that the weathering profile is typical for the southeastern Piedmont region. Based on observations made during the August 2010 and April 2011 site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, respectively, as well as independent review of references cited in both the FSAR and Report 2091-PR-03, Revision 0, G. Stirewalt concludes that the weathering profile at the location of Unit 2 is typical of the southeastern Piedmont region, including thickness of the saprolite overlying sound bedrock (i.e., up to 21.3 m [70 ft] thick).

7. Section 2.5 (“Geochronology and Thermal History”) summarizes the results of $^{40}Ar/^{39}Ar$ radiometric age dating.

Minerals analyzed from the Unit 2 excavation included hornblende, biotite, muscovite, and K-feldspar. Samples from which the minerals were taken for analyses represented all rock types present in the excavation, including the altered zones associated with fractures and shear zones characterized by K-metasomatism and the presence of epidote and chlorite. The derived age dates represent the times at which the different minerals closed to migration of Ar, which correspond to the primary mineral crystallization age for undeformed and unaltered samples, and to a post-primary mineral recrystallization deformation/alteration age for deformed and altered samples. Therefore, the derived dates made it possible to determine the ages of both rock units in the Unit 2 excavation and the subsequent fracturing, shearing, dilation, and hydrothermal alteration that affected the rock units.

- Hornblende “closure temperature” ages ranged from 293.1-306.95 Ma, and were identical for diorite and quartz monzonite within analytical uncertainty at about 307 Ma. The youngest ages (Samples 21-4-1 and 21-10-1, discussed below in Item 8) were for hornblendes taken from fine-grained amphibolites of Charlotte Terrane xenoliths, consistent with predicted grain-size variation effects on closure temperature (i.e., smaller grains exhibit slightly lower cooling temperatures and show younger ages). Hornblende ages indicate thermal conditions in the Unit 2 excavation began to cool below the closure temperature of hornblende to Ar diffusion (500 ^{0}C) at about 307 Ma.

- For biotite and muscovite, closure temperature ages were interpreted to represent virtually a single point on a time and temperature profile at 325 ^{0}C, the closure temperature of the two minerals to Ar diffusion, around 291 Ma.

- Magmatic K-feldspar samples from undeformed and unaltered quartz monzonite and aplite of the Winnsboro Plutonic Complex gave closure temperature ages of 263.2 Ma and 267.18 Ma, respectively. Results indicate cooling of K-feldspar through 250 ^{0}C, the closure temperature of the mineral to Ar diffusion, at about 265 Ma.

- K-feldspar from fractured and hydrothermally altered zones near fracture/shear zones that contain epidote, chlorite, and alteration “pinking” consistently gave younger closure temperature ages ranging from 193.5 Ma to 214 Ma. The preferred explanation was for a lowering of the closure temperature for altered K-feldspar in and around fracture/shear zones relative to that for undeformed and unaltered K-feldspar. Potential mechanisms for lowering the closure temperature for the deformed K-feldspar include grain-size reduction from fracturing; introduction of crystal structure defects due to fracturing and chemical alteration; and enhanced mobility of chemical components due to reactions with hydrothermal fluids. These mechanisms allow for re-setting the K-feldspar in and around the fracture/shear zones at lower temperatures and younger ages than for the undeformed and unaltered parts of the Winnsboro Complex.

8. Attachment I of the report provides a detailed discussion of $^{40}Ar/^{39}Ar$ mineral ages sample by sample, including altered K-feldspars, with the purposes of constraining crystallization and thermal history and obtaining an age estimate for timing of development of brittle fracture/shear zones at the VCSNS site. Mineral separates of hornblende, muscovite, biotite, and K-feldspar were analyzed.

   - Sample 21-1-1 was a hydrothermally altered quartz monzonite from shear zone BSZ1, with alteration interpreted to have occurred during post-magmatic crystallization fracturing. A preferred age of 214.5 +/- 0.55 Ma was obtained on altered K-feldspar from the sample. (Based on information provided in the report and field observations, BSZ1 and other fracture/shear zones may have experienced both dilation and shearing movements.) The description of Sample 21-1-1 as quartz monzonite appears to be in disagreement with the rock type shown at that sample location on the map presented in Plate 6a, which indicates the sample was taken in diorite. The applicant may expand the discussion of Sample 21-1-1 in a future revision of Report 2091-PR-03 to clarify this apparent minor descrepancy in regard to the rock type sampled. However, neither interpretation of rock type would alter the conclusion regarding a lack of tectonic deformation features younger than Mesozoic (i.e., not < 65.5 Ma) in bedrock of the Unit 2 excavation.

