Draft Final report

Sediment assessment of Lake 19 (City of Naples)

Final report submitted to:
City of Naples

Submitted on 09/06/2020 by:
Serge Thomas, Ph.D.
The Water School, Inland Ecology Research Group
10501 FGCU Blvd. S
Fort Myers, FL 33965-6562
Ph. 239-590-7148, Cell. 239-204-0920
sethomas@fgcu.edu

Table of Contents

List of figures

List of tables

I. Introduction

The City of Naples requested limnological work to be performed on three of their stormwater lakes (lake 11, 19 and 31). One of the lakes (11, see below) has undergone studies in 2008 (MACTEC, 2008[1]) as well as in 2012 (Thomas, 2013a[2]). Along with lake 22 (Thomas, 2013b[3]), lake 11 already was eutrophic with significant amount of organic sediment and flocculent on its bed. Sediment often exceeded the soil cleanup target levels (SCTLs) for some metals. This lake as well as lake 22 were good candidates for dredging. Lake 22 was then dredged, reshaped and planted with natives within its littoral as well as riparian zone. Surrounding watershed improvements were also implemented, e.g. the use of pervious asphalt to improve the drainage. Most of the lakes within the City's limits are indeed old (well over 30 years of age; Pers. Comm. From the City of Naples) and have never been dredged. Thus, as for Lake 22, the City seeks data-driven insights to restore the original flood mitigation and ecological filtration of its lakes. Measures including lake dredging, bank restoration, shoreline restoration/re-shaping as well as bioremediation such as littoral planting will be therefore considered as restoration measures.

II. Methods

1. Study site and coring locations

Lake 19 is a detention lake located within the City of Naples (17R 420466m E 2894258m N). This lake of 3.46 acres had its sediment cored from late April through early May 2020. A total of 28 cores which locations were scattered within the lake's boundaries were taken and composited as outlined in TABLE 1.

[1] MACTEC. 2008. Spring Lake. Report of the surface water and sediment testing, Naples, Collier County, Florida. Mactec project 6787-08-1859.

[2] Thomas S. 2013. Bathymetry and sediment characterization of Spring Lake, City of Naples, FL. Streets and Stormwater, City of Naples FL.

[3] Thomas S. 2013. Bathymetry and sediment characterization of Lake Manor, City of Naples, FL. Streets and Stormwater, City of Naples FL.

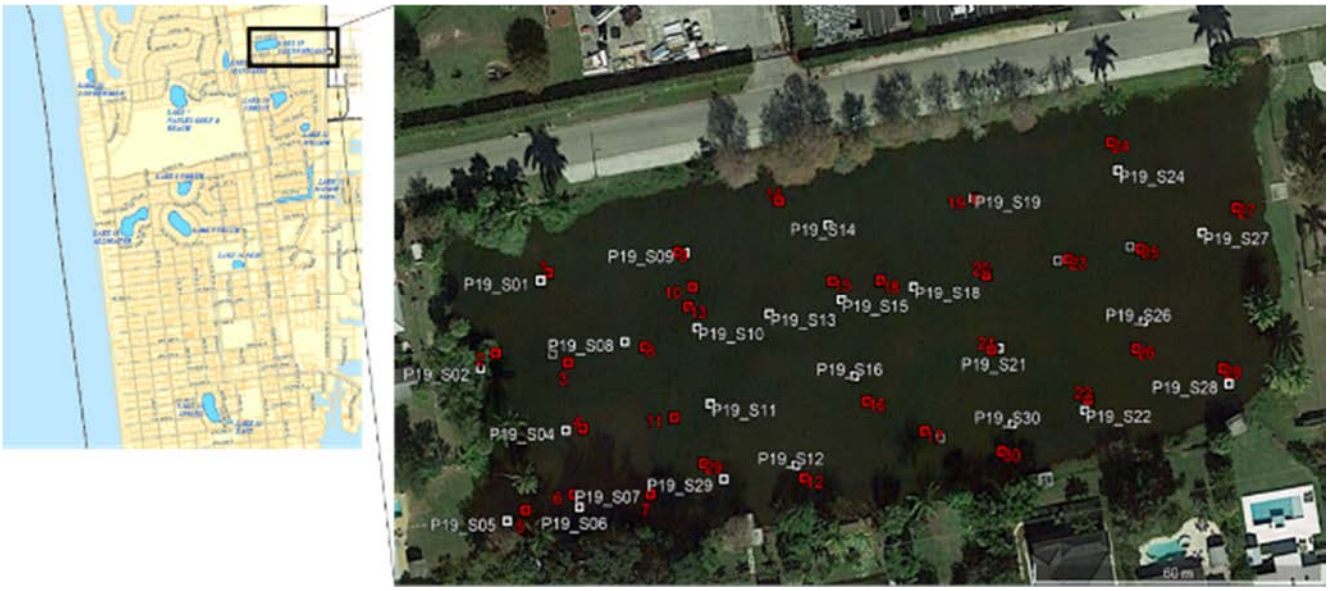


FIGURE 1. Lake 19 and its planned (white) and actual (red) coring locations (squares).

TABLE 1. Coring names and locations of Lake 19. The table is also showing how the cores were planned to be composited. Numbers in parentheses in the "composited" column refer to the sediment cores which did not have enough sediment to be composited with the other cores (where applicable). Refer to the methods section for more insight.

Core #	Sample ID	Easting (m)	Northing (m)	Composited
1	P31_S01	420398	2894266	1,(2),3,(8)
2	P31_S02	420387	2894250	
3	P31_S03	420402	2894248	
8	P31_S08	420418	2894251	
4	P31_S04	420405	2894235	4,5,6,7
5	P31_S05	420393	2894219	
6	P31_S06	420403	2894222	
7	P31_S07	420419	2894222	
9	P31_S09	420425	2894270	(9),10,13,14
10	P31_S10	420428	2894263	
13	P31_S13	420427	2894259	
14	P31_S14	420446	2894280	
11	P31_S11	420424	2894237	11,(12),(16),29
12	P31_S12	420451	2894225	
16	P31_S16	420464	2894240	
29	P31_S29	420430	2894228	
15	P31_S15	420457	2894264	15,(18),19,20
18	P31_S18	420467	2894264	
19	P31_S19	420487	2894280	
20	P31_S20	420489	2894265	
17	P31_S17	420476	2894234	17,21,22,30
21	P31_S21	420490	2894250	
22	P31_S22	420510	2894240	
30	P31_S30	420492	2894230	
23	P31_S23	420506	2894268	23,24,25,(27)
24	P31_S24	420515	2894291	
25	P31_S25	420521	2894270	
27	P31_S27	420541	2894278	
26	P31_S26	420520	2894250	26,28
28	P31_S28	420538	2894246	

2. Field methods

The collection of the sediment was done from a Tracker TOPPER™ 1436 aluminum Jon boat using a homemade PVC handheld corer equipped with a one-way check valve and a machined PVC boot adapter to securely couple a clear extruded 3.5" OD acrylic 1/8" thick barrel. The barrels came in various lengths to accommodate the sediment thickness. The station locations were preloaded in a handheld Garmin GPSMAP 64st GNSS unit with GPS, GLONASS and WAAS enabled. At each station, the boat was anchored at both ends and coring was proceeded from either the port or starboard side. Prior to core, the water depth was sounded. Next, a sediment core was taken by pushing the acrylic core vertically into the lake's bed until refusal. The barrel containing the core was then hauled to the surface, plugged at both ends and a visual description of the

various sediment strata were recorded. Photographs of the sediment core in its barrel along with the core's visual characteristics were then taken against a white background using a rugged 12-megapixel Olympus TG-1iHS camera. The core was then extruded from bottom up and strata were then described and measured again. These cores characteristics are presented in TABLE 3. The flocculent stratum defined as material which flows and does not free stand was measured but discarded. Only the "sediment" stratum defined as organic material, silt or other materials (sometimes clay) which obviously settled above the sand, limestone, or marl was kept and eventually combined with other sediment materials from other station(s) (cf. TABLE 1 for further details). In the event of core composition, special care was taken so that the amount of material taken at each location was roughly equivalent in volume. The materials underneath the sediment were described, their strata widths measured and discarded.

3. Sediment parsing

The sediment was thoroughly mixed with a silicone spatula in either a plastic or a metal mixing bowl depending on the type of analyses performed. Part of the sediment was then conditioned in glass jars provided by Pace Analytical Laboratories (www.pacelabs.com) and kept on ice in an enclosed cooler. The remainder of the sediment was kept in doubled zip-lock™ bags which were also chilled in the cooler. Once the samples arrived at the laboratory, the sediment was kept in a walk-in refrigerator until being shipped overnight in a cooler packed with ice to Pacelabs in Pompano Beach. The sediment in plastic bags were transferred into 1L plastic specimen jars and kept in the walk-in refrigerator at 5ºC until being processed at FGCU.

4. Outsourced NELAC laboratory (www.pacelabs.com) methods (TABLE 2)

TABLE 2. Methods used by Pacelabs.

Analyte	Method
Nitrogen, Ammonia	EPA 350.1
Nitrogen, Kjeldahl, Total	EPA 351.2
Phosphorus, Total (as P)	EPA 365.4
Arsenic	EPA 6010
Arsenic, SPLP	
Barium	
Barium, SPLP	
Cadmium	
Cadmium, SPLP	
Chromium	
Chromium, SPLP	
Copper	
Copper, SPLP	
Lead	
Lead, SPLP	
Selenium	
Selenium, SPLP	
Silver	
Silver, SPLP	
Petroleum Range Organics	FL-PRO

Analyte	Method
Mercury, SPLP	EPA 7470
Mercury	EPA 7471
4,4'-DDD	EPA 8081
4,4'-DDE	
4,4'-DDT	
Aldrin	
Chlordane (Technical)	
Dieldrin	
Endosulfan I	
Endosulfan II	
Endosulfan sulfate	
Endrin	
Endrin aldehyde	
Endrin ketone	
Heptachlor	
Heptachlor epoxide	
Methoxychlor	
Toxaphene	
alpha-BHC	
beta-BHC	
delta-BHC	
gamma-BHC (Lindane)	

Analyte	Method
PCB-1016 (Aroclor 1016)	EPA 8082
PCB-1221 (Aroclor 1221)	
PCB-1232 (Aroclor 1232)	
PCB-1242 (Aroclor 1242)	
PCB-1248 (Aroclor 1248)	
PCB-1254 (Aroclor 1254)	
PCB-1260 (Aroclor 1260)	
1-Methylnaphthalene	EPA 8270
2-Methylnaphthalene	
Acenaphthene	
Acenaphthylene	
Anthracene	
Benzo(a)anthracene	
Benzo(a)pyrene	
Benzo(b)fluoranthene	
Benzo(g,h,i)perylene	
Benzo(k)fluoranthene	
Chrysene	
Dibenz(a,h)anthracene	
Fluoranthene	
Fluorene	
Indeno(1,2,3-cd)pyrene	
Naphthalene	
Phenanthrene	
Pyrene	

a. Nutrients

Sediment nutrients were analyzed using the following EPA methods: EPA 350.1 (ammonia), EPA 351.2 (Total Kjeldahl Nitrogen, TKN) and EPA 365.4 (Total Phosphorus, TP).

b. Organochlorine pesticides and polychlorinated biphenyls (PCBs, Polyvinyl chloride)

Organochlorine pesticides and PCBs were analyzed using the EPA 8081 and 8082 methods respectively.

c. Polynuclear Aromatic Hydrocarbons (PAHs)

PAHs were analyzed using the EPA low level method 8270.

d. Total Recoverable Petroleum Hydrocarbons (TRPH)

TRPH were analyzed using the FDEP approved Florida Petroleum Residual Organic (FL-Pro) method and targets the detection of aromatic hydrocarbons in a carbon chain range of C8-C40.

e. Resource Conservation and Recovery Act (RCRA) metals (8) and copper

The 8 RCA metals and copper were measured using the EPA methods 7471 and 6010.

f. Synthetic Precipitation Leaching Procedure (SPLP) on RCRA metals and copper

SPLP was done using the EPA leachate method 1312 and the analyzes performed using the EPA methods 7470 and 6010 for the 8 RCA metals and copper.

5. FGCU laboratory methods

a. Water, organic, inorganic contents and bulk density

Water, organic and inorganic contents were determined using the ASTM D2974-87 method whilst the bulk density was determined using the ASRM D4531-86 method.

b. Grain size analysis

The grain size analysis of each sample was determined using the wet sieving method following the ASTM D 422 for particles larger than 75µm and D1140 for materials finer. Additionally, each sample was run in a Malvern Mastersizer 3000 for a more precise grain size analysis.

c. Atterberg limits for liquid limit, plasticity limit and plasticity index

Sediment liquid limit (LL), plasticity limit (PL) and plasticity index (PI) were determined using the ASTM D4318 method.

6. Mapping

Mapping of the data, when provided, was made using surfer 17 (www.goldensoftware.com) using the Kriging method and appropriate variogram to interpolate spatially the data.

