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2.5.3 Surface Faulting

NRC Regulatory Guide 1.165, *Identification and Characterization of Seismic Sources and Determination of Safe Shutdown Earthquake Ground* Motion (RG 1.165), defines a capable tectonic source as a tectonic structure that can generate both vibratory ground motion and tectonic surface deformation, such as faulting or folding at or near the earth's surface in the present seismotectonic regime. This section evaluates the potential for tectonic surface deformation and non-tectonic surface deformation at the site. Information contained in Section 2.5.3 was developed in accordance with RG 1.165 and is intended to satisfy 10 CFR 100.23, *Geologic and Seismic Siting Criteria*.

There are no capable tectonic sources within the 5-mi VEGP site area radius, and there is a negligible potential for tectonic fault rupture. There is only limited potential for non-tectonic surface deformation in shallow deposits within the 5-mi site area radius, and this potential can be mitigated by means of excavation. The following sections provide the data, observations, and references to support these conclusions.

2.5.3.1 Geological, Seismological, and Geophysical Investigations

The following investigations were performed to assess the potential for tectonic and non-tectonic deformation at and within a 5-mi radius of the VEGP site:

- Compilation and review of existing data and literature
- Interpretation of aerial photography
- Field reconnaissance
- Aerial reconnaissance
- Review of historical and recorded seismicity
- Collection and interpretation of seismic reflection data at the VEGP site
- Discussions with current researchers in the area
- Collection and interpretation of survey data collected from a Quaternary fluvial terrace located at the SRS overlying the surface projection of the Pen Branch fault.

An extensive body of information is available for the VEGP site. This information is contained in five main sources:

- Work performed for the existing VEGP Units 1 and 2.
- Published geologic mapping performed by the US Geological Survey (USGS), the South Carolina Department of Natural Resources, and other researchers.
- Numerous, detailed investigations of the nearby Savannah River Site (SRS), perhaps the most extensively studied portion of the US Atlantic Coastal Plain.

- Seismicity data compiled and analyzed in published journal articles, EPRI (1986a), and the updated EPRI catalog, performed as part of this study.
- Seismic reflection data collected near the site within the Savannah River channel **(Henry 1995)**.

This existing information was supplemented by aerial and field reconnaissance performed within and beyond the 25-mi site vicinity radius, and by interpretation of aerial photography within the 5-mi site area radius. Given the extensive geologic and geomorphic studies performed previously at the SRS, the interpretation of aerial photography performed for the ESP study focused on the area southeast of the SRS. These studies were performed to document, where possible, the presence or absence of geomorphic features indicative of potential Quaternary fault activity within the Coastal Plain sediments or underlying bedrock.

2.5.3.1.1 Previous VEGP Site Investigations

This section summarizes previous site investigations performed for existing VEGP Units 1 and 2. Previous investigations for VEGP Units 1 and 2 did not identify the existence of tectonic faulting **(Bechtel 1974a, 1974b, 1978e, 1981, 1989)**. Detailed geologic mapping and inspection of excavations during VEGP construction revealed no evidence of geologically recent or active faulting. However, minor, non-tectonic dissolution-induced collapse features (including minor folds and small joints and faults confined to the near-surface) were recognized and logged in detail on site **(Bechtel 1984b)**.

Bechtel (1974a) identified, discussed in Section 2.5.1.2.3, a northwest-dipping monoclinal flexure beneath the site in the Blue Bluff Marl. This feature, referred to as a dip reversal because the strata locally dip gently northwest against the regional southeast dip of the Coastal Plain sediments, was interpreted as a syndepositional, sedimentary feature **(Bechtel 1974b)**. Later investigations by Bechtel (1978, 1981) describe “stratigraphic irregularities” recognized in site excavations associated with the Blue Bluff Marl. Because these stratigraphic irregularities were observed to be underlain by flat-lying, laterally continuous strata, Bechtel (1978, 1981) concluded that these irregularities were produced by syn-depositional processes.

Alterman (1984) reported observing a number of “clastic dikes” at the VEGP site and in the site vicinity during an NRC visit. Alterman’s report does not, however, interpret the origin of these features. Bechtel (1984) identified the presence of a variety of small-scale deformation structures in the walls of a garbage trench on the VEGP site within Tertiary Coastal Plain sediments. These structural features, including warped bedding, fractures, joints, minor offsets, and injected sand dikes, were interpreted as local phenomena related to dissolution of the underlying Utley Limestone and resultant plastic and brittle collapse of overlying Tertiary sediments. These features and their potential for non-tectonic surface deformation at the site are further discussed in Section 2.5.3.8.2.1 below. Bechtel (1984) also noted the presence of “clastic dikes" in the garbage trench and interpreted these features to be the result of near-surface pedogenic processes.

As described in Section 2.5.1.2.4.1, the Pen Branch fault was first discovered at the SRS in 1989, which initiated investigations at the VEGP site and a series of studies at the SRS. Investigations at the VEGP site concluded that the fault was not onsite or in close proximity to Units 1 and 2 **(Bechtel 1989)**. Studies of the Pen Branch fault at the SRS continued through the 1990s, but had still not definitively located the southwestward projection of the fault to the Georgia side of the Savannah River. As shown in Figures 2.5.1-21, 2.5.1-22, 2.5.1-23 and 2.5.1-34, projections of the fault into Georgia included locations northwest of the VEGP site **(Snipes et al. 1993a)** and directly southeast of the VEGP site **(Cumbest et al. 2000)**.

In light of the data gathered from studies of the Pen Branch fault at the SRS during the 1990s and recent investigations at the VEGP site, some conclusions of the previous studies regarding the location of the Pen Branch fault in site studies and the FSAR should be revised. Because the Pen Branch fault has been located adjacent to the VEGP site and beneath the monocline in the Blue Bluff Marl, it is now clear that the Pen Branch fault is associated with the monocline (or dip reversal) and that there is a Tertiary fault within 5 mi of the VEGP site. However, the new information only alters the past location of the Pen Branch fault. After considerable study, no new information gathered on the Pen Branch fault has changed the original conclusions of Snipes et al. (1989) that the youngest strata deformed by the fault are late Eocene and that the fault is not a capable tectonic source. In fact, recent studies, for this ESP study, have provided additional lines of evidence to support the non-capable status of the Pen Branch fault, a conclusion that has been supported in multiple NRC and DOE reviews (NUREG-1137, NUREG-1137-8, NUREG-1821).

2.5.3.1.2 Published Geologic Mapping

Geologic mapping of the site vicinity (25-mi radius) and site area (5-mi radius) in the past two decades has been largely focused on the SRS and surrounding regions of South Carolina (Figure 2.5.1-28). The USGS has published 1:100,000 scale and 1:48,000 scale geologic maps of the SRS area **(Prowell 1994a, 1996)**. In addition, the South Carolina Department of Natural Resources has published numerous 1:24,000 scale geologic maps within the site vicinity. Significantly fewer and less detailed geologic maps have been published for the Georgia portion of the VEGP site vicinity (Figure 2.5.1-28).

Additional studies focused on mapping and assessing specific geologic and/or tectonic features in the site vicinity. These include mapping and interpreting small-scale deformation structures **(McDowell and Houser 1983; Bartholomew et al. 2002)** and possible Quaternary tectonic features **(Crone and Wheeler 2000; Wheeler 2005)**.

McDowell and Houser (1983) mapped the distribution of small-scale deformation structures in the Upper Coastal Plain in the greater Columbia, South Carolina, to Augusta, Georgia, area.

