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Coastal Assessment of Proposed

Beach Enhancement Works

At Jumby Bay Beach

Long Island

Antigua

September 2021

Contents

1.0 Introduction

Jumby Bay Island Company Limited (JBIC) seeks to carryout “Beach Improvements Works” to Jumby Bay Beach located on the central western side of Long Island. See Enclosure no.1 & 2. To this end, a marine contractor has provided a proposal for the intended improvements work. The proposed works as captured under Plan Application #G13-2021 envisage the removal of approximately 16 inches of sandy silt over a beach length of approximately 800 feet and a width of approximately 40 feet, amounting to a total replacement volume of 1200 m^3.

JBIC also wishes to remove the accreted sand on the south side of the Guest Arrival Jetty on the southern 3^{rd} of the beach and place on the northern side as captioned in application G13 2021

As is required by the Physical Planning Act (PPA) No. 6 of 2003, the Development Control Authority (DCA) referred the applications to the Department of Environment (DoE) for its approval of the requested works. The DoE was not satisfied with the level of information presented in the application and requested that further information be supplied, including a coastal study and assessment of the effect of the proposed work on the coastal dynamics of the area and any likely effect of the surrounding areas.

Civil Engineering and Associated Services Limited (CEAS Ltd.) was commissioned as part of the Environmental Consultant Team to carry out the coastal study and prepare the required report providing further information and guidelines and best practices for achieving the required objectives.

2.0 Beach Location & Nature, Profile, and History

2.1 Location & Nature of Beach

Jumby Bay Beach is located along the central western coastline of Long Island (also referred to as Jumby Bay). See Enclosure No. 2. The beach which has a crenulate shaped, is the main beach on the island and measures approximately 2000 ft. from the southwestern headland to the northeastern headland. It is understood that the beach has had previous manmade interventions which were geared towards its improvement. It is further understood from the review of literature and discussions with locals familiar with the offshore islands that the beach is a naturally occurring one but has been influenced by the said manmade interventions geared at its improvement.

The beach is a relatively sheltered one, being sheltered on the west from the mainland, and on the east by the island itself. There is also some level of sheltering on the south by maiden Island, Crabbs Peninsula and Guiana Island. Further there is an offshore reef located northwest, seaward of the beach. The reef along with the flat bathymetry of the bay is such that a significant percentage of waves would break offshore before they are able to propagate to the beach thereby affecting coastal processes.

The above boundary conditions explain the tranquil nature of the area and why the seabed sedimentology tends to be silty, and foster the development of seagrass.

2.2 Beach Profile

The foreshore which extends landwards from the water line to the vegetation lines elevates up to about 1 to 2 m above mean sea level (MSL). The width varies along the beach but is estimated to be approximately 40m. From the shoreline, a narrow moderately sloping surf zone exist. This is the area where most of the small waves break before running up onto the shore. The width of the surf zone is dependent on the prevailing wave height and direction and is approximately 5 m under normal sea conditions as existed on the days of the site visits. Seaward of the surf zone, a very mildly sloping nearshore area extends seawards. This area flattens out to being relatively flat after a distance of approximately 200 m from the shoreline. Thereafter, the seabed is irregular with undulations in the bathymetry. Some areas further than 200 m are actually shallower than further inshore.

2.3 History

The beach is reported to be a natural sandy beach which have existed for decades. The northern and southern headlands provide the natural boundary and the indentation from the headlands provides an indication of the likely regress in shoreline location over time.

We are of the opinion that the beach has been naturally stable under normal circumstances and that the reported erosion which the beach has undergone is as a result of extreme conditions such as during a hurricane.

It is understood that beach improvement works were carried out at least twice in recent history. It has been reported (Moffatt & Nichol 2013) that the beach has undergone a few beach improvement works which were generally geared toward the improvement of beach quality with respect to beach “feel” and water clarity. Reports are that in the early 1990’s JBIC contracted a dredging contractor to remove 1-2 feet of sediment within the defined swim area to improve the appearance and feel of the sea bottom. A suction dredger was used to pump the dredged material onshore after a sand dyke was constructed parallel to the beach to act as a retention pond. It is further understood that fines in the slurry wash was allowed to flow back to the sea on the northern side. While the coarser sand collected was redistributed onto the beach and the nearshore area.

It has also been reported that the last time that the beach was nourished was in 2013 when sand from offshore was pumped hydraulically onto the shore where a similar dyke was constructed to retain the material. The coarse particle sizes were again retained and distributed along the beach. The fines were apparently left to flow back into the water through the overflow pipes, and may have contributed to the excessive fines currently present within the nearshore.

This methodology was considered somewhat flawed as it allowed significant amount of fines to return within the bay. Further it did not appear that the required sand particle size was given much consideration and that whatever material was available was what was used.

Sand is reported to accrete on the southern side of the Guest Arrival Jetty. This sand accretion is likely due to the partial blockage due to the jetty. JBIC has indicated that in the past a backhoe was used to remove the accreted sand from the shoreline and nearshore and place it on the other side (referred to in Coastal Engineering as “bypass” . The sand removal serves to maintain the water depth along the jetty. Currently the are on the south of the jetty is significantly shallower than the north side and is therefore only able to accommodate vessels with a very small draught.

3.0 Proposed Scope of Works & Methodology of Implementation

3.1 Sand Replacement

The proposed Beach Improve Works consist of the removal of approximately 16 inches of the existing fine sandy silt/ silty fine sand (See sieve analysis of collected sample- Appendix No.1) over a length of approximately 800 ft at the central section of the beach from approximately 20 ft. from the shoreline out approximately 40 ft. A total volume of 1200 m^3 of material is to be replaced over an area of approximately 3000 m^2. The depth of the water where the sand replacement is to be carried generally varies between 0.5 m to1.5 m. This is not the entire cordoned off swimming area, but the area termed the wade area where one is able to walk in the water.