III. Results

1. Field characterization of sediment

The floc and sediment of Lake 19 were 4.0±S.D.3.0 cm and 9.3±S.D.9.9 cm respectively. The floc accumulation was thus small and much less that the sediment (FIGURES 2 & 3). Spatially, there was more floc in the center north portion of the lake and to its northwestern side. The floc was mostly greenish brown. The sediment was very variable spatially and it was mostly found in greater thickness in the central portion of the lake. The sediment thickness was limited in the center of the lake, east and west portions of the lake. The sediment was mostly brown in color and overlying sometimes a clay layer. The bottom of the core was almost always sand of various colors and grain sizes.

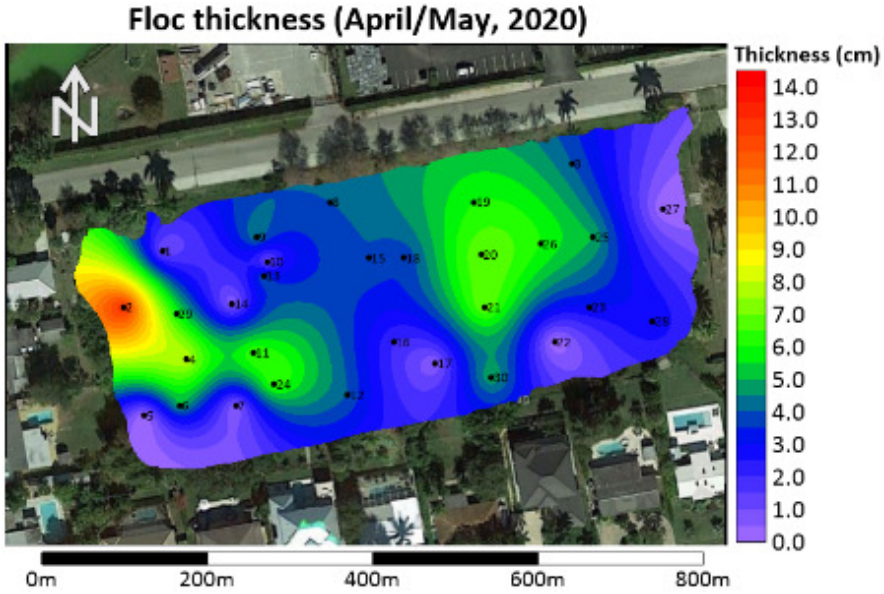


FIGURE 2. Floc thicknesses in Lake 19. The black dots and associated numbers refer the coring stations names.

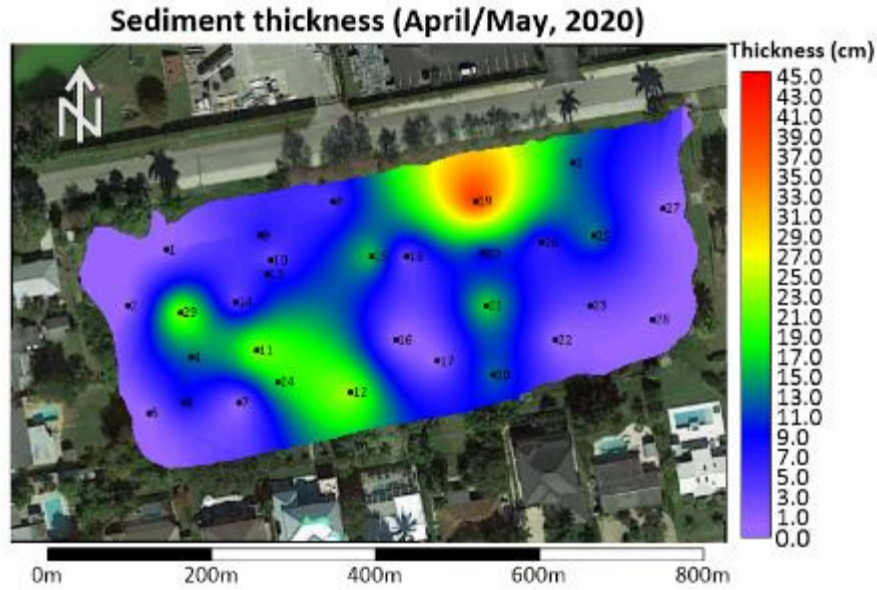


FIGURE 3. Sediment thicknesses in Lake 19. The black dots and associated numbers refer the coring stations names.

TABLE 3. Sediment characteristics of Lake 19 measured in the field.

ID_Station	UTM X (m)	UTM Y (m)	water depth (cm)	Tot. core length (cm)	Floc. Length (cm)	Sed. Length (cm)	Core description
P19_S01	420398	2894266	92	21.0	1.0	0.0	Light green floc with slight algae growth overlying 6.5cm of coarse light brown sand mixed with white and gray layers with little shell fragments and fine sand with small traces of organic muck. 13.5cm of clay with sand and organic material.
P19_S02	420387	2894250	222	48.0	13.0	0.0	Light brown floc with decaying organics overlying 19cm of light gray to white tan clay overlying 16cm of sand miced with peat and fine sand.
P19_S03	420402	2894248	320	57.0	6.0	23.5	Light brown floc (no decaying matter), overlying very light brown mousse like sediment overlying 20cm of clay with the top being green/gray and darker brown/tan clay underneath overlying 7.5cm of dark tan sand.
P19_S04	420405	2894235	340	67.0	8.0	13.0	Dark brown floc with shell fragments overlying brown sediment overlying 20cm of light gray clay overlying 25cm of light tan clay.
P19_S05	420393	2894219	125	14.0	0.0	0.0	Black to light gray mud with organic material, coarse sand and shell fragments.
P19_S06	420403	2894222	322	45.0	5.0	9.0	Floc not described. Dark brown sediment overlying 13.5cm of light gray clay, overlying 12cm of dark tan clay overlying 7cm of sand.
P19_S07	420419	2894222	252	37.0	0.5	0.0	Brown floc with mulch. 16.5 cm of coarse sand overlying 5cm of what appears sediment, overlying 4cm of light dark clay overlying 9cm of grained sand.
P19_S08	420418	2894251	290	29.0	0.5	6.0	Green brown floc overlying light tan sediment with decayed organic matter overlying 12.5cm of gray mottled with white clay overlying 8.5 cm of fine light tan sand.
P19_S09	420425	2894270	248	40.5	4.5	7.5	Greenish brown floc with same color and light decaying organic with leaf fragments sediment mixed with decayed leaf fragments overlying 10cm white-tan-green clay with 18.5cm dark tan sand overlying light tan sand.
P19_S10	420428	2894263	292	39.5	1.0	2.5	Light green floc overlying fine sand mixed with brown-green organic matter overlying 36cm of light colored to dark sand.
P19_S11	420424	2894237	339	63.0	6.5	23.0	Floc not described. Medium brown sediment overlying 25cm of light tan gray clay overlying 9cm of dark brown mud mixed with shell fragments
P19_S12	420451	2894225	279	57.5	4.0	24.0	Floc not described. Dark brown sediment mixed with organic matter overlying 7cm of brown to light gray sediment mixed with organic matter overlying 8.5cm of light gray clay overlying 13cm of deep brown sediment with fine to coarse grained sand.
P19_S13	420427	2894259	302	43.0	4.0	8.0	Floc is very light brown mixed with shell/leaf fragments overlying 5cm of dark brown organic sediment overlying 3cm of white clay mixed with fine sand overlying 23cm of mottled sand w/ peat.
P19_S14	420446	2894280	290	33.0	4.0	4.5	Light brown floc with loose organic material overlying very light brown sediment/clay mixed with organic material overlying 24.5cm of tan sand
P19_S15	420457	2894264	319	28.0	4.0	17.0	Floc is green with organic material. Sediment is light brown mousse like material with dark decaying organics. Transition to white clay (3cm) then darker sediment with more decaying material (4cm) of mottled organic peat/clay with dark brown to tan sand.
P19_S16	420464	2894240	295	33.0	2.0	0.0	Floc not described. Whole core is sand. No collection.
P19_S17	420476	2894234	294	20.0	0.5	0.0	Floc not described. No sediment. 19.5cm of dark gray layerd sand with organics. Sand is rough grained.
P19_S18	420467	2894264	324	25.5	3.5	2.5	Green floc overlaying very light brown sediment overlaying 19.5cm dark tan sand.
P19_S19	420487	2894280	336	49.5	6.0	41.5	Greenish floc overlying light brown sediment w/ leaf and twig fragments overlying white/tan clay with organic materials overlying 2cm of tan sand.
P19_S20	420489	2894265	342	37.5	7.0	9.0	Greenish-brown floc overlying light brown/green mousse like sediment w/ fibrous material overlying 21.5cm of dark tan sand with leaf and fragments of sticks.
P19_S21	420490	2894250	355	40.0	7.0	18.0	Floc not described. Sediment not described. 15cm of light tan fine sand.
P19_S22	420510	2894240	319	19.5	0.0	0.0	No floc. No sediment. 19.5cnm of dark green fine sand mixed with organic matter to light tan fine sand.
P19_S23	420506	2894268	364	39.0	6.0	6.0	Floc not decribed. Brown sediment overlying 27cm of tan sand.
P19_S24	420515	2894291	320	51.0	4.0	12.5	Floc not described. Brown sediment overlying 31cm of tan smooth clay overlying 3.5cm of dark brown sand.
P19_S25	420521	2894270	367	30.0	5.0	14.0	Floc not described. Brown sediment overlying 8cm of tan clay overlying 3cm of beige sand.
P19_S26	420520	2894250	364	40.0	3.0	3.0	Floc not described. Sediment not described. 34cm of dark gray fine sand.
P19_27	420541	2894278	194	26.0	0.0	0.0	26cm of tan sand only. No sample taken.
P19_28	420538	2894246	238	19.0	1.0	4.0	Organic matter mixed with floc. Sediment not described overlying 14cm of tan colored sand which is darker brown on the bottom
P19_29	420430	2894228	320	62.0	6.5	18.0	Floc not described. Tan brown sediment (upper 1/2) overlying lighter brown sediment (lower 1/2) overlying 19cm of tan to dark brown clay overlying 14.5cm coarse grained sand (dark colored).
P19_30	420492	2894230	329	40.0	5.0	13.0	Floc not described. Sediment not described. 7cm of clay overlying 15cm of light brown fine sand.
		average:	293	38.5	4.0	9.3	
		S.D.	66	14.1	3.0	9.9	

2. Sediment grain size, D60, D30, D10 and plasticity limits

Sediment textures class in Lake 19 varied from fine sandy loam to silt loam. There were discrepancies between the D values measured with the Malvern (Dx) and the wet sieving (D). Wet sieving shows that, in average, 60 percent of the particulate was less than 0.18±S.D.0.07mm in size. It was most not possible to get the size of the particulate for the D30 beside for one sample (0.16mm). It was impossible to determine the D10 because most of the particles were very fine and thus went through the size 200 (i.e., 0.074mm pore size) sieve. The Malvern provides the following averages of 0.22±S.D.0.04mm, 0.07±S.D.0.02mm, 0.02±S.D.0.01mm and 0.009±S.D.0.002mm for Dx(90), Dx(60), Dx(30) and Dx(10) respectively. Liquid limits were in average 43.8±S.D.9.4% and the plasticity limit was 30.7±S.D.3.1% for a plasticity index of 13.0±S.D.8.6%.

TABLE 4. Sediment grain size, D90, D60, D30, D10 and plasticity limits for the sediment in lake 11. Dx values were measured with the Malvern. Acronyms in the table headers: vfs= very fine sand, fs= fine sand, ms= medium sand, cs= coarse sand, vcs= very coarse sand.