They identified small-scale folds, brittle faults, and convoluted bedding features exposed in roadcuts, excavations, and stream cuts. McDowell and Houser noted that some of these features appear to be non-tectonic in origin, whereas others are less clear and may be related to strong ground shaking.

Bartholomew et al. (2002) described exposures of "clastic dikes" in the VEGP site vicinity. One of these exposures is located in the upper Eocene Tobacco Road sand near Hancock landing (north of existing VEGP Units 1 and 2 within the VEGP site area). They interpret these clastic dikes as evidence for "strong paleoearthquakes, probably associated with late Eocene to late Miocene oblique-slip".

In addition, the USGS has published a compilation of all known Quaternary faults, liquefaction features, and possible tectonic features in the central and eastern United States **(Crone and Wheeler 2000)**, updated in **(Wheeler 2005)** (Figure 2.5.1-17). The only feature within the 5-mi VEGP site area radius identified by this compilation is the Pen Branch fault (discussed in detail in Section 2.5.1.2.4.1). Crone and Wheeler (2000) classified the Pen Branch fault as a Class C feature (Table 2.5.1-1) because of its demonstrated early Cenozoic activity but absence of evidence for post-Eocene slip.

2.5.3.1.3 Previous Savannah River Site Investigations

SRS studies include numerous geological, geophysical, seismologic, and hydrologic investigations. These studies identified a number of basement faults that are mapped at the SRS based on interpretation of seismic reflection data, borehole data, gravity and magnetic data, and/or groundwater anomalies. Several of these faults are located within the 5-mi radius of the VEGP site (Figures 2.5.1-21, 2.5.1-22, and 2.5.1-23).

The SRS is one of the most extensively studied portions of the Coastal Plain in terms of geology. Accordingly, an exhaustive description of all SRS geologic studies is not given here. Instead, the key studies that locate and characterize tectonic features of the SRS are summarized in this section. These studies include Chapman and DiStefano (1989), Snipes et al. (1993), Stieve et al. (1991), Stephenson and Stieve (1992), Geomatrix (1993), Domoracki (1994), Stieve and Stephenson (1995), and Cumbest et al. (1998, 2000). As described in Section 2.5.1.1.4.5, the majority of evidence for the presence of faults at the SRS is based on the interpretation of seismic reflection surveys; therefore, the depiction of buried fault locations differs between researchers and has also evolved through time with the successive availability of additional data.

Chapman and DiStefano (1989) conducted a vibroseis seismic reflection survey to refine existing knowledge of the basement structure beneath the SRS. This survey identifies first-order features of the basement surface, including the northern boundary fault of the Mesozoic Dunbarton Basin, later named the Pen Branch fault.

Based on core logs and supplemented by seismic reflection data from Chapman and DiStefano (1989), Snipes et al. (1993) mapped the location of the Pen Branch fault across the SRS. Snipes et al. (1993) recognized up-to-the-southeast movement for the Pen Branch fault and suggested that the fault formed originally as a Mesozoic normal fault bordering the northwestern Dunbarton Basin that was later reactivated in the Tertiary as a reverse fault.

Stieve et al. (1991) presented the results of a drilling program designed to further characterize the displacement history of the Pen Branch fault on the SRS. This study concludes that the base of the late Miocene Upland Formation is not deformed across the projected trace of the fault and thus provides direct stratigraphic evidence for the absence of activity on the Pen Branch fault within the past 5 Ma (million years ago).

Stephenson and Stieve (1992) and Stieve and Stephenson (1995) combined seismic data, borehole data, and potential field data to construct a subsurface structure model for the SRS. Their subsurface fault map identifies six basement-involved faults, including the Pen Branch, Steel Creek, ATTA, Ellenton, Crackerneck, and Upper Three Runs faults (Figure 2.5.1-21). These faults are described in Section 2.5.1.1.4.5 and Section 2.5.3.2.

Geomatrix (1993) performed a Quaternary and neotectonic study to assess geologic and geomorphic evidence for active tectonic deformation at the SRS. No evidence for active tectonic deformation was observed. Longitudinal profiles on Savannah River fluvial terraces show no evidence for warping or faulting of terrace surfaces associated with the surface projections of the Pen Branch and Steel Creek faults within a resolution of 7 to 10 ft (2 to 3 m).

Domoracki (1994) used 170 mi of reprocessed seismic reflection lines to map the geometry of the Dunbarton Basin and to refine the subsurface locations of SRS basement-involved faults. The report identified the Dunbarton Basin as a half-graben bounded solely by the Pen Branch fault and suggested that the Pen Branch fault possibly soles into the Augusta fault at depth (see Section 2.5.1.1.4.3 for discussion of the Augusta fault).

Cumbest et al. (1998, 2000) integrated data from more than 60 boreholes and more than 100 mi of seismic reflection profiles to provide the most-recent mapping of subsurface structure and basement-involved faults at the SRS. Cumbest et al. (1998) found no evidence for capability on any faults at the SRS. These data were used in combination with geometrical fault models to constrain slip histories for the Pen Branch and Crackerneck faults **(Cumbest et al. 2000)**.

Cumbest et al. (2000) also compared the SRS faults with other Atlantic Coastal Plain faults and concluded that both sets of faults exhibit the same general characteristics and are closely associated. These characteristics include:

- Maximum offset less than 80 m (260 ft) at the base of the Coastal Plain sediments
- Regional-scale features that strike approximately northeast-southwest
- Predominantly reverse sense of slip
- Movement beginning in the Cretaceous Period and decreasing with time

Based on the strength of this association, and based on the fact that many of the other Coastal Plain faults are known to be non-capable, Cumbest et al. (2000) concluded by association that the SRS faults are also non-capable.

In situ stress measurements in basement rocks have been made in deep boreholes at the SRS. As part of a study of seismic hazards, magnitudes and orientations of in situ stresses were determined in five boreholes in 1998 and a 4,000-ft-deep borehole in 1992 **(Moos and Zoback 2001)**. Results from the 4,000-ft-deep well (NPR hole) and previous borehole measurements at the SRS are consistent with a northeast-southwest direction of maximum compressive stress in the Altantic Coastal Plain province **(Moos and Zoback 2001)**. While the orientation of maximum horizontal stress was observed to range from N75ºE to N33ºE in the NPR hole, the majority of other orientations are closer to approximately N60ºE. Thus, the maximum horizontal stress is oriented roughly parallel to the Pen Branch fault (about N55ºE), indicating that it is unlikely to accommodate reverse or strike-slip faulting earthquakes in the present stress regime **(Moos and Zoback 2001)**.

2.5.3.1.4 Previous Seismicity Data

The EPRI catalog of historical seismicity has demonstrated that no known earthquake greater than body wave magnitude (m_b) 3 has occurred within the VEGP site vicinity (25-mi radius) prior to 1984 (Figure 2.5.1-16). Considering micro-seismicity (m_b<3) recorded since 1976 by the SRS seismic recording network, there has been no recent earthquake activity within the site area (5-mi radius) (Figure 2.5.1-16). The nearest micro-earthquake to the VEGP site is about 7 mi (about 11 km) to the northeast and located on the SRS **(Stevenson and Talwani 2004)**.

The local SRS seismic network recorded three small earthquakes in 1985 (magnitude 2.6), 1988 (magnitude 2.0), and 1997 (magnitude 2.5), and a small earthquake sequence in 2001–2002 within the boundaries of the SRS **(Stevenson and Talwani 2004)**. These small SRS earthquakes, as well as a 1993 event located north of the SRS in Aiken, South Carolina, have been studied by researchers in an effort to evaluate possible correlations to tectonic features. As described in Section 2.5.3.3, this minor activity is not correlated with any known faults.

