surface generally exhibits only minor relief related to karst development. There are no pronounced lineaments across the site location that suggest the presence of a through going fault or major fracture system.

The potential for nontectonic deformation at the site from phenomenon other than karst-related collapse or subsidence is negligible.

The LNP site area is situated in an area that could potentially have karst feature development (see FSAR Subsection 2.5.1). An assessment of aerial photos and site investigation was conducted to identify key features associated with solution subsidence activity. Although evidence of solution activity was encountered in some of the boreholes advanced as part of this COLA, findings from the soils and rock borings, along with geophysical testing, did not indicate the presence of major solution features that would have a significant impact on the safety of a nuclear plant with a properly designed foundation.

2.5.0.4 Stability and Uniformity of Subsurface Materials and Foundations

Surface geologic deposits observed at LNP 1 and LNP 2 consist of undifferentiated Quaternary age fluvial and marine terrace sediments, primarily silty fine sands. The sands overlie the Avon Park Formation, a shallow marine carbonate rock unit of mid-Eocene age, characterized as cream to brown or tan, poorly indurated to well-indurated, variably fossiliferous limestone, interbedded in places with tan to brown, very poorly to well-indurated, fossiliferous, vuggy dolostones. Carbonized plant remains are common in the rock sequence in the form of thin, poorly indurated laminae and cyclic interbeds.

The depth of undifferentiated Quaternary (unit S1) and Tertiary (units S2 and S3) sediments varies. The top of rock (unweathered Avon Park Formation) occurs at an approximate elevation of -7.3 m (-24 ft.) NAVD88 at the LNP site, with undulations due to the erosional nature of the surface. The reactor islands of LNP 1 and LNP 2 will be founded at basemat elevation +3.5 m (+11.5 ft.) NAVD88. Therefore, the Avon Park Formation rock is below the bottom of the basemat of each nuclear island. The Avon Park Formation rock has a weighted mean dip of 2 degrees at both LNP 1 and LNP 2 within the subsurface investigation depth, i.e. 152 m (500 ft.).

A subsurface investigation program, consisting of geotechnical boreholes, geophysical surveys, in situ testing, and laboratory testing, was performed from January 2007 through January 2008 in accordance with Regulatory Guide 1.132 and Regulatory Guide 1.138. A total of 118 boreholes were advanced, including 10 initial phase boreholes, 90 main phase boreholes, and 18 supplemental boreholes. The depth of these boreholes ranged from less than 30 m (100 ft.) to nearly 152 m (500 ft.) below the ground surface (bgs) with at least 19 at each nuclear island with depths of more than 61 m (200 ft.). Geophysical survey methods were conducted in representative boreholes. These survey methods included suspension P-S velocity logging, downhole shear-wave logging, acoustic televiewer surveys, and non-seismic borehole geophysical surveys, including natural gamma logging, gamma-gamma logging, neutron-neutron

logging, and induction logging. In addition, pressuremeter testing (PMT) was performed at various depths in one borehole at each LNP site. A total of 213 special-care rock core samples were laboratory tested for unconfined compressive strength (UCS) and other index tests. Forty two special-care rock core samples were laboratory tested for split tensile strength and other index tests. Nine special-care rock core samples were used for triaxial compressive strength tests in laboratory. Numerous soil samples were tested for index properties.

Engineering properties of subsurface materials were characterized from the site investigation activities. Two of the key properties are summarized as follows:

- The average shear-wave velocity (V_S) from all suspension P-S velocity logging at LNP 1 varied from 760 to 1680 meters per second (m/sec) (2500 to 5500 feet per second [fps]) below the top of rock. At LNP 2, the average V_S varied from 760 to 1520 m/sec (2500 to 5000 fps) below the top of rock. Three and four rock layers were defined for engineering analysis based on shear-wave velocity at LNP 1 and LNP 2, respectively.

- The average UCS from laboratory tests on intact rock core samples of the rock layers varied from 4.8 to 25.5 megaPascals (MPa) (700 to 3700 pounds per square inch [psi]) at LNP 1 and varied from 4.8 to 20 MPa (700 to 2900 psi) at LNP 2. UCS results range from 0.9 to 127.3 MPa (131 to 18458 psi) among all samples tested from the LNP site.

