



### 3. SITE CHARACTERISATION AND FIELD OBSERVATIONS

#### 3.1. *Geology*

##### 3.1.1. Structural Geology

Unlike most islands of the Lesser Antilles, Trinidad is of sedimentary origin, rather than volcanic composition. The island lies within a 200 km wide tectonic plate boundary zone, between the Caribbean Plate and the South American Plate (Burke, 1988). This tectonic zone has a predominantly right lateral strike slip character, as the Caribbean Plate pushes to the east, past the South American continent. The area has been tectonically active for the last 30 million years (Oligocene to present) and has a complex geologic history.

Trinidad consists of three up-thrust ranges of mountains and hills, separated by two deep sedimentary basins. Metamorphic rocks of the Northern Range transition abruptly southwards across the El Pilar – Arima Fault Zone (PAFZ) to undeformed, essentially flat lying, Holocene and Pleistocene alluvial and marginal marine sediments of the Northern Basin.

The Northern Basin is a late Miocene – Pleistocene extensional feature with 7000 – 9000 ft of sedimentary fill resting on highly indurated Lower Cretaceous basement. The Guatapajaro – Guico Anticline forms an east-west drainage divide, upon either side of which runoff derived from the south and north, drains into east-west trending transverse river systems along the basin axis (Figure 3.1).

The Couva Hospital Site is located within the south western foothills of the Central Range.

South of the Central Range highlands lies the Naparima Fault Belt and the Central Trinidad Fault Zone (CTFZ). The latter is a dominantly right lateral wrench fault system with both transpressional and transtensional components. The Naparima Fault Belt is tectonically active but remains topographically low because of the soft nature of the sediments presently being uplifted.



To the south is the Southern Basin, a deep Cretaceous – Tertiary sedimentary basin and prolific hydrocarbon province. The Southern Basin is bounded along the south coast by the South Trinidad Fault Zone (STFZ), an active right lateral wrench system. Bedding along the eastern south coast is vertical and the Southern Range is really a series of low sand-prone ridges, erosionally delineated from up-thrust sands and clays. The pervasive compressional deformation between the CTFZ and the STFZ has resulted in uneven hilly terrain with a series of northeast trending thrust anticlines, adjacent to similarly trending, large synclines. The former structures, such as the Rock Dome Anticline (Figure 3.1), are composed of clay rich, deep marine, lower and middle Tertiary sediments that were deposited in a foreland basin trough.

### 3.1.2. Structure/Seismicity

Structure in the context of Geology (Structural Geology) refers to the crustal formations of the earth on a scale of tens to hundreds of kilometres. Here we include the study of the location and activity of geological faults, as they are likely to influence and define the seismology and stability of slopes in the area (Figure 3.1-3.2).

Seismological phenomena shall be studied in the context of developing appropriate earthquake loading parameters. In the early 1980's the Ministry of Works adopted the then Earthquake Zone system where Trinidad and Tobago was placed in Zone 3 as defined in the SEAOC code at that time. Practitioners in Trinidad and Tobago typically followed this methodology up to about 2000 through the Uniform Building Code. This method was to be replaced by the International Building Code (latest version IBC 2009), in which the ground accelerations are defined at a 2% probability of exceedance in 50 years (2500 year return period). This methodology represents a significant deviation from previous practice, as it demands a different set of frequency dependent ground parameters to be developed. In the design of the proposed building infrastructure and slopes the methods outlined in the IBC 2009 should be adopted.