The characteristics of the sand to be used for the replacement was not specified and only the approximate location of where the sand is to be mined from was indicated. The location was indicated as being approximately 1000 feet from the shoreline in a perpendicular direction. Samples (Samples 3,4,6)were collected from the area proposed to mind the sand, and laboratory sieve analysis confirm that the particle sizes of these samples are too fine. It was therefore concluded that there is no suitable sand to any significant extent from which the required sand could be mined at the said location.

Having reviewed the Contractor's Proposal and having had further discussions with him, it is understood that the intention is to use an excavator mounted on a barge to excavate between 1.5 to 2 ft. of the existing material located approximately between 20 ft. from the shoreline to 60 ft from the shoreline over a length of approximately 800 ft. The excavated material is to be placed in a hopper and disposed of at the approved designated dredging offshore disposal site (with coordinates 17 03 00 Lat, 62 01 30 Long (St. John's Deep Water Harbour Port Environmental Impact Assessment- 15th November 2017). This method of disposal is in keeping with the agreed disposal methodology and location and prevents the fines excavated from contaminating or "siltizing" the replenished sand, thereby fostering the development of the mushy/ slimy feel as currently exists.

Suitably sized sand would then be mined offshore of the beach and be transported to the nearshore area where the sandy silt was removed from. It is expected that the depth of sand to be mined would be kept to a minimum (1 ft.) while using a larger area 4,500 m^2 to produce the required volume. By keeping the depth of the mined sand to a minimum we are minimizing the effect of the dredging. Suitably sized sand was identified on the southern end of Long Island approximately 1.5 km away, adjacent to the channel between Long Island and Maiden Island.

As an alternative, the replacement sand may be imported by barge from Barbuda. The latter is preferably as the sand shape is more spherical with a better "feel" and contains less silt.

The replacement is anticipated to be a quick one (estimated to be within a week by the contractor) thereby minimizing the likelihood of any natural movement of silt to fill the temporary cavity produced during the silty sand removal. Our understanding is that the hopper used for the offshore disposal would be used for the sand replacement if the sand is being mined locally. However, if the sand is to be imported from Barbuda another barge may have to be commissioned as the sand would be required immediately after the excavation is completed.

Samples of appropriate sand particle sizes were collected from beaches which provided the beach feel and water clarity that JBIC is trying to achieve. The grain size analyses for these are presented in Appendices 1,2, 3 & 4 and is very similar to the sand currently found onshore.

3.2 Sand Bypassing

The quantity of sand to be relocated was not indicated. However based on observations on site, it is estimated that an area of approximately 100 m^2 is to removed immediately along the south side of the dock. The depth of sand to be removed depends on the location and is estimated to vary from 0 up to a maximum of 1 m. The total volume of sand to bypass the jetty is estimated to be in the region of 50 m^3. This is a relatively small volume.

4.0 Present Condition of Bay

Having inspected the Beach (foreshore and shore area) it was observed that the beach is comprised of creamish white medium sand. Laboratory analysis of samples taken from representative area indicate a D_{50} particle size of between 0.3 to 0.36 mm See table below extracted from Appendix 1 & 4. The D_{50} is the median particle size.

A dive through the Bay on 14^{th} & 19^{th} August indicate a surf zone comprised of medium grain sand with D_{50} particle size slightly coarser than the sand onshore. This material extended from the swash zone, just beyond the wet sand line to approximately 20 feet into the water. This material is likely to have been generated from the sorting of the foreshore material by the waves, where the coarser material was dispersed along the surf zone and the finer particle sizes transported to the more tranquil nearshore (wading) area.

Beyond 20 ft. into the water the bottom bathymetry although possessed a mild slope downwards, was fairly irregular with irregular small undulations along the seabed with small peaks 1 ft. and low depressions 0.5 ft. above and below surrounding levels. See Enclosures Nos.3D & E. The surface sedimentology consists of a silty fine sandy with moderately dense seagrass. The sediment in reality may actually be finer than indicated by the laboratory test due to the loss in fines during the collection process.

The bottom surface may be described as mushy/ slimy with a sense on compression of the surface as one walked along the nearshore area. Appendix 1 shows the sieve analysis for 2 samples taken within the nearshore area. Further seaward the bathymetry is relatively flat with only a mild downwards slope seawards. The seabed lithology consisted of a similar fine sandy silt as encountered in the nearshore area but appeared in some areas to be finer than the material encountered further shoreward. There was however a marked reduction in the density of the seagrass. See Enclosure No.3H.

The bay is generally calm and at the time of the site visits there were no appreciable waves. This is expected based on the nature and location of the beach.

The undisturbed water appears to be very clear but readily becomes murky whenever disturbed as occurs when one walks on the seabed or even slightly disturbs the seabed while diving. See Enclosure No. 3F.

There were no signs of any significant erosion on the beach and the fact that the sediment found was extremely fine suggest that there is not much sediment transport capacity within the bay, else the sediment particle size would be significantly larger. This relationship between wave and current strength with beach particle size is clearly seen on the south and southwestern side of the island where the sediment particle sizes is much coarser on account of the greater wave and current climate on the southern side.