- Sample 21-2-1 was relatively fresh diorite, with textures interpreted to have developed during magmatic crystallization, containing magmatic epidote. A preferred age of 306.95 +/- 2.21 Ma was obtained on hornblende, and 306.78 +/- 0.48 Ma on biotite, from the sample.

- Sample 21-3-1 was from quartz monzonite containing K-feldspar, hornblende, and biotite. K-feldspar and ferro-magnesian minerals lacked evidence of alteration, and textures were interpreted to represent magmatic crystallization. A preferred age of 306.9 +/- 0.7 Ma was obtained on hornblende, 292.55 +/- 0.85 on biotite, and 263.2 +/- 2.3 Ma on K-feldspar from the sample.

- Sample 21-4-1 was amphibolite (i.e., mapped unit “Za”), with a cross-cutting vein containing quartz, K-feldspar, calcite, and amphibole formed at a moderately high-temperature (400-500 ^{0}C) during a late metamorphic stage of the amphibolite. A preferred age of 299.6 +/- 6.4 Ma was obtained on hornblende, and 290.5 +/- 0.8 Ma on biotite, from the sample.

- Sample 21-6-1 was a pegmatite containing coarse plagioclase feldspar, quartz, and disseminated muscovite with all phases interpreted to have crystallized from a volatile-rich siliceous melt. Textures reflect magmatic processes and reactions with fluids that evolved during crystallization of the melt. A preferred age of 291.3 +/- 0.32 Ma was obtained on muscovite from the sample. (Note: Plagioclase feldspar was excluded from age analyses because it is a low-K mineral phase that may contain fluid inclusions with excess ^{40}Ar.)

- Sample 21-7-1 was an aplite dike containing K-feldspar, quartz, biotite, and sparing muscovite. The aplite was considered to be coeval with the pegmatite. A preferred age of 267.18 +/- 0.39 Ma was obtained on K-feldspar, 293.0 +/- 1.4 Ma on biotite, and 285.2 +/- 1.1 Ma on muscovite, from the sample.

- Sample 21-8-1 was from fracture/shear zone BSZ3 in quartz monzonite. A preferred age of 193.5 +/- 2.9 Ma was obtained on altered K-feldspar from the sample. The report stated that the overall pattern of Ar release was consistent with a K-feldspar crystal that began initial retention of Ar prior to about 250 Ma and experienced Ar loss around 194 Ma.

- Sample 21-9-1 was from fracture/shear zone BSZ1 in quartz monzonite. Fractures contained chlorite, epidote, and Fe-Ti oxides. A preferred age of 196.0 +/- 1.2 Ma was obtained on altered K-feldspar from the sample. The report stated that variations in ages were associated with K-feldspar crystals that began to retain Ar prior to about 210 Ma, with a loss of Ar around 196 Ma. The ages obtained on altered minerals from BSZ1 and BSZ3 indicate that shearing and/or dilation and hydrothermal alteration is not younger than Mesozoic (i.e., not < 65.5 Ma).

- Sample 21-10-1 was from foliated amphibolite (mapped unit "Za") containing undeformed plagioclase feldspar, hornblende, and biotite. The overall metamorphic assemblage and texture was interpreted to have formed during middle amphibolite facies metamorphism, with final metamorphic mineral development occurring post-kinematically relative to the deformation that produced the foliation. A preferred age of 293.1 +/- 0.7 Ma was obtained on hornblende from the sample.

- Ages of K-feldspar older than 200 Ma came from samples not affected by fracturing, shearing/dilation, and hydrothermal alteration.

9. Section 2.5 ("Geochronology and Thermal History"), also summarizes the results of (U-Th)/He radiometric age dating.

   - Results for zircon indicate no significant differences in ages between altered and unaltered samples, showing that both cooled through a He closure temperature of about 160-190 ^{0}C between about 190-220 Ma.

   - Results for apatite also indicate no systematic differences in ages between altered and unaltered samples, showing that both cooled through a closure temperature of about 50-70 ^{0}C between about 90-120 Ma.