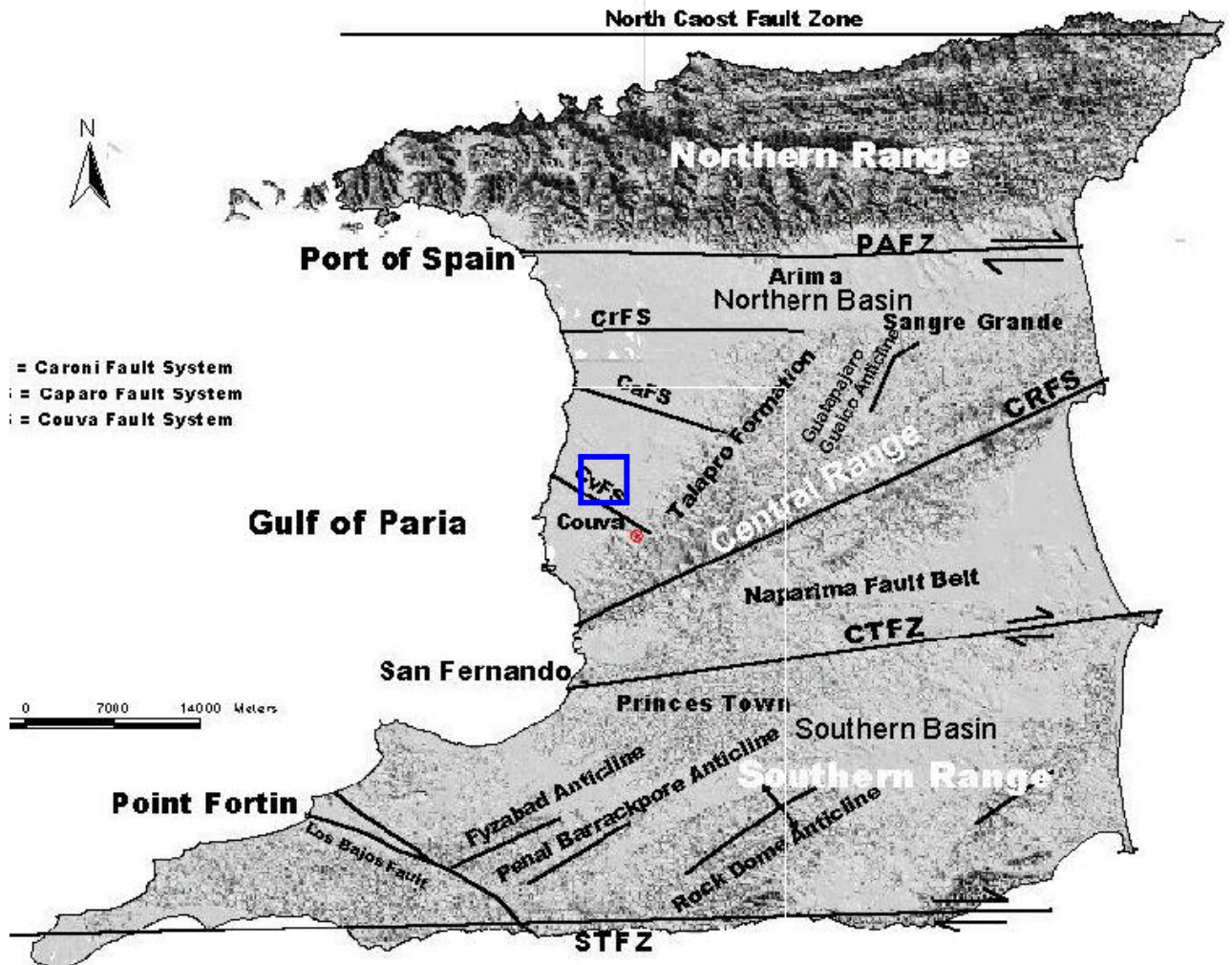


Figure 3.1 COUVA CHILDREN'S HOSPITAL, COUVA, located over Geomorphology Map of Trinidad (de Verteuil et al. 2001).

