The Feasibility Study of the Flood Control Project for the Lower Cagayan River in the Republic of the Philippines Final Report Supporting Report

ANNEX III : GEOLOGY

THE FEASIBILITY STUDY OF THE FLOOD CONTROL PROJECT FOR THE LOWER CAGAYAN RIVER IN THE REPUBLIC OF THE PHILIPPINES

FINAL REPORT

Volume III-1 SUPPORTING REPORT

ANNEX III GEOLOGY

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CHAPTER 1 INTRODUCTION

In the Cagayan valley, Northern Luzon, Philippine inhabitants are suffering from severe and frequent flood by heavy rain and typhoon every rainy season so that flood control structures and river channel improvement are required.

In connection with it, this project, "The Feasibility Study for the Lower Cagayan River Flood Control", is being carried out by Japan International Cooperation Agency (JICA) cooperating with GOP, DPWH, NIA and NAPOCOR from March 1999. The geological investigation has been executed at two terms namely (1) from March-June 1999, and (2) July-October 2000.

The main purposes in the geological survey are as follows:

- (1) To collect existing data and reports from government agencies concerned,
- (2) To carry out field reconnaissance survey for General geological condition of the basin,
- (3) To explore the geotechnical conditions for the prospective river channel widening at Magapit and Nassiping narrows,
- (4) To explore the geotechnical conditions for the foundation of the prospective flood control structures in Tugegarao,
- (5) To explore the availability of construction materials for levees in Tugegarao and Cabagan.

CHAPTER 2 DATA COLLECTION

During the course of the field work, the Study Team visited various offices concerned, exchanged view with officials and collected data. Main data are the regional geological map by Mines and Geoscience Bureau (MGB), and the construction material sources (sand and gravel pits) maps and boring records along the Philippines –Japan Friendship road by DPWH.

The publications by MGB furnished rather detailed information with regard to the geology of the Study area. The corrected data are as listed in Table 2.1.1.

CHAPTER 3 GENERAL GEOLOGY

3.1 General Geology of the Philippines

The Philippine Archipelago forms a part of the Circum-Pacific volcanic and seismic belt and defined by island arcs marginal basins. It has a maximum North-South length of 1600 km and an average width of 400 km.

The region is characterized by lithologies and regional structure developed during Cretaceous-Tertiary period. During this period there was an extensive ultramatic intrusion tectonism, andesitic and dacitic volcanism and the sediments are diverse including sandstone, conglomerate, tuffs, siltstone, shale, reef limestone and coal. Diorite, quartzdiorite and andesitic stocks were intruded at various times. The oldest rocks found in the region are Cretaceous spilite, shale, greywacke and chert.

The present geologic features of the Philippines are recognized as a model for an actively developing archipelago. These geologic features are divided into four zones as follows:

- 1. Stable zone (Palawan and Sulu region)
- 2. Mobile Belt zone (covers Luzon, part of Visaya and Mindanao)
- 3. Manila Trench
- 4. Mindanao and East Luzon Trench

The Stable zone includes Palawan, Cuyo islands Sulu sea, Southern Mindanao and Zamboanga. This region is characterized by less seismicity, reduced Tertiary activity, and prevalence of quartzose and alkalirich sedimentary rocks.

The Mobile belt extends longitudinally through Luzon, Visaya and Mindanao. It is characterized by pronounced earthquake activity, active and recently active volcanoes, prevalence of Mesozoic to Tertiary igneous rocks and greater rocks deformation and metamorphism.

The Mindanao and East Luzon Trench separates the east and south of the belts from the Philippine sea and Manila Trench separates Luzon from the South China sea. (Refer to Figure 3.1.1).

3.2 General Geology of Northern Luzon

(1) Physiography

Northern Luzon proper belongs to the mobile belt of the Philippines and four major physiographic and structural provinces are recognized in this region. These are 1) Ilocos basin, 2) Cordillera Central, 3) Sierra Madre and Caraballo range and 4) Cagayan basin. (Refer to Figure 3.2.1).

The Ilocos basin forms the coastal folded belt of Northern Luzon and extends north and south between the high Cordillera Central and South China Sea. Structurally this region is characterized by intensely folded and faulted north-trending anticlines. The major fault trends are north-south and northwest-southeast with a secondary fault system trending generally northeast-southwest.

The Cordillera Central is located along the east side of the Cagayan valley and is composed of intermediate to mafic plutonic masses with great thickness of bedded volcanics and metasediments (basalt and greywacke) along the marginal areas. Silicic intrusive and extrusive are known in this area. In Cordillera Central major lineaments have a north-south orientation essentially parallel with the trends in the mountains. Infolded and down-dropped blocks of Miocene carbonates and clastics occur at many places.

Sierra Madre and Caraballo mountains form the eastern and southern margins, respectively, of the Cagayan valley. They are composed of intermediate (andesitic) igneous rocks in their cores with early Tertiary bedded metavolcanics and metasediments along their margins, and coarse crystalline diorite intrusive are also known to occur at various places.

The Cagayan basin is a sedimentary trough whose sedimentary rock is dated late Paleogene to Recent. The thickness was calculated to be more than 7,000 m. Rocks in the basin are predominantly sedimentary clastics with interformational limestone. Volcanic and volcano clastics constitute the next widely distributed rocks in the area. A Cretaceous to Paleogene volcanic and sedimentary rocks form the basement upon which the sediments were deposited. Rocks within the basin also include intrusive, consisting mainly of diorite and granodiorite distributed generally at the core of the mountain ranges.

(2) Faults

Numerous faults are also present in Northern Luzon. They are generally persistent over long distances and oriented parallel to the longitudinal direction of the Cordillera Central. The most prominent of these faults are; 1) the Kabugao Fault in Apayao, 2) the Vigan-Vintar Fault in Ilocos province, 3) the Hapao-Kalinga Fault at the eastern part of Cordillera and 4) the Baloy-Abra Faults wherein the Baloy fault transects the mid-section of the lower half of the Cordillera while the Abra fault runs parallel to the Abra river.

(3) Seismicity of Northern Luzon

In Northern Luzon, many earthquakes are experienced yearly. The epicenters according to magnitude are shown in Figure 3.2.2. Significant seismic area is off the Manila Bay and west coastline; which corresponds to eastward subduction of Manila Trench, and southeastern coast; which corresponds to westward subduction of East Luzon Trench. And relatively fewer earthquakes occurred within Cagayan Valley, but nevertheless of significant intensities. On the whole, intense earthquakes is assumed to be tectonic origin and rarely of volcanic nature.

The major earthquake occurred in July 16, 1990 about 70 km south of Santa Fe. The epicenter of this earthquake was located at 15.68°N latitude and 121.17°E longitude. The magnitude of this earthquake was recorded at 7.8 in Richter scale. This earthquake injured seriously stability of the mountain slopes in the south-western watershed area and has been causing the serious debris sediment problem in the tributaries of the Cagayan river in this area.

The earthquake was decidedly of tectonic origin due to readjustments of rock strata within the earth's crust. No volcanic action occurred in connection with this earthquake.

(4) Structure

In the Master Plan Study, the false-colored landsat image of Northern Luzon (1983) was analyzed for interpretation of the lineament structure. The photograph covers the whole part of northern Luzon from 16°N to 20°N. (Refer to Figure 3.3.3)

Many major lineaments interpreted, lie in the south-western part of Northern Luzon and decrease in north and east. These major lineaments occupy the Cordillera mountain region, west of the Cagayan basin.

Generally, lineaments trend north and braches into north-east and north-west direction. West of the Cagayan basin, the intensity of lines is higher in comparison to the eastern region.

Strong and clear lineaments are traceable for a about a hundred kilometer long and continue more as many small lineaments of several kilometers from major lines.

The trends, distribution and extent of interpreted lineaments correspond to the major elements in Northern Luzon. In Cordillera region, these lines represent the infolded and faulted of Miocene rocks, and, in Sierra Madre and Caraballo region, these represent NE-SW normal faults. In Magat and Chico rivers area, these lineaments comprise the faulted and folded belt of the region.

The most strong and clear lineaments, that lie in the west-southern part of Northern Luzon, were interpreted as part of the Philippine Fault Zone which runs from Lingayen Gulf through Dingalan Bay.

3.3 General Geology of Cagayan River

(1) Physiography

The Cagayan river basin is a north-south trending asymmetrical trough circumscribed by a channel in the north and major mountain ranges along the south, east and west sides. The basin measures about 240 km long and 85 km wide. It underlies an area of approximately 20,000 km². It is gently sloping and shallow along the eastern side but deep and highly disturbed along the western flank. The basin can be divided into two main physiographic regions namely the mountainous regions and highs are composed of great mountain ranges: Central Cordillera, Sierra Madre and Caraballo Mountains.

(2) Stratigraphy

The stratigraphy of the whole Cagayan valley is not necessarily unified at present, because rock facies vary show considerable lateral variation. Thus, stratigraphy is mainly adopted from Darkee and Pederson.

Rocks in Cagayan basin are represented by a thick sequence of pre-Tertiary metamorphic and plutonic rocks. These were uplifted by igneous intrusions during the Late Tertiary and Quaternary. An Oligocene to Pliocene Marine section occupies the main basin area. It is up to 9,000 m thick along the flanks but attains a maximum thickness of over 12,000 m at the center of the basin. The Oligocene section consists of basic lava flows, metamorphosed conglomerate, tuff breccia and tuffaceous sandstone and siltstone. Late Pleistocene to Recent sands, silts, gravels and pyroclastics are found generally in the central basin area and the sequence is entirely non-marine.

Rocks exposures in the area are divided into West side and East side of the Cagayan valley and they are classified according to rock formation.

From top to bottom they are:

West Side Holocene Deposit Awiden Mesa Formation Ilagan Formation Mabaca River Croup Sicalao Limestone Basement Complex East Side Holocene Deposit Awiden Mesa Formation Ilagan Formation Callao Limestone Gatangan Creek Formation Basement Complex

HOLOCENE DEPOSIT

Holocene deposit consists of alluvium, volcanic material and terrace gravel. Alluvium materials are gravel, sand, clay and other fluviatiles, they are generally found along the river channel and flood plains. Terrace gravels are particularly well developed along the Chico river at Tabuk, Kalinga where at least three levels of terraces demonstrate recent isostatic adjustment or changes in base level. Other terraces occur near Butigui on the Siffu river, along the Magat river at Oscariz Isabela and of Jones Isabela.

AWIDEN MESA FORMATION

Awiden Mesa Formation is nearly equivalent to Tabuk Formation on the geological map the Figure 3.3.4. This formation is distributed in the central plain of Cagayan Valley.

This formation is composed of welded tuffs and tuffaceous sediments of a dacitic type. It is characterized by the presence of bipyramidal quartz phenocrysts (generally less than 5%) and euhedra of hornblends and sodic feldspar. The tuffaceous sediments are various shades of tan and gray and show variable clast sizes and rounding, though they maintain their homogeneity of composition. The quartz euhedra commonly form an erosional residue with a sparkling appearance to the surface of the ground where the formation is present.

The Awiden Mesa Formation is overlain by Holocene deposit and uncomformably overlies folded strata of Tertiary age in the type area. The maximum thickness is found at Awiden Mesa, 6 km northwest of Lubuangan, Kalinga sub-Province, Mountain Province. Scattered sections of the formation in Kalinga show that it is a valley-filling deposit unconformable on an irregular surface of deformed Miocene rocks. At Awiden Mesa, the tuff beds attain a thickness of at least 300 m.

ILAGAN FORMATION

Ilagan Formation extends on the hilly lands which make a margin to the central plain of the Cagayan valley.

This formation is commonly seen as rock exposures along the Ilagan river. This formation is sandstone which exhibits the typical fluviatile depositional nature. No detailed description of the formation is given because great lateral lithological variations occur in short distances. The best exposures occur along the Tao Tao, Siffu and Mallig rivers. A very good exposure is also present on the flanks of the Pangul anticline, which is breached to the Buluan formation. The uppermost units of the Ilagan are well exposed on the Enrile and Tumauini anticlines.

MABACA RIVER CROUP

Mabaca River Croup is nearly equivalent to Lubuagan Formation which makes a mountainous zone extending over the outer margin of Cagayan valley.

This group represents all strata occurring west of (below) the Ilagan Formation escarpment near the mouth of the Mabaca river and east of (above) the Sicalao Limestone. This formation is a thick terrigeneous sequence of lutites and interbedded arenites and locally some pyroclastics. The rocks of the Mabaca River Group could be subdivided, from top to bottom, into:

Buluan-Formation Balbalan-Formation Asiga - Formation

BULUAN FORMATION

The Buluan Formation consists mostly of siltstones while part of it is a shaly structure. Finely grained intercalated sandstones, and small pebble conglomerates occur. The individual beds do not exceed 50 cm at the bottom of the formation, and 15 cm on the upper part. Depending on the degree of lithification, the silt/claystones can further be divided into resistant and non-resistant units with regard to weathering and erosion.

BALBAIAN FORMATION

The Balbalan Formation is a greywacke, sandstone/siltstone sequence, with a thickness of 1,165 m at its type locality. The sandstones range from fine to coarse-grained, with inclusions of pebble zones. Few conglomerates occur with pebble size mafic igneous clasts. Sandy claystone, with sandstone intercalations, form the transition to the overlying Buluan formation. Occasionally, well-indurated claystones can also be found in the lower part. From the Macaba river to the south of the Chico river region, the Balbalan Formation contains more conglomerates than in a typical section. The fraction of sandstone decreases respectively. Claystone, siltstone, and sandy siltstone layers occur more frequently, however, they are not as well indurated, and thus prone to loose their strength

when exposed to the surface. Although the Balbalan Formation is a mappable unit throughout the eastern part of Kalinga, its upper and lower boundaries are difficult to distinguish by their facies changes. Broader transition zones occur to the south, which can often be misinterpreted as the underlying Asiga, or the overlying Buluan Formation

ASIGA FORMATION

The Asiga Formation, partially overlying the basement, forms the oldest unit of the Mabaca River Group. It is distinguished by its high claystone portion of 60%, with the remaining 40% being arenites. The lithogic beds are thinly stratified. They are best exposed along the Pasil river, from Ableg to the east, and in the western part of the region. Detailed investigation at the Pasil river bridge determined that this part is not the upper portion of the Asiga Formation. Despite the alternation of siltstone/sandstone layers, the siltstone content including all siltstone laminae in sandstone beds, does not exceed 15%.