10. Attachment II of the report presents a detailed discussion of apatite and zircon (U-Th)/He geothermochronologic analyses for samples from the Unit 2 excavation. Samples included altered quartz monzonite from a brittle shear zone (21-11-1, with zircons of very poor quality and many grains significantly abraded; apatites highly abraded and all grains broken), altered diorite from a brittle shear zone (21-12-1, with zircons of fairly good quality; apatites highly damaged), diorite (21-13-1), Charlotte Terrane amphibolite (21-14-1), and quartz monzonite (21-3-2).

    - For zircon, the full range of age dates from all samples is 182-239 Ma with a mean of 211 Ma and one standard deviation of 12 Ma. The report states that these data are consistent with relatively rapid cooling of samples through the zircon (U-Th)/He closure temperature (about 160-190 ^{0}C) at 211 +/- 12 Ma.

- For apatite, aside from two spurious dates, the range of age dates is 83-128 Ma. The report states that these data are consistent with relative slow cooling of samples through the apatite (U-Th)/He closure temperature (about 50-70 ^{0}C) at about 90-120 Ma.

11. The permissive, and simplest, monotonic cooling history suggested based on the zircon and apatite dates is as follows:

    - Relatively rapid cooling (> 5-10 ^{0}C/million years) to less than ~ 140 ^{0}C no later than about 200 Ma.

    - Relatively slow cooling (~ 1 ^{0}C/million years) from ~ 140 ^{0}C to 40 ^{0}C between about 200-100 Ma.

    - Slow cooling (~ 0.1-0.3 ^{0}C/million years) from ~ 40 ^{0}C to 15 ^{0}C, the approximate surface temperature, between about 100 Ma to present.

Based on observations made during the August 2010 and April 2011 site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, respectively, as well as independent review of Attachments I and II and references cited in both the FSAR and Report 2091-PR-03, Revision 0, G. Stirewalt concludes that the cooling history presented for rocks in the Unit 2 excavation is accurate and age dates for development of fractures and fracture/shear zones in the excavation are well-constrained by radiometric dating techniques. G. Stirewalt further concludes that no data indicate the presence of tectonic structures younger than Mesozoic (i.e, not < 65.5 Ma) in bedrock of the Unit 2 excavation.

12. Section 2.6 ("Geologic History") summarizes the geologic history of rocks in the Unit 2 excavation in Figure 2.6-1, based on mineral closure temperatures, as follows:

    - 50-70 ^{0}C reached for apatite at 90-120 Ma (Cretaceous) based on (U-Th)/He dates
    - 160-190 ^{0}C reached for zircon at 200 Ma (Triassic-Jurassic) based on (U-Th)/He dates
    - Dilational reactivaton of fractures/shear zones associated with K metasomatism and hydrothermal alteration at > 200 Ma (Triassic-Jurassic)
    - 250 ^{0}C reached for K-feldspar at 265 Ma (Permian) based on $^{40}Ar/^{39}Ar$ dates
    - 325 ^{0}C reached for muscovite/biotite at 291 Ma (Carboniferous) based on $^{40}Ar/^{39}Ar$ dates
    - 500 ^{0}C reached for hornblende at 307 Ma (Carboniferous) based on $^{40}Ar/^{39}Ar$ dates
    - Intrusion of Winnsboro Complex quartz monzonite preceded by diorite, with development of fractures and small-scale shear zones at 309 Ma (Carboniferous)
    - Formation, metamorphism, and penetrative deformation of Charlotte Terrane lithologies during late PreCambrian-Early Cambrian at > 506 Ma.

Based on observations made during the August 2010 and April 2011 site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, respectively, as well as independent review of Attachments I and II and references cited in both the FSAR and Report 2091-PR-03, Revision 0, G. Stirewalt concludes that the cooling history presented for rocks in the Unit 2 excavation is accurate; age dates for development of fractures and fracture/shear zones in the excavation are well-constrained by radiometric dating techniques; and no data indicate the presence of tectonic structures younger than Mesozoic (i.e., not < 65.5 Ma) in bedrock of the Unit 2 excavation.