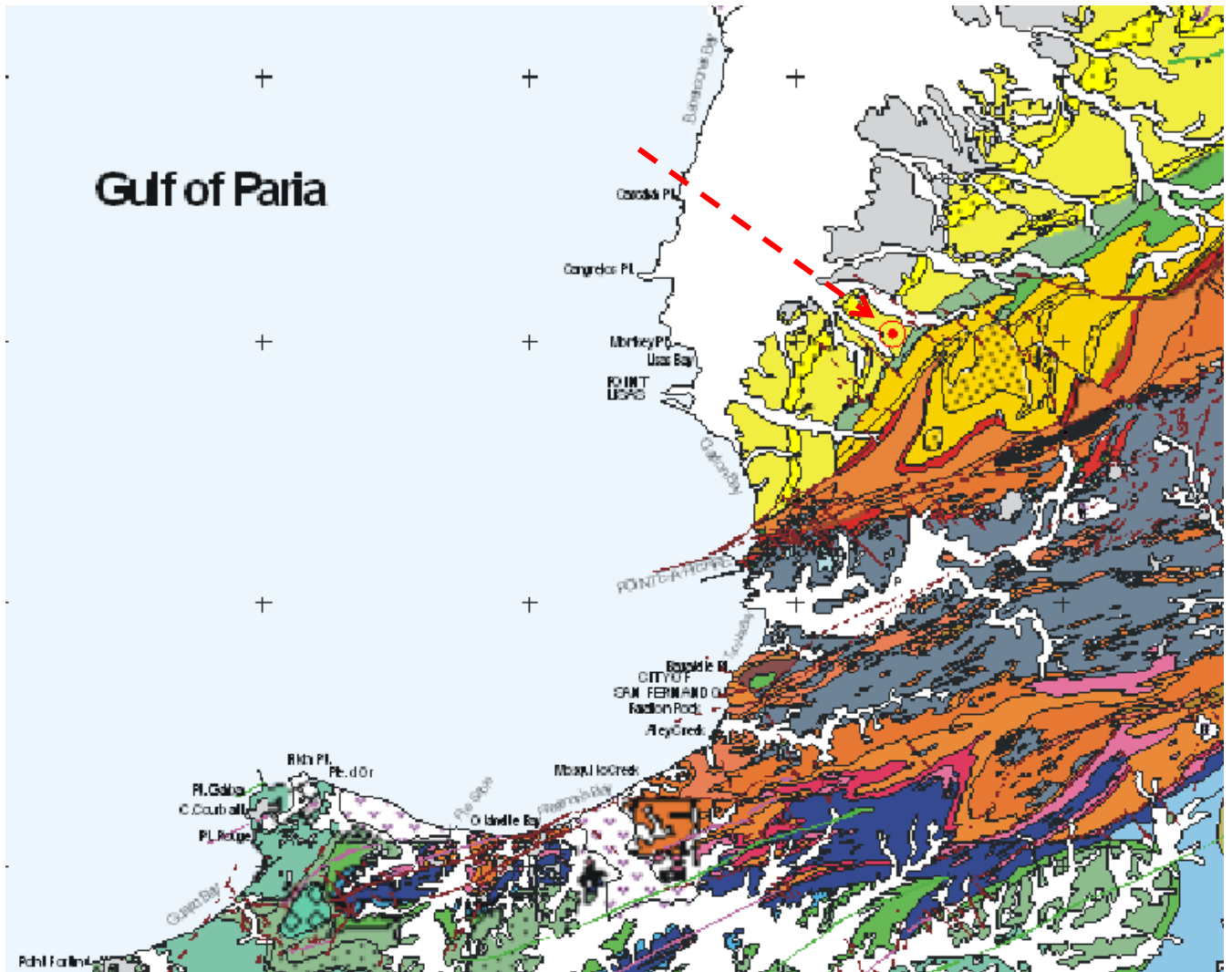



Figure 3.2 COUVA CHILDREN'S HOSPITAL, COUVA, Site located over Structural Geology Map of Trinidad (de Verteuil et al. 2001)

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### 3.2. *Hydrogeology*

The hydrogeological map of Trinidad (Water Resources Agency, 1989) indicates that the Naparima Peneplains region comprise “strata with local and limited groundwater resources or strata with essentially no groundwater resources”. This is significant insofar as fully developed deep artesian systems are not likely in this area. However, shallow bedded alluvial sands, recharged by surface and perched water table systems can give rise to unusual pore water pressure development with the near surface (5-6 m depths).