SICALAO LIMESTONE

Sicalao Limestone is rather continuously scattered at western and southern-southeastern margin of Cagayan valley. This is called Ibulao Limestone at the southern portion of Lagawe.

This limestone is a massive-bedded calcarenites and calcirudites. With the Cagayan valley, the Sicalao Limestone is correlative with the Callao Limestone on the margins of the Baggao embayment, along the north flank of the Casiggayan nose, and the northeast peninsula of Luzon. The formation can be traced nearly continuously along the west margin of the Cagayan valley from Luna, Apayao, near the north coast, southward to the vicinity of Salegseg, Kalinga. In the latter region the formation is absent because of Miocene faulting and erosion and subsequent Neogene tectonic activity. North of the Saltan river at Salegseg is a large gently east-dipping limestone mass (Mt. Kilkilang), and in the Saltan river at the south and the Mabaca river at the north there is no limestone present.

CALLAO LIMESTONE

Callao Limestone is distributed at the east margin of the Cagayan valley.

The type area for the Callao Limestone is at Barrio Callao, Cagayan. The section described here was measured at Callao Canyon in which right bank, there are significant cave formations like the Callao Cave, along the Pinacanauan de Tuguegarao river. The formation is a calcarenite, it is thin-bedded at the top and becoming more poorly bedded and thicker-bedded in lower part. The Callao limestone south of the type area is the age equivalent of the middle part of the

Mabaca river group of the west of the valley and the Baggao embayment. The basal part of the limestone, which migrates downward across the time lines north of the type area toward the Baggao embayment, is the age equivalent of progressively lower and lower units of the Mabaca River Croup, until the Callao Limestone of Intal river region on the south margin of the Baggao embayment is the age equivalent of the Sicalao Limestone of the west margin of the Cagayan valley.

GATANCAN CREEK FORMAT I ON

Gatangan Creek Formation is distributed at the outer margin of Cagayan valley, and it is the age nearly corresponding to lower section of Lubuagan Formation.

The Gatangan Creek formation is composed of greywacke sand-stone and layers of claystone. It is overlain by the Callao limestone and underlain by andesite flows of the basement complex. Exposures along the Gatangan Creek are excellent and nearly continuous and the formation is 1,010 m thick. The Gatangan Creek formation is the age equivalent of the Asiga and Balbalan formation of the lower Mabaca River Group. It is lithologically similar to the Asiga formation in some respects but has a greater percentage of coarse clastics.

BASEMENT COMPLEX

Basement complex is distributed over the mountainous land surrounding the Cagayan valley.

Basement complex is composed of some type indistinctly bedded mafic agglomerates, or an interbedded sequence of pyroclastics and indurated sedimentary rocks. The anticlinal peninsula area southeast of Capoe Engano contains an estimated thickness of 2,440 m of interbedded pyroclastics and "metasediments". Along the western margin of the valley mafic flows, agglomerates, some thin indurated greywackes and conglomerates occur in the basement complex beneath sedimentary section. These rock types are exposed in every major drainage feature, such as the Abulug, Matalag, Mabaea, Saltan and Pasil rivers. In the southwestern margin of the Cagayan valley and around the isolated outcrops of sedimentary rocks of the fault-preserved Kiangan-Ibulao Gato area, the mountains are composed of metasediments and interbedded igneous rocks.

In most places it was also observed that the indistinctly bedded basement rocks have a similar structural attitude to the overlying clastics or carbonates of the sedimentary section. Some exceptions to this general conformity were found along the south side of the Baggao embayment (Intel river) where there is nearly a right-angle convergence of strikes between the basement and the overlying limestones.

(3) Folding

Folding, faulting, and intrusion by igneous rocks are well displayed in the Kalinga foothills and the Cagayan anticlinal belt. The intensity of folding in these areas decreases from west to east. The folds of the Kalinga foothills are very large, in part nearly isoclinal, and much broken by normal and strike-slip faults. Andesite-diorite stocks are present. It is not improbable that these folds are slightly older than those on the east within the Cagayan Anticlinal belt.

The folds of the Cagayan anticlinal belt form three general groups.

The folds of the Cagayan anticlinal belt form three general groups. The western trend extends from Butigui anticline northward to Camcamalog anticline. These folds have weak west flanks and in the case of Camcamalog some asymmetry in the west is present. The next trend on the east, extending from the Tumauini anticline N30°W to the Tuao fold, consists of folds 15-20 km long with vertical closures of 700-1,300 m on beds within the Ilagan formation. The folds of this trend are characterized by high-angle reverse faults along their east flanks. The component folds of this trend are arranged en echelon from southeast to northwest either by folding (Tumauini-South Tumauini) or epi-anticlinal strike-slip faulting (Dagupan-North Dagupan).

The third group includes all folds in the northern and eastern third of the Cagayan anticlinal belt. The easternmost folds of this area are asymmetrical toward the east, e.g., Enrile anticline, whose west flank dips 5° - 10° and whose east limb is vertical. The Piat anticline in the western part of this area is asymmetrical toward the west as opposed to the eastward asymmetry of the Faire anticline, which is separated from Piat anticline by the Tabang syncline. This is the area where the fold trends change in direction from north south to east-northeast.

(4) Intrusions

Along a trend bearing N 20°W in the Kalinga Foothills are six andesite-diorite intrusives. West of the Pasunglao ferry on the Chico river are three intrusives. They seem to bear no or Nanong intrusive has a diameter of about 3,000 m and is emplaced within the northwest-dipping limb of the Tappao syncline. Northeast of and associated with this stock is a well-defined group of radial tension faults. The Mambucayan intrusive on the east is about 1,000 m in diameter and is located in the axial region of the isoclinal beds of the Mambucayan nose. The position of this stock may be only fortuitous and its true relation may be that both it and the

small Dalimuno intrusive (750 m in diameter), the middle one of the three, may be located along a radial tension fracture which extended eastward from the Nanong intrusive. Metamorphic aureoles do not extend beyond 50 m into the sediments adjacent to the intrusives.

Another large intrusion is present along the Mabaca river west of Asiga, Kalinga. Southward, intrusions have been recognized in the Pinto nose and three small intrusives are located at Cordon, Nueva Vizcaya. All of these intrusives lie on the general trend of N 20°W.

(5) Faults

The major faults of the Cagayan valley are shown in Figure 3.3.4. In general, there are two major zones of faulting. One of these extends along the west margin of the valley from the vicinity of Aglipay, Nueva Vizcaya, northward to Talifugo, Apayao. There this fault zone narrows, leaves the sedimentary region, and continues north-northwest in the basement rocks for 80 km or more. The second important trend of faulting is along the south margin of the Sicalao-Casiggayan high. The faults of these two major zones of importance are either wrench faults, or a combination of the two different types of movement at different periods of time.

The Dummun river fault zone along the south margin of the Casiggayan nose is one of the most important ruptures, as it separates the Sicalao-Casiggayan high and Aparri Plain block from the southern part of the Cagayan valley. This fault is defined by surface mapping and is characterized by some hot springs along its trace. It is indicated on Aerial photographs by prominent lineaments that continue eastward across the Sierra Madre to the east coast. Bathymetric data support the supposition that this zone continues north and east into the Pacific for a short distance. This east-west trend is approximately in the same latitude as the eastward offset in the coastline of northeastern Luzon. This suggests that the offset is the manifestation of right-lateral movement along the Dummun river fault zone which may have begun in late Miocene time and had recurrent movement in Pleistocene time.

This fault possibly had its origin as a normal fault in middle or late Miocene as demonstrated by seismic data that indicate possibly 1,000 m or more of late Miocene strata on the downthrown (south) side of the fault near Gattaran, Cagayan. The change in anticlinal trend, from north-south in the latitude of Tuguegarao to northeast-southwest in the Paret river area suggests some possible drag effect in late Pliocene time of the southern Cagayan valley block against the Aparri Plain block along the Dummun river fault zone.

Of the faulting along the west margin of the Cagayan valley, the fault systems in the Kalinga Foothills are most accessible, best exposed, and because of the maximum amount of Miocene rocks known to occur in this region, it is probably the most important region to consider relative to the faulting along the west side. One of theses fault zones, the Cogowi Creek fault is 3 km wide in the Mallig river area, being comprised of much distorted, faulted, and triturated Miocene sediments. It is in this zone that numerous small oil and gas emanations are found. This faultzone separated the Kalinga Foothills from the Cagayan anticlinal belt. At the Pasunglao ferry near Tabuk, Kalinga, this zone has about 4,000 m of throw and indirect evidence indicates a strike-slip component of more than 6 km as demonstrated by offset in anticlinal axes and Ilagan formation outcrops of the Tuga nose and Tapac anticline. The total length of the Cogowi Creek fault zone is about 50 km and it is upthrown on the west.

The western part of the Kalinga Foothills has two major fault zones that trend north-south, of which the northernmost is the Kalinga fault zone and the southern one is the Chico river fault zone. The combined length of these two zones exceeds 80 km. The west side is upthrown along both zones. In the Pasil river bridge area, north of Lubugan, Kalinga, an imbricate anastomosing relation occurs between these two zones. Combined strike-slip movement on the faults has offset (left-lateral) the syncline at Lubugan town by 10 km. In general, the Kalinga Foothills region appears to have moved up and north relative to the Cagayan anticlinal belt.

CHAPTER 4 GEOTECHNICAL AND MATERIAL INVESTIGATION

4.1 General

In order to clarify the geotechnical properties of the Magapit and Nasiping narrows, where excavation of the original ground is prospective for widening of the present river channel, the core boring was carried out. In the bore holes, the standard penetration test and field permeability test were carried out and the undisturbed samples were taken for the laboratory soil test.

In order to clarify the foundation bed condition in Tuguegarao, where some flood control structures are prospective, three core borings of 20 m depth each were carried. In the bore holes, the standard penetration test and field permeability test were carried out and the undisturbed samples were taken for the laboratory soil test.

In order to locate the candidates of the borrow pits for the levee embankment material, each five test pits of 3 m depth were excavated in Tuguegarao and Cabagan, where the embankment levees are prospective, to clarify the subsurface condition and to examine availability of the earth material for the levee embankment. From the each test pit, the samples were taken for the laboratory soil test.

The quantity of the investigation is shown in Table 4.1.1.

Other than the investigation mentioned above, the material sources for concrete aggregates and boulders were investigated mainly with the data prepared by the Revision I Office of DPWH. Some of the material sources were reconnoitered.

4.2 Geotechnical Properties of Magapit and Nasiping Narrows

4.2.1 Magapit Narrow

The geology of Magapit narrow area consists of the alluvial plane of clay and sand and the hills of the marl and mudstone.

Two (2) core borings of 50 m depth each were sunk at the locations as shown on Figure 3.6.1. The boring logs are shown on Figure 3.7.1.

At the bore hole MB-1, the clay layer is distributed from the ground surface to the depth of 22 m, the soft rock of marl is distributed from 22 m depth to 38 m and the fresh and hard mudstone is distributed below the marl. At the bore hole MB-2, the clay layer is distribute from the ground surface to the depth of 18 m, the fine

sand layer is distributed from 18 m depth to 34 m and the fresh and hard weathered marl is distributed below the fine sand.

The N-values of the clay layer range from 6 to 35 and most of them are higher than 8 which is generally the boundary between the medium-hard layer and the stiff layer as shown on Table 4.2.1. Therefore no serious problem is foreseen in the cut slope for widening of the river channel. The N-values of fine sand layer ranges from 6 to 44 and 70% of them are less than 20 which is the boundary between the medium layer and the dense layer. If this layer becomes the objective of the excavation, some slope stability measures will be required. This layer, however, is situated at the deeper portion and accordingly the slope stability measures will be limited to this section. The further investigation, however, will be necessary in order to clarify the distribution status of this layer in the detailed design stage.

The permeability coefficients of the clay layer range from 10^{-4} to 0 cm/sec and those of the sand layer from 10^{-2} to 10^{-5} cm/sec as shown in Table 4.2.2. These permeability coefficients are reasonable and no trouble is judged to occur in the cut slope.

The laboratory soil test result is shown in Table 4.2.3. The index property test result is judged to be reasonable. With regard to the triaxial compression test result of the consolidated-undrained and consolidated-drained conditions, however, the cohesions are judged to be to high. For the design values of the design in the feasibility study stage, the following values are recommended.

Condition	Cohesion	Interna	al friction degree
Uncosolidated-	undrained	80 kPa	5 degrees
Consolidated-u	ndrained	10 kPa	25 degrees
Consolidated-d	rained	0 kPa	30 degrees

The rock test result is shown in Table 4.2.4. Most of the bulk densities range from 2.06 to 2.386 ton/m³ and judged to be reasonable. For the design value, 2.30 ton/m³ is recommended. Absorptions ranges from 5.05 to 9.39% and judged to be reasonable from the compression strength. The unconfined compression strengths range from 38.8 to 141.7 kPa and this rock is judged to be excavated without blasting. The rock distributed in the hilly area, however, is judged to be necessary for blasting for excavation. Some blasting is recommended to be taken into account for channel widening excavation although the amount will depend on the alignment of the channel widening. The elastic moduli range from 4,480 to 10,345 kg/cm² and are judged to be too high from the compression strength. For the design value, 2,000 kg/cm² is recommended from the compression strength.

The Poisson's ratios range from 0.26 to 0.40 and most of them are reasonable and 0.35 is recommended for the design value.

4.2.2 Nasiping Narrow

The geology of the Nasiping narrow area consists of clay, silt and sand in the alluvial plane and marl and mudstone in the hills.

Five (5) core borings of 50 m depth each were sunk at the locations as shown on Figure 3.6.2. The boring logs are shown on Figure 3.7.2.

At the bore hole NRB-1, the clay layer is distributed from the ground surface to the depth of 7 m and the fine sand layer is distributed from the depth of 7 m to the depth of 50 m (the bore hole bottom). At the bore hole NLB-1, the decomposed mudstone is distributed from the ground surface to the depth of 3 m, the moderately-highly weathered mudstone is distributed from 3 m depth to 16 m and the decomposed mudstone is distributed below the weathered mudstone intercalated with the weathered mudstone of a few meters thickness. At the bore hole NLB-2, the silty sand layer is distributed from the ground surface to the depth of 2 m, the fine sandy/clayey silt layer is distributed from 2 m depth to 40 m and the fine silty sand is distributed below the silt layer. At the bore hole NLB-3, the clay layer is distributed from the ground surface to the depth of 30 m and the alternation of decomposed marl and mudstone is distributed below the clay layer. At the bore hole NLB-4, the fine silty sand layer is distributed from the ground surface to the depth of 3 m, the sandy clay layer from 3 m depth to 11 m, the sandy silt layer from 11 to 20 m, the sandy clay from 20 to 32 m and the and silty/clayey sand layer from 32 to 50 m (the bore hole bottom).