Although the report convincingly makes the case for Mesozoic reactivation of older fractures and shear zones in the Winnsboro Plutonic Complex, Figure 2.6-1 indicates that only dilational reactivation of the fractures and shear zones, and not shearing movements, occurred. In light of the complex deformational history of the Winnsboro Plutonic Complex, the multiple fracture sets interpreted to be Mesozoic in age in the site region, and reported Mesozoic faulting in the site area (e.g., the Wateree Creek Fault), it is possible that fracturing and minor shearing may also have occurred along pre-existing fracture/shear zones, as well as dilation, during Mesozoic time. The applicant may modify Figure 2.6-1 in a future revision of Report 2091-PR-03 to indicate that both fracturing and minor shearing, as well as dilation, may have occurred during Mesozoic time. However, neither interpretation (i.e., dilation or shearing) would alter the conclusion regarding a lack of tectonic deformation features younger than Mesozoic in bedrock of the Unit 2 excavation.

13. Section 3.0 (“Conclusions”) compares geologic conditions reported for the Unit 2 excavation with those discussed in the FSAR for VCSNS Units 2 and 3 in regard to lithology, structure, and weathering.

(a) For lithology, Section 3.1.1 notes that rock types are essentially the same (i.e., intrusive igneous diorite and quartz monzonite of the Winnsboro Plutonic Complex, Charlotte Terrane inclusions in the intrusive masses, and migmatite) and reflect the same spatial distributions, although minor differences in nomenclature exist for rock units in the Winnsboro Complex.

(b) For structure, Section 3.1.2 states that field observations indicate many of the fractures and fracture/shear zones initially occurred during intrusion of the Winnsboro Plutonic Complex at 309 Ma. The youngest fractures and fracture/shear zones are marked by pink alteration and related to Mesozoic reactivation of older structures around 200 Ma or slightly older. Prominent fractures and fracture/shear zones strike northwest (350^0 [N 10^0 W] and 300^0 [N 60^0 W]) and northeast (025^0 [N 25^0 E]). Section 3.1.2 also states that shear zones mapped in the Unit 1 excavation showed a similar history of development related to Mesozoic reactivation of older structures around 200 Ma or slightly earlier.

(c) For weathering, Section 3.1.3 indicates that the weathering profile at the location of Unit 2 is typical of the southeastern Piedmont region.

Based on observations made during the August 2010 and April 2011 site field audits reported in ADAMS Accession Nos. ML102380451 and ML111505741, respectively, G. Stirewalt concludes that the above concluding statements presented in Section 3.0 are accurate.

Conclusions from the Data Documentation Audit

As a result of this data documentation audit of Report 2091-PR-03, Revision 0, as well as observations made by NRC geologists during site field audits to directly examine lithologies and geologic features (including minor shear zones and fractures) in the VCSNS Unit 2 excavation for both top of sound rock (August 2010 reported in ADAMS Accession No. ML102380451) and top of foundation grade level bedrock (April 2011 reported in ADAMS Accession No. ML111505741), G. Stirewalt concludes that Report 2091-PR-03, Revision 0, presents data confirming the accuracy of statements made by the applicant in the FSAR regarding the expectation that no potentially detrimental tectonic structures, particularly any of Quaternary age (2.6 Ma to present), or non-tectonic features occurred in foundation grade level bedrock in the excavations for safety-related structures at the VCSNS Unit 2 site. This conclusion is possible because no data suggest that fractures, shear zones, dilation across or shearing movements along fractures or shear zones, and K-metasomatism and hydrothermal alteration are younger than Mesozoic in age (i.e., not < 65.5 Ma). G. Stirewalt also concludes that Report 2091-PR-03, Revision 0, satisfied statements presented in the FSAR (Sections 2.5.1.2.4, 2.5.1.2.5, and 2.5.3.1.1) indicating that detailed geologic mapping of the excavations for safety-related structures would be performed to document the presence or absence of minor shear zones such as those reported in bedrock of the Unit 1 excavation.

Also as a result of this audit, G. Stirewalt posed three technical questions about content of Report 2091-PR-03, Revision 0, to the VCSNS applicant in February 2012. The three questions were as follows:

- Question 1: Information shown in Figure 2.6-1 implies that Mesozoic shearing and fracturing can be discounted in litholgies found in the Unit 2 nuclear island excavation because mainly alteration related to movement of hydrothermal fluids in dilational veins, and not minor shearing and fracturing, is suggested to have occurred during Mesozoic (> 65.5 Ma) time. Is it not possible that minor shearing and fracturing of rock units in the Unit 2 excavation, as well as dilation and hydrothermal alteration, may have occurred during Mesozoic time?

- Question 2: Can you clarify the apparent discrepancy between the rock unit description in Attachment I from which Sample 21-1-1 was taken (i.e., quartz monzonite) and what is shown as the sampled rock type on the geologic map of Plate 6a (i.e., diorite)?