Sample #	D60	D30	D10	Dx (10)	Dx (30)	Dx (60)	Dx (90)	Liquid Limit	Plasticity Limit	Plasticity Index	Clay	Silt	Sand	vfs	fs	ms	cs	vcs	Soil texture class
#	mm	mm	mm	mm	mm	mm	mm	%	%	%	%	%	%	%	%	%	%	%	
P19_S01/03	0.07	ND	ND	0.01	0.03	0.06	0.20	32.6	32.6	0.1	3.49	50.56	46	22.25	19.86	3.89	0	0	silt loam
P19_S04/05/06/07	ND	ND	ND	0.01	0.02	0.04	0.18	41.5	32.6	8.9	5.21	61.18	33.63	17.1	11.52	4.85	0.16	0	silt loam
P19_S11/29	0.22	ND	ND	0.01	0.03	0.09	0.24	49.2	27.2	22.1	3.67	41.49	54.81	24.19	21.36	8.8	0.46	0	fine sandy loam
P19_S10/13/14	0.24	ND	ND	0.01	0.02	0.09	0.25	32.3	28.9	3.4	5.27	44.56	50.19	18.08	22.25	9.42	0.44	0	fine sandy loam
P19_S15/19/20	0.15	ND	ND	NA	NA	NA	NA	56.0	34.6	21.4	ND	ND	ND	ND	ND	ND	ND	ND	ND
P19_S17/21/22/30	0.13	ND	ND	0.01	0.01	0.04	0.17	49.6	31.3	18.3	9.22	54.46	36.34	18.47	14.32	3.55	0	0	silt loam
P19_S26/28	0.26	0.16	ND	0.01	0.02	0.08	0.23	36.1	25.9	10.1	8.16	44.4	47.44	17.74	22.74	6.96	0	0	loam
P19_S23/24/25	0.22	ND	ND	0.01	0.03	0.10	0.28	52.8	32.8	20.0	4.09	37.9	57.99	23.38	22.11	10.45	2.01	0.04	fine sandy loam
average	0.18	0.16	NA	0.009	0.02	0.07	0.22	43.75	30.73	13.02									
S.D.	0.07	NA	NA	0.002	0.01	0.02	0.04	9.37	3.05	8.57									

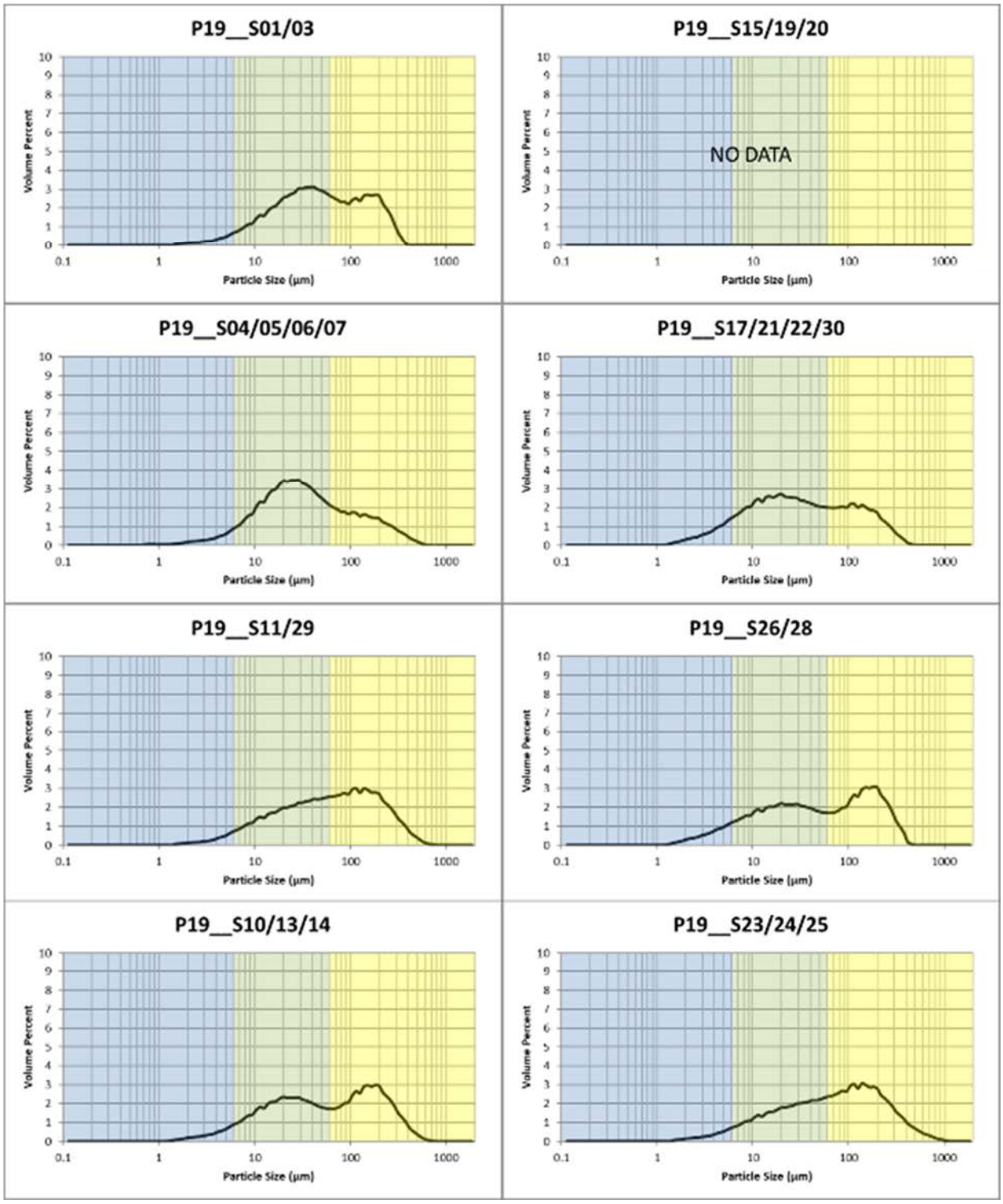


FIGURE 4. Grain size distribution of the sediment in Lake 19. There was no sediment left to process sample P19_S15/19/20 with the Malvern.

3. Sediment bulk density, water and organic contents

Sediment fresh bulk density was in average 1.32±S.D.0.10 g/ml whilst it was 62.5±S.D.9.3% and 6.6%±S.D.2.4% for the water and organic contents respectively.

TABLE 5. Sediment bulk density, water and organic contents in Lake 19.

pond	Sample #	bulk density FW	bulk density DW	water content	organic content	Inorganic content
#	#	g/ml	g/ml	%	%	%
19	P19_S01/03	1.46	0.73	50.23	4.03	95.97
19	P19_S04/05/06/07	1.38	0.59	57.20	4.69	95.31
19	P19_S11/29	1.26	0.40	68.47	7.40	92.60
19	P19_S10/13/14	1.41	0.67	52.60	3.65	96.35
19	P19_S15/19/20	1.21	0.33	72.72	10.24	89.76
19	P19_S17/21/22/30	1.26	0.41	67.40	9.08	90.92
19	P19_S26/28	1.40	0.60	57.02	5.80	94.20
19	P19_S23/24/25	1.20	0.31	74.20	8.08	91.92
	average	1.32	0.50	62.48	6.62	93.38
	S.D.	0.10	0.16	9.32	2.44	2.44

4. Sediment water leachates

Barium levels were below the set criterion for groundwater (not set criterions for freshwater and saltwater). For cadmium, the values were below the set criterion for groundwater and saltwater (no criterion for freshwater). Most arsenic levels exceeded the criterion for groundwater but were below those for freshwater and saltwater. Chromium levels were below the criterion for groundwater, but most were higher than the criterion for freshwater and not for saltwater. Copper levels were in excess for saltwater only (no criterion for freshwater and no exceedance for groundwater). Lead levels were for nearly all the occurrences in exceedance for groundwater and these levels were all in exceedance for saltwater (no criterion for freshwater). When above the detection level, mercury leachates were in excess for both freshwater and saltwater, but all values were below the criterion for groundwater. Selenium and silver leachates were below the detection limits in all samples which were larger than the criterions for both freshwater and saltwater (i.e., no conclusions can be drawn). However, selenium and silver leachates detection limits were well below the criterion for groundwater.

TABLE 6. Synthetic precipitation leaching procedure for various metals in Lake 19. "U" stands for undetected whilst "I" is denoted when the reported value is greater than or equal to the laboratory method detection limit but less than the laboratory practical quantitation limit. "NA" is used when there is not a set criterion. Cells in yellow indicate when the value exceeds the leachability based on groundwater criteria limits. Bold values indicate when the value exceeds the freshwater surface limit and when underlined, when it exceeds the saltwater surface limit.

Sample #	Arsenic, SPLP	Barium, SPLP	Cadmium, SPLP	Chromium, SPLP	Copper, SPLP	Lead, SPLP	Selenium, SPLP	Silver, SPLP	Mercury, SPLP
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
P19_S01/03	0.0072 I	0.0282	0.00033 U	0.0065	0.0438	0.0103	0.0085 U	0.0010 U	0.00010 U
P19_S10/13/14	0.0093 I	0.0333	0.00045 I	**0.0189**	0.0346	0.0222	0.0085 U	0.0010 U	0.00010 U
P19_S11/29	0.0153	0.0293	0.00039 I	0.0104	0.0845	0.0189	0.0085 U	0.0010 U	0.00020 U
P19_S15/19/20	0.0164	0.0448	0.0010	**0.0482**	0.0601	0.0560	0.0085 U	0.0010 U	**0.00032 I**
P19_S17/21/22/30	0.0178	0.0728	0.0014	**0.113**	0.0862	0.105	0.0085 U	0.0010 U	**0.00094**
P19_S23/24/25	0.0141	0.0338	0.00069 I	**0.0243**	0.0914	0.0351	0.0085 U	0.0010 U	0.00020 U
P19_S26/28	0.0120	0.0499	0.00068 I	**0.0512**	0.0527	0.0482	0.0085 U	0.0010 U	**0.00050**
Leachability Based on Groundwater Criteria (mg/l)	0.01	2	0.005	0.1	1	0.015	0.05	0.1	0.002
Freshwater surface criteria (mg/l)	0.05	NA	NA	0.011	NA	NA	0.005	0.00007	0.000012
Saltwater surface criteria (mg/l)	0.05	NA	0.0093	0.05	0.0029	0.0085	0.071	0.0004	0.000025

Exceeds Leachability Based on Groundwater Criteria Limits

Exceeds freshwater surface criteria

Exceeds saltwater surface criteria

5. Sediment petroleum range organics

The petroleum range organics were well below the leachability criterion for groundwater as well as for the direct exposure for both residential and commercial limits.

TABLE 7. Petroleum range organics analyzed in the sediment from Lakes 19. "U" indicates "concentration below the method detection limit (MDL)". Residential and commercial direct exposure limits are from Table 2 of Chapter 62-777, FAC.

Sample #	Petroleum Range Organics
	mg/kg
P19_S01/03	15.2 U
P19_S10/13/14	22.0 U
P19_S11/29	17.6 U
P19_S15/19/20	29.1 U
P19_S17/21/22/30	14.0 U
P19_S23/24/25	33.7 U
P19_S26/28	10.8 U
Leachability Based on Groundwater Criteria (mg/kg)	340
Direct Exposure Residential (mg/kg)	460
Direct Exposure Commercial/Industrial (mg/kg)	2,700
Exceeds Leachability Based on Groundwater Criteria Limits	
Exceeds Direct Exposure Residential Limits	
Exceeds Direct Exposure Commercial/Industrial Limits	

6. Sediment non-carcinogenic PAHs

None of the analytes analyzed for non-carcinogenic PAHs were above the set criteria for either their leachability based on groundwater nor do they exceed direct exposures for both residential and commercial.

TABLE 8. Sediment non-carcinogenic PAHs analyzed in the sediment from Lake 19. "U" indicates "concentration below the method detection limit (MDL)". "I" indicates concentration between the MDL and the practical quantification limit (PQL). Residential and commercial direct exposure limits are from Table 2 of Chapter 62-777, FAC

	Soil Non-Carcinogenic PAHs										
Sample #	Naphthalene	1-Methylnaphthalene	2-Methylnaphthalene	Acenaphthene	Acenaphthylene	Anthracene	Benzo(g,h,i)perylene	Fluoranthene	Fluorene	Phenanthrene	Pyrene
#	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
P19_S01/03	0.047 U	0.054 U	0.052 U	0.047 U	0.043 U	0.048 U	**0.13 I**	0.53	0.049 U	**0.17**	0.46
P19_S10/13/14	0.041 U	0.046 U	0.045 U	0.041 U	0.037 U	0.042 U	0.030 U	0.039 U	0.042 U	0.039 U	0.037 U
P19_S11/29	0.085 U	0.098 U	0.095 U	0.086 U	0.078 U	0.088 U	**0.083 I**	0.14 I	0.089 U	0.082 U	0.12 I
P19_S15/19/20	0.073 U	0.084 U	0.081 U	0.074 U	0.067 U	0.075 U	0.053 U	0.083 I	0.076 U	0.070 U	0.079 I
P19_S17/21/22/30	0.070 U	0.080 U	0.078 U	0.071 U	0.064 U	0.072 U	0.051 U	0.067 U	0.073 U	0.067 U	0.065 U
P19_S23/24/25	0.080 U	0.091 U	0.089 U	0.080 U	0.073 U	0.082 U	0.058 U	0.076 U	0.083 U	0.076 U	0.073 U
P19_S26/28	0.055 U	0.063 U	0.061 U	0.056 U	0.050 U	0.057 U	0.041 U	0.053 U	0.058 U	0.053 U	0.051 U
Leachability Based on Groundwater Criteria (mg/kg)	1.2	3.1	8.5	2.1	27	2500	32000	1200	160	250	880
Direct Exposure Residential (mg/kg)	55	200	210	2400	1800	21000	2500	3200	2600	2200	2400
Direct Exposure Commercial/Industrial (mg/kg)	300	1800	2100	20000	20000	300000	52000	59000	33000	36000	45000
Exceeds Leachability Based on Groundwater Criteria Limits											
Exceeds Direct Exposure Residential Limits											
Exceeds Direct Exposure Commercial/Industrial Limits											

7. Sediment carcinogenic PAHs

Benzo (a) pyrene equivalent and Benzo(a)pyrene were once in exceedance for residential exposure especially at the locations P19_S01/03 (northwest corner of the lake).