The N-values of the decomposed rock layer is more than 30 and judged to be hard as shown on Table 4.2.1. The N-values of the clay layer range from 3 to 30 and most of them are higher than 8 which is generally the boundary between the medium-hard layer and the stiff layer. The N-value of 3 is recorded at 10 m depth and judged to be caused by insufficient cleaning of the temporary bore hole bottom. Therefore no serious problem is foreseen in the cut slopes for widening of the river channel. The N-values of fine sand layer except at depths of $7 \sim 14$ m in the bore hole NRB-1 and $0 \sim 3$ m in the bore hole NLB4 are more than 20 and no serious stability problem will occur except erosion problem. The low N-values in the bore hole NLB-4 is not a serious problem since they are judged to have been measured at the quite limited deposit. The low N-values in the bore hole NRB-1, however, is judged to have the potential to cause some serious slope stability problem when it is exposed as an unsupported cut slope. If this layer becomes the objective of the excavation, some slope stability measures will be required. This layer, however, is situated at the deeper portion and accordingly the slope stability measures will be limited to this section. The further investigation, however, will be necessary in order to clarify the distribution status of this layer in the detailed design stage. The N-values of the silt layers range from 4 to 31. The low N-values are judged to have been caused by the insufficient cleaning of the temporary hole bottom since all of them are recorded at considerably deep points. Therefore, no serious stability problem will occur in the cut slope in the silt layer.

The permeability coefficients of the clay layer range from 10^{-3} to 0 cm/sec, those of the sand layer from 10^{-3} to 10^{-5} cm/sec, those of the silt layer 10^{-2} to 0 cm/sec, and those of the decomposed/weathered rock 10^{-3} as shown in Table 4.2.2. Most of these permeability coefficients are reasonable and no trouble is judged to occur in the cut slope.

The laboratory soil test result is shown in Table 4.2.3. The index property test result is judged to be reasonable. With regard to the triaxial compression test result of the consolidated-undrained and consolidated-drained conditions, however, the cohesions are judged to be to high. For the design values of the design in the feasibility study stage, the following values are recommended.

Condition	Cohesion	Interna	al friction degree
Uncosolidated-	undrained	80 kPa	5 degrees
Consolidated-u	ndrained	10 kPa	25 degrees
Consolidated-d	rained	0 kPa	30 degrees

The rock test result is shown in Table 4.2.4. The bulk densities range from 1.87 to 2.08 ton/m³ and judged to be reasonable. For the design value, 2.00 ton/m³ is recommended. Absorptions ranges from 13.9% to 18.4% and judged to be reasonable for the compression strength. The unconfined compression strengths range from 10.5 to 29.4 kPa and this rock is judged to be excavated without blasting. The rock distributed in/nearby the hilly area, however, is judged to be necessary blasting for excavation. Some blasting is recommended to be taken into the account in the channel widening excavation though it is dependent on the alignment of the channel widening. The elastic moduli range from 1,190 to 6,024 kg/cm² and are judged to be too high from the compression strength. For the design value, 1,200 kg/cm² is recommended for the compression strength. The Poisson's ratios range from 0.22 to 0.30 and most of them are reasonable and 0.30 is recommended for the design value.

4.3 **Properties of Foundation Bed in Tugegarao**

The geology in and around Tuguegarao consists of the clayey soil in the hilly area and the sand and sand/gravel in the alluvial plain. The sand/gravel is distributed along the Tuguegarao river and the right bank of the Cagayan river at the vicinity of the confluence with the Tuguegarao river.

Three core borings of 20 m depth each were carried out at the location as shown on Figure 3.8. The boring logs are shown on Figure 3.9.

At the bore hole TBH-1, the sandy clay layer is distributed from the ground surface to 1.5 m depth, the sand and gravel layer with some cobble from 1.5 m to 8 m and the sand layer from 8 m to 20 m (the hole bottom). At the bore hole TBH-2, the silty clay layer is distributed from the ground surface to 20 m depth (the hole bottom) and the silty sand and gravel layer with cobble and boulders is intercalated from 0.6 m depth to 1.7 m. At the bore hole TBH-3, The silty clay layer is distributed from the ground surface to 2 m depth and the fine sand layer from 2 m to 20 m (the hole bottom).

The N-values of the sand layer ranges from 9 to 29, the most of them are more than 15 and there are no problem for the foundation of the levee embankment as shown on Table 4.2.1. Depending on the load intensity, however, the foundation piles or some special foundation structures will be required for the concrete structures. N-values of the clay range mainly from 11 to 22 and judged to be the stiff base. The clay layer also is judged to be sufficient to support the levee embankment but the foundation piles or some special foundation structures may be required for the heavy structures although it depends on the load intensity.

The permeability coefficients of the sand and sand/gravel layers range from 10^{-3} to 10^{-4} cm/sec as shown on Table 3.4 and is judged to be reasonable. No seepage measure will be generally required for the foundation. Those of the clay layer range from 10^{-3} to 10^{-5} cm/sec and are judged to be too high since a considerable numbers of them are on the order of 10^{-3} cm/sec. This is judged to have been caused by lack of water-tightness between the casing pipe and the original ground. No seepage measure will be generally required for the foundation.

The laboratory soil test result is shown in Table 4.2.3. The index property test result is judged to be reasonable. With regard to the triaxial compression test result of the consolidated-undrained, however, the cohesions are judged to be to high. For the design values of the design in the feasibility study stage, the following values are recommended.

Condition	Cohesion	Interna	l friction degree
Uncosolidated-un	drained	80 kPa	5 degrees
Consolidated-und	rained	10 kPa	27 degrees

4.4 Properties of Embankment Materials in Tuguegarao and Cabagan

4.4.1 Tuguegarao

Six (6) test pits of 3 m depth each were excavated at the locations as shown in Figure 3.10.1. The logs of the test pit are shown on Figure 3.11.1

In all the test pits except the test pit TP-T2, the clay layer, which is suitable for the levee embankment, is distributed. Among them, the material at TP-T4 is the best since it contains the sand and gravel. The soil distributed around the TP-T2 also is judged to be usable for the levee embankment with some erosion measures since it is classified to the non-plastic silt which is vulnerable to erosion.

The laboratory test result is shown in Table 4.4.1. The test result, except the triaxial compression test under the unconsolidated-undrained condition, is judged to be acceptable since most of the cohesions and some of the internal friction angles are judged to be too high from our experience. For the design parameters, the following values are recommended.

Condition	Cohesion	Internal friction degre	ee	
Uncosolidated-undrain	ned:	each test values		
Consolidated-undraine	ed: 10 k	Pa 25 degrees		

Abundant fine sand is distributed along the river. This sand is recommended to be used inside of the levee embankment to save the amount of the expensive clay material because of the long distance required for transportation of the higher levee embankment. The minimum width of the clayey material is recommended to be 5 m on the river side and 3 m on the land side.

4.4.2 Cabagan

Six (6) test pits of 3 m depth each were excavated at the locations as shown on Figure 3.10.2. The logs of the test pit are shown on Figure 3.11.2

In all the test pits except the test pit TP-C2, the clay layer, which is suitable for the levee embankment, is distributed. Among them, the material at TP-C1 is the best since it contains the sand and gravel. The soil distributed around the TP-T2 is also judged to be usable for the levee embankment with some erosion measures since it is classified as non-plastic silt which is vulnerable to erosion.

The laboratory test result is shown in Table 4.4.1. The test results, except the triaxial compression test under the unconsolidated-undrained condition, are judged to be acceptable since most of the cohesions and some of the internal friction angles are judged to be too high from our experience. For the design parameters, the following values are recommended.

Condition	Cohesion	Internal friction	degree
Uncosolidated-undrain	ned:	each test values	
Consolidated-undraine	ed: 10 k	Pa 25 deg	rees

Abundant fine sand is distributed along the river. This sand is recommended to be used on the inside of the higher levee embankment. The minimum width of the clayey material is recommended at 5 m on the river side and 3 m on the land side.

4.5 Material Sources for Aggregate and Boulder

The material source map for the concrete aggregate and boulders prepared by DPWH Region 2 Office are shown on Figures 3.12.1 and Figure 3.12.2. On the figures, the available quantity is presented. Some of them have already been consumed. According to the site reconnaissance, however, it appears that the materials are being supplied by the floods every year and there is an abundant amount of the materials.

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Tables

Tabe 2.1.1 List of Data Collected

Geological Map	
Geological Map of Cagayan River Basin (Scale: 1/500,000)	
Geological Map of Aparri Quadrangle (Scale: 1/50,000)	
Geological Map of Buguey Quadrangle (Scale: 1/50,000)	
Geological Map of Gattaran Quadrangle (Scale: 1/50,000)	
Geological Map of Tumauini Quadrangle (Scale: 1/50,001)	
Geological Map of Illagan Quadrangle (Scale: 1/50,002)	
Geological Map of Mallig Quadrangle (Scale: 1/50,003)	
Geological Map of Loxas Quadrangle (Scale: 1/50,004)	
Geological Map of Cabatuan Quadrangle (Scale: 1/50,005)	
Geological Investigation Report	
Soil Investigation/Proposed San Pablo Bridge ISABERA	
Soil Investigation/Proposed Naguilian Bridge ISABERA	
Soil Investigation/Proposed Tuguegarao Submerged Bridge CAGAYAN (1)	
Soil Investigation/Proposed Tuguegarao Submerged Bridge CAGAYAN (2)	
Boring Log	
Marana II Bridge	
Santa Bridge	
Aguiguican Bridge	
Cansan Bridge	
Carig III Bridge	
Malabbac Bridge	
Iguig Bridge	
Bobogan Bridge	
Baculud Amulong Bridge	
Baculi Bridge	
Nalbo Bridge	
Balasig Bridge	
Material (Concrete Aggregates) Source Maj	
Package VI A (Upstream Area)	
Package VII A (Midstream Area)	
Package VIII A (Downstream Area)	
Cagayan Province	
Isabela Province	
Directory of Mines and Quarries in Regeon 02	
Land Use Map	
Barangay Carig Norte Tuguegarao City	
Barangay Carig Sur Tuguegarao City	

Work Item		Cut	Slope	Foundation	Embankment Material	
		Magapit	Nasiping	Tuguegarao	Tuguegarao	Cabagan
	Core Boring	50 m x 2 = 100 m	50 m x 5 = 250 m	20 m x 3 = 60 m	-	-
	Test Pit Excavation	-	-	-	3 m x 6 = 18 m	3 m x 6 = 18 n
	Standard Penetration Test (nos)	72	193	54	-	-
Field Works	Field Permeability Test (nos)	19	135	50	-	-
	Perforated Pipe Installation (m)	100	250	-	-	-
	Undisturbed Sampling (nos)	4	10	5	-	-
	Sampling of Disturbed Soil	-	-	-	6	6
	Specific Gravity (nos)	4	10	6	6	6
	Noisture Content (nos)	4	10	6	6	6
	Grain Size Analysis (nos)	4	10	6	6	6
	Plastic/Liquid Limits (nos)	4	10	6	6	6
Laboratory Soil Test	Proctor Test (Compaction) (nos)	-	-	-	6	7
Laboratory Soli Test	Unconfined Compression (nos)	4	10	5	-	-
	Triaxial Compression (UU*) (nos)	3	10	5	6	6
	Triaxial Compression (CU**) (nos)	1	3	1	6	6
	Triaxial Compression (CD***) (nos)	1	2	-	-	-
	Consolidation	-	-	6	-	-
Laboratory Pock Test	Bulk Density & Absorption (nos)	6	6	-	-	-
Laboratory Rock Test	Unconfined Compression**** (nos)	6	6	-	_	-

 Table 4.1.1 Summary of Geotechnical Investigation Work Quantity

Note:

UU*: Uncosolidated- Undrained Condition

CU**: Cosolidated- Undrained Condition

CD***: Cosolidated- Drained Condition

****: with measurement of Elastic Moduli and Poisson's Ratio

Nacining		Maganit		Tuquegarao						
D (1	NIDD 1		Nasiping			Ivias			uguegan	
Depth	NBR I	NLB I	NBL 2	NLB 3	NLB 4	MB I	MB 2	TBHI	TBH2	TBH3
(m)	N	N	N	N	N	N	N	N	N	N
$0.70 \sim 1.00$	10	29	16	20	3	11	16			
$1.70 \sim 2.00$	12	46	12	26	5	12	9	10	14	11
$2.70 \sim 3.00$	12	40	15	14	8	12	16		22	9
$3.70 \sim 4.00$	12		14	16	12	24	9		16	11
4.70 ~ 5.00	11		12	7	11	22	18		14	13
5.70 ~ 6.00	12		13	5	9	23	11		11	14
6.70 ~ 7.00	12		20	7	9	8	4		13	15
7.70 ~ 8.00	12		24	8	9	6	10		17	17
8.70 ~ 9.00	12		34	8	10	9	10	20	13	20
9.70 ~ 10.00	12		33	3	9	10	11	22		22
10.70 ~ 11.00	15		28	6	21	9	7	20	14	19
11.70 ~ 12.00	16	35	48	6	6	7	7	17	12	21
$12.70 \sim 13.00$	17	78	105	10	12	8	12	19	15	23
13.70 ~ 14.00	20	67	55	7	17	9	9	18	17	23
14.70 ~ 15.00	21	64	65	8	5	9	8	15	16	24
15.70 ~ 16.00	21		5	11	4	10	40	16	6	24
$16.70 \sim 17.00$	20		24	11	6	6	15	16	3	25
$17.70 \sim 18.00$	22		26	18	7	6	44	17	7	27
$18.70 \sim 19.00$	21		28	17	20	7	12	19	8	28
$19.70 \sim 20.00$	23		17	14	19	6	10	19	17	29
$20.70 \sim 21.00$	23	84	19	29	24	35	7	17	17	
$20.70 \sim 22.00$	23	77	15	12	21	113	25			
$21.70 \sim 22.00$	24	86	19	63	<u></u> <u> </u>	115	11			
$22.70 \approx 23.00$	20	80	30	8	16		16			
$23.70 \sim 24.00$	31		25	35	0		10			
$24.70 \approx 25.00$	30		23	30	14		7			
$25.70 \sim 20.00$	28		10	14	21		/			
$20.70 \sim 27.00$	26		19	22	10		10			
$27.70 \sim 28.00$	20		10	23	10		10			
$28.70 \sim 29.00$	27		10	20	16		12			
$29.70 \sim 30.00$	20		13	05	55		10			
$30.70 \sim 31.00$	20		12	65	55		52			
$31.70 \sim 32.00$	27		/	70	20		32			
$32.70 \sim 33.00$	37		12	/0	32		20			
$33.70 \sim 34.00$	42		1/	85	40		39			
$34.70 \sim 35.00$	43		20		<u>80</u>		122			
$35.70 \sim 30.00$	4/		30 50		50		12			
$30.70 \sim 37.00$	44		38		54 27		125			
$3/./0 \sim 38.00$	49		02 75		<u> </u>		125			
$38.70 \sim 39.00$	49		/5		41		6/			
$39.70 \sim 40.00$	54		58		38		84			
$40./0 \sim 41.00$	55		51		47		46			
$41.70 \sim 42.00$	61		55	ļ	46		98			
$42.70 \sim 43.00$	/3		60		60		/4			
$43.70 \sim 44.00$	/0		38		/1		80			
$44.70 \sim 45.00$	85		42		52		83			
$45.70 \sim 46.00$	7/8		63		34		70			
$46.70 \sim 47.00$	80		40		26		65			
$47.70 \sim 48.00$	81		27		28		60			
48.70 ~ 49.00	84		31		28		81			
49.70 ~ 50.00	88		35		32		74			