- Question 3: In addition to shear zones BSZ1, BSZ2, BSZ3, and BSZ5 shown in Plate 6a ("Geologic Map of Final Foundation Grade, Nuclear Island Excavation") of the Summer Unit 2 Geologic Mapping Report (Revision 0) and discussed in that report, a minor shear zone that is not discussed in the report was also mapped at the top of sound rock in the southeastern part of the CWS excavation as shown in Plate 5b ("Geologic Map of TOR, Circulating Water System (CWS)

Pipe Trench Area") of the report. This shear zone generally parallels the northwest strike direction of BSZ1 as mapped in the Unit 2 nuclear island excavation. Can the shear zone be traced from the power block into the CWS pipe trench area excavation as a continuation of BSZ1, which is well-documented in regard to its geometry and age?

During a teleconference call with the NRC on February 16, 2012, the applicant indicated that the following information would be provided to the NRC in Revision 1 of Report 2091-PR-03 to address the three questions stated above, if necessary, G. Stirewalt will review and evaluate Revision 1 of the report specifically with regard for this clarifying information.

- RE - Question 1: Information in Figure 2.6-1 will be modified in Revision 1 of the Unit 2 excavation geologic mapping report to include possible fracturing and minor shearing, as well as dilational reactivation of fractures associated with K metasomatism-hydrothermal alteration, at > 200 Ma (i.e., during the Mesozoic). The change will be a refinement for clarity and completeness only. It will not alter the conclusion that no Quaternary age tectonic structures occur in the Unit 2 excavation, since no evidence exists to suggest that shearing deformation is younger than Mesozoic (i.e., not < 65.5 Ma).

- RE - Question 2: The geologic map of Plate 6a ("Geologic Map of Final Foundation Grade, Nuclear Island Foundation") will be checked to determine if a minor change should be made for either geologic contacts or location of Sample 21-1-1. If deemed necessary, a change will be made in Revision 1 of the Unit 2 excavation geologic mapping report as a refinement for clarity and completeness only. It will not affect the quality or overall accuracy of the geologic map shown in Plate 6a and will not alter the conclusion that no Quaternary age tectonic structures occur in the Unit 2 excavation, since age dates on altered samples, whether diorite or quartz monzonite, do not indicate any tectonic or hydrothermal alteration effects younger than Mesozoic.

- RE - Question 3: A statement will be added in Revision 1 of the Unit 2 excavation geologic mapping report to indicate that the unlabeled shear zone mapped in Plate 5b ("Geologic Map of TOR, Circulating Water System [CWS] Pipe Trench Area") can be continuously traced from the power block into the CWS pipe trench area excavation as BSZ1, which is well documented in regard to geometry and age in the report. This change will be a geologic refinement for clarity and completeness only to show that all shear zones have been adequately characterized. It will no alter the conclusion that no Quaternary age tectonic structures occur in the Unit 2 excavation.

The NRC issued a license for the VCSNS site in March 2012 for construction and operation of two new Westinghouse AP1000 design nuclear power facility units located adjacent to the original Unit 1 power plant. Geologic mapping of safety-related excavations at the VCSNS Unit 3 site was performed by the VCSNS licensee to address a geologic mapping License Condition for that unit. Just as done for Unit 2 in this report, conclusions formulated by NRC geologists based on review and evaluation of geologic mapping results from excavations for safety-related structures at VCSNS Unit 3 will be presented in a detailed technical report by G. Stirewalt once those results are provided to the NRC.

G. Stirewalt
March 2012

Results of a Data Documentation Audit Conducted on March 25, 2013 to Review Virgil C. Summer Nuclear Station Unit 2 Geologic Excavation Mapping Report 2091-PR-03, Revision 1

Dr. Gerry L. Stirewalt

Between the time that Revisions 0 and 1 of Report 2091-PR-03 were issued and independently reviewed and evaluated by Dr. Gerry L. Stirewalt, the U.S. Nuclear Regulatory Commission (NRC) issued a license for the Virgil C. Summer Nuclear Station (VCSNS) site (i.e., in March 2012) for construction and operation of two new Westinghouse Electric Company (Westinghouse) AP1000 design nuclear power facility units located adjacent to the original Unit 1 power plant. Therefore, the VCSNS licensee is referred to, when appropriate, in this data documentation audit report for Report 2091-PR-03, Revision 1.