Summary of Sediment Type found at Jumby Bay Beach

Sample No	**Location**	**Sample Description**	**D_{50} (mm)**
A1	Shoreline 100m from jetty	Creamish white medium sand	0.30
1B	25m offshore 100m N of Jetty	Greyish white silty fine sand	0.18
2A	Shoreline 200m N of jetty	Creamish white medium sand no silt	0.36
2B	25 m offshore 200m from jetty	Greyish white silty sand	0.24
3	300m from shoreline	Greyish white silty fine sand	<0.074
4	500 m from shoreline	Greyish white silty fine sand	0.08
5	Runaway shore (control)	Creamish white medium sand	0.35
6	Near Reef	Greyish white silty fine sand	0.1

5.0 Coastal Analysis

The evaluation of the coastal zone was carried out to determine the likely impact of the coastal processes on the proposed sand replacement works and also the likely impact of these works on the coastal dynamics and coastal zone from a coastal morphological perspective. The evaluation was based on field observations and measurements coupled with information from bathymetric charts, and predicted nearshore wave climate.

A Storm Surge Atlas was developed by The Caribbean Institute for Meteorology & Hydrology for USAID/ OAS Caribbean Disaster Mitigation Project October 1999) to assist in providing nearshore parameters for analysis and design. This Atlas provides Storm Surge levels at various locations around the Coastline for various storm intensities/ return periods. Similar Wind and Wave Probabilistic charts were developed by PDGM (May 2001)for USAID. We were able to extract information which provided data on the nearshore wave climate for making our assessment.

Probability of Occurrence	**Wave Height**	**Storm Surge**	**Wind Speed**
10 %/ year/ 10 year return period	1.5 m	0.5 m	30 m/s
4%/ year/ 25 year return period	1.7 m	0.9	38 m/s
2%/year 50 year return period	1.8	1.2	44 m/s
1 % / year / 100 year return period	2.0	1.6	49 m/s

The data above indicate that waves during condition indicated can approach the shoreline and will cause erosion resulting in the sand onshore and in the surf zone (extended surf zone) being transported offshore.

During normal conditions the shoreline morphology suggest that the sediment transport is from south to north. This explains why there is a sediment block on the south side of the Guest jetty.

5.1 Coastal Dynamics and Coastal Erosion

Coastal Erosion is nature's way of trying to redevelop a stable coastline capable of resisting the prevailing wave conditions which incident the coastline. This is achieved by redistributing the sediment (silt, sand, gravel, cobbles etc.) in the near-shore and onshore areas to a stable profile capable of resisting the prevailing wave conditions (water level, wave height/ direction). In order to develop this stable profile sufficient sediment must be available in the near-shore areas for redistribution. If sufficient sediment is not available in the near-shore area, any available sand onshore is generally mobilized into the system. This process will tend to continue until a stable profile is reached. This process is indeed what we refer to as erosion/ accretion.

A stable beach profile is therefore specific to a particular set of boundary conditions. Consequently, whenever one of these boundary conditions changes, the beach profile has to adjust accordingly. This accounts for the seasonal beach changes where section of the beach become smaller at a particular time then rebuild at another.

If extreme events (such as hurricanes) modify the bathymetry and foreshore profile then if sufficient sediments are not available erosion could occur. In such situations considerable land onshore may have to be lost before this natural stable profile is attained. It may not always be desirable or acceptable that the coastline be allowed to develop its own stable profile in which cases coastal engineering intervention may be required. Essentially the costal engineering intervention is an attempt to provide or restore a stable beach/ shoreline or to manage the rate of erosion to acceptable limits. A stable shoreline could be subjected to erosion or accretion if the nearshore wave climate changes. Changes in nearshore wave climate could result from either a change in offshore wave climate or a change in the physical boundary conditions within the bay.

5.2 Existing Stability of the Beach & Effect of Proposed Works.

As previously indicated the beach is sheltered on the west from the mainland and on the east by the island itself and partially on the south by maiden Island, Crabbs Peninsula and Guiana Island. Consequently, under normal conditions the bay is generally very calm and there is very little sediment transport capacity. This is borne out in our observations and reports from various individuals. The fact that the sediment type is very fine is further evidence that there is very little sediment movement and that the Beach is stable.

The subject coastline appears to be a relatively stable coastline under normal conditions and although erosion is possible under extreme conditions, the level of erosion anticipated to be small based on the extensive flat and shallow bottom bathymetry of the bay and the relatively sheltered nature of the bay. Studies conducted by others previously, also indicated that the beach is relatively stable.

The proposed "Beach Enhancement Work" will provide a supply of sediments which is of a coarser quality than the existing sediments. This will result in the beach being more stable as corresponding larger critical wave velocity would be required to be generated to mobilize the heaver particle sizes. So, in effect the proposed sand replacement operations will result in a more stable coastline.

During extreme events or winter swells the predominant direction which waves can approach is from the north and north west. But these waves are limited in height due to limitations on wave height to water depth forced by the extensive shallowness of the bay (often less than 10 ft.) and the sheltering effect previously stated. These wave directions would cause a sediment tr ansport in a southern direction. And could result in some erosion if similar sand quantities are not mobilized to replace that lost.

The proposed work will result in the sediment particle size being increased. It is recommended that sand with a D_{50} particle size of.35 to.45 be used in the sand replacement. The effect of this is that that the wave energy and currents required to create the “Critical Velocity” to mobilize the particle size is increased. The effect of this is that the beach/ bay becomes more stable both under normal and extreme events by replacing the existing material with sand of a greater particle size.

5.3 Effect of the proposed works on Erosion and Coastline Stability

The proposed sand replacement is anticipated to replace the material removed within the defined area, and change in the bathymetry other that creating a less uneven surface is expected to be minimal. To this end the bathymetry which existed prior would be very similar after the replacement. The works will therefore not have any significant effects on the coastal dynamics with respect to the nearshore parameters (wave heights, wave direction, shoaling, refraction and therefore no effect on the incident wave climate on the shoreline both during normal conditions and during extreme conditions. Consequently, the coastline morphology is not anticipated to increase the severity of the boundary conditions nor does it cause any amplification in wave conditions.