 Table 4.2.1 Record of Standard Penetration Test

	Nasiping				Magapit		Tuguegarao			
Depth (m)	NRB 1	NLB 1	NLB 2	NLB 3	NLB 4	MB 1	MB 2	TBH1	TBH2	TBH3
1	0.00E+00	1.03E-03			7.00E-05					0.00E+00
2	0.00E+00	5.57E-04			5.50E-05			2.19E-03		1.05E-04
3	0.00E+00	3.47E-04			1.21E-04					2.00E-04
4	0.00E+00	2.85E-05	1.70E-04		1.80E-05					3.80E-04
5	0.00E+00			0.00E+00	7.00E-06	0.00E+00	8.20E-05			5.45E-04
6	3.80E-04				6.00E-06				6.10E-05	3.63E-04
7	9.52E-04				5.40E-05			1.52E-04	3.84E-04	3.80E-04
8	1.14E-03				4.80E-05			7.90E-05	1.45E-03	4.00E-04
9	2.38E-03				9.60E-05			7.90E-05	1.25E-03	1.05E-04
10	9.52E-04		1.35E-03	2.17E-03	4.80E-05	0.00E+00	0.00E+00	5.50E-05	1.34E-03	1.24E-03
11	2.60E-03				4.50E-05			7.10E-05	1.10E-03	1.77E-03
12	4.09E-03	1.67E-04			2.40E-04			5.40E-04	7.42E-04	1.39E-03
13	5.71E-03	3.46E-05			4.80E-05			3.40E-05	1.18E-03	1.80E-03
14	9.04E-03	6.10E-05			3.80E-05			6.90E-05	8.88E-04	1.78E-03
15	8.76E-03	2.50E-05	1.60E-03	1.36E-03	4.90E-05	0.00E+00	6.30E-04	1.36E-04	4.44E-04	2.50E-03
16	7.84E-03	2.60E-04			6.00E-06			4.50E-05	4.00E-04	2.40E-03
17	7.59E-03				3.00E-06			6.80E-05	1.15E-03	2.90E-03
18	7.29E-03				6.00E-06			7.40E-05	4.12E-04	2.40E-03
19	7.13E-03				6.30E-05			5.40E-05	3.52E-04	3.20E-03
20	7.15E-03	8.58E-05	5.80E-04	3.08E-04	3.10E-05	5.40E-04	5.43E-05	7.40E-05	3.19E-04	3.22E-03
21	6.35E-03	2.46E-04			8.40E-05					
22	6.33E-03	3.84E-04			1.70E-05					
23	5.75E-03	3.07E-04			6.00E-06					
24	5.54E-03				6.00E-06					
25	9.54E-03		0.00E+00	9.00E-05	6.00E-06		1.04E-02			
26	5.04E-03				6.00E-06					
27	5.18E-03				3.40E-05					
28	5.27E-03				1.70E-05					
29	5.42E-03				1.00E-05					
30	5.51E-03		0.00E+00	7.30E-05	3.40E-05	2.17E-03	5.06E-04			
31	5.60E-03				1.70E-05					
32	5.73E-03				3.40E-05					
33	5.82E-03	1.48E-04			6.80E-05					
34	5.87E-03				3.40E-05					
35	5.98E-03		4.00E-04		6.80E-05	2.53E-03	1.58E-02			
36	8.43E-03				6.80E-05					
37	4.97E-03				1.05E-04					
38	5.26E-03				1.05E-04					
39	9.10E-03				3.50E-05					
40	8.97E-03		5.75E-04	7.02E-04	7.00E-05	2.02E-03	1.53E-03			
41	9.22E-03				1.05E-04					
42	8.89E-03				7.00E-05					
43	7.71E-03	1.40E-04			1.05E-04					
44	7.69E-03				1.05E-04					
45	9.16E-03		0.00E+00	1.10E-03	1.05E-04	2.00E-03	9.18E-03			
46	8.51E-03				1.05E-04					
47	5.89E-03				3.50E-05					
48	7.54E-03	1.57E-04			3.50E-05					
49	8.09E-03				1.70E-05					
50	8.00E-03		1.64E-03	1.14E-03	1.70E-05	1.78E-03	1.91E-02			

Table 4.2.2 Field Permeability Test Result (unit: cm/sec)

														Unco	nfined		Tri	axial Co	ompress	ion
LOCATION	Boring	Depth (m)	Gs		Gradatio	n	Cc	nsister	ncy	NMC	Co	nsolidat	ion	Comp	ression	U	U	C	U	
	N0.			gravel	sand	silt/clay	LL	PL	PI		e ₀	Pc	Cc	e_{f}	q_u	c _{uu}	ϕ_{uu}	c'	φ'	1
				(%)	(%)	(%)	(%)	(%)	(%)	(%)		(kPa)		(%)	(kPa)	(kPa)	(deg.)	(kPa)	(deg.)	(1
	MB-1A	2.00	2.67	0	4	96	66	28	38	53	-	-	-	10.75	111.4	84	5	67	23	
MAGAPIT	MB-1B	3.00	2.73	0	5	95	44	31	13	49	-	-	-	9.33	66.5	80	3			
Wirton III	MB-2A	2.00	2.58	0	67	33	36	26	10	22	-	-	-	5.23	128.1	71	8			
	MB-2B	3.00	2.69	0	60	40	38	27	11	24	-	-	-	8.30	60.0					
	NLB-1A	2.00	2.61	0	9	91	41	28	13	14	-	-	-	7.69	135.4	64	6			
	NLB-1B	3.00	2.62	0	11	89	54	34	20	17	-	-	-	4.15	133.5	69	4	48	25	
	NLB-2A	2.00	2.59	0	59	41	39	28	11	18	-	-	-	8.57	35.3	87	6			
	NLB-2B	3.00	2.63	0	58	42	37	27	10	27	-	-	-	9.79	42.0	90	5			
NASIDING	NLB-3A	2.00	2.56	0	75	25	35	25	10	12	-	-	-	6.51	32.9	74	6			
MASIFING	NLB-3B	3.00	2.52	0	68	32	38	27	11	18	-	-	-	5.80	39.7	68	7	27	29	
	NLB-4A	2.00	2.62	1	23	76	40	29	11	29	-	-	-	9.54	96.5	72	8	44	27	
	NLB-4B	3.00	2.61	0	23	77	43	30	13	16	-	-	-	7.76	85.2	75	6			
	NRB-1A	2.00	2.61	0	12	88	57	35	22	33	-	-	-	6.79	124.9	68	4			
	NRB-1B	3.00	2.71	0	8	92	66	30	36	38	-	-	-	9.55	128.2	78	8			
	TBH-1A	0.55 ~ 1.00	2.60	0	60	40	42	29	13	35	1.164	17.0	0.345	9.66	32.36	62	4			
	TBH-1B	1.50 ~ 2.00	2.57	0	88	12	NP			9	0.944	19.0	0.323							
TUQUEGARAO	TBH-2A	5.50 ~ 6.00	2.68	3	3	94	65	29	36	49	1.322	12.5	0.363	16.78	17.02	70	2			
TUGUEGARAU	TBH-2B	9.50 ~ 10.00	2.65	0	1	99	70	30	40	54	1.321	13.0	0.389	9.86	33.73	74	3			
	TBH-3A	0.55 ~ 1.00	2.69	0	3	97	59	35	24	37	1.158	12.5	0.363	10.50	31.41	80	2	44	27	
	TBH-3B	1.50 ~ 2.00	2.72	0	2	98	67	28	37	34	0.722	16.5	0.231	9.06	45.82	72	4			

 Table 4.2.3 Summary of Laboratory Test on Undisturbed Samples taken from Bore Hole

Area	Location	Depth		Bulk Density	Absorption	q _u	Е	ρ
		(m)		(ton/m^3)	(%)	(kg/cm ²)	(kg/cm^2)	
	MB1	22 ~	23	2.060	9.39	38.8	5,882	0.35
	MB1	25 ~	26	2.236	5.65	141.7	4,480	0.26
Maganit	MB1	26 ~	27	1.439	5.06	74.6	10,345	0.31
Magapit	MB1	27 ~	28	2.276	5.30	53.4	5,263	0.36
	MB1	28 ~	29	2.275	6.65	71.4	7,065	0.36
	MB1	29 ~	30	2.386	4.41	54.8	6,868	0.40
	LNB1	4 ~	5	1.974	18.37	16.5	2,370	0.22
	LNB1	5 ~	6	1.866	17.59	10.5	1,190	0.30
Nacining	LNB1	6 ~	7	2.094	14.08	24.4	1,330	0.22
Nasiping	LNB1	7 ~	8	1.873	14.94	29.4	3,030	0.29
	LNB1	8 ~	9	1.902	13.91	27.7	6,024	0.30
	LNB1	9~	10	2.080	15.30	24.4	3,683	0.24

 Table 4.2.4
 Summary of Laboratory Rock Test Result

Note

 $\boldsymbol{q}_{u:}$ Unconfined compressive strength

E: Elastic moduli

 ρ : Poisson's ration

Boring	Denth (m)	Gs		Gradatio	n	Co	ncister	ICV	NMC	Proctor		Tri	iaxial Co	ompress	sion
Doring	Deptii (III)	03		Gradatio	11	CU	11515101	lсу	INNIC	110	CIOI	U	IU	C	CU
N0.			gravel	sand	silt/clay	LL	PL	PI		OMC	MDD	c	φ	c'	φ'
			(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(t/m^3)	(kPa)	(deg.)	(kPa)	(deg.)
TPT-1	0.00 ~ 3.00	2.763	0	3	97	45	29	16	37	25.0	1.53	100	13	130	21
TPT-2	0.00 ~ 3.00	2.791	0	8	92	NP	NP	NP	25	20.0	1.57	92	13	52	35
TPT-3	0.00 ~ 3.00	2.773	0	3	97	67	21	46	32	25.5	1.45	81	11	60	30
TPT-4	0.00 ~ 3.00	2.875	18	19	63	39	23	16	14	19.0	1.67	76	14	45	37
TPT-5	0.00 ~ 3.00	2.665	0	1	99	76	27	49	35	26.0	1.33	90	5	71	26
TPT-6	0.00 ~ 3.00	2.797	8	35	56	67	29	38	29	23.0	1.42	95	10	60	31
TPC-1	1.85 ~ 3.00	2.667	2	27	71	38	16	22	19	17.0	1.74	70	20	70	27
TPC-2	0.00 ~ 1.70	2.665	0	47	53	NP	NP	NP	15	15.0	1.78	68	16	37	38
TPC-2	1.70 ~ 3.00	2.654								15.0	1.66				
TPC-3	0.00 ~ 3.00	2.779	0	1	99	51	25	26	38	26.0	1.47	78	12	57	32
TPC-4	0.00 ~ 3.00	2.703	11	28	61	40	20	20	15	18.5	1.68	87	13	40	36
TPC-5	0.00 ~ 3.00	2.706	0	28	72	38	17	21	22	16.0	1.65	87	11	38	33
TPC-6	0.00 ~ 3.00	2.743	0	3	97	51	22	29	31	25.0	1.43	100	10	35	33

 Table 4.4.1 Summary of Laboratory Test on Embankment Material

The Feasibility Study of the Flood Control Project for the Lower Cagayan River in the Republic of the Philippines Final Report Supporting Report Annex III: Geology