*TABLE 9. Soil carcinogenic PAHs in Lakes 19. "**" stands for leachability values not applicable whilst "#" codes for a Direct Exposure value not applicable except as part of the Benzo(a)pyrene equivalent. "U" indicates "concentration below the method detection limit (MDL)". "I" indicates concentration between the MDL and the practical quantification limit (PQL). Residential and commercial direct exposure limits are from Table 2 of Chapter 62-777, FAC.*

	Soil Carcinogenic PAHs							
Sample #	Benzo(a)pyrene	Benzo(a) anthracene	Benzo(b)fluoranthene	Benzo(k) fluoranthene	Chrysene	Dibenz(a,h)anthracene	Indeno(1,2,3-cd)pyrene	Benzo (a) pyrene equivalent
#	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	(mg/kg)
P19_S01/03	0.20	0.23	0.27	0.12 I	0.24	0.035 I	0.12 I	0.30
P19_S10/13/14	0.029 U	0.034 U	0.036 I	0.032 U	0.037 U	0.027 U	0.027 U	0.035
P19_S11/29	0.078 I	0.071 U	0.13 I	0.067 U	0.083 I	0.057 U	0.067 I	0.13
P19_S15/19/20	0.053 U	0.061 U	0.063 I	0.057 U	0.067 U	0.049 U	0.049 U	0.063
P19_S17/21/22/30	0.051 U	0.059 U	0.055 U	0.055 U	0.065 U	0.047 U	0.047 U	0.057
P19_S23/24/25	0.058 U	0.067 U	0.062 U	0.062 U	0.074 U	0.054 U	0.053 U	0.065
P19_S26/28	0.040 U	0.046 U	0.043 U	0.043 U	0.051 U	0.037 U	0.037 U	0.045
Leachability Based on Groundwater Criteria (mg/kg)	8	0.8	2.4	24	77	0.7	6.6	**
Direct Exposure Residential (mg/kg)	0.1	#	#	#	#	#	#	0.1
Direct Exposure Commercial/Industrial (mg/kg)	0.7	#	#	#	#	#	#	0.7

Exceeds Leachability Based on Groundwater Criteria Limits

Exceeds Direct Exposure Residential Limits

Exceeds Direct Exposure Commercial/Industrial Limits

8. Sediment VOAs TRPHs and metals

Arsenic was found to be in exceedance for direct exposure residential limits a little more than half of the occurrences.

TABLE 10. Sediment VOAs TRPHs and metals analyzed in the sediment from Lakes 19. "NS" indicates "Not Sampled". "" indicates "leachability value may be determined using TCLP".*

	Soil VOAs TRPHs & Metals									
Sample #	Benzene	Ethyl-benzene	Toluene	Tolal Xylenes	MTBE	TRPHs	Arsenic	Cadmium	Chromium	Lead
	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
P19_S01/03	NS	NS	NS	NS	NS	15.2 U	1.0	0.11	3.7	6.4
P19_S10/13/14	NS	NS	NS	NS	NS	22.0 U	1.0 I	0.16	7.4	9.6
P19_S11/29	NS	NS	NS	NS	NS	17.6 U	2.7	0.26	11.6	15.3
P19_S15/19/20	NS	NS	NS	NS	NS	29.1 U	3.3	0.32	21.8	20.9
P19_S17/21/22/30	NS	NS	NS	NS	NS	14.0 U	2.8	0.33	35.1	26.1
P19_S23/24/25	NS	NS	NS	NS	NS	33.7 U	2.6	0.26	14.5	15.5
P19_S26/28	NS	NS	NS	NS	NS	10.8 U	1.3	0.15	16.5	11.3
Leachability Based on Groundwater Criteria (mg/kg)	.007	.6	.5	.2	.09	340	*	7.5	38	*
Direct Exposure Residential (mg/kg)	1.2	1500	7500	130	4400	460	2.1	82	210	400
Direct Exposure Commercial/Industrial (mg/kg)	1.7	9200	60000	700	24000	2700	12	1700	470	1400

Exceeds Leachability Based on Groundwater Criteria Limits

Exceeds Direct Exposure Residential Limits

Exceeds Direct Exposure Commercial/Industrial Limits

9. Sediment TRPH and TRPH fractions

Only soil TRPHs using the Florida Petroleum Organic Method (FLPRO) were analyzed by the outsourced laboratory. None of the aliphatic and aromatic hydrocarbons were analyzed as they all were reported as "Not Sampled" (NS). Soil TRPHs (FLPRO) did not exceed the set criteria for leachability based on groundwater criteria limits and direct exposures for both residential and commercial.

TABLE 11. Soil TRPH (FLPRO method) in the sediment of Lake 19.

Sample #	TRPHs (FLPRO) (mg/kg)
P19_S01/03	15.2 U
P19_S10/13/14	22.0 U
P19_S11/29	17.6 U
P19_S15/19/20	29.1 U
P19_S17/21/22/30	14.0 U
P19_S23/24/25	33.7 U
P19_S26/28	10.8 U
Leachability Based on Groundwater Criteria (mg/kg)	340
Direct Exposure Residential (mg/kg)	460
Direct Exposure Commercial/Industrial (mg/kg)	2700

10. Sediment nutrients

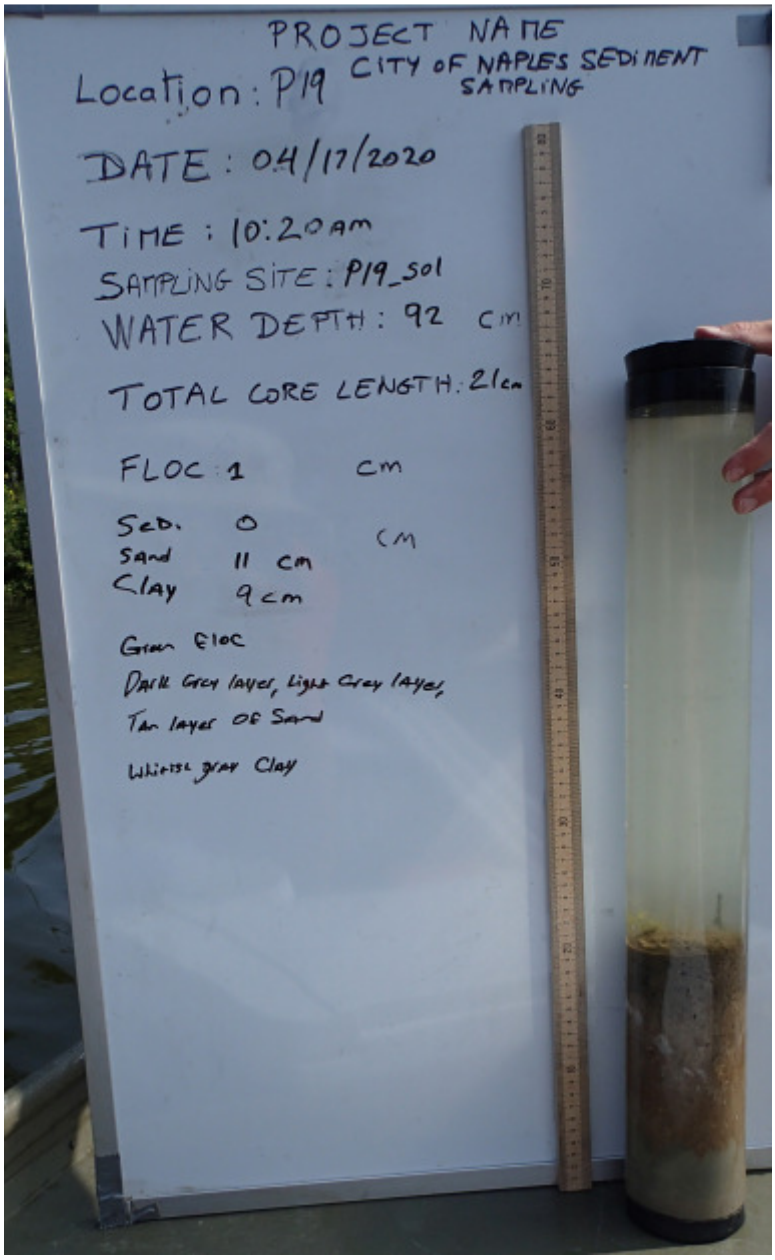
Sediment nutrients were highly variable spatially. Average TKN was 1471±S.D.1129 whilst it was 327±S.D.329 for TP. These are moderately high values and reflect a moderate eutrophication level of Lake 19.

11. Sediment other contaminants

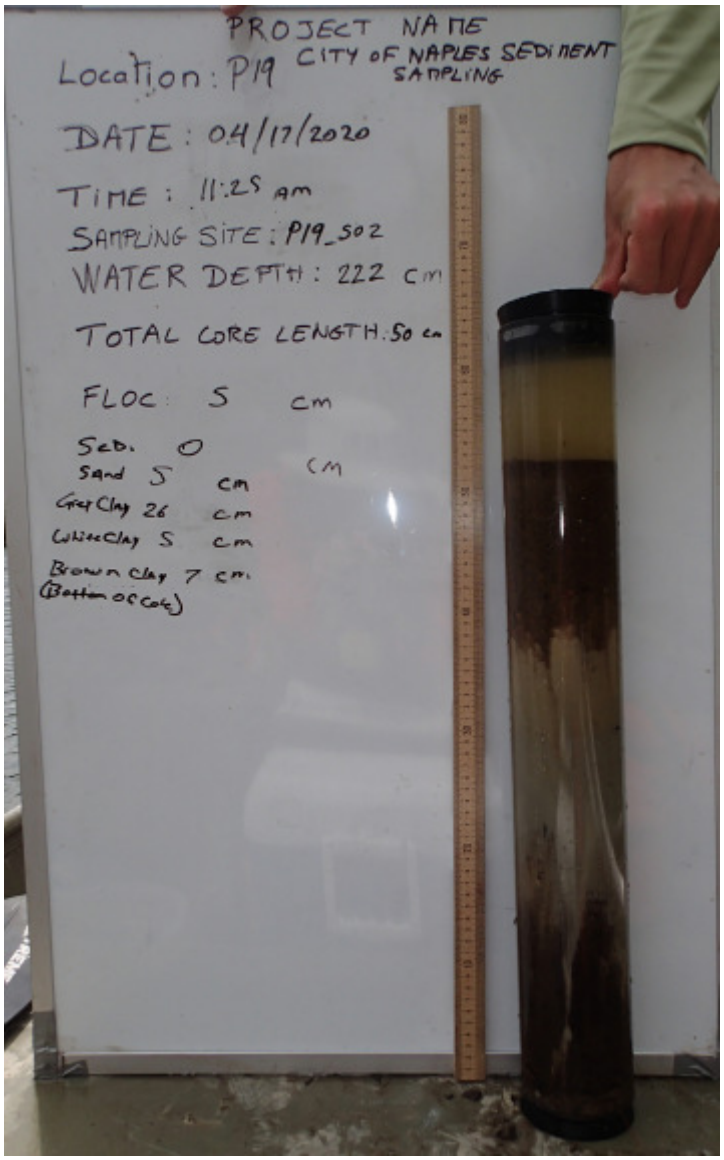
The detection limit of the organochloride dieldrin was always reached for all samples and this limit was above the criterion for groundwater. Hence, it is not possible to conclude whether there is exceedance or not. All the other analytes are below the criterions for the leachability based on groundwater criterion as well as for the residential and commercial limits.