The sand bypassing proposed is not anticipated to create any adverse condition or cause any erosion to the subject beach or the neighbouring areas as the bypassing of sand is merely a manmade intervention to undo the accumulation of sand on the windward side of the jetty caused by the jetty itself. Had the jetty not been there the sand would have been distributed by natural coastal processes along the Northern side of Jumby Bay.

6.0 Conclusions & Recommendations

The predominant wave direction influences the direction of any sediment movement along the beach. Observation of the nearshore wave at the time of the site visit though very small were approaching from the west almost perpendicular to the shoreline This direction is not necessary the predominant wave direction as the wave direction generally varies with time, but may be as a result of shoaling and diffraction and other wave transformation processes as waves propagate from offshore. The orientation of the shoreline is also another factor as the direction of approaching waves is limited to waves from the seaward side of the land i.e., north, northwest, west and south.

The physical coastal boundaries, lithology, the nearshore bathymetry and nearshore wave climate together determine the dynamics of the coastline. The nearshore wave climate in turn is determined by the offshore wave climate and the bathymetry of nearshore. Thus, there is a very complex relationship between the offshore conditions and the effect on the coastline. The coastal processes are very complex and probabilistic, with the outcome of a particular analysis being determined by parameters which may change significantly based on any change of one of the influencing parameters. Coastal analyses therefore depend heavily on the ability to carry out intricate mathematical modeling where several scenarios are examined. The table in section 5.0 provide nearshore coastal parameters generated for Antigua that are used for determining coastal dynamics under extreme conditions and consequently the likely shore response.

- Long Island/ Jumby Bay Island is located along the Atlantic Ocean the actual site is located on the lee side of the island and is extremely well sheltered by the island itself, the mainland and to a lesser extent the other island and peninsulas around.
- The proposed beach improvement work will not modify the bottom bathymetry of the seabed and therefore will have no significant influence on the nearshore wave conditions.
- The proposed "Beach Improvement Works" provides the beach with a sediment of larger particle size than existing and therefore creates a more stable beach.
- It is recognized that the area to be affected has fairly dense seagrass and that the seagrass contributes to the stability of the seabed, however the

increased stability due to the seagrass is compensated for by the more stable heavier particle size.

- The area over which the seagrass was encountered was extensive and is significantly greater that the area that it is to be removed from to facilitate the “Beach Improvement Works” (estimated to be less than 5%). Therefore, from an environmental perspective the effect of removing the seagrass from this area is expected to be minimal.
- It is recognized that the quality of a beach contributes significantly to the perceived quality of a resort, consequently the quality of the beach is very important to a high-end resort such as Jumby Bay. In light of this we are of the opinion that the benefits of the Beach Improvement Works exceed the negative effects.
- There were a few Star fish & other Sea Life observed within the area earmarked for the improvement work. It is recommended that these animals be removed by a team of Divers and be relocated outside of the affected zone.
- The bypassing of sand around the jetty from the south to the north is not anticipated to, in any way adversely affect the coastal processes or coastline morphology.
- It is recommended that the improvement works be monitored by the authorities or an independent suitably qualified consult to ensure that the works are carried out in compliance with the final recommendations of DoE, Fisheries, and the EIA which this report forms a part.
- A complete land survey should be carried out on completion of the Beach Improvements works, both onshore and nearshore within the identified coastal boundaries. This survey will serve as a baseline for comparison of future shoreline changes.
- The above surveys should be coupled with aerial photography.
- Permanent benchmarks should be established to allow consistency in the surveys and ease of monitoring changes.

7.0 References

- Moffatt & Nichol 2013
- Storm Surge Atlas-Caribbean Institute for Meteorology & Hydrology
- Probabilistic Coastal Parameters for Various Return Periods -PGDM / USAID
- Shore Protection Manual SPM 1984- US Army Corps of Engineers

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R. Everon Zachariah

Civil /Structural & Costal Engineer

B Sc (UWI) M Sc (Delft, Holland)