Figures





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GEOLOGIC LOG OF DRILL HOLE			GEOLOGIC LOG	7 OF DRILL HOI	LE
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01.03 5/26/00 (DENSING) 6/4/00 (DEPTITION OVERHORING) 21.76.51 REG	MINDRILL F-20	18:GEN 5/26/00 HAUS	SHED 6/4/00	DEPUTION OVER BURDEN	2) 76 M PRG MINDRILL F-20
тота, de#fn. <u>50.00.ju</u> , elle of wa th зай де: 2.60 М , токвалато <u>WU,</u> соктика 2	ciok <u>ki</u>	TOTAL DEPTH	OF WATER TABLE: 2.60 N	DARAED BY WIT	CUNSERACTION (C)
SOILS ON WATER TA- SCORE PERMEABULITY TEST INF. LEVELS WATER RECOVERY DEPTIL CONSC We The GOUPTON K O D GRA- RETUR CHARACTER O HOR COMPO FR TO O TENTANT	:SU'KH'I 16##	SOTES ON WATER TA- BLE, LEVELS WATER RECOVERY RETVEN CHARACTER DILOW CONNE	DEFTIL CIS SOC FR TO O strangers	64 DEP(11 R. Q. 12 GR. (A4) (**) P56 144	A- DESCRIPTION G
	ay, skuk gaayish color, wet in estic, with slight anosunt of	OF DMILLING ETC.	20 20 20 20 25 25 25 25 25 25 23 23 23 30 30 30 30 30 30 30 30 30 3		 16.0-21.76 m, Fot Clay, dark bluish gray, wet in place, not high plastic. 21.76-37.7 m Cakanonic, light brownish color, medianu-washaeed, with iron exide ou matrix). joint and factore place, booken longeng from 1 cut to 2 m, bedding atmost boulzontal as shown by the general aktivate of the fracturation, moderately knot or locken by slight luminary blow.
1882-190. <u>NO-1</u> -00130				HOLENO, Å	40-4 SUPET NO <u>230[4</u>
EXPLANATION J-3 6-11joint5/m Win - Weathering Number J-3 6-11joint5/m W-1 Sound J-4 11-20joit5/m W-2 Stight's Wentherick appreciable oxidation if joint j J-5 >20joit5/m W-3 Maximum Weatherick (matrix slightly weatherick) the - flandness Number W-4 Deeply Weatherick (matrix deeply weatherick) the - flandness Number W-5 Totally Weatherick (matrix deeply weatherick) the - fland clocke tendly looken by home W-5 Totally Weatherick (matrix deeply weatherick) the - fland clocke tendly looken by home W-5 Totally Weatherick (matrix deeply weatherick) the - fland clocke tendly looken by home W-5 Totally Weatherick (matrix deeply weatherick) the - fland clocke tendly looken by home Ja - Joint Number the - fland clocke tendly looken by home J-1 typestime the - fland clocke tendly looken by home J-1 typestime the - fland clocke tendly looken by home J-1 typestime the - fland clocke tendly looken by home J-1 typestime the - fland clocke tendly looken by home J-1 typestime the - fland clocke tendly looken by home J-2 typestime the - fland clocke tendly looken by home J-2 typestime the - fland clocke tendly looken by home J-2 typesti	ик() (ка) милист) * MB-1 (1)	LXPLANATION Wit - Weathering Hundler W. 1 Sound W. 2 Slightly Weathered in W. 3 Minumun Weathered (W. 4 Deeply Weathered, ang W. 5 Totally Weathered, ang Ja. Joint Number J. 4 Joint Mumber J. 2 2.5joints/in	preciable axidation of joint) matrix slightly weathered) artix deeply weathered altified (only traces of original structure)	J-3 6-10jeiu J-4 11-20jei J-5 >20jeii In- Hawkes II-3 Very Ha II-2 Hard (ed II-3 Medium Fig. 3.7.1 (a)	ts/m ts/m /m s Number at (hardit broken by hammer) ge hardity broken by hammer) tbrd (easily broken by hammer) Boring Log of MB-1 (2)

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			O I.42 X 10⊨3				-		• • • • •	-
10				{ '						
			O2.71 X 10-1				-			
···			0	1				1.		
		[◄.18 X 10-1 						::::	
۲ <u>ا اا</u>			O 5,85 X 10-3	ł				1	::::	
13								ł		
			0 7.25 X 19 - J				-	1	[
14									[::::	
			O 8.89 X 10-3				-			
15P				I				1		
								HOLE N	o. <u>Nru</u>	-1SHERTNO
EXPLANATION			-							
Wg - Westhertur Num	ber							j.3 6.14	houtste	
W-I Sound								JA IL	20juits/ns	
W-2 Slightly Weathere W-3 Minunua Weather	xa, appreciabl red (matrix s	ie oxid dightly	weathered)					.i-), >2% Ilu-iian	ujonts/m idaress Nu	ndver .
W-4 Deeply Weatherer W-5 Totally Weatherer	i(matrix dee d. argilitical (pły we lawi z #	nthered) Toost of original st	nche	net 1			H-UVery	y Hurd (bu d (edec hu	ndly broken by hammer) adly broken by hammer)
Ja - Joint Number					~,			II-3 Mod	lium i lard	(casily broken by hammer)
J-2 2-Sjoints/m							Fig	. 3.7.2	(a) Bo	ring Log of NRB-1 (1)

GEOLOGIC LOG OF DRILL HOLE

ENO: NRO-L	coord	UNATES	16 171	GROUND FLEX	ATON	11.4	SAGATAN SAGATAN INCLINATION VERTICAL
5/8/00	FINISH	ED 8718700		DEPOLATION	OTHER DATES		i issioster
			40.0				LEADER RAD TONE_THE
AL DEPTH:	INC. ELF. OF	WATER FABLE:	TVN	LOGGED BY			CONTRACTOR: ICI
TES ON WATER TA-	CORE	PERMEADELITY TEST					
E. LEVELS WATER RI	COVERY	DEPTH onvises	wu 16	46 DEPTH	R. Q. D	GRA-	1 Million Taratte Kina Jawa
F DRILLING ETC.		R TO O TATAN		(14)	CH.	LOG	
		07492 013				:: <i>:</i> ::	
160					1		20.00 - 40.00 kl; Sand , pourly graded
		5.49 X (8-3				** ***	generally fine, lower, mut-shottic, with shink
17-60]			annumi uf sili, dark grav culur.
		D 7.35 X 10-3					• • • • • •
18-13							
-411		07.18 X 10-3					;
190							
		D 7.21 X 10-3					
20 - 9							
		O 6.43 X (0-3					•
21 - 6							
		D 6.39 X 10-3				·· · · ·	
22							
	rui III	O 5 79 X 10-3			ŀ		
23 - 6							
		O 5.55 X 10-3					
24							
		O 35% X 16-3					
25							
		O 5 04 X 10-1		-			
38 C					l ľ.		
		O 5.17 X 10-3			l t	• • • •	
27 10						• • • •	
		O 5.24 X 10-3				• • • •	
26 0				-	f.		
		O 5 41 X 10-3		-	ŀ.		
29 - 1					ļ,		
		O 5.48 X 10-3					
30 1							
					HOLE NO.	NRD - I	SHEET NO. 2 of 4
EXPLANATION							
Wa - Westherson M	, muher						
W-I Sound					7-3 6-10j0 3-4 11-20j	unts/m pits/m	
W-2 Shightiy Weath W-3 Minumun West	cred(apprecia lacred (matrix	ble oxidation at joint)			J-5 >20ja	its/m	_
W-I Deeply Westlue	red(matrix de	reply weathered)			iai-ruarda II-1 Very I	ens reaand land (hardij	a y broken by hananer)
W-) fotally Weathe	red, argillifico	I (only traces of original stru	clure)		i i-2 i lardi (i	edge hardly	y broken by hammer}

ATURE:	PRIOJECT: 112WER CASA N	YAN NIYER FLO	99339993	REN. 1760.	BATTARAN
5/9/00	E	GROUND FUE	VATE IN	<u> 4</u>	45 M INCLINATION VERTICAL
	FINISHED5/16/QO	DEPTH OF OV	ERRENTEN	·	ANNE REPAIRS
TAL DEPTH 50 00 m	ELE. OF WATER TABLE: 6.40 M	. LOCKIED (IV			CONTRACTOR: KI
DTES ON WATER TA-	RE PERMEADELTY TEST WERY DEPTH Convises We H		Tran		······································
OF DRILLING ETC.	COLING FR TO O meaning	(64)	(***)	PHIC	DESCRIPTION
-	C-01 X (L.2 O				
31					Sand, provely graded, fine, home, non-plantic
	O 5,74 X 10-3		1 1		with slight amount of sits, dark gray color.
32		-			
	O 5.#4 X 10-3				
33			1		
<u></u>	U 5.48 X 10-3		1 [•
	O CHUY IN L	-	[i
35-1 -			1		
	O 5.78 X 10-3		:		
36		\Box			
	D 5.07 X 10-3				
37 10			i k		
	D 5 57 X 10-3		ŀ		
38 []		- _	F		
	O 10 X 10-3		l.		
39-1 00			1		·
	D 897 X 10-3				
"~_ M/					
	0 4 12 X 10-3			• • •	
	Ossixio		ŀ	: :::	
42			:	::::	
	0 805 X 10.1		:		
43 (:	::::	
	O 105 X 10-3		-	::::	[
44			;*:	::::	
-	O 4.32 X 10-3			::::	
45					
		 1	IOLE NO	NRU - 1	SUBETINO 3 of a
EXPLANATION:					
Wn - Weathering Number	r				
W-1 Sound W-2 Slightly Wasthered		ز ز	-3 6-10pm -3 11-20pm	urstan Arsta	
W-3 Minimum Weathered	appreciable exalision at joint) (matrix slightly weathered)	,	5 >20jan	×/10	
W-4 Deeply Weathered(n W-5 Totally Weathered -	natrix deeply weathered)	4 ář	ar tsatan c: i-iVery∐ar	ss Nounber 4 d (leardly	r / broken, by homoner)
· · · · · · · · · · · · · · · · · · ·	"Bennes the State of A second structures of the second structures of th	•		'	

GEOLOGIC LOG OF DRILL HOLE PROJECT: LOWER CAGAYAN RIVER FLOOD CONTROL PROJECT. JAKATAM: SOTTAKAN. N. J. 987. 158.62. N. J. 987. 158.62. KKEND MULL COORDINATES GRAND PLEVATION: 11.45 M. INCLUSION MEDICAL C 564.768.73 TUNE_THS-5 TOTAL DEPTH: <u>50.00.00</u> ELE: OF WATER TABLE: **6.40 M** LOCKED BY: <u>WUJ.</u> CONTRACTON <u>KU</u> NOTES ON WATER TA-PERMEABULITY TEST 16 Ja DEPTH [K. Q. D] GRA-RETURN CHARACTER O BLOW COUNT DESCRIPTION (M) (**) PHC OF DRILLING ETC. LOG O # 16 X 10-1 Sand, promby graded generally line fragments :::: O 6.15 X 10-3 loose, non-plassic , with slight minuted of site ·: :: 47 wet in place. ----0760X103 48 1 h O 8.15 X 10-3 ::: 49 | : . : : O 8.19 X 10-3 Π 51 -52 -53 --54 -55---_ 56-57 -58 -59 60 HOLENO NUL 1 SLEETNO 4144 EXPLANATION: Wa - Weathening Number J-3 6-10jainis/m W-I Sound 1-4 11-20joits/m W-2 Slightly Weathered(appreciable oxidation at joint) 1.5 >20jests/en W-) Minumun Weathered (matrix slightly weathered) Lin - Hardness Number W-I Deeply Weathered(matrix deeply weathered) 11-1 Very Hard (hardly broken by humaner) W-5 Totally Westhered, argillified (only traces of original structure) 11-2 Hatu (cone hardly broken by humaner) Jn - Joint Number 11-3 Medium Hard (casily broken by humaner) J-1 ljoint/m J-2 2-5joints/m Fig. 3.7.2 (a) Boring Log of NRB-1 (4)

NLB-1

	GEOLOGIC	Ľ	00	G ()F DR	ILL I	IOLE	2
FEATURE:	PRIMECT: I STATE	ίζα	int	oni	UTAERDEPU	OU.CONT	KOLUSK	ARCT LOCATION: STOL NIÑO
HOLE NO: NED-1 COUNDA	N 1,995,632.	<u>12.</u>		-	CHIND ELL	VATION:	9	CAUAYAN
HEGUN: 4/25/00 FINISHEE	6/1/00	<u></u>		OE	P THE OF OV	ERIBERILDEN	·	RIM ABORE TONE THE-S
TOTAL DEPTH:	ATER TABLE: 4.22 m.			14M	IGED IIY:	W11		CONTRACTOR: ICI
NOTES ON WATER TA-	PERMEABILITY TEST		Γ	Γ			<u> </u>	
RETURN CHARACTER O NOW COUNT FR		1***	"	-	DEPTH (M)	R.Q.D (%)	GRA- FIIIC	DESCRIPTION
OF DRITLENG ETC. 7						- <u></u>	1,00	
	O 1.29 ± 10 ⁻¹							0.00-3.00 m: Fotally wenthered Sandatone,
	O 1.04 x 10 ⁻¹	5	,	,	_		::::	Friable and louse
2 			;		. –		••••	
	Q 43±884					1		3.00-16.00 m: saudatone, anoderate to
~_1 m N/////	0 3.61 a 184						** **	highly weathered, 2-5 ⁸ dap of heas, with
▲ ₩ ₩				3		•	** **	leakes of silistone at the depth of
	0 241104			1	-		••••	6.54-6.40 m, extremely weathered at the
5-11111							••••	dapih ol 15-16 materix.
6							••••	
			ч.	•	_	1	** **	
7 —		1					••••	
							••••	
·						ł	** **	
∍_ φ]					_	•	••••	
-1111111111							••••	
10								
					· _		** **	
12					_			
	O 4.34 x 10 ³				-		••••	
ווווזאקן ב יי					-		••••	
	U 1.56 x 10"							
	0 2.94 ± 10 ⁻³		,				::::	
is_[[‼ö[[]]]]	<u> </u>		_				. <u>М</u> .В-1	SINGET NO
EXPLANATION:								
Wa - Weathering Number						ش01⊷6 [J	uints/us	
W-2 Sound W-2 Slightly Weatherself agreement	excidence at initial					J-4 11-20	juits in	
W-3 Minimun Weathered (matrix a	ightly weathered)					Fin - Flende	ncsa Nuu	laca
W-5 Totally Weathcroit, argilitized (o	ry weatheroit) why funces of original struc	lwrc)				H-1 Very 1 11-2 Elandi	tard (bar cdgc han	By broken by hannace) By broken by hannace)
Jassant Numbr∑r J-1 ijotat/m						II-3 Media	un 1 tard (casily twoken by humaner)
J-2 2-Sjointsm					Fig.	3.7.2 (b) Bo	ring Log of NLB-1 (1)