### 3.3. *Topography and Drainage*

The site is located within the North West foothills of the Central Range where topography is primarily described as rolling hills which are predominated by over-consolidated clays. Significant variations in elevation can be expected, as much as 20.0 m where elevations range between +56.0 MSL to +36.0 MSL, Figure 3.3.

Several natural water courses originate from the site which flow to the north basin into the Savonetta River system which meanders and outfalls in the Gulf of Paria along the west coast of Trinidad.

Surface flows are also considered significant given the observed erosion channels as presented in Figure 3.4. Generally the drainage at the site tends to follow the existing topography.

As previously discussed the site is present used for agricultural purposes and as such several ponds were observed over the site. These ponds were excavated by Farmers for crop irrigation however this could lead to saturation of the surface given the proximity of the slopes.



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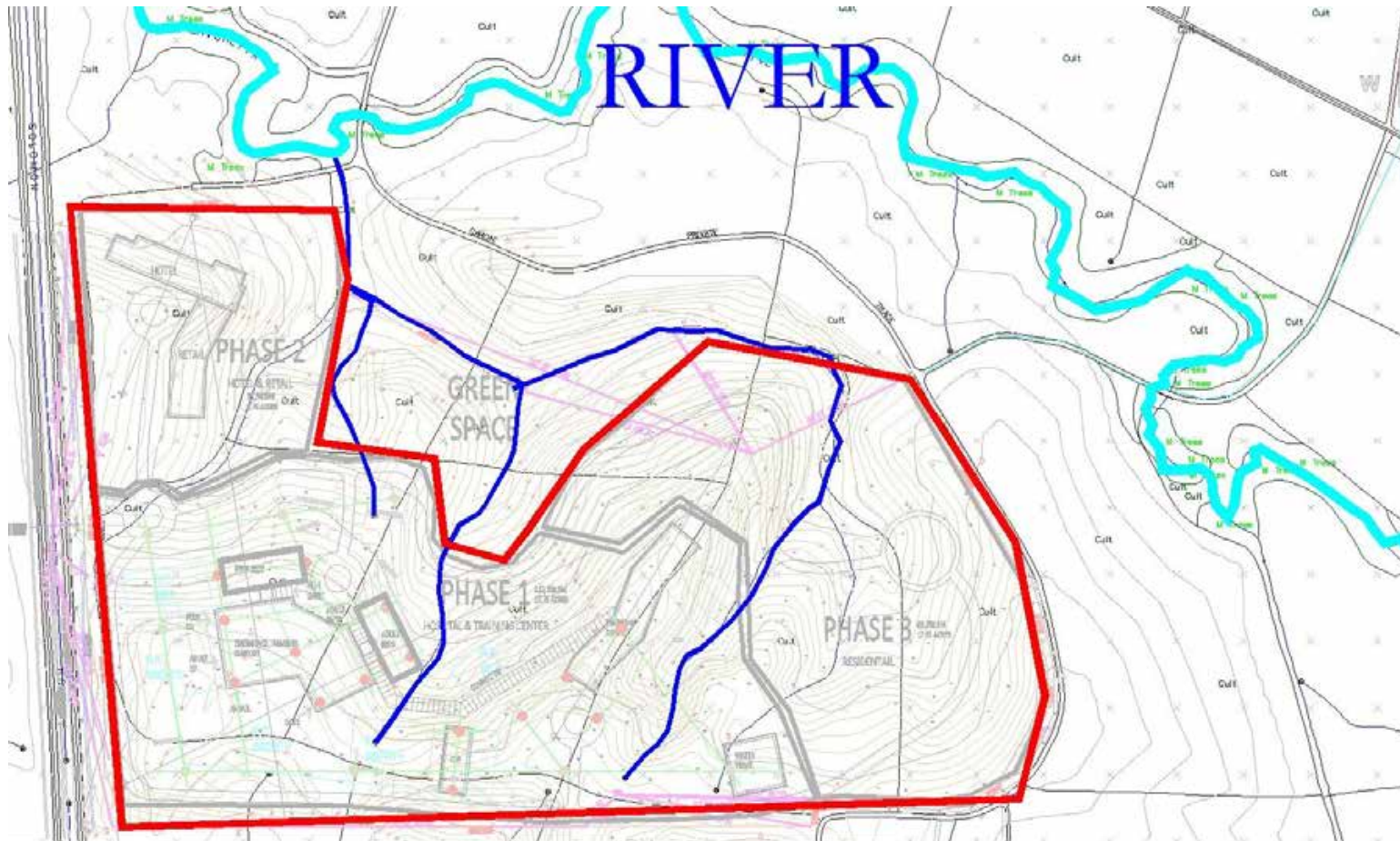