Enclosure No1

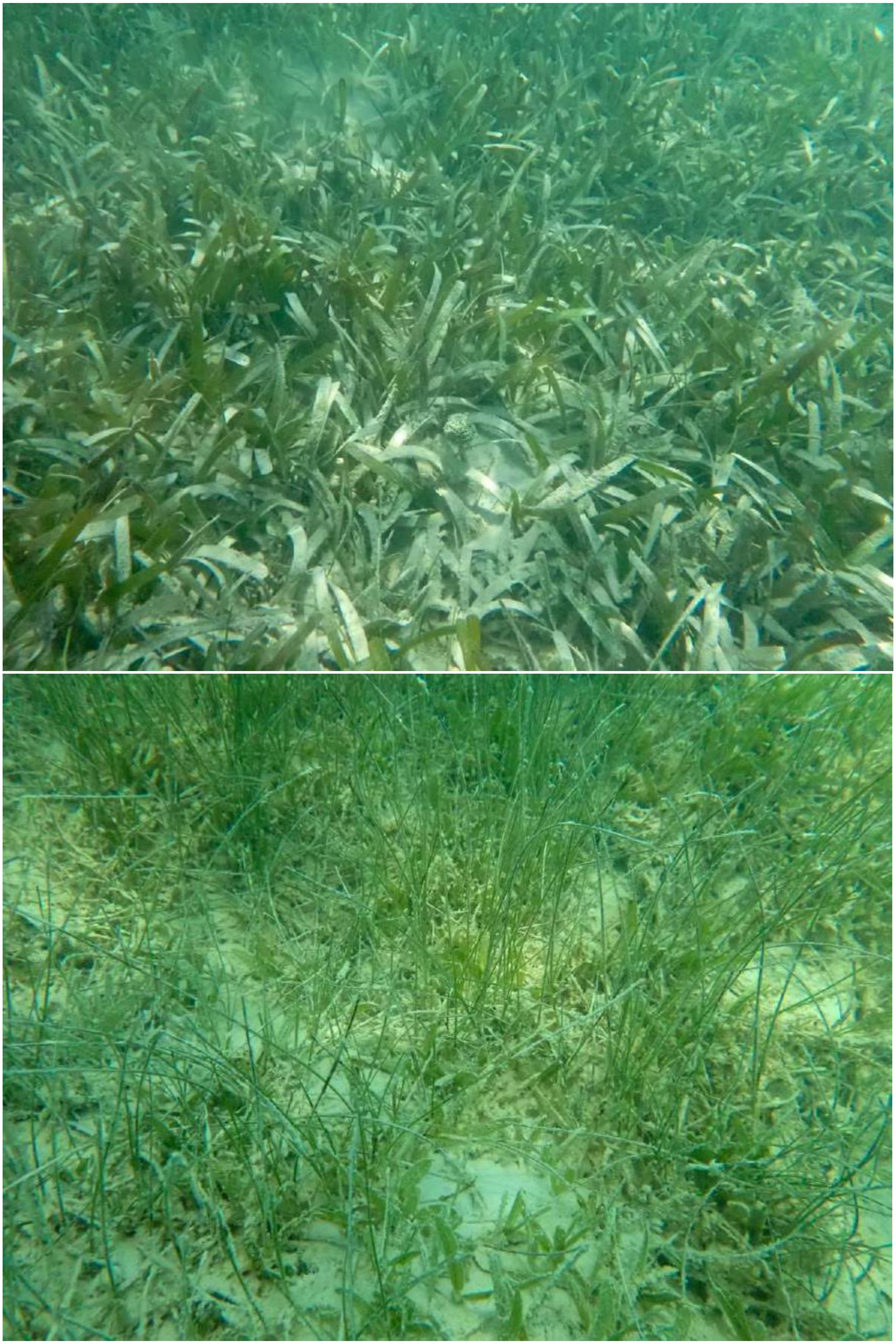
Location of Long Island

Enclosure No2

Site Location - Jumby Bay Beach


Enclosure No1
Location of Long Island
Legend
Feature 1
Feature 2
N17°10'48"
N17°10'12"
N17°09'36"
Long Island
Main Land
N17°09'
VC Bird Int'l Airport
W 61°48'36"
W 61°46'12"
W 61°45'
W 61°43'48"
W 61°42'36"
Bible Believers
Computer reset Site
APC Site of LNG PLant
N17°07'12"
N17°06'36"
N17°06'
Untitled Placemark
2 mi
N
Google Earth


Enclosure No2
Site Location - Jumby Bay Beach
Legend
Feature 1
Feature 2
N17°09'40.32"
45'54.72"
W 61°45'28.8"
W 61°45'2.88"
Jumby Bay Beach
N17°09'14.4"
Long Island
Google Earth
N
1000 ft



Contrasting sea grass type in Bay **Enclosure No3A**

Seagrass with significant fines covering suggesting easily suspended fines

Enclosure No.3B

Star Fish Encountered in nearshore area

Enclosure No3C

Shallow depressions encountered along Sea Bed

Enclosure No.3D

Low mounds encountered on sea bed **Enclosure No3E**

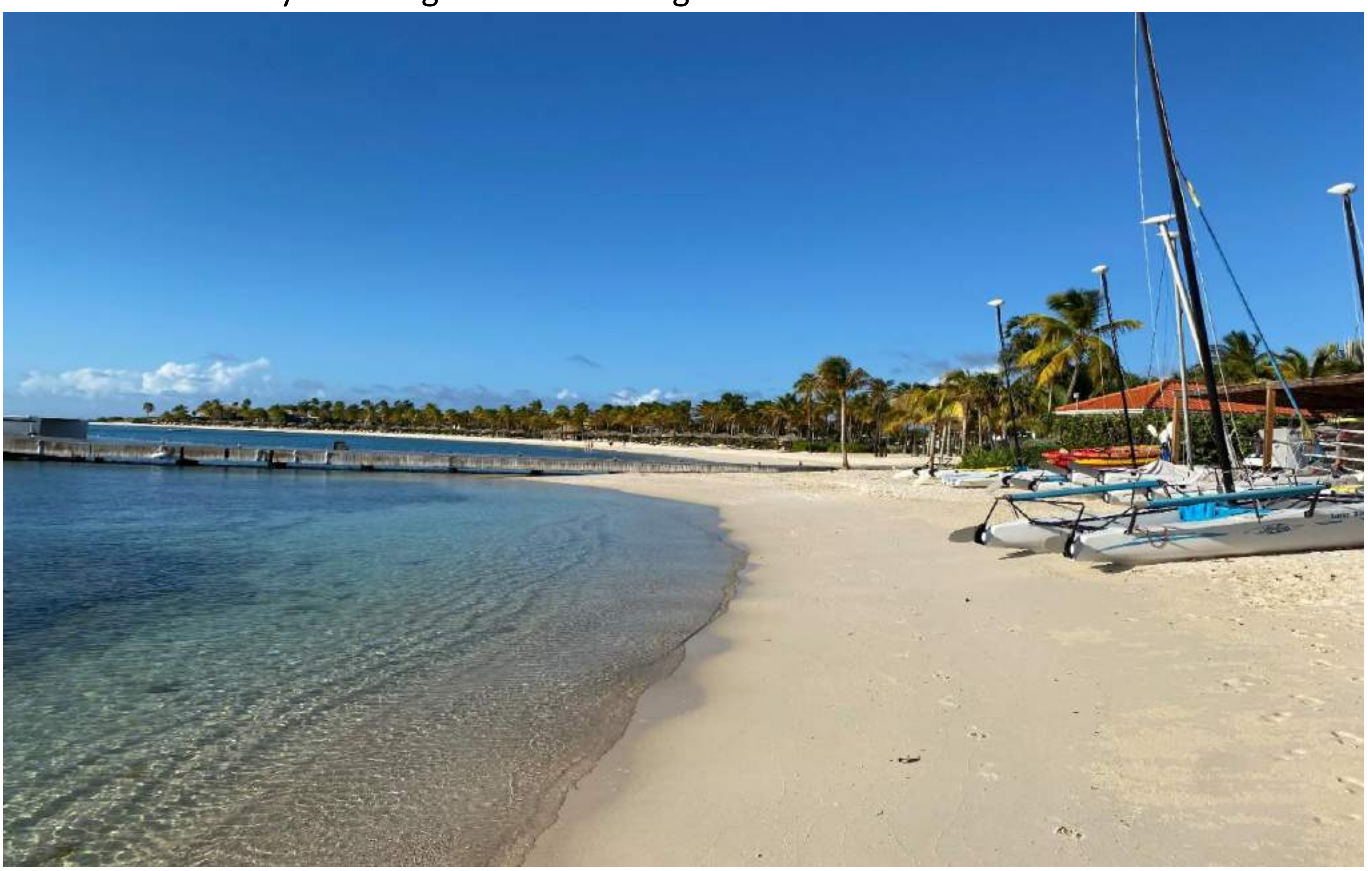
Decrease in water clarity when bottom sediment is slightly disturbed **Enclosure No.3F**