III-F9

[/	(GEOLOGIC	CL	00	30	DF DR	ILL I	IOLI	с. — — — — — — — — — — — — — — — — — — —
FEATURE: HOLE MO:NLB-L BEOLN: 4/23/0	CUO 10 FINE	N NU2INATI Z SHED	RIGHECT: LOWE 	R.S.M 2	GAY 	ONLI GHI DE	LIVEB JLOX OLIMO FLEV FIN OF OVE	DECONE ATION: RIERDEN	ROLJR 	DIECT. LOCATION: STD. NER <u>Satayan</u> 9.73 M. Includation: VERTICAL .N.M. Indice: TONE TH3-5
TOTAL DEPTH:	_\$Q.QQ.IA ELE.	OF WAT	ER TABLE: 490 M.			143	oged int:	wi3		CONTRACTOR: ICI
NOTES ON WATER TA- BLE. LEVELS WATER RETURN CHARACTER OF DRILLING ETC.	CORE RECOVERY O MON COUNT	PER DEPTI Fir 1	the carbon test	-	134		DEPTH (M)	R Q. D (%)	DILA- MINC LUG	DESCRIPTION 6
		10	 1.40 x 10⁴ 33 33 34 34 35 36 37 38 39 39 39 30 30 30 31 31 32 33 34 35 36 37 38 39 39 39 39 30 /ul>			3		47 9 18		32.00-32.90 nc; Manhatone, anchinan to decely weathered, broken by haramer blow, with leases of carbonaccous material, thek gray. 39.20-43.00m; Sandstone, anchinan to decely weathered with carbonaccous material.
42 43 44	6	4)	0	1		\$	· 	9	••••	dack groy. 43 (103-50) Jühn, Mudstone, medicum to doeply weathered, fractured and brokesvifuectured and easily broken by finger pressure.
			U 1.5/ X 10 ⁻⁴							
EXPLANATION We - Weath W-1 Sound W-2 Signity W-3 Maxim W-4 Decity Ja - Joint Ni J-1 i joint J-2 2-Sjoint	rring Number Weathered(appres m Weathered(mashi Weathered, angibi mber mber shon shon alon	nisble on tris slight t dropfy u fied (only	idation at joint) ify weathcrad) weathcrad) traces of original struc	durc)			Fig.	J-3 6-10j J-4 11-24 J-5 >20j lin - Hard li-1 Very 11-2 Hard 11-3 Medii 3,7,2 (ointe/m Sjoite/m nese Nan Land (ben (enge han ann Hand (b) Bo	nber nber nby lawaser) nby lawaser) (cuily broken by lawaser) (cuily broken by lawaser) pring Log of NLB-1 (3)

		(GEOLOGI	C LO	G e	OF DR	ILL I	IOL	E.
FEATURE: INOLE NO:	COQ FINE	N RDINAT E. SIIED	100/ECT: 120WE 1,944,632.1 Es 565,777.1 6/1/00	R сала 2 14	YAN. GR	BLYEBJDQ OUND ELEN PTH OF OVE	QD_CONT ATKIN: RISURDEN		04651 LOCATION: SJD. NGO CADATAN 9-73 M. INCLINATION: VENTICAL 20 M
NOTES ON WATER TA	CORE	OF WAT	ER TADLE: 8.20 DL]'`T	 T	GGED HY:	₩ <u>11.</u>	 T	CUNTRACTOR: 1C1
RETURN CHARACTER	ow count	Fit 1		["" "		DEPTII (M)	R. Q. D (%)	GRA- MINC LOG	DESCRIPTION
			() 1.57 x 10 ⁻⁴	3	3				Mandalance, mentiums to douply veraficered, broken Africaned to Zean, To Sean
51									
•								<u> </u>	SIDEET NO. 4 of 4
EXPLANATION: Wn - Weathering Num W-1 Sound W-2 Slightly Weathere W-3 Minimous Weathere W-5 Totally Weathere Ja - Joint Number J-1 Ijoint/m J-2 2-Sjoints/m	iber d(approxis rod (metris d(metrix de l, argifii(iod	ble oxida t slightly teply wa (only ta	skon af joint) weathered) sthered) sees of origanal atructu	rc)		ہے ای ان Fig. 3.7	3 6-10join 4 11-20jo 5 >20join 5 >20join 5 >20join 5 >20join 5 >20join 5 >20join 5 >20join 5 >20join 6 >20join 6 >20join 7 >20	ntø/m hts/m s/m se Neusbu ud (hardt løc hardt) BOFIL	er y broken by bannuser) troken by hannuser) 1g Log of NLB-1 (4)

NLB-2

		,	GEOLOGI	ĊLOG	OF DI	RILL II	OLE				G	EOLOGI	C LOC	G OF Ð	RILL	llOLI	E	<u></u>
	FEATURE: INUE NO:	N COORDINAT E FINISHED L ELE. OF WAT	RIGHECT: 1,997,088,1 5559,389, 5569,389, 6/10/00 TER TABLE:14.	10	RIVER FLOX RECEND FLEV FITH OF OVE DOGGED BY:	N2 CONTROL ATION: RIBRIDEN: 	. PK949 	STLOCATION: CARALLANGON	FEATURE: HOLE NO: BEGUN: G/ # / QO. TOTAL DEPTH:	2000	PRK N RDINATES E SHED OF WATER	ARCT: 10WFR .947.968.91 566.399.79 19/99 TABLE: 14.	5 3 30 N	SROUND FALE DEPTH OF OV	OD CONT VATION: ERBURDEN	<u>12</u> .	EET	SANGLIANGAN. MASIA, SANGYAN YERTICAL KY-20
	NOTES ON WATER TA- BLE LEVELS WATER REC RETURN CHARACTER DED OF DRILLING ETC.	ORE PEI OVERY DEPT COUNT FR	RMEABILITY TEST 11 calvise: 10 •"" 10 •"" 10 •""	Wa 1be Ja	DEPTH (M)	R. Q. D (%)	GRA- MIIC LOGI	DESCRIPTION	NOTES ON WATER TA- BLE. LEVELS WATER RETURN CHARACTER OF DRILLING ETC.	SCORE RECOVERY	PERASE DEPTH FR TO	ABILITY TEST	wa ila J	DEPCII (M)	R. Q. D (%)	GRA- PINC LOG	DESCRIPTIO)N
III-F11			O i .25 X 10 ⁻⁴ O i .34 X 10 ⁻³ O i .95 X 10 ⁻³					0.00-2.00 m; Silly mond, non-plastic, frinkle, loose, duck brown color. 2.0-6.0 m; Claycy nik, slightly plastic, noft, reakish brown color. 6.00-13.0 m; Silly noul, non-plastic, loose, duck gray color.				O 7.5 X 10 ⁴ No Water Tinke No Water Take					Claysty / Saudy site, singer b dark bheist sotre.	O ma plastic.
	EXPLANATION:					HOLE NO.	NLD-2	SUEET HO9[4	EXPLANATION;	<u> </u>					TKALE NO	NU3-2	SHEET NO.	29[4
	Wa - Weathering Nu W-1 Sound W-2 Stightly Weather W-3 Miniman Weath W-4 Decepty Weather W-3 Totally Weather Ja - Joint Namber J-1 I joint/m J-2 2-Sjoints/m	mber radi approxishie ered (matrix dig cal, matrix doepi cal, argiililiod (ar	midation at joins) phy weathered) www.thered) hy traces of original st	investionee)	Fig.	J-3 6-19jni J-4 11-20j J-5 > 20jni Ha - Hardar H-1 Very H H-2 Hard (c 11-3 Medium 3.7.2 (c)	ats/an pits/an As/an ess Neque ard (hard dge hard dge hard dge hard dge hard dge hard dge hard dge hard dge hard dge hard d	er ty broken by hanner) ty broken by hanner) assily broken by hanner) ng Log of NLB-2 (1)	Wn - Weather W-1 Saund W-2 Stightly W-3 Minimu W-4 Deepty W-5 Totally M-5 Totally Jn - Joint Nu J-1 - Ijoint J-1 - Ijoint	ing Number Weathered (appro) Weathered (material Veathered (material veathered, angili ober n /m	cciable oxidi trix slightly t deeply we fied (only tr	Nice at joint) weathered) shered) aces of original stra	clure)	· Fig.	J-3 6-10j J-4 11-20 J-5 >20j Ha - Hard H-1 Very 1 H-2 Hard H-3 Media 3.7.2 (oints/m ijoits/m ints/m ints/m ints/hand ints/hand ints/hand ints/	ner Hy broken by hummer) Hy broken by hummer) maily broken by hummer) ing Log of NLB-	-2 (2)

n di se prese

	GEOLOGIC LO	G OF DRILL	HOLE
FEATURE:	N 1.387 041 97	AN INVERTELOOOD CONTR	DUPROFECT LOCATION CARALLANGAN
HOLE NO. NLB-2	COORDINATES	GROUND ELEVATION:	12.66 M INCLINATION : YEBTICAL
BEGLIN: 5/2/90	FINISHED 4/10/00	DEPTH OF OVERBURDEN	>20.0 M #HIUNED: KY-20
ТОТАL DEPTH: 50 00 л	ELE. OF WATER TABLE: 14.10 M	LOGGED IN WILL	CONTRACTOR: KI
NOTES ON WATER TA-	ORE PERMEABILITY TEST	In DEPTH R. Q. D (M) (%)	GRA- MIC 1421
	O 5.38 x 10 ⁴		30.00-40.0ar; Claycy sill, slightly plastic with few face soul, soft when noist, dark gray color 40.0-50.0 m, Silly soul, friable, non-plastic, loose, dark gray color
		HOLE NO.	NLD-2 SHEET NO
EXPLANATION: Wn - Wenthering Norr W-3 Singhtly Westher W-3 Minimum Wenther W-4 Doeply Wenthero W-5 Totally Wenthero Ja - Jeins Namber J-1 Ljoinst/m J-2 2-Sjointsfm	nber rol(approxisible oridition at joint) crol (anatix slightly weathered) cl(anatix deepty weathered) cl, argillified (only traces of original structure)	J-3 6-16ja J-4 11-20j J-5 > 20ja H-6 Hender H-1 Very H 11-2 Hender H-3 Mechen Fig: 3.7.2 (a	sints/in sist/in si

GEOLOGIC LOG OF DRILL HOLE fure: 12.86 M INCLINATION - VENTICAL GROUND ELEVATION: ENO: MLB-2 COORDINATES DEPTH OF OVERILIRDEN: _____20.0.M___RIGUSED: KY-20 CONTRACTOR: ICI TES ON WATER TA- SCORE PERMEABILITY TEST LE LEVELS WATER RECOVERY DEPTIL CONTOCT E LEVELS WATER DEPTH R. Q. D URA-16.4 DESCRIPTION (M) MIC (**) F DRILLING ETC. 1.00 ÷ 47-... • 48 00 49 O 1.72 x 10⁻³ 90 _ 51-52 53 54 55 56 57 64 60 HOLE NO. NIJB-2 SHEET NO. 4 of 4 EXPLANATION: We - Weathering Number J-3 G-10joints/m W-I Sound J-4 11-20joits/m W-2 Slightly Westbered(appreciable oxidation at joint W-3 Minimum Westbered (matrix slightly wathered) J-5 >20joils/m Re - Hardness No W-4 Dauply Weathered; matrix deeply weathered) W-5 Totally Weathered, argililified (only truces of original structure) E1-1 Very Hard (headly broken by I 13-2 Hard (cone hardly broken by hommer) Ju - Joint Number II-3 Medium Hard (cesily broken by humoner) J-L tjoint/m J-Z '2-Sjoints/m Fig. 3.7.2 (c) Boring Log of NLB-2 (4)

NLB-3

ATURE	PRIOJECT: LOWF	LCAGAYAN	NYFR FLOOD CONT	ROLPROJECT EDCATION: STO NIÑO
NLENO:	N 1,905 OIG. COORDINATES	4	CUND ELEVATION	18.95 M NELINATEN VERTICAL
CIN 5/28/00	E: 347,988.			
			FILL OF OVERILLES	*
TAL DEPTH:21993	UELE. OF WATER TABLE:	.05M LO	00ED BY:₩]	CONTRACTOR: Kt
OTES ON WATER TA-	TORE PERMEABILITY TEST			l [
ETURN CHARACTER O NO			(M) (%)	FIIC DESCRIPTION
OF DRULLING ETC.		┼╶╂━┠━	 	L00
			-	
1-164				0.00-13.00 as; Fat clays high plastic, not
			·	when anoist, firm or hard when dry,
2				yellowish brown color (E).
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ווארי			-	
~111111			: -	
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s	0 66×105			
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° 71 M I I			_	
-111111			-	
7-1761			-	
			-	
8 — 8 — 1			_	
<u> </u>				
			1 1	
10-991	0 1.8 x 10 ³		-	
-41111				
13				
			_ [
¹³ —13			-	111131 1 13.00-20.00 M, Pat Carya, Cara gray Color,
			-	high plastic when moist, soil when wet, with
×			_	slight amount of silt and fine sand
15HKII				
			LI	<u>arring</u>
CYDE AMARTIN			HOLE NO). <u>NLU-3</u> SIDEET NO. <u>1974</u>
EAFLANATION:				
WR - Weathening Nu W-1 Sound	noe:		J-3 6-144	(Distriz/)12
W-2 Slightly Weather	redi appreciable oxidation at inist?		J-4 []-20 L1 >30%	มายคนระกาณ เออร์ (สะคร
W-3 Manianan Weath	crod (matrix slightly weathered)		ila - Llardi	iucas Namber
W-4 Deeply Weather	ed(matrix deeply weathered)		th Very	Hard (herdly broken by hammer) 🦉
W CT. in the				· · · · · · · · · · · ·
W-5 Totally Weather Jo - Joint Number	ed, argillified (only traces of original st	wature}	H-2 (lard)	(edge hardly broken by human)

GEOLOGIC LOG OF DRILL HOLE P PROJECT: LOWER CAGAYAN RIVER FLOOD CONTROL PROJECT LOCATION: STOL NING FEATURE 18.95 M INCLINATION : YENTICAL HOLE NO: 1 MLU-1 567,988.00 £____ BEGUN: 5/28/00 FINISHED \$/4/00 DEPTH OF OVERBURDEN: 35.00 M BEARING: .Kak. M.S. TOTAL DEPTH: _______ SO OF THE ELE OF WATER TABLE: 10.05 M LOOKED BY: WIJ. CONTRACTOR: ICI SCORE PERMEABILITY TEST RECOVERY DEPTIL control BLOW COUNT FR TO 0 NOTES ON WATER TA-BLE. LEVELS WATER ₩≖İlân İm DEPTH R. Q. D GRA-DESCRIPTION RETURN CHARACTER O BLOW COUN (M) PIAC **(**19) OF DRILLING ETC. 1.00 111 18 -17 -18-19 20 O 3.33 x 10 20.00-30.00 ar; Silty must probably 21weathered sand stone, friable, reddish brown onlor 22-23-24 -25 -O 1.61 x 10⁻⁴ 26 -27 -28 29 ο 7.3 x 10⁴ 30 -HOLE NO. NELL-) SERVET NO. - 2 OF 1 EXPLANATION: Wa - Weathering Number J-3 6-10joints/m W-1 Sound J-4 Li-20joits/m W-2 Slightly Wenthered(appreciable oxidation at joint) J-5 >20joits/m W-3 Minimun Weathered (matrix slightly weathered) Handacar Na H-1 Very Hard (landly broken by hattaner) W-4 Deeply Weathered(matrix deeply weathered) W-5 Totally Weathered, orgililified (only traces of original structure) 14-2 Hard (edge hardly broken by humaner) Ja - Joint Number H-3 Medium Hani (ensity broken by hammer) J-1 ljoint/m J-2 2-5joints/m Fig. 3.7.2 (d) Boring Log of NLB-3 (2)