2.5.3.1.5 Previous Seismic Reflection Data

In addition to the numerous seismic reflection surveys conducted at the SRS, several other seismic reflection studies have been performed in the VEGP site area. These include two surveys conducted within the Savannah River **(Bechtel 1982; Henry 1995)** and one conducted in a land-based survey located about 1.5 mi west of VEGP Units 1 and 2 **(Summerour et al. 1998)**.

As part of its investigation of the postulated Millett fault, Bechtel (1982) collected seismic reflection data along the Savannah River. Nelson (1989) reprocessed and re-interpreted these data from Utley Point southeastward to about 1 mi northwest of Griffins Landing to evaluate whether the Pen Branch fault extends southwest across the Savannah River beneath the VEGP site (Figure 2.5.1-34). Nelson (1989) concluded that there is no evidence of faulting and concluded that if the Pen Branch fault does occur in the SRS area in South Carolina, its upward termination is below the limit of survey penetration at approximately 750 ft (beneath at least the upper part of the Late Cretaceous Tuscalloosa Formation).

As part of a groundwater contamination study in Burke County, Georgia, Henry (1995) collected and interpreted seismic reflection data from two lines located in the Savannah River between Hancock Landing and the VEGP boat ramp (Figure 2.5.1-34). Henry (1995) concluded that the Pen Branch fault appears as a high-angle, southeast-side-up reverse fault located approximately 1,000 ft downstream from Hancock Landing (Figure 2.5.1-34). Henry (1995) interpreted the Pen Branch fault as a growth fault extending upward through the Paleocene Black Mingo Formation and into Eocene strata that lie below the unconformity at the base of Savannah River alluvium.

A land-based seismic reflection survey was performed along an unimproved road about 0.5 mi west of River Road (about 1.5 mi west of VEGP Units 1 and 2) and included in a report by Summerour et al.(1998) (Figure 2.5.1-34). Similar to Henry (1995), this research was also part of a groundwater contamination study in Burke County, Georgia. The seismic line was roughly situated across the westward projection of the Pen Branch fault within the site area and southwest of the VEGP site. Numerous, minor faults belonging to the Pen Branch fault were interpreted to cut reflectors within the Coastal Plain section. The basement reflector, however, is not clearly faulted and, therefore, these data suggesting the location of the Pen Branch fault are questionable.

2.5.3.1.6 Current Seismic Reflection Studies

Seismic reflection and refraction data were collected on the VEGP site in January and February 2006 as part of this ESP study. The seismic array was designed to: (1) image the Pen Branch fault, with the assumption that it continues on strike to the southwest from the SRS into the VEGP site area, and (2) assess the depth and character of the basement rocks beneath the Coastal Plain deposits. The survey included four seismic reflection and three seismic refraction lines (Figures 2.5.1-35 and 2.5.1-36, respectively). The results of this seismic reflection profiling clearly document that the Pen Branch fault is imaged in the basement beneath the VEGP site (see discussion in Section 2.5.1.2.4.2, and Figures 2.5.1-34 and 2.5.1-37). These data indicate that the Pen Branch fault strikes between N34ºE and N45ºE across the VEGP site, and dips 45º to the southeast.

2.5.3.1.7 Current Aerial and Field Reconnaissance

Field and aerial reconnaissance inspections reveal no evidence for surface rupture, surface warping, or the offset of geomorphic features indicative of active faulting. Likewise, interpretation of aerial and satellite photography and topographic maps reveals no evidence of geomorphic features indicative of potential for tectonic surface deformation (faulting or warping).

As part of the field reconnaissance performed for the ESP study, many of the features previously mapped within the site vicinity (25-mi radius) as evidence for possible tectonic activity have been observed [including those mapped by **(McDowell and Houser 1983)** and **(Bartholomew et al. 2002)**]. Based on field observations and similar characteristics to features studied in a large excavation at the VEGP site **(Bechtel 1984b)**, these features are assessed to be of non-tectonic origin. Even if the Bartholomew et al. (2002) "clastic dikes" are of tectonic origin, they interpret these features to be evidence for earthquakes that occurred during or prior to the late Miocene. "Clastic dikes" are discussed in detail in Section 2.5.3.8.2.2.

2.5.3.2 Geological Evidence, or Absence of Evidence, for Surface Deformation

As shown in Figure 2.5.1-21, four bedrock faults are mapped within 5 mi of the VEGP site **(Cumbest et al. 1998, 2000; Stieve and Stephenson 1995)**. These four faults are:

- Pen Branch fault
- Ellenton fault
- Steel Creek fault
- Upper Three Runs fault

These faults were first identified on the SRS based on the interpretation of seismic reflection, borehole, gravity and magnetic, and/or groundwater data **(Chapman and DiStefano 1989; Stieve et al. 1991; Stephenson and Stieve 1992; Snipes et al. 1993a; Domoracki 1994; Stieve and Stephenson 1995; and Cumbest et al. 1992, 1998, 2000)**. Each of these faults appears to terminate upward beneath the near surface. The youngest deposits deformed are Eocene in age. No deformation or geomorphic features indicative of potential Quaternary activity have been reported in the literature for these faults. Aerial and field reconnaissance and air photo interpretation performed for the current ESP study show that no geomorphic features indicative of Quaternary activity exist along any of the mapped fault traces. These four faults are summarized in Table 2.5.3-1 and described below.

2.5.3.2.1 Pen Branch Fault

The more than 20-mi-long (more than 30-km-long) Pen Branch fault is the northwest bounding fault of the Mesozoic Dunbarton Basin, strikes northeast, traverses the central portion of the SRS, and trends southwestward into Georgia near the VEGP site **(Snipes et al. 1989, 1993a)**. Seismic reflection profiling performed as part of this ESP study has imaged the southeast-dipping Pen Branch fault beneath the VEGP site (see discussion in Section 2.5.1.2.4.2, Figure 2.5.1-40). The Pen Branch fault was reactivated in the Tertiary as an up-to-the-southeast reverse fault

(Snipes et al. 1993a), and possibly soles into the Augusta fault (described in Section 2.5.1.1.4.3) at depth **(Domoracki 1994; Stieve and Stephenson 1995)**.

The Pen Branch fault is not exposed or expressed at the surface **(Snipes et al. 1993a; Stieve and Stephenson 1995; Cumbest et al. 2000)**. Borehole and seismic reflection data collected from the SRS show no evidence for post-Eocene slip on the Pen Branch fault **(Cumbest et al. 2000)**. SRS studies have been specifically designed to assess the youngest deformed strata overlying the fault through shallow, high-resolution reflection profiles, drilling of boreholes, and geomorphic analyses and have consistently concluded that late Eocene is the youngest strata deformed as described in Section 2.5.1.2.4.1.

The Pen Branch fault is not expressed geomorphically, nor is microseismicity associated with this fault. Therefore, it is concluded that the Pen Branch fault is not a capable fault within the site area. Within a resolution of 7 to 10 ft (2 to 3 m), longitudinal profiles along Quaternary fluvial terraces overlying the surface projection of the Pen Branch fault show no evidence of warping or faulting of the 350 ka to 1 Ma Ellenton (Qte) fluvial terrace **(Geomatrix 1993)**.