Clarity of water in undisturbed area dense & sparce seagrass **Enclosure No.3G**

Area of Sparce Sea grass

Enclosure No. 3H

Guest Arrivals Jetty showing accreted on Right hand Site



Southern side of Jetty on Jumby Bay beach where sand is to be removed

Enclosure No. 3I

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

(SPECIFICATION ASTM C - 136 / D - 422)

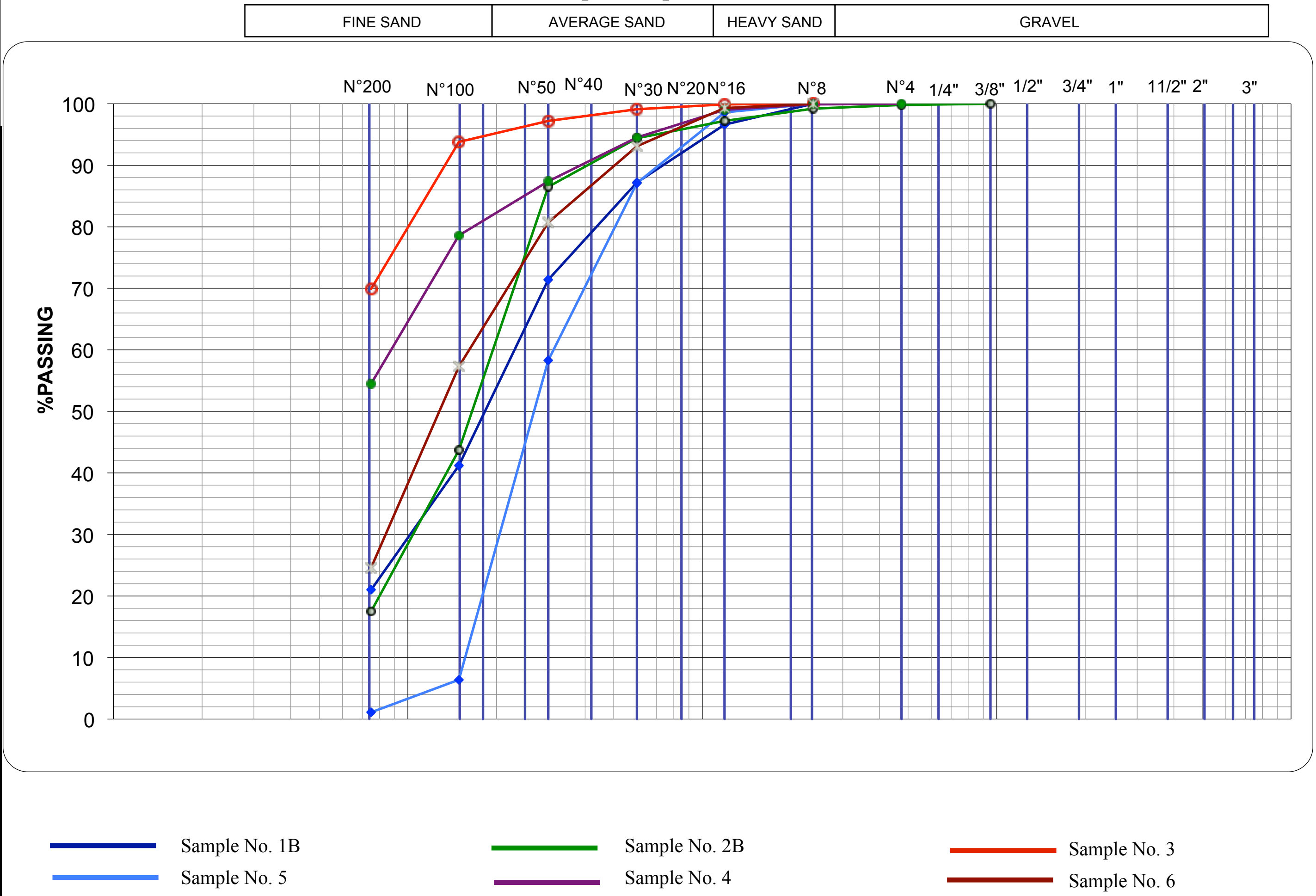
PROJECT :
MATERIAL : Sand
ORIGIN :