Appendices: Pictures of the sediment cores

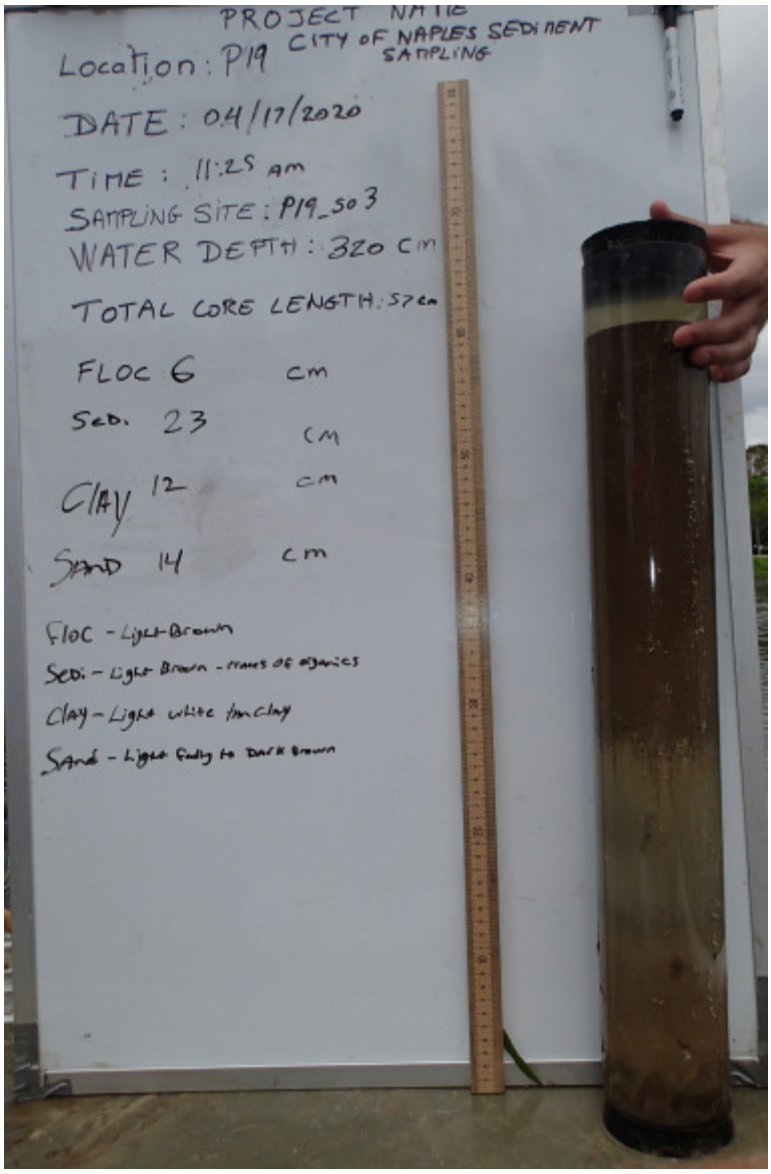
P19_S01



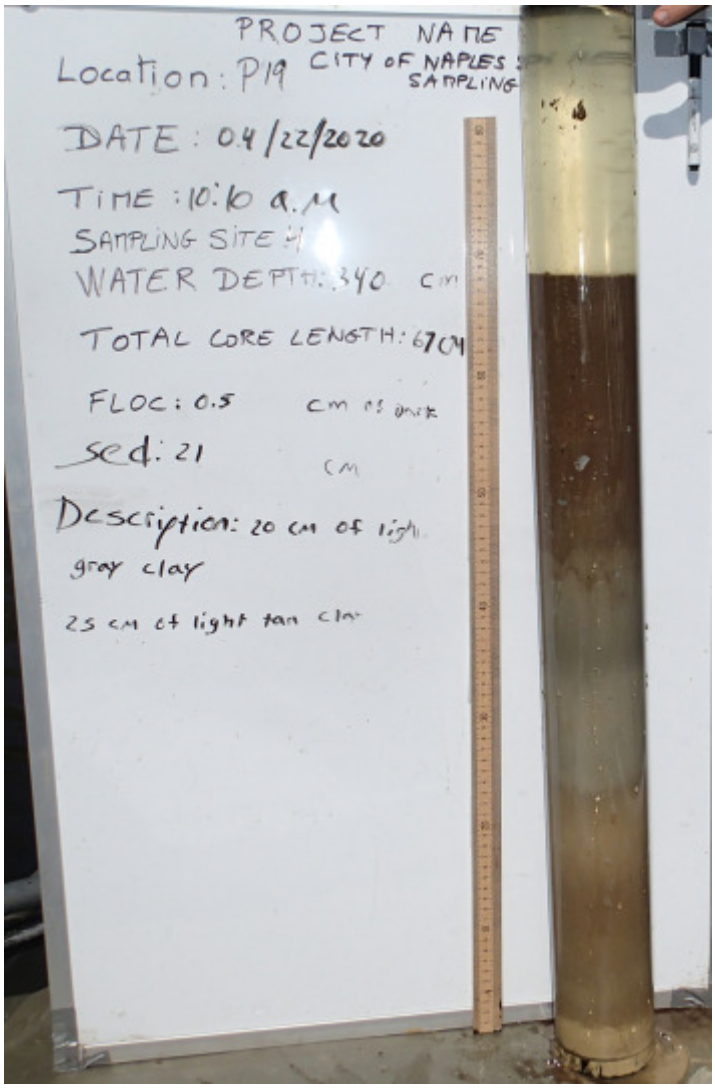
P19_S02


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 04/17/2020
TIME: 11:25 am
SAMPLING SITE: P19_S02
WATER DEPTH: 222 cm
TOTAL CORE LENGTH. 50 cm
FLOC 5 cm
Sed. 0
Sand 5 cm
Grey Clay 26 cm
White Clay 5 cm
Brown Clay 7 cm.
(Bottom of Core)
cm

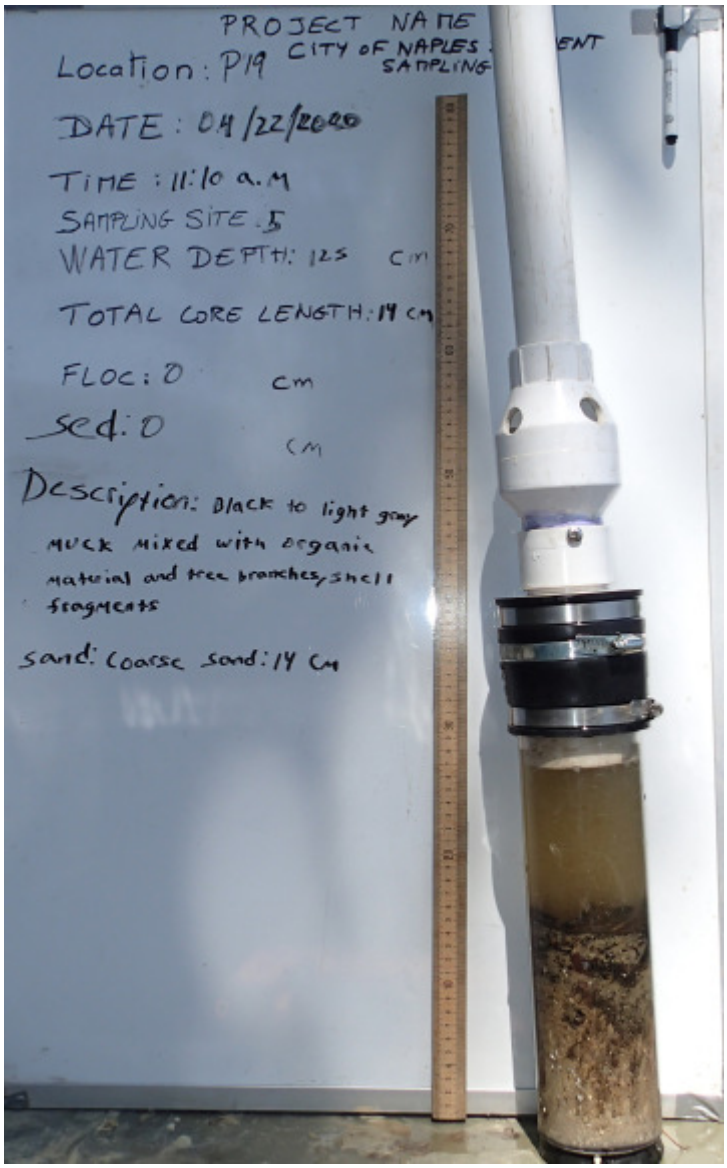
P19_S03


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 04/17/2020
TIME: 11:25 AM
SAMPLING SITE: P19_S03
WATER DEPTH: 320 cm
TOTAL CORE LENGTH: 57cm
FLOC 6 cm
SED. 23 cm
CLAY 12 cm
SAND 14 cm
FLOC - Light Brown
SED. - Light Brown - traces of organics
CLAY - Light white firm clay
Sand - Light fudy to Dark Brown

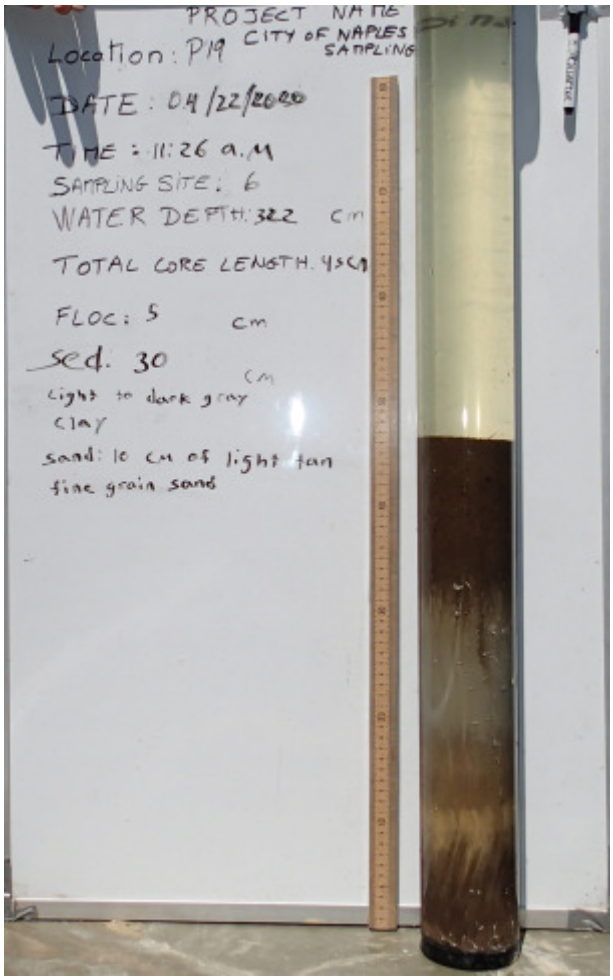
P19_S04


PROJECT NAME
Location: P19
CITY OF NAPLES
SAMPLING
DATE: 04/22/2020
TIME: 10:10 a.m
SAMPLING SITE #
WATER DEPTH: 340 cm
TOTAL CORE LENGTH: 67CM
FLOC: 0.5 cm of
sed: 21 cm
Description: 20 cm of
gray clay
25 cm of light tan

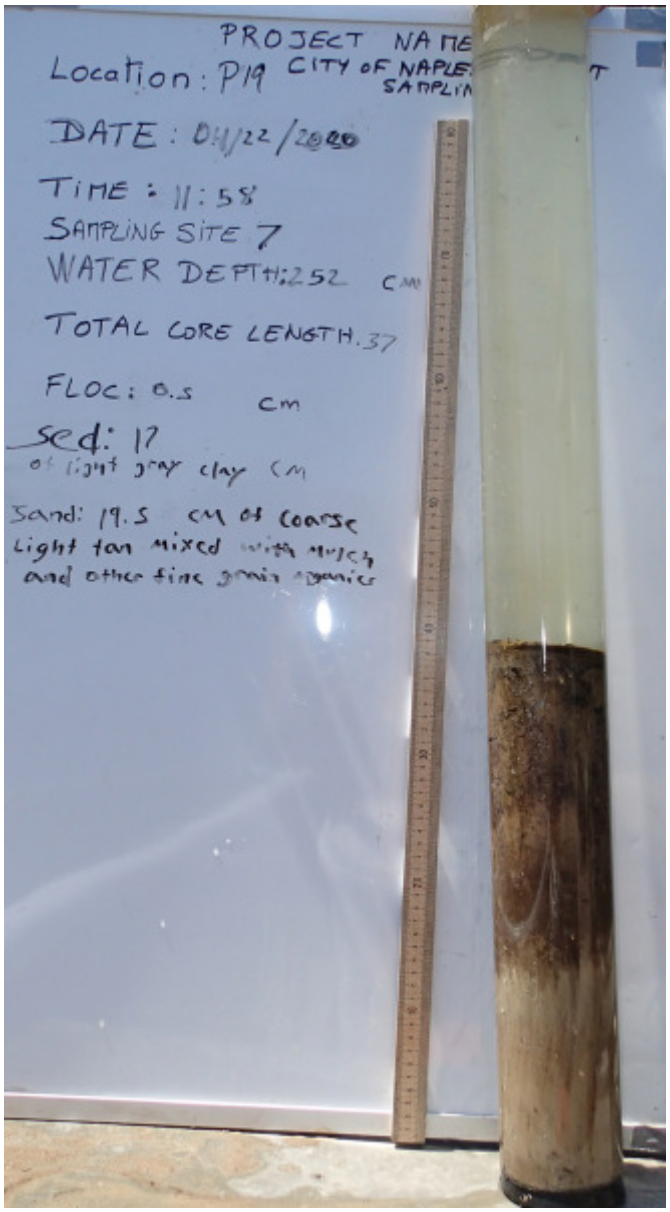
P19_S05


PROJECT NAME
CITY OF NAPLES
SAMPLING
Location: P19
DATE: 04/22/2020
TIME: 11:10 a.m
SAMPLING SITE: 5
WATER DEPTH: 125 cm
TOTAL CORE LENGTH: 19 cm
FLOC: 0 cm
sed: 0 cm
Description: Black to light gray muck mixed with organic material and tree branches, shell fragments
sand: Coarse sand: 14 cm