FIGURE 3.3 COUVA CHILDREN'S HOSPITAL, COUVA, TRINIDAD – EXISTING TOPOGRAPHY AND DRAINAGE



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FIGURE 3.4 COUVA CHILDREN'S HOSPITAL, COUVA, TRINIDAD – EROSION CHANNEL CAUSED BY SURFACE FLOWS.



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FIGURE 3.5 COUVA CHILDREN'S HOSPITAL, COUVA, TRINIDAD – TYPICAL PONDS DUG BY FARMERS FOR IRRIGATION OF CROPS



### 3.4. Climate

Climate plays an important role in the context of soil behaviour in highly over-consolidated clay soils. Both volume change potential and slope stability are directly influenced by rainfall and evapotranspiration. Many researchers have demonstrated the influence of these parameters on stability in these soil environments (ASCE 1989, Nelson and Miller 1992, Ramana 1993, Gay 1994). The mean annual rainfall expected at the site is 1700 mm with a mark dry season of 2-3 months. The Thornthwaite Moisture Index (TMI) is perhaps the simplest moisture balance parameter that can be used in the study of volume change potential. In conjunction with soil plasticity and classification parameters we shall use this parameter in the determination of the expansive potential of soils. The climatic data to determine the TMI is available through the Water Resources Agency.