Introduction

Geologic mapping of safety-related excavations at the VCSNS Unit 2 site was performed by the VCSNS applicant to assure that a geologic mapping License Condition need not be included in the Final Safety Analysis Report (FSAR) specifically for Unit 2. The primary purpose of this data documentation audit, which was conducted by Office of New Reactors (NRO), Senior Geologist, G. Stirewalt, on March 25, 2013, was to independently review and evaluate Revision 1 of the following report that presents the results of geologic mapping of excavations for safety-related structures, particularly the nuclear island, at the VCSNS Unit 2 site:

> Report 2091-PR-03, Revision 1: “V. C. Summer Unit 2 Excavation Mapping Report,” SCE&G, dated 25 October 2012 and prepared by Fugro Consultants, Inc. (Released for construction by Shaw Engineering on November 7, 2012)

Revision 0 of Report 2091-PR-03 was reviewed and evaluated by G. Stirewalt on January 17-18 and 30-31, 2012. The goal of that effort was to independently verify the accuracy of statements made by the then VCSNS applicant in the FSAR regarding the expectation that no potentially detrimental tectonic structures, particularly any of Quaternary age (2.6 million years [Ma] to present), or non-tectonic features occurred in foundation grade level bedrock in the excavations for safety-related structures at the location of VCSNS Unit 2. Results of the January 2012 data documentation audit of Revision 0 of Report 2091-PR-03 were presented in a summary report prepared by G. Stirewalt in March 2012, which is included as part of this package so the detailed information presented therein need not be repeated.

The goal of this data documentation audit of Report 2091-PR-03, Revision 1, was to examine changes made to Revision 0 by the VCSNS licensee in response to the three questions stated in the March 2012 report that was prepared by G. Stirewalt. This goal enabled G. Stirewalt to independently verify the accuracy of statements made by the VCSNS applicant in the FSAR regarding the expectation that no potentially detrimental tectonic structures, particularly any of Quaternary age (2.6 million years [Ma] to present), or non-tectonic features occurred in foundation grade level bedrock in the excavations for safety-related structures at the location of VCSNS Unit 2. The three questions from the March 2012 report by G. Stirewalt were as follows:

- Question 1: Information shown in Figure 2.6-1 implies that Mesozoic (251-65.5 Ma) shearing and fracturing can be discounted in lithologies found in the Unit 2 nuclear island excavation because mainly alteration related to movement of hydrothermal fluids in dilational veins, not minor shearing and fracturing, is interpreted to have occurred during Mesozoic time. Is it not possible that minor shearing and fracturing of rock units in the Unit 2 excavation, as well as dilation and hydrothermal alteration, may have occurred during Mesozoic time?

- Question 2: Can you clarify the apparent discrepancy between the rock unit description in Attachment I from which Sample 21-1-1 was taken (i.e., quartz monzonite) and what is shown as the sampled rock type on the geologic map of Plate 6a (i.e., diorite)?

- Question 3: In addition to shear zones BSZ1, BSZ2, BSZ3, and BSZ5 shown in Plate 6a ("Geologic Map of Final Foundation Grade, Nuclear Island Excavation") of the Summer Unit 2 Geologic Mapping Report (Revision 0) and discussed in that report, a minor shear zone that is not discussed in the report was also mapped at the top of sound rock in the southeastern part of the Circulating Water System (CWS) excavation as shown in Plate 5b ("Geologic Map of TOR, CWS Pipe Trench Area") of the report. This shear zone generally parallels the northwest strike direction of BSZ1 as mapped in the Unit 2 nuclear island excavation. Can the shear zone be traced from the power block into the CWS pipe trench area excavation as a continuation of BSZ1, which is well-documented in regard to its geometry and age?

The VCSNS licensee prepared Report 2091-PR-03, Revision 1, and made it available to the NRC for review to provide final documentation of results of the detailed geologic mapping of the Unit 2 nuclear island excavation. In addition to minor modifications addressing the three questions stated above, the report contained the completed detailed geologic maps, associated data, and final results and conclusions derived from geologic mapping of the VCSNS Unit 2 nuclear island excavation, which was performed by the then applicant to address the following regulatory requirements:

- 10 CFR Part 52, which requires that geologic characteristics of a proposed site be described in the FSAR.

- 10 CFR Part 100.23(c), which specifically indicates the need for geologic data related to tectonic and non-tectonic surface deformation.