III-F13



GEOLOGIC LOG OF DRILL HOLE

FEATURE:			IOJECT: LOWE	R CA	GAY.	AN R	VER FLO		no pa	Marr		
HOLE NO: NULI-3	00		.1,926,,016.	06					1024110	232L	LOCATION;	STO NNO
5/28/0	л	E	567,988.	00		040	DUND ELEV	ATION:		.95 M	INCLINATION	VENTICAL
BEGLAN:	T. FINI	SHED	4/9/90			DEI	PTH OF OV	ENHARIDEN	÷ _3	5.00 M	HEARING:	KSK-BLG
TOTAL DEPTH		OF WATE	R TABLE: 16	.05	M	LOC	KRED IN:	WLL				
			•		-						CONTRACTOR	« <u>ICI</u>
NOTES ON WATER TA-	- + CORE	PERM	EABILITY TEST	T -	Т	т—		r	τ-	<u> </u>		
BLE. LEVELS WATER	RECOVERY	DEPTH	08/105		Ha	.	DEPTI	R.Q.D	GRA-		DECONTROL	
OF DRULLING ETC.		FR TO	0		1		. <u>(M</u>)	69	PIIIC	f	DESCRIPTION	
	JIIIIIINI	45		T				<u> </u>				
48-							-	30				
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47	]		1				_	23				
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	]		D 1.06 x 10"	4	•		~	36				
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49	111111111111		<b>∦</b> ∿.			-		<b>  </b>				
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								IOLE NO.		_		
EVER AND								FOLE NO.	1917-3	S	HEET NO.	<u>4 9 4</u>
EAPLANA DON:												
Wa - Weather	ring Number						1	-3 6.100	intsfin			
W-I Sound W-2 Stinketer	Wantherst						ĩ	4 11-20je	oits/m			
W-3 Minimum	a Weathered ( mate	ix alightly :	tae at joint) weathered)				بر ان	5 >20jui	ils/m Maart	_		· ·
W-4 Deeply V	Neathered matrix	deeply wea	(hered)				H	l-IVeryik	and (laard	 ly broken b	y hopmer)	
W-2 Lotally V Ju - Joint Num	Wonthered, argillifi Inder	ed (only tra	ces of original stru	cture)			11	2 Fland (c	cige hard	y broken by	hammer)	
J-1 ljoint/								-J MCMAN	n steni (c	estly broke	n by basamer)	
J-2 2-Sjoints	/m						Fig. 3	.7.2 (d)	) Bori	ing Log	of NLB-3	(4)
·							-				-	

## NLB-4

SATURE:	GEOLOGIC LO	G OF DRILL H	DLE LIROUET LOCATION: GABALLANGAN
ουμείνο: <u>Νίβ-4</u>	N 1.983 151.05	OROUND ELEVATION	15.27 M INCLINATION : VERTICAL
IGUN: 5/3/00 FT	INISINED	DEPTH OF OVERDORDEN:	
DTAL DEPTH:	LE. OF WATER TABLE: II . 33 M	LOOGED BY:	CONTRACTOR: <u>ICI</u>
OTES ON WATER TA- U % CORE BLE LEVELS WATER RECOVER	PERMEABILITY TEST		
OF DRILLING ETC.	MT FR TO 0	(M) (S)	DESCRIPTION
	O 7.9 x 10 ⁻³		reer → → → · · · · · · · · · · · · · · · · ·
	O 5.5 x 10 ⁻³		noll, moist in place, reddish brown color.
2-00			<del>30</del>
3[0] [] [] [] [] [] [] [] [] [] [] [] [] [] [			1.0-11.0m; Sandy/silty clay, slightly plastic
	Q 1.8 x 10 ⁻¹		when wet, soft reddish brown color.
	0 70×10 ⁻¹		
s — 6 – 1			
₅,	O 6.0 x 10 ⁴		
_	O 5.4 x 10 ⁻³		
8 — <b>6</b> — 8			
	O 9.6 x 10 ⁻³		
· - / • / • / • / • / • / • / • / • / • /	0 48×103		
10			
	O 4.8 x 10 ³		11.0-18 0 m: Sandy silt slight to non-relastic
	O 2.4 x 10 ⁻⁴		soil when wet, louse, dark bluish.
12—0 <b>П</b>		-     {	
13 - 2 - 1 - 1 - 1 - 1	4.6 × 10'		
	O 3.8 x 10 ⁻³		
	0 4.9 x 10 ⁻⁵		
15			
		HOLE NO. N	III)-4 SIBEET NO. 1 of 4
EXPLANATION:	· · · · · · · · · · · · · · · · · · ·		
Wa - Weathcruig Number W-1 Sound		J-3 6-10joiu	s/in
W-2 Stightly Weathcred( app W-3 Minimum Weathcred ( a	reciable axidation of joint) and shiphily wanthered)	7-4   -20joit: J-3 >20joits/	ina la la la la la la la la la la la la la
W-4 Deeply Westhered, mate W-5 Totally Westhered, areid	rix docply weathered) Hilled (only traces of original structure)	1 m - 1997dects 12-1 Very Hard 14-2 Martin - 14-1	rommer / I (bardly broken by banguer)
Ja - Joint Number J-1 ljoint/m		21-2 I Sard (edg 23-3 Medium )	c menty troken by hammer) lard (ensily broken by hammer)
2-2 2-5joints/m		Fig. 3.7.2 (e)	Boring Log of NLB-4 (1)

¹ Marine Marine

	GEOLOGIC LOG	GOF ÐRILL HOLE
FEATURE:	PRIOECT: LOWER CAGAYA N. L.983, J5L.85 COORDINATES 567, 422.06 FUNISHED \$\\$700 FUNISHED \$\\$700 S017.99 ELE OF WATER TABLE: 11.33 M	IN RIVER FLOOD SOMERCE, PROJECT LOCATION: SABALLANGON. A SAVA-SAVANA GROUND ELEVATION:
NOTES ON WATER TA- BLE. LEVELS WATER RETURN CHARACTER OF DRULLING ETC.	ACORE PERMEADULITY TEST RECOVERY DEPTH Confoc We Ha MOW COLORY FR TO O MANAGEMENT	Jm DEPTII R. Q. D. GRA- (M) (%) PHIC DOG
	$ \begin{array}{c}                                     $	<ul> <li>18.0-20.00m; Sandy sill, soft when moist, slight to non-plastic, brownish color.</li> <li>20.0-32.0m; Sandy clays soft when moist, medium to high plastic, durk gray color.</li> </ul>
EXPLANATION: Ws - Westher W-1 Sound W-3 Stagety W-3 Ministrue W-4 Decepty W-3 Totely Jan - Joint Nug J-1 I Joint/ J-2 3-Joints	/ ¹ ing Number Washered( approciable oxidation at joint) Weathered( matrix slightly weathered) Weathered( antiric deeply weathered) Weathered, argillified (only traces of original structure) aber a in	HOLE NO. <u>N111-4</u> J-3 6-10jointa/m J-4 11-20jointa/m J-5 >20jointa/m Hu, - Harcheess Namber Hi, - Harcheess Namber H-1 Very Hard (hardly broken by hummer) H-3 Hoding hardly broken by hummer) H-3 Moding Hard (edge hardly broken by hummer) H-3 Moding Hard (edge hardly broken by hummer) H-3 Moding Hard (edge hardly broken by hummer) H-3 Moding Hard (edge hardly broken by hummer)

111-F15

		GEOLOGICI	00	2.0				
			.00	. 0	г рк	LL fi	OLI	Ľ
TURE:		PRICHECT: 10WIRCA	(IAY)	AH RI	MER ELSE	n com	650 LHO	WEET LOCATION: SARALLANGAN
LE NO: <b>MLD-1</b>	coc	RUNATES		UNC	UND ELEV	ATKIN:		27 M INCLINATION VED TIGAL
ILN: 5/8/0	) FINI	SILED 0/0/00		DEP	THOFORE	NAME OR LONG IN		
AL DEPTH:	50 00 m ELE	OF WATER TANKS 11.33	м	1.00	c=1/15.005*		·	South and South 1
			-71-	13.44				CINTRACTOR: 103
TES ON WATER TA-	S CORE	PERMEAINLITY DEST	T		······	<u> </u>		I
E LEVELS WATER TURN CHARACTER	RECOVERY	DEPTII cautoo W	16	-	DEPTR	R. Q. D	GRA-	DESCRIPTION
F DRILLING ETC.		FR 70 O				1:04	LAXI	
-	<b>  </b>	O 1.7 x 10 ⁻³			4			
31					-		9	
-		O 3.4 x 19 ³						
32					-			32.0-43.0 m; Silly and non-plastic to
		U 5.6x 10"	1		- T			color
		0.14 × 10 ⁻¹					ī	
34	<b> 0</b>				]		<u></u>	
		0.6.8 x 10 ⁻³					<del></del>	
35								
-		O 6.8 x 10 ⁻³			~		•	
36—					_	ľ	<u></u>	
-		O 1.05 x 10 ⁻⁴				ŀ	<u></u>	· -
37	17711111		11	_	-	ĺ		
36		0 1.05 x 10*						-
· ~_		0.35+103	{ [				ц <u>і</u>	
39	5			1			<u> </u>	
F		0 7.0 x 10 ⁻³			]		<del>.</del>	
40-	<b>[6</b> ] [ ] ] ] ]					ŀ	<u></u>	ļ
-	I NI I I I I I I I	O 1.05 x 10 ⁻⁴				ŀ	<del>9</del>	
41-						ŀ		
		O 7.05 x 10 ⁻⁵		+		ľ	<u>8</u>	,
42-						l		
		O 1.05 x 10 ⁻⁴			-11		ĭ.	
"]		0.00				[	<u> </u>	
44		V 1.05 x 10				-	<u>''''</u>	45.0-50.0 m; Clayey sand, non-mastic to
	1#N11111	0 105×104				-	<u></u>	slightly plastic, dork gray color.
45	₩					-	<del>.</del>	
					1	I.		
						IOLE NO.	<u>NI.1)-4</u>	SPRET NO 3 of 4
EXPLANATION:	1							
Wa - Weathe	ing Number				L	-) 6-10ja	ials/m	Ì
W-I Sound W-2 Slightly	Wenthered again	risbic midation of inines			1	4   -20j	oits/m	
W-3 Minimu Wat Decenter	Weathered ( ma	icia slightly weathered)			Í	- > >20ja lat - 1 Januta	cel Nuel	har
W-5 Totally	Vondered, ergillä	i occurry weathered) fied (unly traces of original structure	c)		1	1-1 Very 11 1-2 Hard &	ind (inc dec her	ily broken by hanner) ************************************
Jm – Joient Nua J-8 – Dissient/	aber B. J		•		i	I-3 Mediu	n Hard (	ctuily broken by housiner}
	-							

e versen en

		GEO	DLOGIC	C LO	GC	)F DR	ILL I	IOLI	C			
FEATURE		PRICE	CT: LOWER	LCAGA	YAN R	IVER FLO	OD CONTI	ikcal. Jync				
HOLE NO:NUD-1	cox	HI.	202.JAL.	95	GR	DUND FLEY	ATKN:		27 M INTIMAT	MENA-SHOTAN		
BEGLIN: 5/8/0	O FINI	E SELED	167 <u>,472</u> ,9 9 <u>7,99</u>	P <b>6</b>	DEI	rni or ovi	ERIJURDEN	4:		WELLINATERN: YERTICAL		
TOTAL DEPTH	.XQ.99.nt ELE	OF WATER TA	DLE: 11.	33 M.	. 1.00	KOELL DY:			CONTRACT	DR: ICI		
NOTES ON WATER TA-	CORE	PERMEAU	HUTY TEST	П	Т	<u> </u>	T	T	1			
RETURN CHARACTER OF DRILLING ETC.		DEPTU Fit TO C	(199/23)   10/1   10/1	**•   18	•]•	DEP7() (M)	R. Q. D (%)	GRA- PINC	(MESCRIPTION)	an I		
	I <b>M</b> IIIII	0	7.35 x 10 ⁻³				<u> </u>					
46		-	·						Clayoy Sand, nun-plastic	to alightly plantic,		
47-		0	3.5 x 10 ⁻³			-		<u> </u>	dark gray color.			
- 		0	3.5 x 10 ⁻⁴					: : :				
-		0	1.7 x 10 ⁻³					—	:			
49		0	1.7 x 10 ⁻³					:::				
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						<b>ال ه</b>	HOLE NO	ND.	SLIFET NO.	- 4 m -		
EXPLANATION:	iae Numl-											
W-I Sound W-2 Slightly 1	weathered areas	rjetde pučtus:	a laint			i	J-J 6-20ja J-4 L1-20j	nis/m nis/m				
W-3 Minimum W-4 December 1	Weathered ( and	rix slightly wea	i			ļ	J-5 ≥20jq Ela-Hierdu	nisini Issa Nami	her	4		
W-5 Totally W	renthered, orgiläi den	ici (only traces	of original stru	ciure)		1	11-1: Very 1 11-2: Fland (	inci (hari edge hard	Ny broken by <b>hannor)</b> Ny broken by hannor)			
J-1 ljoint/ J-2 2-Sjoint/	α α.μ' Έλλ					Fig. 3	11-3 Media 1.7.2 (e)	n tinei (i ) Bori	ing Log of NLB	4 (4)		