Additional work performed for the ESP study has more accurately located the Pen Branch fault beneath a remnant of this terrace (Figure 2.5.1-43). The geomorphic evaluation of the Quaternary Ellenton terrace (Qte) surface overlying the Pen Branch fault is described in Section 2.5.1.2.4.3. The results of this study demonstrate a lack of tectonic deformation in the 350 ka to 1 Ma fluvial terrace surface within a resolution of about 3 ft. This observation is consistent with previous studies at both the VEGP site and the SRS that have concluded the Pen Branch fault is not a capable tectonic source.

2.5.3.2.2 Ellenton Fault

The Ellenton fault had been located in the southeastern portion of the SRS, about 4.6 mi from the VEGP site (Figure 2.5.1-21), but the Ellenton fault does not appear on the most recent SRS fault maps **(Cumbest et al. 1998, 2000)**. The approximately 4-mi-long Ellenton fault had been interpreted to strike north-northwest, with near vertical to steeply east dip and east-side-down sense of slip **(Domoracki 1994; Stieve and Stephenson 1995)**. No clear relationship exists between the previously located Ellenton fault and regional structural features.

Because the data originally used to identify this fault are of poor quality according to Stieve and Stephenson (1995), the fault is not expressed geomorphically, and microseismicity is not associated with this fault; the current assessment is that this fault likely does not exist. Therefore, it is concluded that the Ellenton fault is not a capable tectonic source within the site area. Neither the Crone and Wheeler (2000) compilation of Quaternary faults and tectonic features in the central and eastern United States, nor the Wheeler (2005) compilation update, identifies the Ellenton fault as a potential Quaternary feature.

2.5.3.2.3 Steel Creek Fault

The Steel Creek fault is located in the northwest portion of the SRS, about 3 mi from the VEGP site **(Stieve and Stephenson 1995; Cumbest et al. 2000)** (Figures 2.5.1-21 and 2.5.1-23). This greater than 11-mi-long, northeast-trending, northwest-dipping, up-to-the-northwest reverse fault is located within the Dunbarton Basin and, along with the Pen Branch fault, forms a horst structure within the basin **(Stieve and Stephenson 1995)**. The Steel Creek fault extends upward into Cretaceous units, but the uppermost extent of faulting remains unresolved **(Stieve and Stephenson 1995)**.

Within a resolution of 7 to 10 ft (2 to 3 m), longitudinal profiles along Quaternary fluvial terraces overlying the surface projection of the Steel Creek fault show no evidence of warping or faulting of the fluvial terraces **(Geomatrix 1993)**. The Steel Creek fault is not expressed geomorphically, nor is microseismicity associated with this fault. Therefore, it is concluded that this fault is not a capable tectonic source within the site area. Neither the Crone and Wheeler (2000) compilation of Quaternary faults and tectonic features in the central and eastern United States, nor the Wheeler (2005) compilation update, identifies the Steel Creek fault as a potential Quaternary feature.

2.5.3.2.4 Upper Three Runs Fault

The Upper Three Runs fault is located in the northwest portion of the SRS, about 5 mi from the VEGP site **(Stieve and Stephenson 1995)** (Figure 2.5.1-21). The location of the Upper Three Runs fault is mapped based on potential field data and interpretation of seismic reflection profiles **(Stieve and Stephenson 1995)**. The Upper Three Runs fault has been interpreted as an older (initially Paleozoic) fault that soles into the Augusta fault at depth, possibly reactivated as a Mesozoic normal fault **(Cumbest and Price 1989b; Domoracki 1994; Stieve and Stephenson 1995)**. The Augusta fault is discussed in Section 2.5.1.1.4.3.

The greater than 20-mi-long, northeast-trending Upper Three Runs fault is restricted to basement rocks. Seismic reflection profiling shows that the Coastal Plain sediments are not offset or deformed by this fault **(Chapman and DiStefano 1989; Stieve and Stephenson 1995)**. The Upper Three Runs fault is not expressed geomorphically, nor is microseismicity associated with this fault. Therefore, it is concluded that this fault is not a capable tectonic source within the site area. Neither the Crone and Wheeler (2000) compilation of Quaternary faults and tectonic features in the central and eastern United States, nor the Wheeler (2005) compilation update, identifies the Upper Three Runs fault as a potential Quaternary feature.

2.5.3.3 Correlation of Earthquakes With Capable Tectonic Sources

Seismicity within the VEGP site vicinity (25-mi radius) is shown in Figure 2.5.1-16. As shown on this figure, there is no spatial correlation of earthquake epicenters with known or postulated faults. No faults or geomorphic features within the site vicinity (25 mi radius) can be correlated with earthquakes. Based on review of existing literature, no reported historical earthquake epicenters have been associated with bedrock faults within a 25 mi radius of the VEGP site (Figure 2.5.1-16). None of these faults within 25 mi of the VEGP site are classified as capable tectonic sources.

In general, the South Carolina and Georgia portions of the Coastal Plain and Piedmont provinces exhibit a higher rate of seismicity than elsewhere in these provinces (Figure 2.5.1-18). This diffuse earthquake activity is not concentrated or aligned with any mapped faults, nor is it associated with any known tectonic structures. Figure 2.5.1-16 shows that no earthquakes of magnitude 3.0 or larger are known to have occurred within 25 mi of the site. However, several small events (m_b<3.0) have occurred within the site vicinity.

The SRS seismic recording network, which consists of nine instruments located within and adjacent to the SRS, has been recording microseismicity in the VEGP site vicinity since it was installed in 1976. This local network recorded three small earthquakes (in 1985 [magnitude 2.6], 1988 [magnitude 2.0], and 1997 [magnitude 2.5]) and a small earthquake sequence in 2001–2002 within the boundaries of the SRS **(Stevenson and Talwani 2004)**. These small SRS earthquakes, and also a 1993 event located north of the SRS in Aiken, have been studied in an effort to evaluate possible correlations with tectonic features (Figure 2.5.1-16).

The June 9, 1985, earthquake of local duration magnitude (M_D) 2.6 was located about 5 mi north of the northwest margin of the Dunbarton Basin (Figure 2.5.1-16). The depth of this event was initially determined to be approximately 0.6 mi (1 km) **(Talwani et al. 1985)**, and was later listed at a depth of 3.5 mi (5.8 km) **(Stevenson and Talwani 2004)**. This earthquake had a focal plane solution that suggests either a sinistral component of slip on a northeast-striking plane or a dextral component of slip on a northwest-striking plane **(Talwani et al. 1985)**. The close location of the event to the northwest margin of the Dunbarton Basin and northeast strike of the sinistral nodal plane led Talwani et al. (1985) to associate this event with the northeast-striking basin border fault (later named the Pen Branch fault). However, Crone and Wheeler (2000) point out that the sinistral sense of slip from the fault plane solution is inconsistent for the Pen Branch fault given the northeast-southwest orientation of principal horizontal stress. Therefore, it is highly unlikely that this event is associated with the Pen Branch fault.

The August 5, 1988, earthquake of magnitude 2.0 was centered southeast of the Pen Branch fault within the Dunbarton Basin (Figure 2.5.1-16). The hypocenter of this event was located at a depth of about 1.5 mi (2.5 km) **(Stevenson and Talwani 2004)** and no focal mechanism solution could be obtained **(Domoracki et al. 1999)**. Domoracki et al. (1999) suggested that this earthquake was associated with the Pen Branch fault. However, Stevenson and Talwani's (2004) more recent hypocenter location for this event suggests no spatial association with a known fault.

The August 8, 1993, Aiken, South Carolina, earthquake with a body wave magnitude estimated from Rayleigh surface waves (m_{blg}) of 3.2 was studied in detail by Stevenson and Talwani (1996), who determined that the event was located within a steep gravity gradient that they interpret to be the edge of a granitic pluton (Figure 2.5.1-16*)*. The hypocenter of this event was located at a depth of about 6 mi (about 10 km) **(Stevenson and Talwani 2004)**. The event is not spatially associated with a known fault.