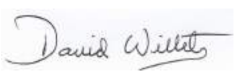
SHEET No. : 1
REPORTED BY : David Willet
DATE REPORTED : 31-Aug-2021

Grading Curve - STATISTICS

	Particle Size Analysis -% Passing Sieve										
	1"	3/4"	1/2"	3/8"	Nº 4	Nº 8	Nº 16	Nº 30	Nº 50	Nº 100	Nº 200
	25.400	19.050	12.500	9.525	4.750	2.380	1.190	0.600	0.300	0.149	0.075
Sample 1B	100.0	100.0	100.0	100.0	100.0	100.0	96.6	87.2	71.4	41.2	21.00
Sample 2B	100.0	100.0	100.0	100.0	99.8	99.2	97.2	94.4	86.5	43.7	17.5
Sample 3	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.1	97.2	93.8	69.9
Sample 4	100.0	100.0	100.0	100.0	100.0	99.9	99.0	94.5	87.4	78.6	54.5
Sample 5	100.0	100.0	100.0	100.0	100.0	100.0	98.6	87.1	58.3	6.4	1.1
Sample 6	100.0	100.0	100.0	100.0	100.0	100.0	99.3	93.1	80.7	57.3	24.6

Graphic Representation





Signature

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

(SPECIFICATION ASTM C - 136 / D - 422)

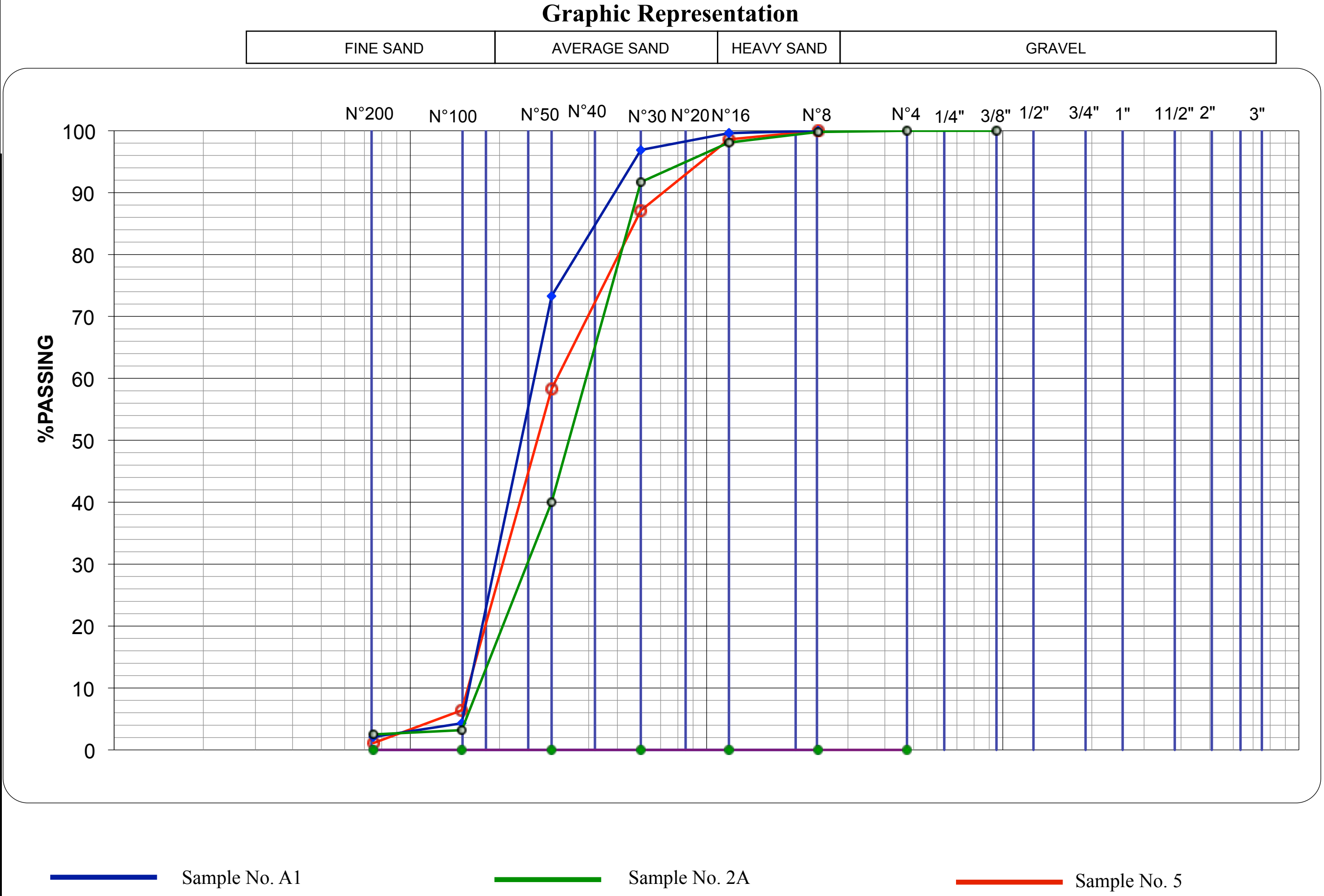
PROJECT :
MATERIAL : Sand
ORIGIN :