The nuclear island building floor elevation for LNP 1 and LNP 2 is elevation +15.5 m (+51 ft.) NAVD88. The ground surface elevation immediately outside of the reactor islands will be at elevation +15.5 m (+51 ft.) NAVD88, except where required to be lower due to water control. The surrounding grade will be lower to accommodate site grading, drainage, and local site flooding requirements. The current ground surface varies approximately from +12.3 to +13.2 m (+40.3 to +43.2 ft.) NAVD88 at LNP 1, and from +12.1 to +13.4 m (+39.8 to +43.9 ft.) NAVD88 at LNP 2. Therefore, site fill of approximately +1.8 to +3.0 m (+6 to +10 ft.) will be required to raise the grade.

The nuclear island basemat will be founded at elevation +3.5 m (+11.5 ft.) NAVD88 on a 11 m (35 ft.) roller compacted concrete (RCC) bridging mat. A waterproof geomembrane will be placed on the RCC and topped with a 15-centimeter (cm) (6-inch [in.]) mudmat, as described in the DCD (Subsection 3.4.1.1.1), prior to placement of the nuclear island basemat. Excavation for construction of the RCC bridging mat and nuclear island is facilitated by permeation grouting and a perimeter diaphragm wall. Grouting from the ground surface will provide a barrier over a 23 m (75 ft.) zone of the Avon Park Formation below the planned RCC. The diaphragm wall will be keyed into the grouted limestone formation and provide a side barrier for excavation dewatering. Grouting reduces gross porosity and permeability to facilitate dewatering but also reduces long-term groundwater flow to minimize potential solution impact.

a higher percentage of recrystallized magnesium carbonate, and would therefore typically be less susceptible to the types of karst activity known to occur within the pure calcium carbonate limestone zones present at the top of the Ocala Formation.

Subsurface data from the LNP site investigation indicate that there is variability in the elevation of the Quaternary/Tertiary unconformity and the contact between the S3 and AV1 units at depth. This topography likely reflects a variety of processes, including: 1) weathering and dissolution related to heterogeneities within the underlying carbonate rocks that are due to variable degrees of dolomitization or initial depositional properties; 2) planation and erosion related to Neogene or Quaternary marine transgressions/regressions; and 3) location and degree of development of the paleo-epikarstic surface that likely formed in the upper strata of the Avon Park Formation over a period of as much as several million years.

The LNP site stratigraphy and surface morphology are consistent with expected characteristics of a developed paleokarst landscape mantled by several meters of sand (i.e., a mantled epikarst subsurface) (Figure 2.5.1-244). There are no recognized sinkholes in the State of Florida sinkhole database within 2 km (1.28 mi.) of the LNP site (Figure 2.5.1-244), and no sinkholes at the land surface were observed during site investigations and reconnaissance within the LNP site. Site borings revealed very few voids in the upper 150+ m (500 ft.).

Although subsurface data from exploration boreholes at the LNP site indicate that there is variability in the elevation of the Q/T unconformity at the LNP site, the Q/T unconformity is generally at an elevation of 10.7 ± 0.6 m (35 ± 2 ft.) NAVD88 under the nuclear islands. It is assumed that this represents the general elevation of the marine planation surface, which is estimated to be older than MIS 9 (340 ka) and most likely middle to early Pleistocene, or possibly late Pliocene in age (FSAR Subsection 2.5.1.2.1.2). The nature, frequency, thickness, and lateral extent of subsurface karst features identified in borings under the safety-related structures are described in FSAR Subsection 2.5.4.1.2.1. These features generally vary in lateral extent from a few centimeters to approximately 1.5 m (5 ft.) when associated with vertical fracturing, and from a few centimeters to approximately 3.0 m (10 ft.) when associated with horizontal bedding planes.

2.5.1.2.6 Site Area Geologic Hazard Evaluation

Evaluation of geologic hazards at the LNP site was based on the compilation and review of published maps and reports, reconnaissance investigations in the site area, discussions with FGS and SWFWMD personnel and karst experts, and results of the site characterization program.

- The LNP site is located in an area of infrequent and low seismicity. Earthquake activity with resulting ground motion effects are considered in the seismic design ground motions for the site (see FSAR Subsection 2.5.2). There are no capable tectonic sources in the site area; thus, there is