The May 17, 1997, earthquake of magnitude 2.5 was located about 0.5 to 1 mi northwest of the Pen Branch fault (Figure 2.5.1-16). Given that this event had a depth of about 3 mi (5 km) **(Stevenson and Talwani 2004)**, it is located in excess of 3 mi from the southeast-dipping Pen Branch fault.

The most recent activity, termed the Upper Three Runs earthquake sequence, included an October 8, 2001, main event of m_{blg} 2.6 centered near Upper Three Runs Creek and a series of seven very small aftershocks occurring through March 6, 2002, in a small area of 6.0 to 6.5 square km **(Stevenson and Talwani 2004)** (Figure 2.5.1-16). All events within this earthquake sequence occurred within depths of approximately 1.8 to 3 mi (3 to 5 km), with a positional uncertainty of about 1600 ft (about 500 m) due to the proximity of the local SRS seismic stations. Single event and composite focal mechanisms indicate a predominantly reverse motion on a fault plane oriented N25ºW, 41ºSW. A 3-D plot of hypocenters defined a fault plane of similar orientation **(Stevenson and Talwani 2004)**.

Stevenson and Talwani (2004) examined gravity data and found a northeast-trending grain to the Bouguer gravity map. Upon further processing to derive a map of the first horizontal derivative of gravity, they defined a small local northwest-trending ridge of gravity that they interpreted as the causative structure. The shallowness and small areal extent of the Upper Three Runs earthquake sequence, combined with the apparent association of a very small basement feature running counter to the regional structural trend, suggest that this earthquake activity is extremely localized and is not attributable to any regional features **(Stevenson and Talwani 2004**).

2.5.3.4 Ages of Most Recent Deformations

As presented in Section 2.5.3.2, none of the four faults within 5 mi of the VEGP site exhibit evidence of Quaternary activity. The Pen Branch fault represents the northern bounding normal fault of the Mesozoic Dunbarton Basin, and this structure was reactivated as a Tertiary oblique-reverse fault. Borehole and seismic data provide no evidence for post-Eocene slip on the Pen Branch fault **(Cumbest et al. 2000)**. Geomatrix (1993) concluded that the Pen Branch fault does not deform Quaternary fluvial terraces of the Savannah River within a resolution of 7 to 10 ft (2 to 3 m). The geomorphic evaluation of this same 350 ka to 1 Ma fluvial terrace surface performed as part of this ESP study demonstrates a lack of tectonic deformation within a resolution of about 3 ft (about 1 m) (described in Section 2.5.1.2.4.3).

The Ellenton fault was previously interpreted as a north-northeast-striking fault **(Stieve and Stephenson 1995)**, but it does not appear in the most recent maps of subsurface SRS faults **(Cumbest et al. 1998, 2000)** and likely does not exist.

The Steel Creek fault extends upward into Cretaceous units, but the uppermost extent of faulting remains unresolved **(Stieve and Stephenson 1995)**. Geomatrix (1993) concluded that the Steel Creek fault does not deform Quaternary fluvial terraces of the Savannah River within a resolution of 7 to 10 ft (2 to 3 m).

The Upper Three Runs fault is restricted to basement rocks. Seismic reflection profiling revealed no evidence for this fault deforming overlying Coastal Plain sediments **(Chapman and DiStefano 1989; Stieve and Stephenson 1995)**.

2.5.3.5 Relationships of Tectonic Structures in the Site Area to Regional Tectonic Structures

The four faults identified within the site area (i.e., the Pen Branch, Ellenton, Steel Creek, and Upper Three Runs faults) are located on the SRS. Only one of these faults (the Pen Branch) is observed west of the Savannah River in Georgia. As described in Section 2.5.3.6, none of the four faults within the site area is considered a capable tectonic feature.

2.5.3.5.1 Pen Branch Fault

The Pen Branch fault likely is the northern boundary fault of the Mesozoic Dunbarton Basin. During the Mesozoic, the fault accommodated crustal extension and thinning with a southeast-side-down normal sense of slip **(Snipes et al. 1993a; Domoracki 1994; Stieve and Stephenson 1995)**. Snipes et al. (1993) suggested that the southeastern margin of the Dunbarton Basin may also be bounded by a fault (the Martin fault), although Domoracki et al. (1999) suggested that the Dunbarton Basin is instead a half-graben bounded only by the Pen Branch fault to the north.

The Pen Branch fault was reactivated as a reverse or reverse-oblique fault during Cretaceous and into Tertiary time, with an up-to-the-southeast sense of slip **(Stephenson and Chapman 1988; Snipes et al. 1993a; Cumbest et al. 2000)**. Stephenson and Stieve (1992) and Stieve and Stephenson (1995) suggested that the Pen Branch fault may sole into the shallow dipping Augusta fault (described in Section 2.5.1.1.4.3) or a Paleozoic/Mesozoic regional decollement at depth (Figure 2.5.1-2).

2.5.3.5.2 Ellenton Fault

The Ellenton fault as mapped by Stieve and Stephenson (1995) is a north-northwest striking fault located within the Dunbarton Basin between the Upper Three Runs and Pen Branch faults. The Ellenton fault orientation is roughly normal to the regional structural grain and to the other SRS faults and bears no clear relationship to regional structures. The Ellenton fault does not appear on the most recent SRS fault maps **(Cumbest et al. 1998, 2000)** and likely does not exist.

2.5.3.5.3 Steel Creek Fault

This northeast-trending Steel Creek fault is roughly parallel to the regional structural grain and is located within the Dunbarton Basin. The Steel Creek fault is an up-to-the-northwest, secondary structure associated with the Pen Branch fault, with which it forms a horst structure within the basin **(Stieve and Stephenson 1995)**.

2.5.3.5.4 Upper Three Runs Fault

The northeast-trending Upper Three Runs fault is roughly parallel to the regional structural grain and is restricted to basement rocks; seismic reflection profiles show that the fault does not offset Coastal Plain sediments **(Chapman and DiStefano 1989; Stieve and Stephenson 1995)**. The Upper Three Runs fault has been interpreted as an older (initially Paleozoic) fault, possibly reactivated as a Mesozoic normal fault **(Cumbest and Price 1989b; Domoracki, 1994; Stieve and Stephenson 1995)**. The Upper Three Runs fault possibly soles into the Augusta fault (described in Section 2.5.1.1.4.3) or a Paleozoic/Mesozoic regional decollement at depth **(Stieve and Stephenson 1995)** (Figure 2.5.1-2).

2.5.3.6 Characterization of Capable Tectonic Sources

Based on studies evaluated in the preceding sections, SNC concluded that there are no capable tectonic sources within 5 mi of the VEGP site. The Pen Branch fault, the nearest fault to the VEGP site, has undergone extensive study and multiple reviews by the NRC. All of these studies, including investigations as part of this ESP study, support the non-capable status of the Pen Branch fault as outlined below:

- NUREG-1137-8 concludes that the Pen Branch fault is not a capable fault and does not represent a hazard to the VEGP site. Similarly, other NRC reviews of the Pen Branch fault for facilities such as the Mixed Oxide Fuel (MOX) Fabrication Facility at SRS have also concluded that the Pen Branch fault is not a capable fault (NURERG-1821).
- The “association clause” of Appendix A 10 CFR 100.23 applies to this discussion as follows: Cumbest et al. (2000) noted that the Pen Branch fault shares characteristics with other Atlantic Coastal Plain faults that are considered non-capable. These characteristics include northeast-southwest strikes, small total offsets of Cenozoic strata in relation to fault age, slip histories that began in the Cretaceous, and offsets that decrease with decreasing age. Cumbest et al. (2000) argued that the abundance of shared characteristics between these faults implies that these faults are genetically related. Several of these faults have been shown to be non-capable. Therefore, Cumbest et al. (2000) concluded that the Pen Branch fault is likely non-capable as well.
- The Pen Branch fault is not exposed or expressed at the surface **(Snipes et al. 1993a; Stieve and Stephenson 1995; Cumbest et al. 2000)**. Reconnaissance work and aerial photograph

interpretation performed for the ESP study confirm that there is no exposure of the fault or geomorphic expression of potential Quaternary activity.