SHEET No. : 2
REPORTED BY : David Willet
DATE REPORTED : 31-Aug-2021

Grading Curve - STATISTICS

	Particle Size Analysis -% Passing Sieve										
	1"	3/4"	1/2"	3/8"	Nº 4	Nº 8	Nº 16	Nº 30	Nº 50	Nº 100	Nº 200
	25.400	19.050	12.500	9.525	4.750	2.380	1.190	0.600	0.300	0.149	0.075
Sample A1	100.0	100.0	100.0	100.0	100.0	100.0	99.6	96.9	73.3	4.3	2.10
Sample 2A	100.0	100.0	100.0	100.0	100.0	99.8	98.1	91.7	40.0	3.2	2.5
Sample 5	100.0	100.0	100.0	100.0	100.0	100.0	98.6	87.1	58.3	6.4	1.1

Graphic Representation



Signature

SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES

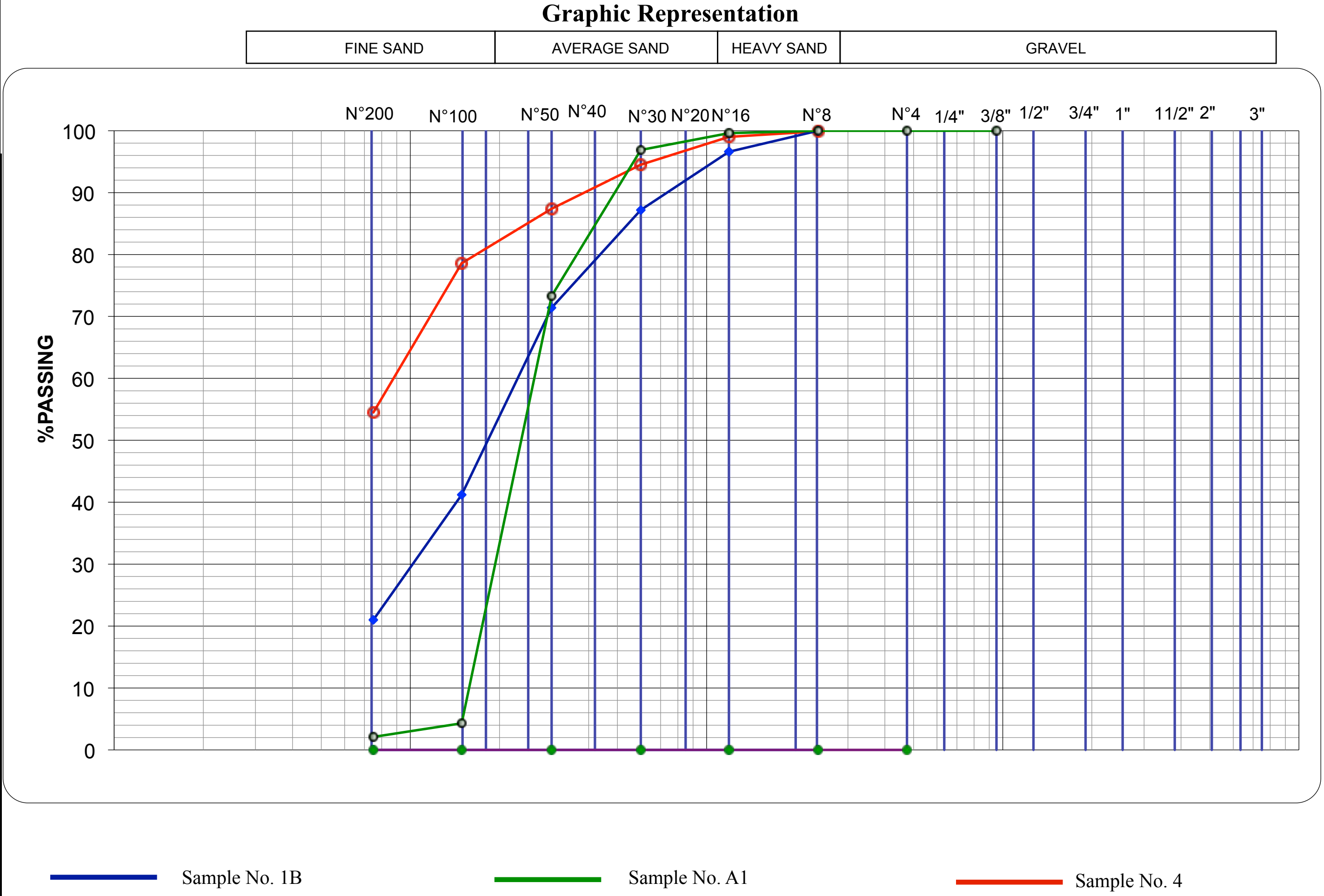
(SPECIFICATION ASTM C - 136 / D - 422)

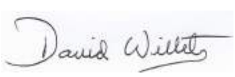
PROJECT	:		SHEET No.	:	3
MATERIAL	:	Sand	REPORTED BY	:	David Willet
ORIGIN	:		DATE REPORTED	:	31-Aug-2021

Grading Curve - STATISTICS

	Particle Size Analysis -% Passing Sieve										
	1"	3/4"	1/2"	3/8"	Nº 4	Nº 8	Nº 16	Nº 30	Nº 50	Nº 100	Nº 200
	25.400	19.050	12.500	9.525	4.750	2.380	1.190	0.600	0.300	0.149	0.075
Sample 1B	100.0	100.0	100.0	100.0	100.0	100.0	96.6	87.2	71.4	41.2	21.00
Sample A1	100.0	100.0	100.0	100.0	100.0	100.0	99.6	96.9	73.3	4.3	2.1
Sample 4	100.0	100.0	100.0	100.0	100.0	99.9	99.0	94.5	87.4	78.6	54.5

Graphic Representation





Signature