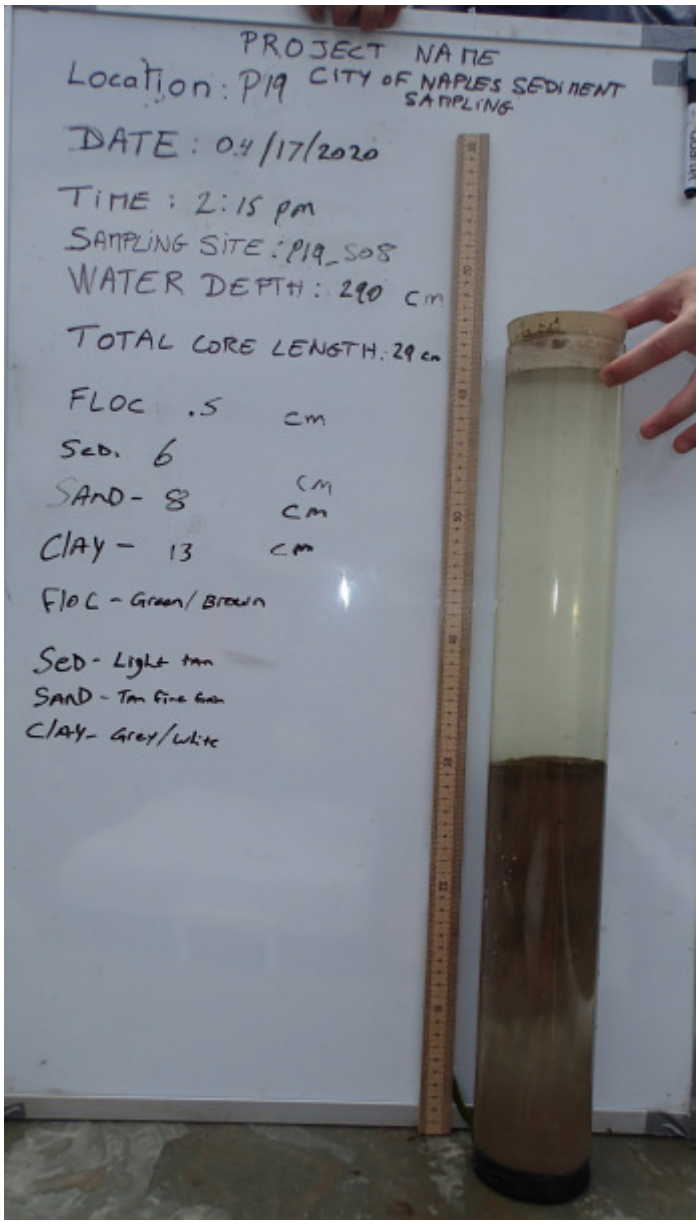
P19_S06


PROJECT NAME
CITY OF NAPLES
SAMPLING
Location: P19
DATE: 04/22/2008
TIME: 11:26 a.m
SAMPLING SITE: 6
WATER DEPTH: 322 cm
TOTAL CORE LENGTH. 45cm
FLOC: 5 cm
sed. 30 cm
light to dark gray
clay
sand: 10 cm of light tan
fine grain sand

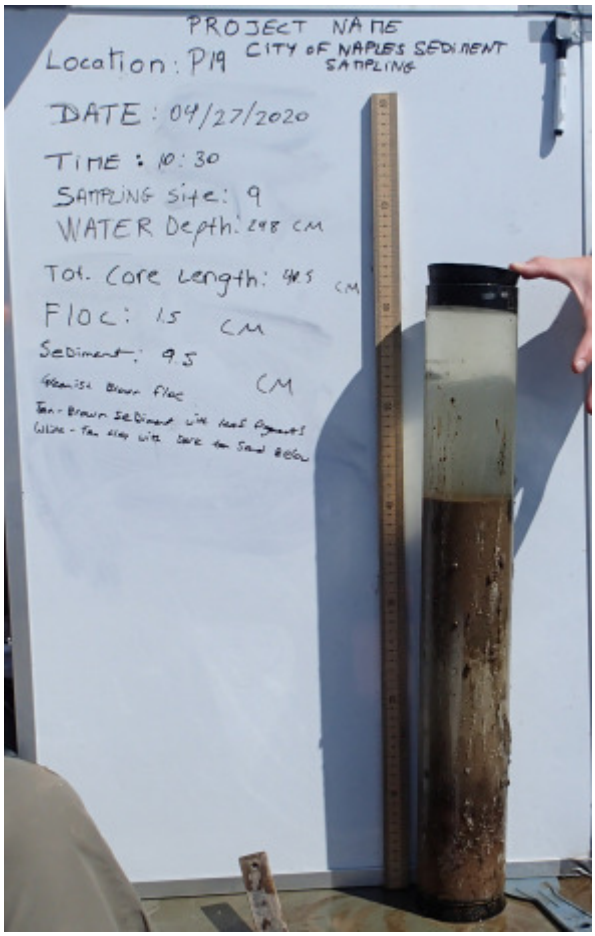
P19_S07


PROJECT NAME
Location: P19 CITY OF NAPLES
DATE: 04/22/2008
TIME: 11:58
SAMPLING SITE 7
WATER DEPTH: 252 CM
TOTAL CORE LENGTH. 37
FLOC: 0.5 cm
sed: 17
of light gray clay CM
Sand: 19.5 CM of coarse
Light tan mixed

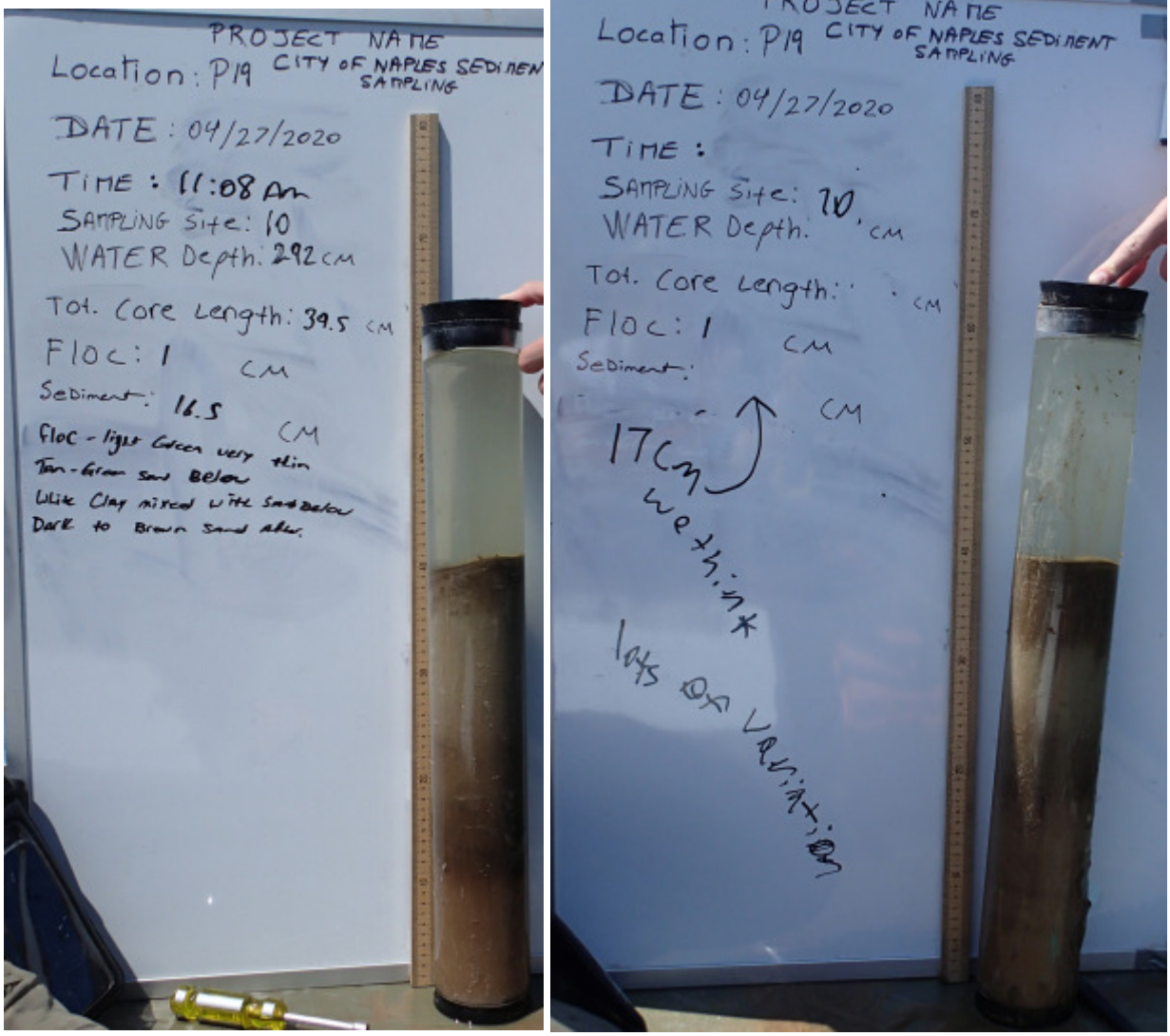
P19_S08


PROJECT NAME
Location: P19 CITY OF NAPLES SEDIMENT SAMPLING
DATE: 04/17/2020
TIME: 2:15 pm
SAMPLING SITE: P19_S08
WATER DEPTH: 290 cm
TOTAL CORE LENGTH: 29 cm
FLOC .5 cm
SED. 6
SAND - 8 cm
CLAY - 13 cm
FLOC - Green/Brown
SED - Light tan
SAND - Tan fine
CLAY - Grey/White

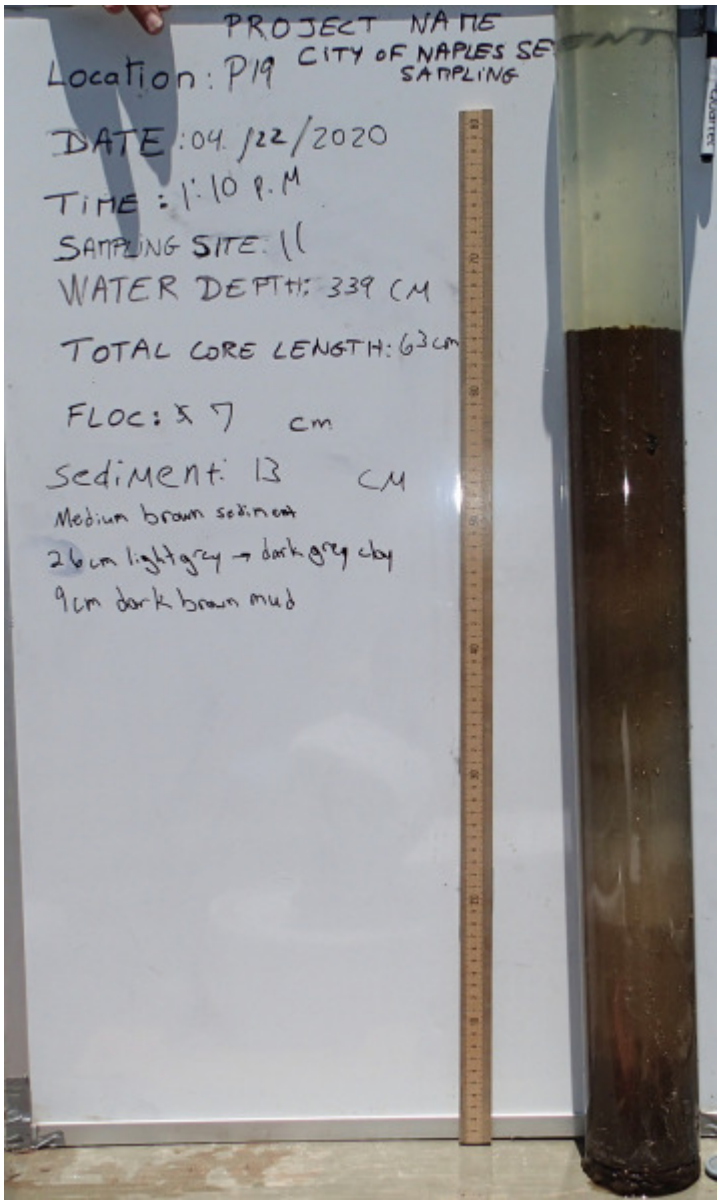
P19_S09


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 04/27/2020
TIME: 10:30
SAMPLING site: 9
WATER Depth: 248 CM
Tot. Core Length: 49.5 CM
Floc: 1.5 CM
Sediment: 9.5 CM

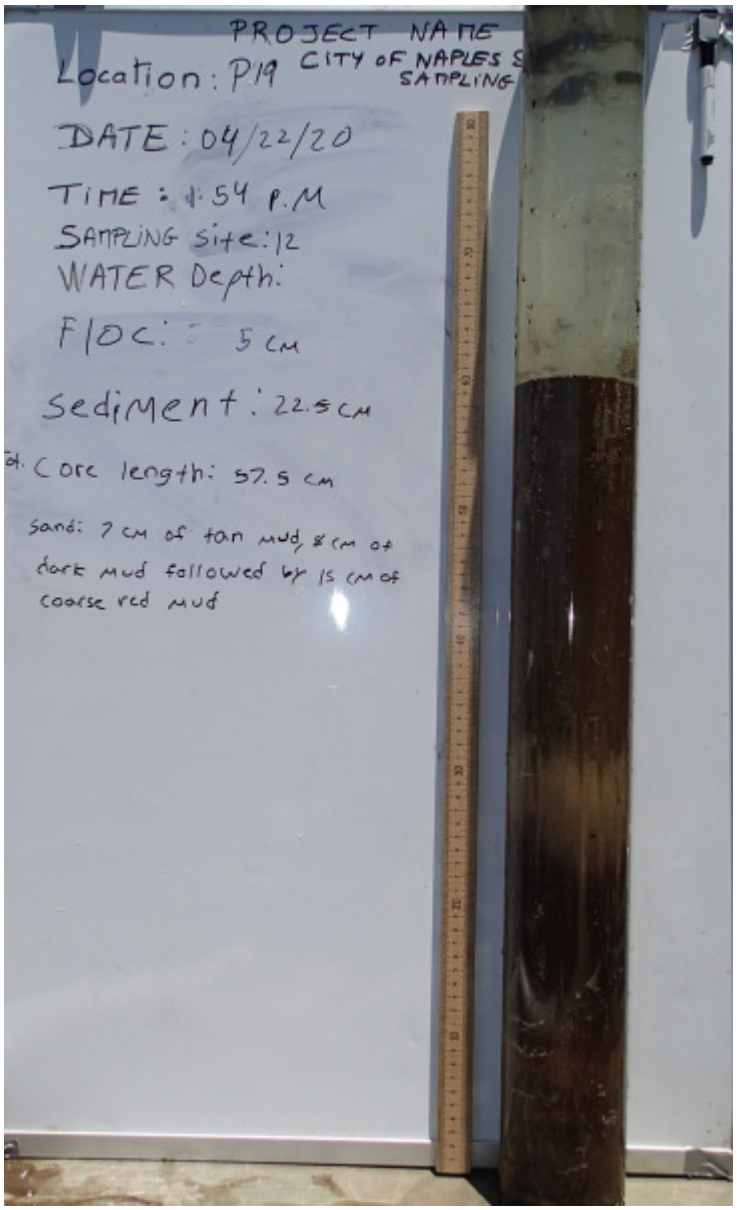
P19_S10 (right picture showing sediment variation)