- Snipes et al. (1993) investigated a 10- to 20-ft-thick (3- to 6-m-thick) Quaternary light tan soil horizon in railroad cuts overlying the projected trend of the Pen Branch fault at the SRS. They observed no detectable offset of this unit. According to Snipes et al. (1993), the youngest horizon known from borehole studies to be faulted is the top of the Dry Branch Formation of Late Eocene age.
- Regional principal stress orientations based on stress-induced wellbore breakouts and hydraulically induced fracturing show that the maximum horizontal stress is parallel to the regional orientation of the Pen Branch fault, which makes “strike-slip faulting unlikely” and “reverse faulting essentially impossible” **(Moos and Zoback 2001)**. The most-recent deformation observed for this fault in Tertiary sediments is reverse faulting.
- Geomatrix (1993) evaluated longitudinal profiles along Quaternary fluvial terraces of the Savannah River and concluded that no evidence of terrace surface warping or faulting exists within a resolution of 7 to 10 ft (2 to 3 m). Additionally, as part of the ESP study, local longitudinal terrace profiles across the now well-located Pen Branch fault support the earlier conclusion that no deformation is observed in the terrace remnant of the Ellenton terrace (estimated as 350 ka to 1 Ma) overlying the Pen Branch fault.
- As part of this ESP study, geomorphic analysis of the 350 ka to 1 Ma fluvial terrace overlying the surface projection of the Pen Branch fault at the SRS demonstrates the lack of tectonic deformation of this Quaternary geomorphic surface within a resolution of about 3 ft. The resolution of this study compared with the previous studies makes it by far the most definitive evidence for the non-capability of the Pen Branch fault both at the Savannah River Site and the VEGP site. Results are described in more detail in Section 2.5.1.2.4.3.

2.5.3.7 Designation of Zones of Quaternary Deformation Requiring Detailed Fault Investigation

No zones of quaternary deformation require detailed investigation within the site area.

2.5.3.8 Potential for Tectonic or Non-Tectonic Deformation at the Site

The potential for tectonic deformation at the site is negligible. There is, however, the evidence for past, and the potential for future, non-tectonic deformation at the site in the form of dissolution-induced collapse features. These conclusions are discussed in the following sections.

2.5.3.8.1 Potential for Tectonic Deformation at the Site

The potential for tectonic deformation at the site is negligible. The presence of the Pen Branch fault adjacent to the VEGP Units 3 and 4 footprint and beneath the monocline in the Blue Bluff Marl (Figures 2.5.1-39 and 2.5.1-42) suggests that past deformation of the Eocene strata has occurred in the form of non-brittle folding. However, this type of deformation associated with the non-capable Pen Branch fault is no longer active and will not impact the ground surface in the future. Since the original site studies in the early 1970s, no new information has been reported to suggest the existence of any Quaternary surface faults or capable tectonic sources within the site area.

2.5.3.8.2 Potential for Non-Tectonic Deformation at the Site

Several non-tectonic features are present in the site area. These include dissolution-induced collapse structures and clastic dikes. As described below, permanent ground deformation at the site may be produced by dissolution within the Utley Limestone, whereas clastic dikes are not potential sources of permanent ground deformation. Dissolution-related permanent ground deformation would be mitigated at the site by the excavation and removal of the Utley Limestone during construction of the site.

Clastic dikes have been reported at the site and in the site vicinity **(Siple 1967; Alterman 1984; Bechtel 1984b; Bartholomew et al. 2002)**. The origin of these features has been subject to considerable debate, but those on-site features described as “clastic dikes” likely were formed by soil weathering processes, as described in Section 2.5.3.8.2.2. NUREG-1137 concludes that no evidence exists that these features represent a safety issue for the plant, whatever their origin.

2.5.3.8.2.1 Dissolution Collapse Features

The potential for non-tectonic deformation at the site resulting from near-surface dissolution-induced collapse has long been recognized as a possibility and has been the subject of several studies e.g., **(Bechtel 1981, 1984b)**. Bechtel (1984b) identified the presence of a variety of small-scale deformation structures in the walls of a garbage trench on the VEGP site within Tertiary Coastal Plain sediments (Figure 2.5.1-34). These structural features, including warped bedding, fractures, joints, minor offsets, and injected sand dikes, were interpreted as local phenomena related to dissolution of the underlying Utley Limestone and resultant plastic and brittle collapse of overlying Tertiary sediments **(Bechtel 1984b)** (Figures 2.5.3-1 and 2.5.3-2).

The dissolution origin for the warped bedding, fractures, small-scale faults, “clastic dikes,” and sand-injected dikes is interpreted largely from the observations and detailed documentation of these features in a large trench exposure that was over 900 ft long, 30 to 45 ft deep, and 25 to 40 ft across **(Bechtel 1984b)**. The high concentration of these features within the trench and the spatial and kinematic relationships between different types of deformation features provide some of the best information regarding their origin. Field mapping efforts performed as part of the VEGP ESP application also identified “clastic dikes” within the VEGP site and surrounding site area, and similarly concluded these features are of a non-tectonic origin based on field observations.

The three-dimensional nature of the warped bedding, combined with the spatial and kinematic relationships of the small-scale faults and fractures along the margins of the more strongly warped depressions, clearly demonstrates a dissolution or sediment collapse origin. The highly irregular, discontinuous nature of folding is consistent with a non-tectonic dissolution origin and inconsistent with a tectonic origin, since there are no laterally persistent fold axes. For example, the upper contact of Unit F, a 1-to-2-ft-thick, moderately consolidated, laminated, red and yellow, silty fine sand, is folded into a highly irregular surface **(Bechtel 1984b)** (Figure 2.5.3-3). If this minor fold deformation was associated with the underlying Pen Branch fault, fold axes should be laterally persistent and parallel to the fault. The discontinuous nature of domes and depressions in an “egg carton” or “dimpled” pattern reflects the more random, non-tectonic process of dissolution (Figure 2.5.3-3).

Most of the small-scale faults have normal displacement toward or into the depressions, and a few exhibit minor reverse slip near the crests of some arches **(Bechtel 1984b)**. These features are of limited dimensions and cannot be traced laterally across the width of the trench. The orientations of fractures and small faults are locally consistent with the limbs of the individual arches and depressions, but vary strongly from fold to fold. In some cases, such as shown in Figure 2.5.3-2, the small faults actually arc over the centers of some of the depressions. These field relationships all support an origin related to very localized settlement of the depressions resulting from dissolution and collapse of underlying strata.

The age of these dissolution features is poorly constrained; however, they are younger than the Eocene and Miocene host sediment and older than the overlying late Pleistocene or eolian sand of the Pinehurst Formation **(Bechtel 1984b)**. No late Pleistocene or Holocene dissolution features have been identified at the site.