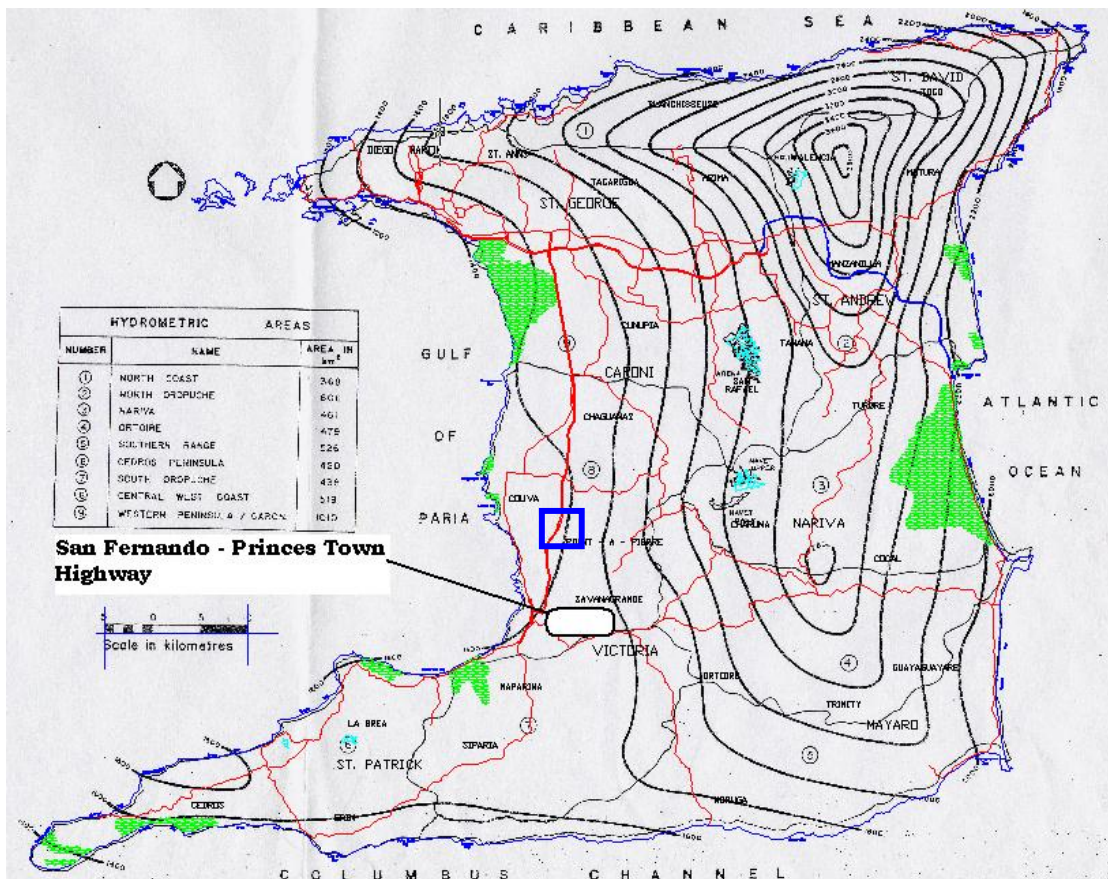


Figure 3.6 Mean Annual Rainfall distribution over Trinidad (Water Resources Agency).





### 3.5. *Vegetation*


Much of the natural vegetation of the site comprises grass and shrubs varying between 3-5 feet in height. These grasses are significant in that they can develop significant suction pressures in these expansive clays invoking shrink-swell behaviour.



Figure 3.8 Vegetation within the proposed Site (Looking north from PB 4 towards PB 3)



Figure 3.9 Vegetation within the proposed Site (Looking south and upslope from BB10)

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### 3.6. *Soils*

The site has been located on the Agricultural Soils and Land Capability Survey maps of Trinidad and Tobago Figure 3.10 (The Ministry of Agriculture and UWI, 1972), which provide an excellent basis for the identification, and classification of soils for engineering purposes. In these, soils are categorised in respect of their lithological and geomorphological characteristics that can typically be related to soil properties (plasticity, activity, and expansive potential) and expected field characteristics (slope instability and erosion potential).

These maps can be typically used in the classification of at grade soil types, particularly when their agricultural soil classifications are converted to their equivalent engineering basis through the methodology of the FAO (Olson, 1973). Venkataramana (1993) also provides a useful starting point for the engineering classification of Trinidad soils.

The soil types are summarized in Table 3.1.


- The **C2 – 177D2 Talparo Clay**, which make up the majority of the area can be classified as soils of high plasticity, which are well known for their instability on slopes and relatively high activity and expansive potential. These soils are then expected to pose problems associated with low CBR (bearing capacity) values and our finds suggest significant saturation to approximately 2.0 m in some areas.
- The soils map indicates an outcrop of soil type **C1-261 D2 Arena Sand** within the boundary of the site. This data observed from the mapping is consistent with our findings from the test pit investigation as observed in Test pit number TP06-05.

**Table 3.1 SOILS: COUVA CHILDREN'S HOSPITAL, COUVA**

Soil Group	Geological Formation		Classification		Lithology	(% ) clay	Plasticity Index (%)	Residual Friction Angle	Volume Change Potential
			Textural - Slope & Erosion Category	Unified					
C1	Cedros	Soils of the intermediate uplands with free internal drainage	261 D2 Arena sand	SC-SM	Sand	~ 0.0 – 30.0			
C2	Cedros	Soils of the intermediate uplands with restricted internal drainage	177 D2 Talparo clay	CH	Clay shale	~60.0	~50.0	7.0	High

Slope Categories: A 0-2°  
 B 2-5°  
 C 5-10  
 D 10-20  
 E 20-30, F > 30

Erosion Categories: 0 - No apparent Erosion  
 1 - Slight < 10% of topsoil lost  
 2 - Moderate > 10% of topsoil lost  
 3 - Severe all topsoil lost