- 10 CFR Part 100.23(d), which explicitly states that geologic and seismic siting factors related to design must include determination of the potential for tectonic and non-tectonic surface deformation.

By conducting the geologic mapping activities, the then VCSNS applicant also considered the guidance provided in the following NRC Regulatory Guides:

- Regulatory Guide 1.132, which indicates that excavations for safety-related structures and other excavations important for verifying subsurface site conditions should be mapped in detail by geologists.

- Regulatory Guide 1.208, which states that faults exposed in site excavations should be mapped and assessed in regard to rupture potential while walls and floors of the excavations are exposed, to include assessment of non-tectonic surface and near-surface deformation.

In addition, the geologic mapping activities satisfied statements presented in the FSAR (Sections 2.5.1.2.4, 2.5.1.2.5, and 2.5.3.1.1) indicating that detailed geologic mapping of the excavations for safety related structures, in particular the nuclear island structures, would be performed to document the presence or absence of minor shear zones such as those reported in bedrock of the Unit 1 excavation, which typically cannot be easily recognized or adequately characterized by surficial geologic mapping or analysis of drill core.

Activities implemented by the licensee for geologic mapping as presented in Report 2091-PR-03, Revision 1, were covered by documents produced by Fugro Consultants, Inc. (FCL), as outlined in the March 2012 data documentation audit report for Report 2091-PR-03, Revision 0, prepared by G. Stirewalt. Those documents were inspected by NRC staff during a Quality Assurance (QA) inspection of the geologic mapping efforts at the VCSNS site conducted in October 2011 (ADAMS Accession No. ML11311A042).

Prior to the review of Report 2091-PR-03, Revisions 0 and 1, by G. Stirewalt, NRC geologists conducted site field audits to directly examine lithologies and geologic features in bedrock exposed in the Unit 2 excavation, including minor shear zones and fractures, for both top of sound rock (i.e., August 2010, reported in ADAMS Accession No. ML102380451) and top of foundation grade level bedrock (i.e., April 2011, reported in ADAMS Accession No. ML111505741). An assessment of blast damage was also performed for top of foundation grade level bedrock in the Unit 2 excavation during the April 2011 site audit. The site audits enabled NRC geologists to observe geologic field relationships in bedrock exposed in the Unit 2 excavation and discuss these relationships with the applicant.

Materials Reviewed

The review and evaluation of Report 2091-PR-03, Revision 1, by G. Stirewalt concentrated on modifications made in the report since Revision 0 was written. Therefore, all materials reviewed for Revision 0, which are covered in detail in the March 2012 data documentation audit report prepared by G. Stirewalt that is part of this package, were not examined in detail in Revision 1 because they were not substantially changed. This statement regarding no substantial changes can be made because G. Stirewalt looked at all minor changes in the text of Revision 1 that were made by the licensee. He also looked at appendices, attachments, figures, tables, and plates to ensure that those materials were consistently the same as what was provided in Revision 0.

Summary Notes and Commentary on Materials Reviewed

G. Stirewalt specifically reviewed information presented in Revision 1 of Report 2091-PR-03 related to answers provided by the licensee to the three questions stated above. In regard to Question 1, the licensee included concise statements in Section 2.6 ("Geologic History") and Figure 2.6.1 of Revision 1 indicating that, based on field data, minor shearing and fracturing could possibly have occurred at the location of the VCSNS Unit 2 site during the Mesozoic (65.5-251.0 Ma), as well as the Paleozoic (> 251.9 Ma). Specifically, a weak lineation observed by G. Stirewalt to occur in the chlorite-epidote hydrothermal mineral assemblage, which developed during the Mesozoic and is commonly associated with minor shears and fractures in the Unit 2 nuclear island excavation, suggests that minor amounts of shearing displacement could have occurred in Mesozoic time. In addition, in light of the complex deformational history of the Winnsboro Plutonic Complex, the multiple fracture sets interpreted to be Mesozoic in age in the site region, and reported Mesozoic faulting in the site area (e.g., the Wateree Creek Fault), it is possible that fracturing and minor shearing occurred along pre-existing fractures and shear zones in the Unit 2 excavation, as well as dilation, during Mesozoic time. The statements added by the licensee in Section 2.6 and Figure 2.6.1 provide clarity and completeness in Report 2091-PR-03, Revision 1, and do not alter the conclusion that no Quaternary (2.6 Ma to present) tectonic structures occur in the Unit 2 excavation since no evidence exists to suggest that shearing deformation is younger than Mesozoic. Therefore, statements made in the FSAR regarding the expectation that no potentially detrimental tectonic structures, particularly any of Quaternary age, or non-tectonic features occurred in foundation grade level bedrock in excavations for safety-related structures at the VCSNS Unit 2 site continue to be fully supported.