Anecdotal accounts provide additional evidence for the potential for dissolution-induced collapse at the site. The presence of a cave located near Mathes Pond, currently under water, and accounts of “soft zones” encountered in boreholes above the Blue Bluff Marl suggest the possibility of dissolution at the VEGP site.

Dissolution-induced collapse structures are not tectonic features, nor do they indicate regionally significant seismicity **(Bechtel 1984b)**. NUREG-1137 concludes that no evidence exists that these features represent a safety issue for the plant. Dissolution collapse, however, represents a potential minor, non-tectonic surface deformation hazard in areas underlain by the Utley Limestone at the site. This hazard could be mitigated during construction through excavation and removal of the Utley Limestone to establish the foundation grade of the plant.

Not all depressions in the VEGP site area are the result of dissolution collapse. Carolina bays are non-tectonic, surficial geomorphic depressions that may resemble surface expression of dissolution collapse features. Carolina bays are commonly found throughout the VEGP site area and discussed in greater detail in Section 2.5.1.1.1. Unlike Carolina bays, surface depressions resulting from dissolution collapse are irregularly shaped and randomly oriented.

Pre-construction topographic maps of the VEGP site show several closed depressions at the site. Site reconnaissance performed for the ESP study shows that these depressions no longer exist and that they were likely destroyed by site excavations and activities. No present-day surface depressions were identified at the VEGP site as part of the ESP study.

2.5.3.8.2.2 Clastic Dikes

Clastic dikes are relatively planar, clay-filled features that typically flare out upward and are on the order of centimeters-to-decimeters wide and decimeters-to-meters long. Clastic dikes are widespread in the Coastal Plain of Georgia and South Carolina in the upper Miocene Barnwell and Hawthorne Formations. Despite the widespread occurrence of clastic dikes, however, their origin or origins are poorly understood. They have been variously attributed to seismic shaking or tectonic activity, to solution of underlying carbonate horizons and sediment collapse, and to weathering and soil-forming hypotheses [e.g., **(Siple 1967; Bechtel 1984b; Bartholomew et al. 2002)**].

Clastic dikes on the VEGP site, in the site area, and on the SRS were described in detail by Alterman (1984)**,** who noted feature dimensions, composition, grain size, and color, but did not propose a favored formation mechanism.

In describing clastic dikes exposed in the walls of a garbage trench more than 900 ft long located on the VEGP site, Bechtel (1984) differentiated two distinct classes of dikes: (1) “sand dikes” that resulted from plastic or liquid injection of loosely consolidated fine sand into overlying, fractured, relatively consolidated sediment, and (2) “clastic dikes” that resulted primarily from weathering and soil-forming processes preferentially enhanced along pre-existing fractures that formed during dissolution collapse. According to Bechtel (1984), the present geographic distribution of clastic dikes is controlled by the depth of weathering and paleosol development in the Coastal Plain sediments and by subsequent erosion of the land surface. Bechtel (1984) concluded that the dikes are primarily a weathering phenomenon that formed at least 10 ka to 100 ka. As part of the field reconnaissance performed for the ESP study, abundant “clastic dikes” have been observed in the site area that have characteristics consistent with a pedogenic or weathering origin, but no features were observed that can reasonably be interpreted to have formed as a result of injected sand. The field reconnaissance of “clastic dikes” exhibited the following primary characteristics, which were summarized by the Bechtel (1984) study of these features within a large trench exposure on the VEGP site:

1. The dikes are widely distributed through the region in deeply weathered clayey and silty sands of the Eocene Hawthorne and Barnwell Formations.
2. The dikes occur in nearly all exposures of the weathered profile but are rare in exposures of stratigraphically lower, less weathered sediment.
3. The dikes contain a central zone of bleached host rock bounded by a cemented zone of iron oxide. Some dikes contain a clay core.

4. Grain size analyses on samples indicate that the dike interval contains the same grain distribution as the host sediment with slightly more silt and clay (excluding clay core).
5. The dikes and associated mottling decrease downward in density and size. In most cases, the dikes taper downward and pinch out over a 5-to-15-ft distance.

NUREG-1137 concluded that no evidence exists that the clastic dikes represent a safety issue for the VEGP site. The SER suggests that the clastic dikes on the VEGP site may be non-tectonic, soft-sediment deformation features that formed 20 to 25 Ma.

In contrast to non-tectonic "clastic dikes," Bartholomew et al. (2002) interpreted sand dike features found in the upper Eocene Tobacco Road Sand near Hancock Landing, Georgia, less than five mi north of the VEGP site, as evidence for strong paleoearthquakes probably associated with late Eocene to late Miocene earthquake activity possibly associated with the Pen Branch and/or Crackerneck faults. Bartholomew et al. (2002) describe sand dikes that cut across poorly bedded clay-rich strata and are filled with massive, medium to coarse sand.

However, the sand dikes identified by Bartholomew et al. (2002) are syndepositional due to the presence of marine animal burrows that cross cut the dikes. The formation of these dikes occurred during the late Eocene while the sediments were in a subaqueous marine environment **(Bartholomew et al. 2002)**. Whether these dikes of Bartholomew et al. (2002) formed as a result of seismic shaking or some other process related to soft sediment deformation (e.g., compaction and de-watering), these features are significantly older than Quaternary and, therefore, do not reflect geologically recent seismic activity.

Table 2.5.3-1 Summary of Bedrock Faults Mapped Within the 5-Mile VEGP Site Radius

Fault Name	Proximity to VEGP Site (mi)	Length (mi/km)	Orientation	Sense of Slip	Relationship to Dunbarton Basin	Evidence for Non-Capability
Pen Branch	On site	>20/>30	NE	SE up, reverse	NW border (normal) fault, reactivated as reverse	a, b, c, d
Ellenton	~4	~4/~6.5	NNW	E down, unknown	Unknown; located NW of basin	b, c, e
Steel Creek	~2	>11/>18	NNE	NW up, reverse	Secondary structure forming horst with Pen Branch	b, c, d
Upper Three Runs	~5	>20/>30	NE-NNE	Unknown	Unknown; located NW of basin	b, c, f

Note: Fault locations based on Cumbest et al. (1998), Stieve and Stephenson (1995), and work performed as part of this ESP study

[a] Seismic reflection and borehole data show lack of post-Eocene slip (NUREG-1137-8; **Cumbest et al. 2000**)