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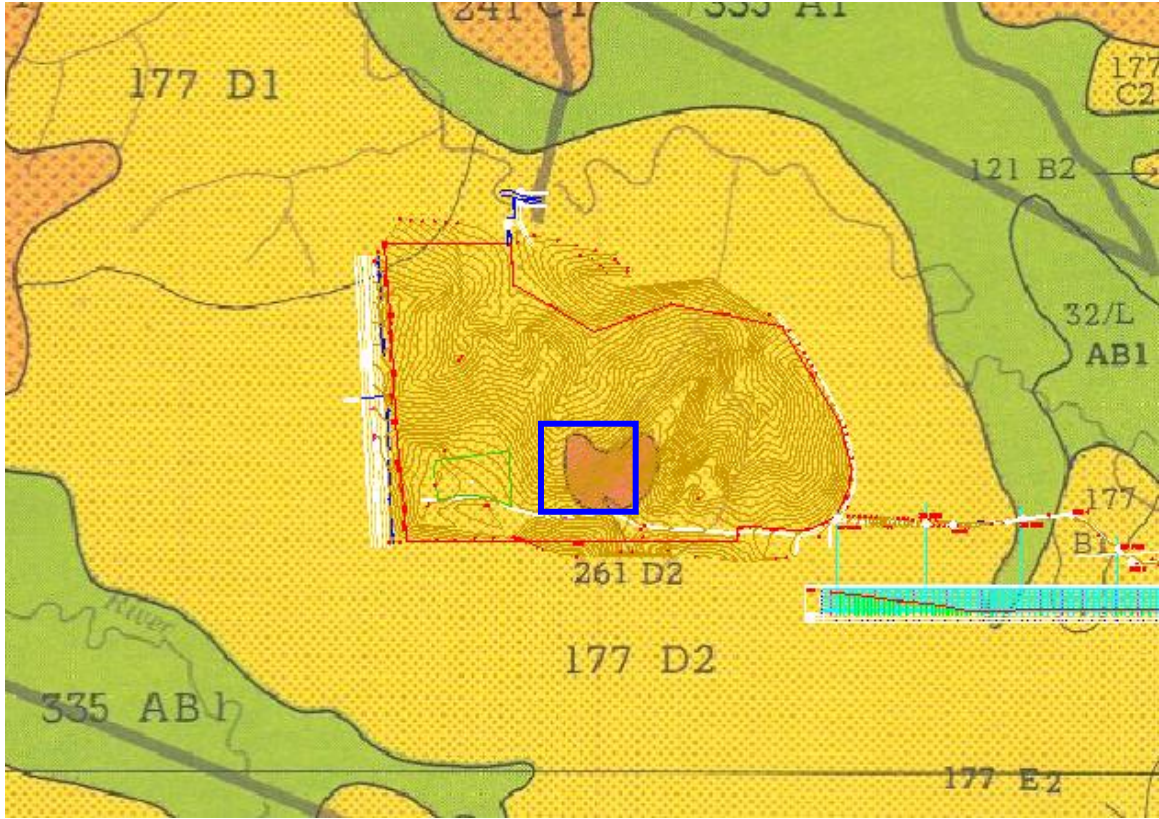



Figure 3.10 COUVA CHILDREN'S HOSPITAL, Couva. Site Location on Trinidad soil Map, Lands and Surveys Division, Note localized outcrop of Soil Type 261 Arena Sand.

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### 3.7. *Geomorphology Features of Peneplains and Landslide Occurance*

This project is located in a geomorphologic region known as the Naparima Peneplain (Beaven, 1964), where the elevation of the ridges is remarkably constant, falling from 60 m in the east to 30 m in the west where the ridge top is narrow, or the slopes over-steep, this can result in landslips toward the water courses.

Water courses have cut into the old over-consolidated uplifted (tectonic uplift) surfaces and the valleys have been widened by the slipping of the clay into the valley bottoms. At the beginning of the wet season, water can penetrate the soil along cracks, which develop in the dry season. If the slope is long, and especially if it is a dip slope, the wet clay - dry clay shale contact will be lubricated to such an extent that the wet mass would slide over a large concave area. Landslip adjustment in this area produces a mature slope of about 14°. Slopes from adjacent valleys now intersect in narrow ridges, which are often used in the location of roads.

