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A site specific geological risk assessment of the proposed location of South Africa's second nuclear power plant, Thyspunt, Eastern Cape

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This study describes the bedrock lithologies and structure of the Ordovician to early Devonian (485 - 419 Ma) Table Mountain Group (TMG), the Devonian (419-358 Ma) lower Bokkeveld Group, and the Miocene to Holocene (<23 Ma) overburden sediments of the Algoa Group within an area identified by Eskom for the potential construction of South Africa's second proposed nuclear power plant (NPP), 'Nuclear-1'. The study area is located along the southern coastal margin of the Eastern Cape Province, South Africa, between Oyster Bay and St. Francis (approximately 88 km west of Port Elizabeth), and encompasses the Thyspunt site where the proposed NPP will be built. The study aims to supplement existing information about the Thyspunt area, related to the geoscientific topic 'Geological Setting', as outlined in section 2.5.1.1 of the US Nuclear Regulatory Commission (USNRC) Standard Review Plan NUREG-800, which details the geological information required for review of a proposed NPP. The results obtained from geoscientific studies are used create a site specific geological hazard assessment for the proposed NPP at Thyspunt. Geological factors considered to potentially affect site safety in terms of the NPP's footprint location, its design layout and construction include: bedrock lithology, stratigraphic bedrock contacts, bedrock palaeotopography, thickness of overburden sediments and structural geology.

Field mapping and petrographic analyses of the TMG, comprising the Peninsula, Cedarberg, Goudini, Skurweberg and Baviaanskloof Formations as well as the lower undifferentiated Bokkeveld Group were undertaken to define the study area's lithologies and structure. Interpretation of geophysical results and the integration of existing borehole data aided in defining the variability in overburden sediments, the identification of contacts between TMG formations beneath overburden, and the palaeotopography of bedrock. Borehole data indicates a clear N-S trend in the thickness distribution of Algoa Group aeolian and marine related sediments. Four coast-parallel trending thickness zones (zones A – D) are recognized within the study area. At Thyspunt overburden thickness reaches a maximum of 61 m, ~1200 m from the coastline, in areas underlain by the argillaceous Goudini and Cedarberg Formations. Overburden thickness is influenced by a combination of dune relief, bedrock lithology, palaeotopography and the area's sediment supply. Interpolation of bedrock elevation points and detailed cross sections across bedrock reveals four NW-SE trending palaeovalleys at Thyspunt, Tony's Bay, Cape St. Francis and St. Francis, where bedrock relief (beneath overburden) is formed to be below present day sea-level. Approximately 450 m NW of Thys Bay, a 1050 m^2 (area below sea-level) palaeovalley, gently sloping SE to a depth of -15.5 m asl, is cut into strata of the Goudini Formation resulting in thicker overburden fill in that area.

Structural analysis of the TMG confirms that NE-SW striking strata form part of the regional SE plunging, north verging Cape St. Francis anticline. Bedding inclination is controlled by the distance away from the fold axis, varying from a 5° SE dip along the broad fold hinge to 65° along its moderately steeper SE limb. Folds within the study area plunge gently southeastward at shallow angles, with axial planes dipping

steeply SW or NE. The previously identified 40 km long, NW-SE trending Cape St. Francis fault occurring offshore within 17.5 km of Thyspunt show no onshore continuation within the bounds of the study area. Late jointing is pervasive within the study area and five joint systems are identified. The dominant joint set J1, trends N-S to NNE - SSW; perpendicular to bedding and has a subvertical dip. Normal right-lateral and left-lateral micro-faults dip subvertically, with a displacement that ranges from a few centimetres to <3 m. Micro-faults trend parallel to joints sets J1 and J4 (ESE-WSW). Inferred faults, identified by the Atomic Energy Co-operation (AEC), are interpreted as zones of closely spaced jointing (shatter zones), and show little to no recognizable displacement.