[b] Lack of geomorphic expression

[c] Lack of seismicity associated with fault

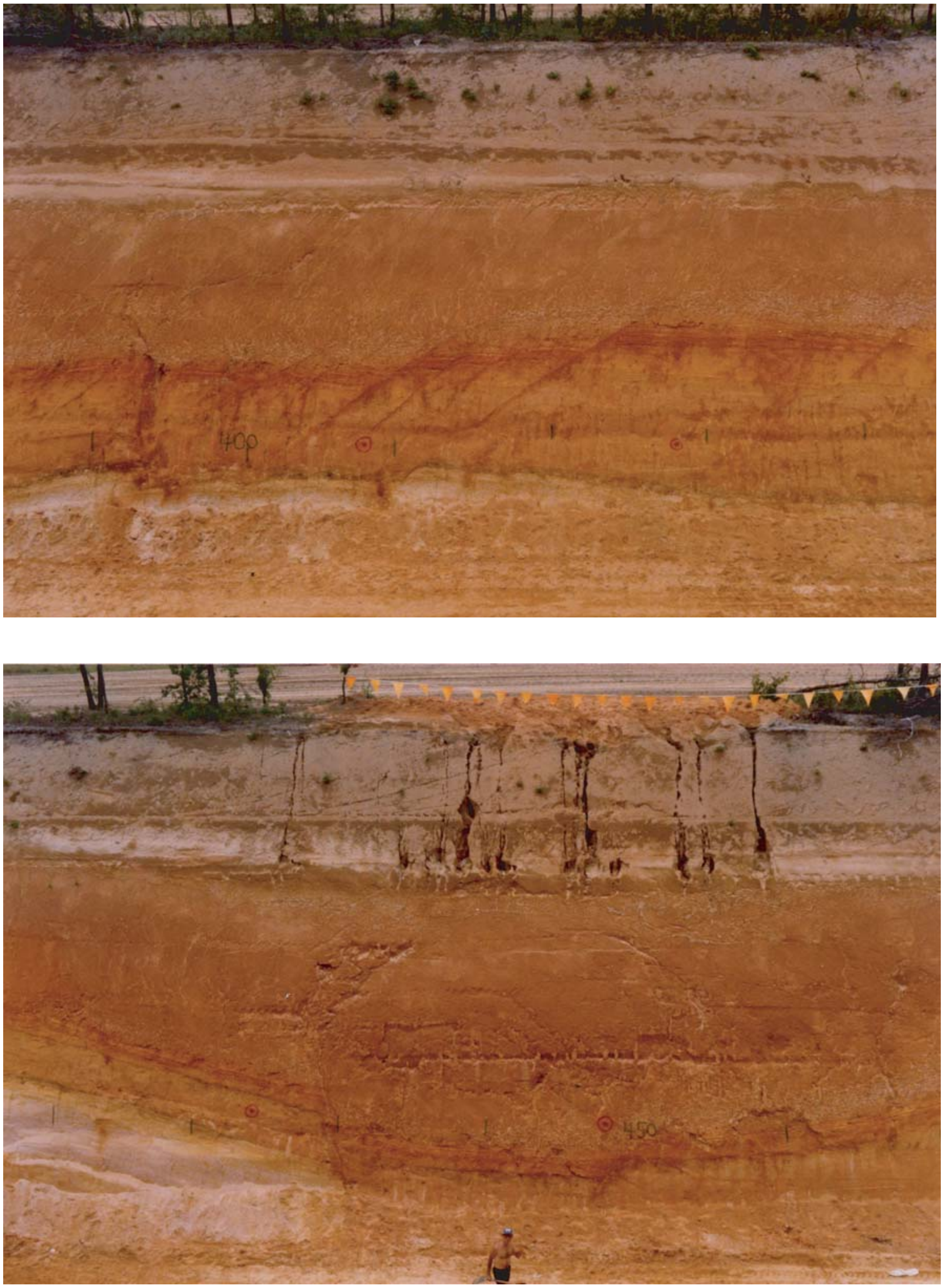
[d] Quaternary fluvial terraces of Savannah River overlying projection of fault appear undeformed **(Geomatrix 1993)**

[e] Fault does not appear in most recent SRS fault maps **(Cumbest et al. 1998, 2000)**

[f] No disruption to base of Coastal Plain section (pre-Cretaceous age) **(Stieve and Stephenson 1995)**

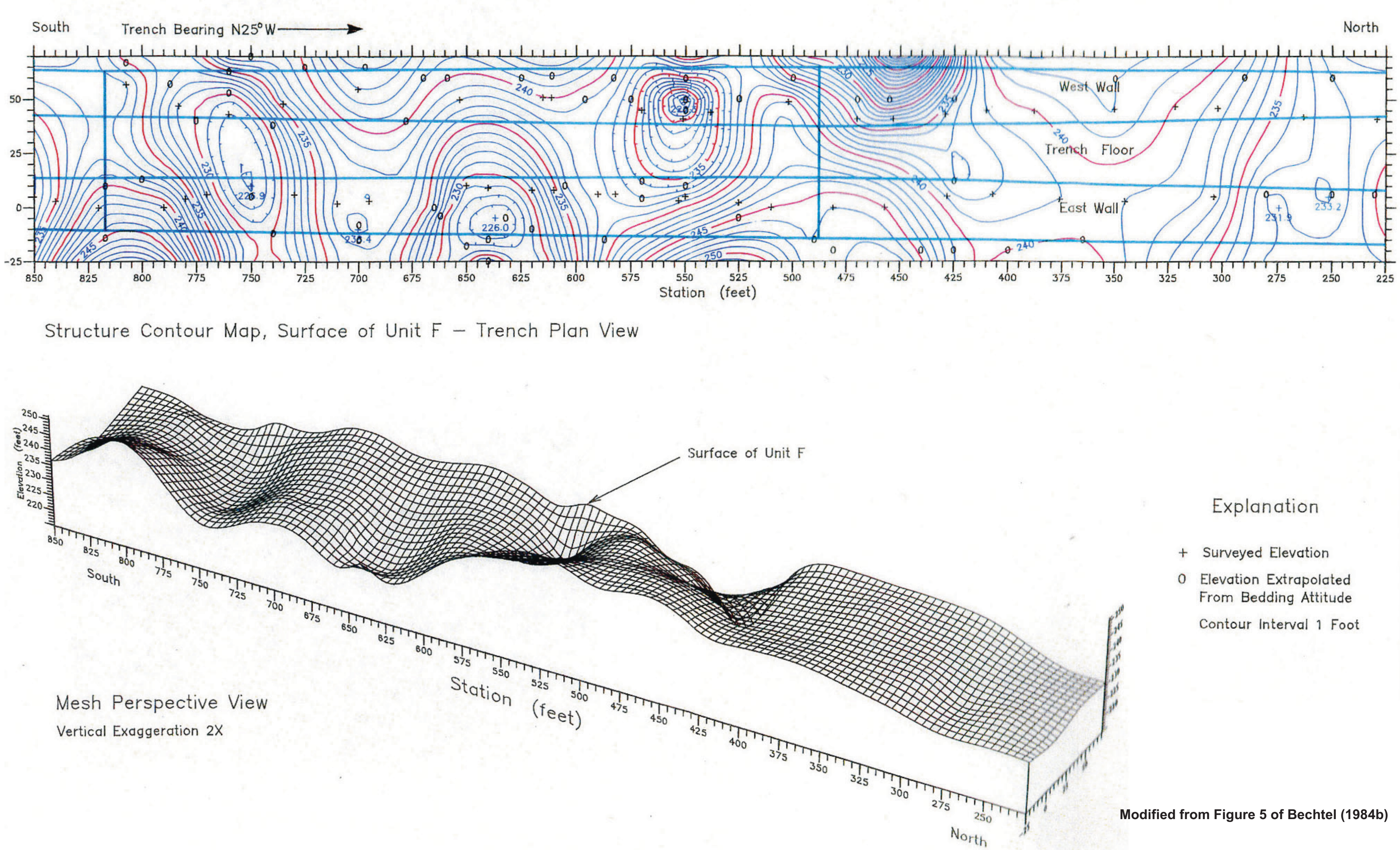
Source: Bechtel 1984b

Figure 2.5.3-1 Contorted Bedding in Garbage Trench at VEGP Site



Source: Bechtel 1984b

Figure 2.5.3-2 West Wall of Garbage Trench Showing Small Offsets (1–24 inches) (Upper) and Arcuate Fractures and Clastic Dikes Over Center of Depression (Lower)



Modified from Figure 5 of Bechtel (1984b)

Figure 2.5.3-3 Surface Geometry of Unit F Illustrating Localized Nature of Deformation

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