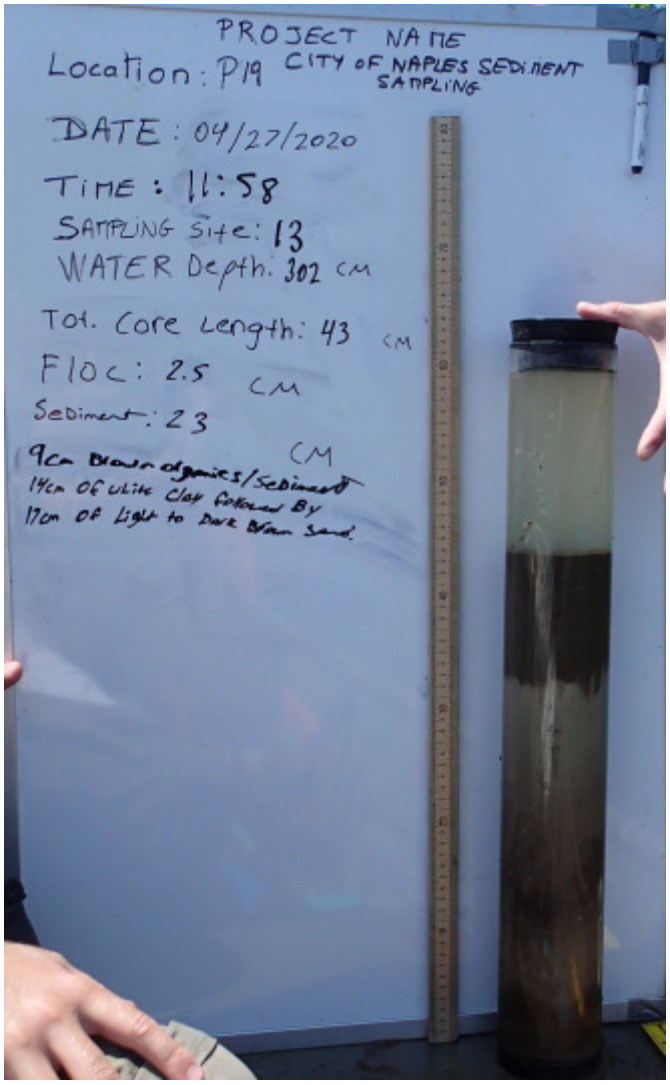
P19_S11


PROJECT NAME
CITY OF NAPLES SE
SAMPLING
Location: P19
DATE: 04/22/2020
TIME: 1:10 P.M
SAMPLING SITE: 11
WATER DEPTH: 339 CM
TOTAL CORE LENGTH: 63 cm
FLOC: 5 7 cm
Sediment: 13 CM
Medium brown sediment
26 cm light grey → dark grey clay
9 cm dark brown mud

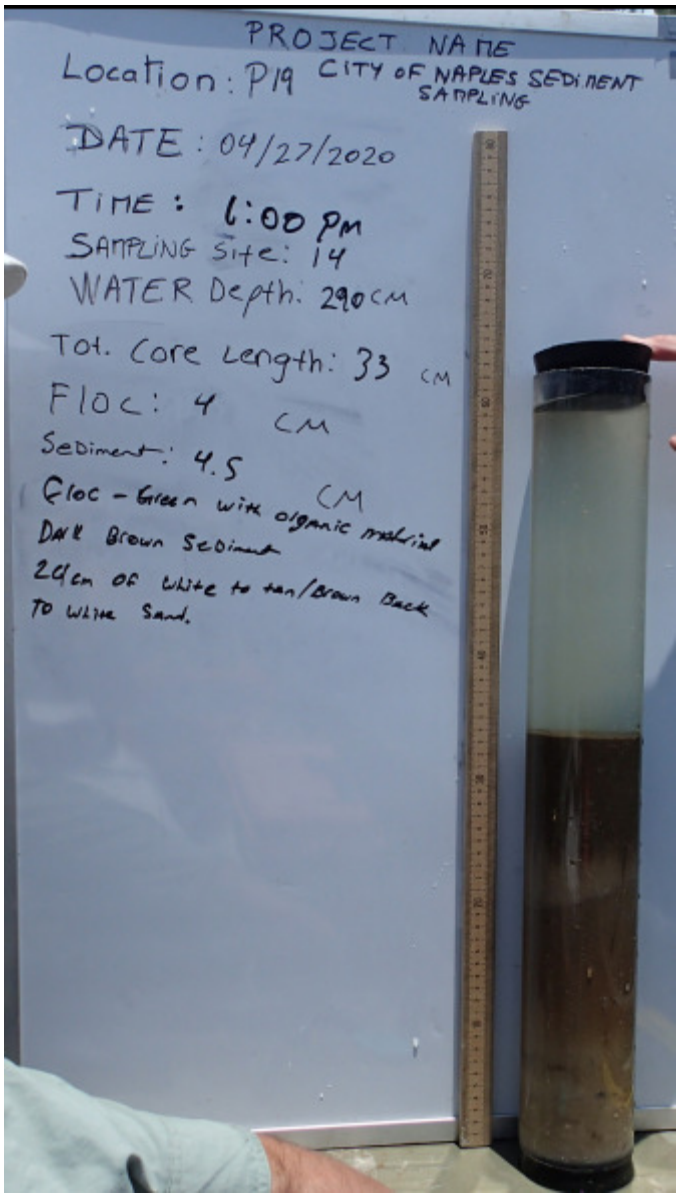
P19_S12


PROJECT NAME
Location: P19
CITY OF NAPLES
SAMPLING
DATE: 04/22/20
TIME: 1:54 P.M
SAMPLING site: 12
WATER Depth:
FLOC: 5 CM
Sediment: 22.5 CM
Core length: 57.5 cm
Sand: 7 CM of tan mud, 8 CM of dark mud followed by 15 CM of coarse red mud

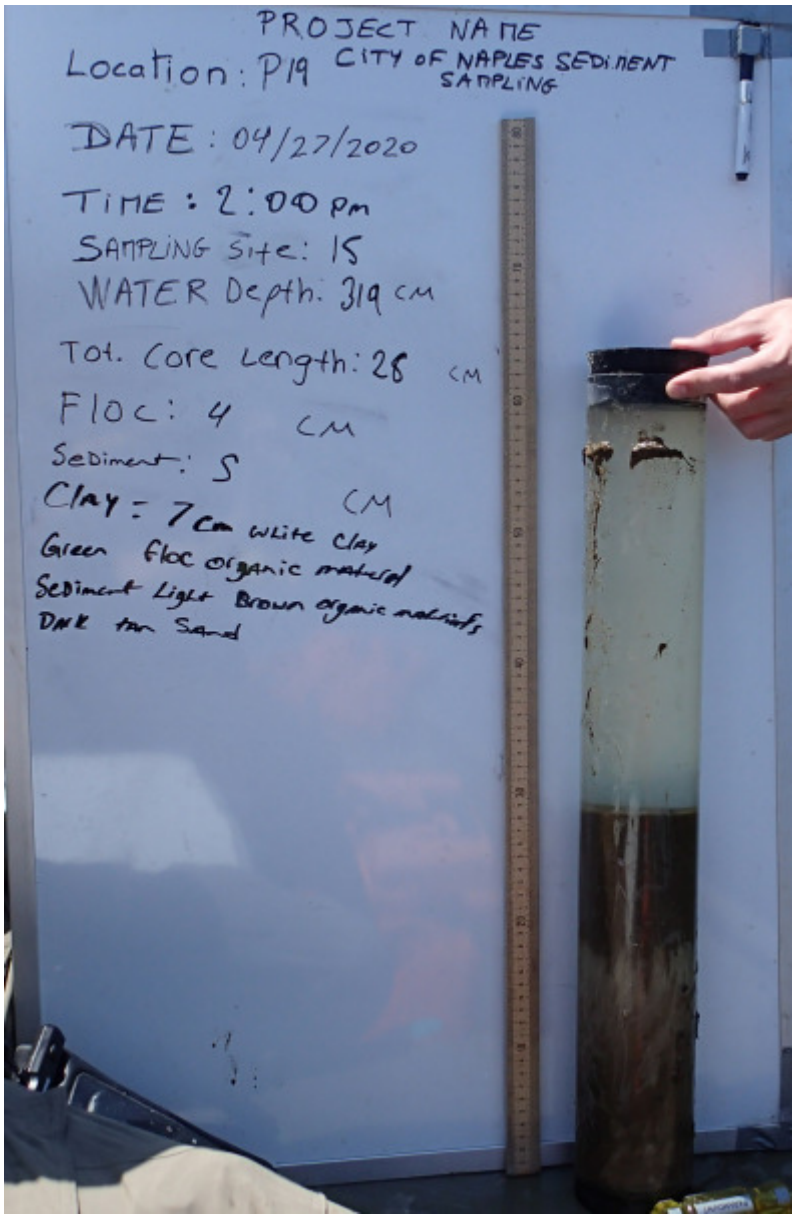
P19_S13


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 04/27/2020
TIME: 11:58
SAMPLING Site: 13
WATER Depth: 302 CM
Tot. Core Length: 43 CM
Floc: 2.5 CM
Sediment: 23 CM
9cm Brown Organics/Sediment
14cm Of Ultra Clay Followed By
17cm Of Light to Dark Brown Sand.

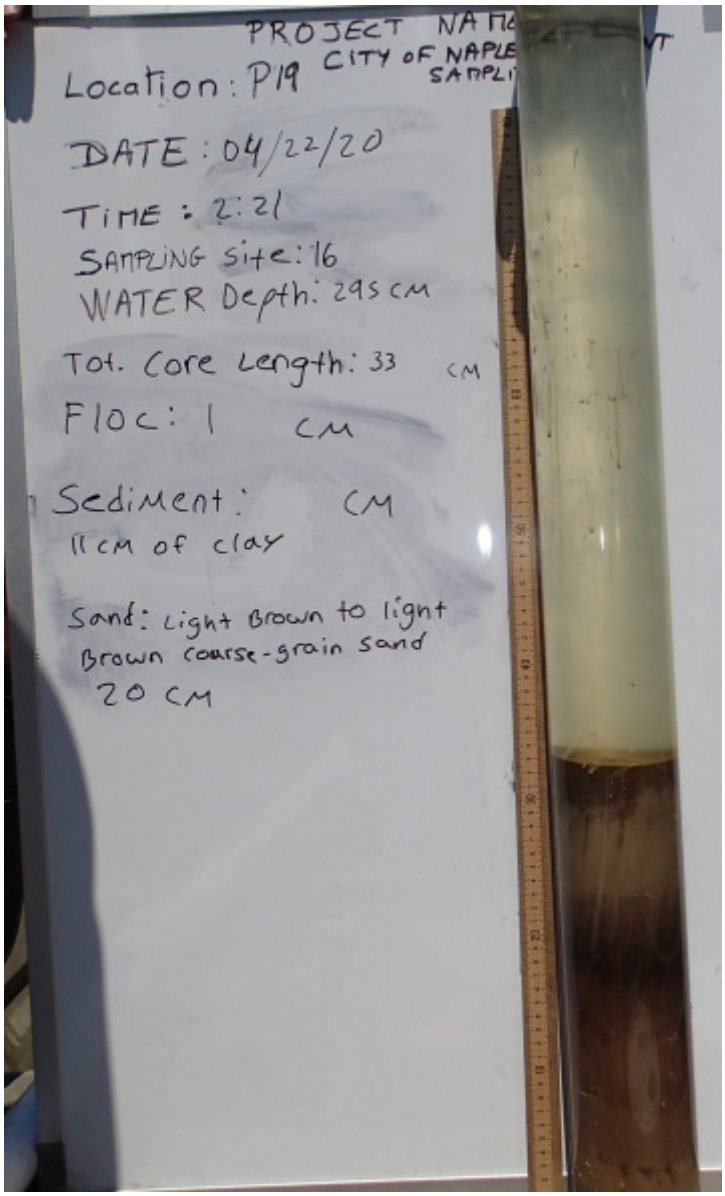
P19_S14


PROJECT NAME
Location: P19 CITY OF NAPLES SEDIMENT SAMPLING
DATE: 04/27/2020
TIME: 1:00 PM
SAMPLING Site: 14
WATER Depth: 290cm
Tot. Core Length: 33 cm
Floc: 4 cm
Sediment: 4.5 cm
Floc - Green with organic material
Dark Brown Sediment
24cm of White to tan/brown Back
TO White Sand.