## TBH-1



#### **GEOLOGIC LOG OF DRILL HOLE** EATURE PROJECT: LOWER CAGAYAN RIVER ELOOD CONTROL ORDECT. LOCATION: BUE BURGE BURGE н HOLE NO. THE !! COORDINATES GROUND ELEVATION INCLINATION : ε... BEGUN: WISKOO FINISHED #/26/00 OCPTH OF OVERBURDEN: > 20 m MODEL : TONE TIS 5 TOTAL DEPTI: 20.00 m. ELE. OF WATER TABLE: 2,00 m. % CORE NOTES ON WATER TABLE PERMEABILITY TEST SPT LEVILS WATER DETUN RECOVERY DEPTH CCR/900 R Q. D GRA-CHARACTER OF DRELING DESCRIPTION ATC. FR TO O (%) PHAC to 100 15 2.98 x 10* 16 1710 6.00 x 10⁻¹ 17 67 Q 7.40 x 10³ 18 177 O 1.26 x 10⁻⁴ 19 18.7 19 20 7.40 x 10⁻⁶ 19.7 21 -22 -23 24 25 26 -27 28 29 HOLE NO. TBH-I SHEET NO. 2,072 EXPLANATION: Wn - Weathering Number J-3 6-10joints/m W-1 Sound J-4 11-20joits/m W-2 Slightly Weathcred( appreciable oxidation at joint) 1-5 >20joits/m W-3 Minimum Weathered ( matrix slightly weathered) He - Hardness Number W-4 Deeply Weathered( anatrix deeply weathered) H-I Very Fintd (hardly broken by hatuner) W-5 Totally Weathered, argillified (only traces of original structure) H-2 Hard (edge hardly broken by insurer)

11-3 Medium Jand (ensity broken by Immer)

Fig. 3.9 (a) Boring Log of TBH-1 (2)

Ja - Joist Number

J-1 lioint/m

J-2 2-Sjoints/m

TBH-2

TIRE:	• • • • • • • • • • • • • • • • • • • •		HONECT: J.OWE	r caga	YAN.8	LYER.	F1.000.00	NTROL	ROFECT	LOCATION: Catagorna Nuevo			
ENQ JUH: 2		RDINATE	5		*	GRO		ATION		INCLINATION : Ventical			
RUPH #/14/00	FIN	FINISIED #1700				DEPTH OF OVERBURDEN > 50 m. MODEL: TOM							
AL DEPTH	GLE	OF WATE	R TABLE: 3.50	. <del>0</del>		1000	ED 9Y:	ЖЦ.,		CONIRACTOR:			
TES ON WATER TAR S	S CORE	PERA	FARM IFY TEST		-		r	<b></b>	· · · · · ·				
ALTER OF DRELEN BACTER OF DRELENG BTC.	RECOVERY	DEPTH FR TO	CR0/mcc CR0/mcc C 0 metro		51		DEPTH (M)	R.Q.D (%)	GRA- PHIC	DESCRIPTION			
								1		0.00 - 0.60 m; Top soil, silty clay, friable,			
ı —										with scotters, signt to mechanic planticity, P1 = < 50, brownish color.			
	าแแท		1				_						
2				1.7	2	ц		1	<u> </u>	0.60 - 1.70 m; Cobble and bookler rock fragments, sussimum dissurter 8 cm. bioched			
_		ŀŀ				Í	_	1	==-	with siley clay americals.			
3 <u> </u>			1	2.7	3	п			亖	1 20 0 70 01- 1 ····			
				÷			-			<ol> <li>I. W 3. AURC. SHITY clay, slight to medium plasticity, stiff, brownish color.</li> </ol>			
4	βIIII Ϊ			3.7	4	16							
							-			medium plasticity, yellowish to brownish			
s —		5		47	1	- 19				mottler with black materials.			
_			0 410 - 10*				-			5.00 - 20.00 mr. Silty stay to sime medium to			
é		6		5.7	6	"				high plasticity, don't gray.			
			0 374 10"				-		33				
' —	9     ∏	,		67	"	1	-1						
			O 1.44 x 10 ⁻¹		_		-						
¥ —		•   '	1	'']	1	"]	-1						
	<b>∥</b>   ¢		O 125 x 10"				-		크				
,	MILLI	۰ I		1 1	1	1			==				
		н	O 133×10'	97	10HU	US	-1		==				
	N	10							三				
]			O 1.10 x 10 ^{.1}	10,7	п	14			EE				
		u   ~			1				==				
<u>ب</u>		12	O 7.42 x 10 ⁻⁴	11.7	12	12	- 11						
		2											
- <b>c</b> i	HII PII	13	O I.II.x 10 ⁻³	12.7	13	15		1					
		۰ ۱							三				
14		н	O #.38 x 10 ⁻¹	137	ы	17		[	=				
		1											
15	ATT TT MAT	15	0 4.44 x 10 ⁻⁴	14.7	15	16	]						
							14	OLE NO	тв	II-2 SHEET NO. Lof 2			
ANATION:		<u> </u>											
Va - Weatherine Nor	her												
W-I Sound							1-1 1-1	1 6-10jo 1 11-20j	unis/m unis/m				
W-2 Slightly Weather W-3 Minimum Weather	d( appreciable ax	idation al j	oiat)				1-5	5 >20ju	its/ui				
W-4 Deeply Weathere	of matrix deeply w	venticed)					Han H-	i - Elardine E Very El	ss Numbe ard (hardi	r y broken by hammer)			
V-5 Totally Weathers a - Joint Number	argillified (only	traces of q	riginal structure)				H	Z Hard (e	dge hardi	y broken by hummer)			
No. 1 and							11-	a Médiun	n I tard (ea	sny broken by taxamer)			

#### URE: N GROUND ELEVATION: NO. THIN . 7 COORDINATES INCLINATION : Vertical £_____ PINISHED #17/00 UN: \$/1400 DEPTH OF OVERBURDEN: > 59 m MODEL: TONE-THES AL DEPT); 20.m. ELE OF WATER TABLE: 150 m LOGGED BY: WIL CONTRACTOR: ES ON WATER TABLE BLS WATER RETURN RACTER OF DISLLING ETC. S CONE PERMEABILITY TEST SPT RECOVERY DEPTH ----R.Q.D GRA-DESCRIPTION ; FR TO O (%) ) nec . . . TO LOG 16 4.00 x 10⁻⁴ 15.7 16 16 16 170 LI3 x 10" 17 -16.7 17 17 18 O 4.12 x 10" 18 17.7 118 - 1 19 0 3.52 x 10⁴ 18.7 19 19 19 20 3.19x 10" 19.7 21 22 -23 -24 25 26 27 28 29 HOLE NO. TBH-1 SHEET NO. 2012 PLANATION: Wn - Weathering Number J-3 6-10joints/m W-I Sound J-4 11-20joits/m W-2 Slightly Weathered( appreciable oxidation at joint) 1-5 >20joits/m W-3 Minimut Weathered ( matrix slightly weathered) Ha - Enrolaces Number W-4 Deeply Weathered( matrix deeply weathered) H-1 Very Hard (hardly broken by hammer) W-5 Totally Weathered, argillified (only traces of original structure) H-2 Hard (edge hardly broken by hacener) Ja - Joint Number H-3 Medium Hard (easity broken by becamer) J-I ljoiat/m 1-2 2-Sjounts/m Fig. 3.9 (b) Boring Log of TBH-2 (2)

**GEOLOGIC LOG OF DRILL HOLE** 

## TBH-3

ATURE				PRIC	NECT: LOWER	saga	YAN	iyer J	1.000.00	NTROL P	RQ/ECT	LOCATION: English Transmiss		
LE NO. THI: 1								GROL	ND ELEV	ATION:		INCLINATION : Yerucal		
GUN	E Finisinedn/26/00							DEPT	I OF OVE	RBURDE	N:	MODEL: MINDRILL		
TAL DEPT]: 20.00 g	<b></b>	ELE	OF W	ATER	TABLE:	۱		1000	ED BY:		k	CONTRACTOR: KCL		
THIS ON WATER TAKE	CONE PERMEABILITY TEST				SPT			OFFTH	<b>R</b> O D	GRA	. <u></u>			
			FR TO O		8	1	то		(M)	(%)	PHIC LOQ	DESCRIPTION		
	tunnut-			<u>kille</u>							-	_	1	E
ı —	-	ŇI				0.7	1	- 14	_		3			
		N			0 2.00 x 10 ⁴ .	17	2	,	-1		00	1.50 - 2.00 m; Clayey / Seady silt, slight		
	][	IIT										prantuczy, triable, możst, PI = < 50, dark gaz		
3 <u> </u>	-	忡			O 2.90 x HP ⁴	2.7	3	11	_					
-		14			O 3.60 ⊭ 10 ⁻⁴				-			2.00 - 20.00 m; Sand, five, poorly graded.		
4				f		.,	1	13	-			durk grzy, non-plastic.		
					O 499 x 10"	4.7	5	- 14	1		: :			
-			<b>`</b>						-		. : •.*:			
6 <u> </u>			6	f	3 103 10	5.7	6	15						
1				τC	3.80 x 10 ⁴	6.7	7	17			· · · ·			
	] []		7						_					
• —	• •	19		ĸ	3 400 x 10 ⁴	77	•	20						
-					O 9.40 x 10 ⁴			72	-		• : • •			
,			9						1					
. 10		181		- wk	.) 6 x 10 ⁻¹	9.7	10.	19						
					) 177 t HT?				-					
11		$\mathbb{N}$	u	- 11		10,7	"	1	-					
12		削		12	D 1.47 x 10 ³	11.7	12	23						
			12						_					
13			0	130	> 1.67 x 10"	12.7	10	23	-					
-				14	0 189 x 10-3	13.7		24	-					
i4			•						]					
IS		141		13	) 2.33 x 10 ⁻³	14.7	15	24						
									н	IOLE NO	·	SHEET NO.		
EXPLANATION:	•							····						
Wa - Weathering N	mber								ŀ	3 6 10ja	oints/m			
W-1 Sound W-2 Slightly Weath	ned appreci	able o	ridatio	n at jo	int)				ر ار	4 11-20) 5 >20)k	ponts/m pits/m			
W-3 Minimum Weat W-4 Deepty Weathe	hered ( matrix red( matrix d	c slight copiy :	ily wea weathe	uhered acd)	h				H 11	in - Hardn - I Very I	ess Numbe lard (harel	r y broken by hammer)		
W-5 Totally Weathe	red, argilliñe	d (ont	y trace	s of or	iginal structure)				H	-2   inrd (	edec laudi	y broken by harmer)		

#### EATURE PRIORECT: LOWER CAGAYAN RIVER FLOOD CONTROL PROJECT LOCATION: Serie Transmiss N HOLE NO. TRI( . ) COORDINATES GROUND ELEVATION. INCLINATION : Verier E ____ FINISHED \$2670 BEGUN ARVOR DEPTH OF OVERBURDEN: MODEL: MINDRILL ELE. OF WATER TABLE. 1.52.19 TUTAL DEPTIL 2000 m LOGGED BY: ₩1, CONTRACTOR: MOTES ON WATER TAIKE LEVELS WATER RETURN CHARACTER OF DRILLING ETC. CONE : PERMEABILITY TEST SPT RECOVERY DEPTH cm/sec FR TO O metalow DEPTH R Q D GRA DESCRIPTION (%) HIC . . . . . то 100 FR 15 16 C 2.40 x 10⁻³ 15.7 ľ 16 16 16 (C) (C) (C) (18 17 2.85 x 10⁻¹ 16.7 17 17 27 18 0 2.65 × 101 17.7 18 21 18 -19^O 3.13 x 10³ 18 2 19 19 28 20 0 3.17 x 10" 19.7 20 21 22 23 — 24 25 -26 27 24 29 HOLE NO. _____ SHEET NO. _____ EXPLANATION: Wa - Weathering Number J-3 6-10joints/m J-4 11-20joits/m W-I Sound W-2 Slightly Weathered( appreciable oxidation at joint) J-5 >20joits/m W-3 Minimum Weathcred ( sustrix slightly weathcred) Ha - Hardman Number W-4 Deeply Weathcred( matrix deeply weathcred) 14-1 Very Hard (hardly broken by bammer) W-5 Totally Weathered, argillified (only spaces of original structure) 11-2 Hard (edge hardly broken by hummer) 11-3 Medium Hard (easily broken by hummer) Jn - Joint Namber J-I ljoint/m Fig. 3.9 (c) Boring Log of TBH-3 (2) J-2 2-Sjoints/m

**GEOLOGIC LOG OF DRILL HOLE** 





## TP-T1 & TP-T2



#### TEST PITS PROFILE (Embankment - Tuguegarao)



### TEST PITS PROFILE (Embankment - Tuguegarao)

Depth		Symbol	Description	Atterberg Limits			Other
(m)				LL	PL PL	PI PI	test results
0	TP (T-3)		(0-3.0 m) Dark gray CLAY, high plastic, traces of fine sand. CH, (A-7-6) (20).	67	21	46	NMC = 32.21 %



Fig. 3.11.1 (a) Log of Test Pit TP-T1 & TP-T2



Fig. 3.11.1 (b) Log of Test Pit TP-T3 & TP-T4

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#### TEST PITS PROFILE (Embankment - Tuguegarao)



#### TEST PITS PROFILE (Embankment - Cabagan)

(Ellivankinchi - Cavagai

Depth	Symbol	Description	Atterberg Limits			Other	
(m)			<u> </u>	PL	PI .	test results	
0 1.0 2.0 - TP (C-1)		(0-3.0 m) Yellowish brown silty CLAY, medium plastic, some fine sand, traces of fine gravel. CL, (A-6) (12).	38	16	22		







Fig. 3.11.2 (a) Log of Test Pit TP-C1 & TP-C2



### TEST PITS PROFILE











Fig. 3.11.2 (b) Log of Test Pit TP-C3 & TP-C4



Fig. 3.11.2 (c) Log of Test Pit TP-C5 & TP-C6



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MINANGA GRAVEL PIT (TUMAUINI, ISABELA) SAND, GRAVEL 0.50 km. FROM KM 424 + 310 (MINANGA BRIDGE) QUARTITY: 15,000 cu.m. MAXIMUM SIZE: 12 cm. OVERSIZE: 10 % MS-20

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THE REVIEW AND APPROVAL OF THESE PLANS DOCUMENTS BY THE DEPARTMENT OF PUBLIC WORES & HIGHWAYS DOES NOT RELEVE THE CONSULTANT OF ACCONTABLITY AND THE RESPONSIBILITY FOR THE SAFETY OF THE STRUCTURE (S)

Figure 3.12.2 Location Map of Material Sources for Aggregate and Boulders (2)