In regard to Question 2, the licensee verbally clarified that age dating Sample 21-1-1 was collected from a gradational contact zone between quartz monzonite and diorite, both of which are rock units of the Winnsboro Plutonic Complex. Therefore, the discrepancy between the rock unit description from which Sample 21-1-1 was taken (i.e., quartz monzonite) in Attachment I and what is shown as the sampled rock type on the geologic map of Plate 6a (i.e., diorite) is not critical for determining age of the Winnsboro Complex and no changes were necessary in the Revision 1 of Report 2091-PR-03 report.

In regard to Question 3, the licensee included concise statements in Subsection 2.3.1 (“Unit 2 Excavation”) of Section 2.3 (“Structure”) in Revision 1 regarding the minor shear zone that was not discussed in Revision 0 of Report 2091-PR-03, but was mapped at the top of sound rock in the southeastern part of the CWS excavation as shown in Plate 5b (“Geologic Map of TOR, Circulating Water System (CWS) Pipe Trench Area”) of Revision 0. The licensee indicated that it parallels the northwestern strike direction of BSZ1 as mapped in the Unit 2 nuclear island excavation (shown in Plate 6a, “Geologic Map of Final Foundation Grade, Nuclear Island Excavation”) and can be continuously traced as shear zone BSZ1 from the power block area into the CWS pipe trench area excavation. Since this minor shear zone in the CWS pipe trench area is a continuation of BSZ1 in the power block area and BSZ1 is well-documented in regard to geometry and pre-Quaternary age, the statements included in Report 2091-PR-03, Revision 1, by the licensee provide clarity and do not alter the conclusion that no Quaternary (2.6 Ma to present) tectonic structures occur in the Unit 2 excavations for safety-related structures. Therefore, statements made in the FSAR regarding the expectation that no potentially detrimental tectonic structures, particularly any of Quaternary age, or non-tectonic features occurred in foundation grade level bedrock in excavations for safety-related structures at the VCSNS Unit 2 site continue to be fully supported.

<u>Conclusions from the Data Documentation Audit</u>

As a result of the data documentation audit of Report 2091-PR-03, Revisions 0 and 1, as well as observations made by NRC geologists during site field audits to directly examine lithologies and geologic features (including minor shear zones and fractures) in the VCSNS Unit 2 excavation for both top of sound rock (August 2010 reported in ADAMS Accession No. ML102380451) and top of foundation grade level bedrock (April 2011 reported in ADAMS Accession No. ML111505741), G. Stirewalt concludes that Report 2091-PR-03, Revision 1, presents data confirming the accuracy of statements made by the applicant in the FSAR regarding the expectation that no potentially detrimental tectonic structures, particularly any of Quaternary age (2.6 Ma to present), or non-tectonic features occurred in foundation grade level bedrock in the excavations for safety-related structures at the VCSNS Unit 2 site. This conclusion is possible because no data suggest that fractures, shear zones, dilation across or shearing movements along fractures or shear zones, and K-metasomatism and hydrothermal alteration are younger than Mesozoic in age (i.e., not < 65.5 Ma). G. Stirewalt also concludes that Report 2091-PR-03, Revision 1, satisfied statements presented in the FSAR (Sections 2.5.1.2.4, 2.5.1.2.5, and 2.5.3.1.1) indicating that detailed geologic mapping of the excavations for safety-related structures would be performed to document the presence or absence of minor shear zones such as those reported in bedrock of the Unit 1 excavation.

Geologic mapping of safety-related excavations at the VCSNS Unit 3 site was performed by the VCSNS licensee to address a geologic mapping License Condition for that unit. Just as done for Unit 2 for Revision 0 and Revision 1 of Report 2091-PR-03, conclusions formulated by NRC geologists based on review and evaluation of geologic mapping results from excavations for safety-related structures at VCSNS Unit 3 will likewise be presented in a detailed techncial report prepared by G. Stirewalt to document conclusions made from his review and evaluation.

G. Stirewalt
May 2013