During a detailed survey of part of the Central Range, Havord was able to distinguish a "landslip phase" of two soil series developed in clay soils where the slope was greater than 10°. In considering the stability of natural slopes in London clay, Skempton has calculated that the critical slope is 9 3/4° when the ground water level is at the surface, although, where the depth to the water table is a quarter of the depth to the slip plane, then the critical angle is increased to 12 1/2°. In an assessment of grass covered slopes the maximum stable slope was 10 1/2°.

Beaven (1964) suggests that saturated soils in this region on slopes greater than 10° are liable to erosion, landslip and soil creep.

This is consistent with the observations of this site and is consistent based on experiences from previous projects in these terrains as illustrated in Figure 3.11.

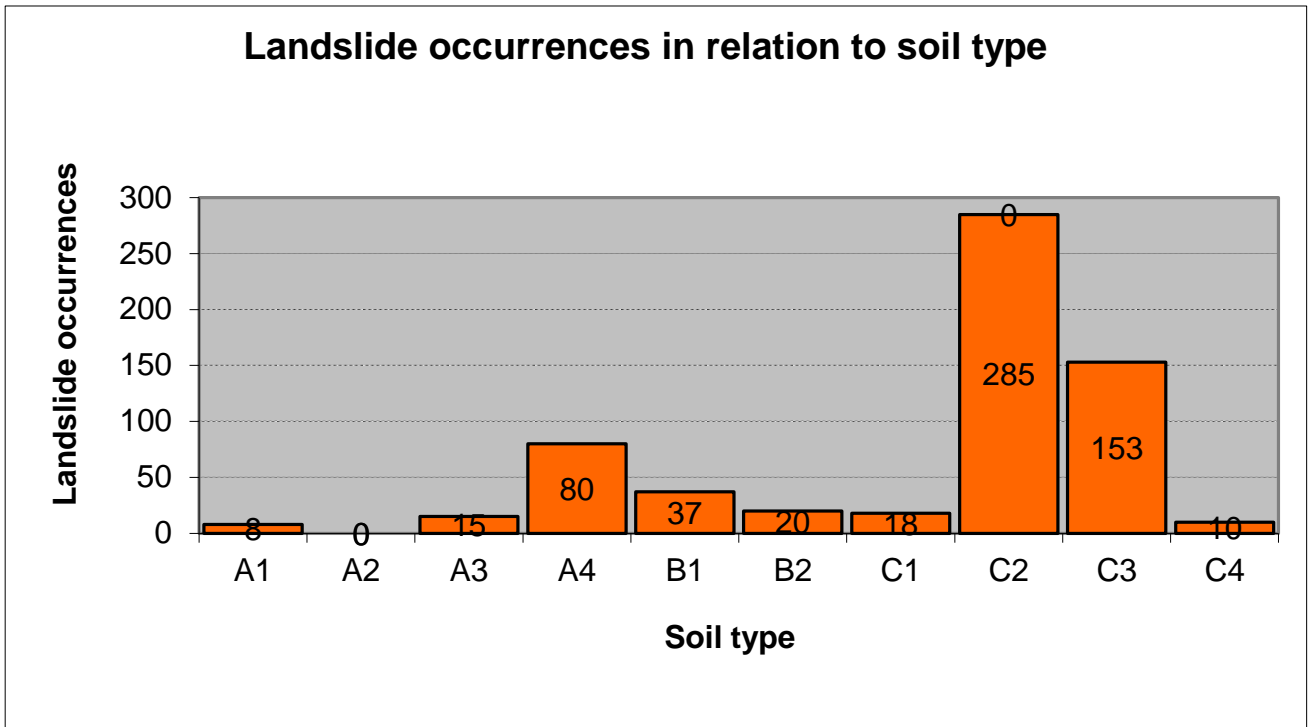


Figure 3.11 Landslide occurrence in relation to Soil Series Type, Central & Southern Range Trinidad (Gay 2004)