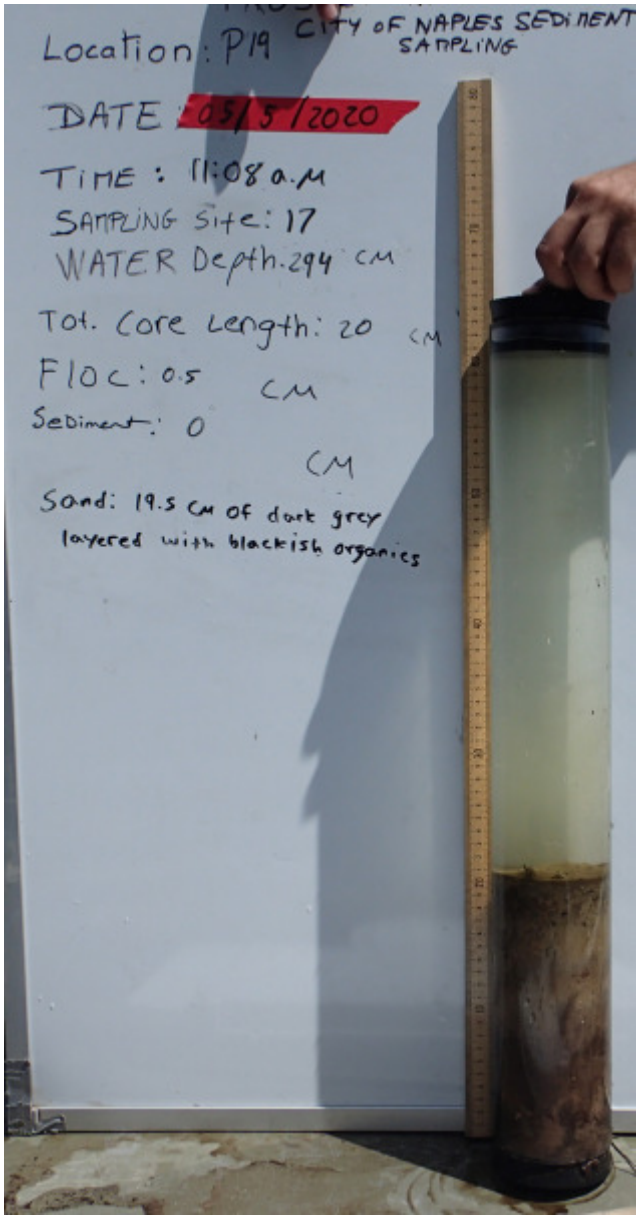
P19_S15


PROJECT NAME
Location: P19 CITY OF NAPLES SEDIMENT SAMPLING
DATE: 04/27/2020
TIME: 2:00 pm
SAMPLING Site: 15
WATER Depth: 319 cm
Tot. Core Length: 28 cm
Floc: 4 cm
Sediment: 5 cm
Clay: 7 cm White Clay
Green Floc organic material
Sediment Light Brown organic material
Dark tan Sand

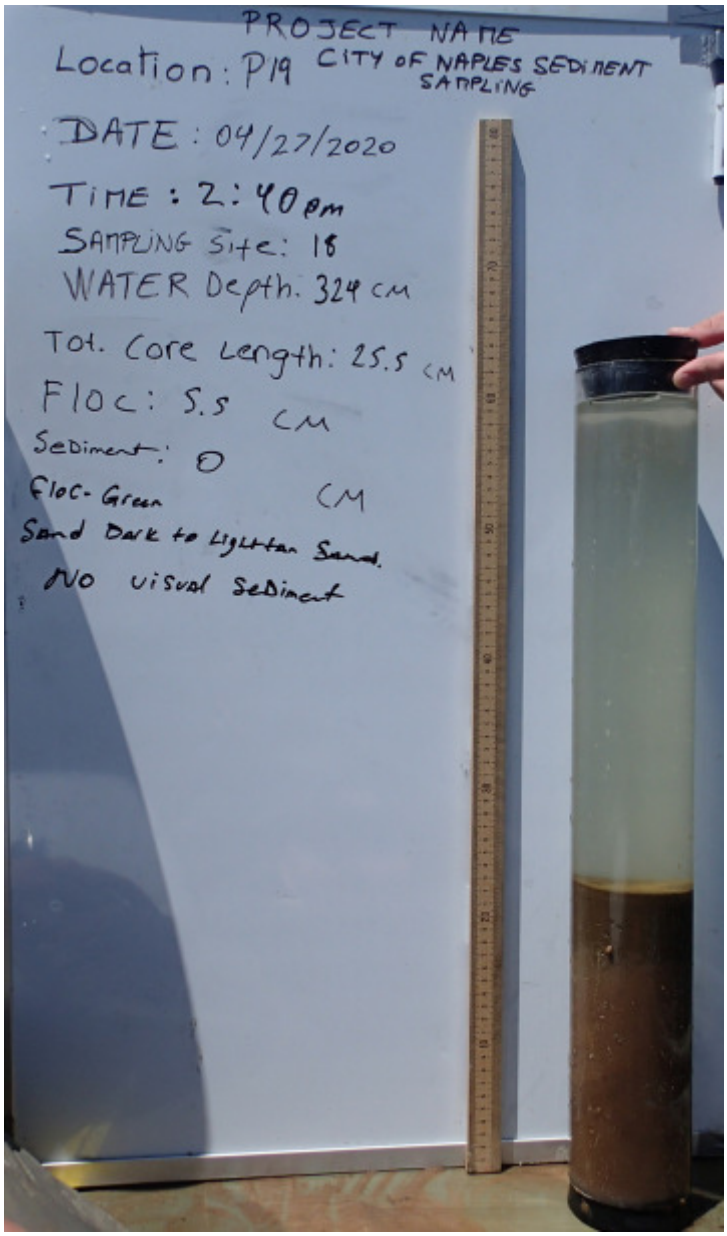
P19_S16


PROJECT NA
CITY OF NAPLE
SAMPLI
Location: P19
DATE: 04/22/20
TIME: 2:21
SAMPLING Site: 16
WATER Depth: 295 CM
Tot. Core Length: 33 CM
Floc: 1 CM
Sediment: CM
11 CM of clay
Sand: Light Brown to light Brown course-grain sand
20 CM

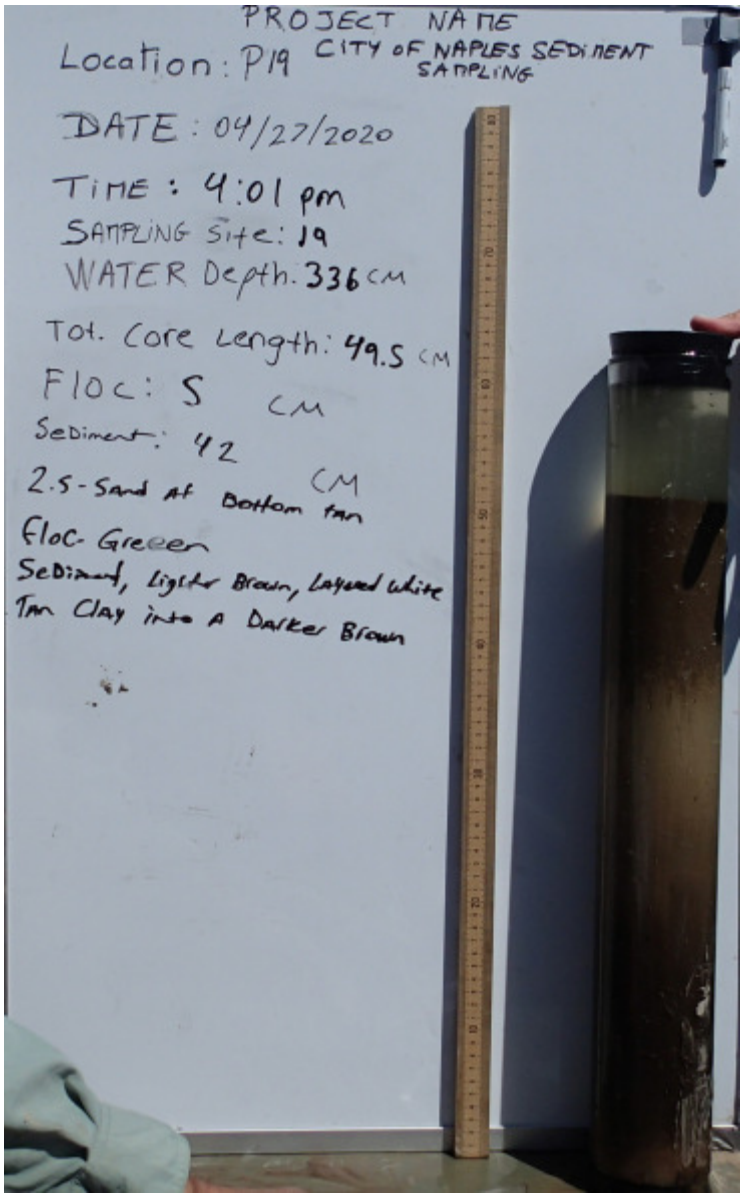
P19_S17


CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 05/5/2020
TIME: 11:08 a.m
SAMPLING Site: 17
WATER Depth. 294 CM
Tot. Core Length: 20 CM
Floc: 0.5 CM
Sediment: 0 CM
Sand: 19.5 CM of dark grey layered with blackish organics

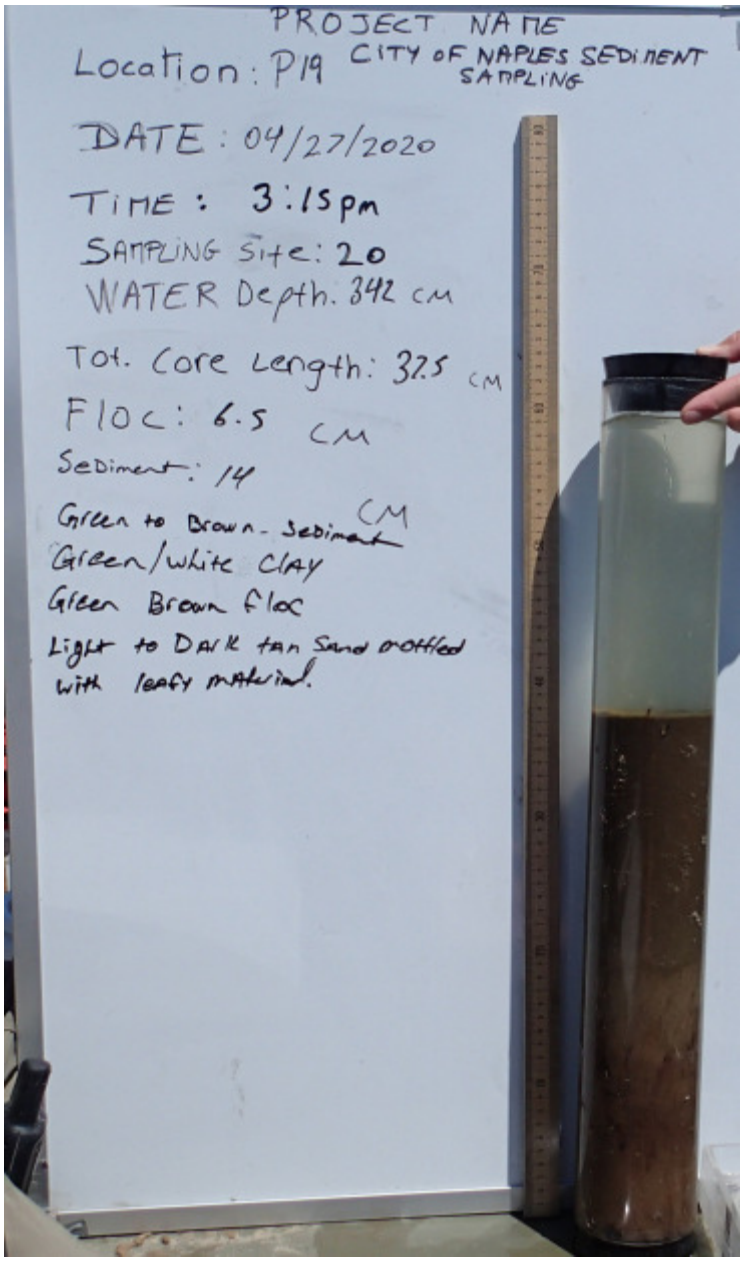
P19_S18


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 04/27/2020
TIME: 2:40 pm
SAMPLING Site: 18
WATER Depth: 324 cm
Tot. Core Length: 25.5 cm
Floc: 5.5 cm
Sediment: 0
Floc- Green
Sand Dark to Lighter Sand.
No visual Sediment

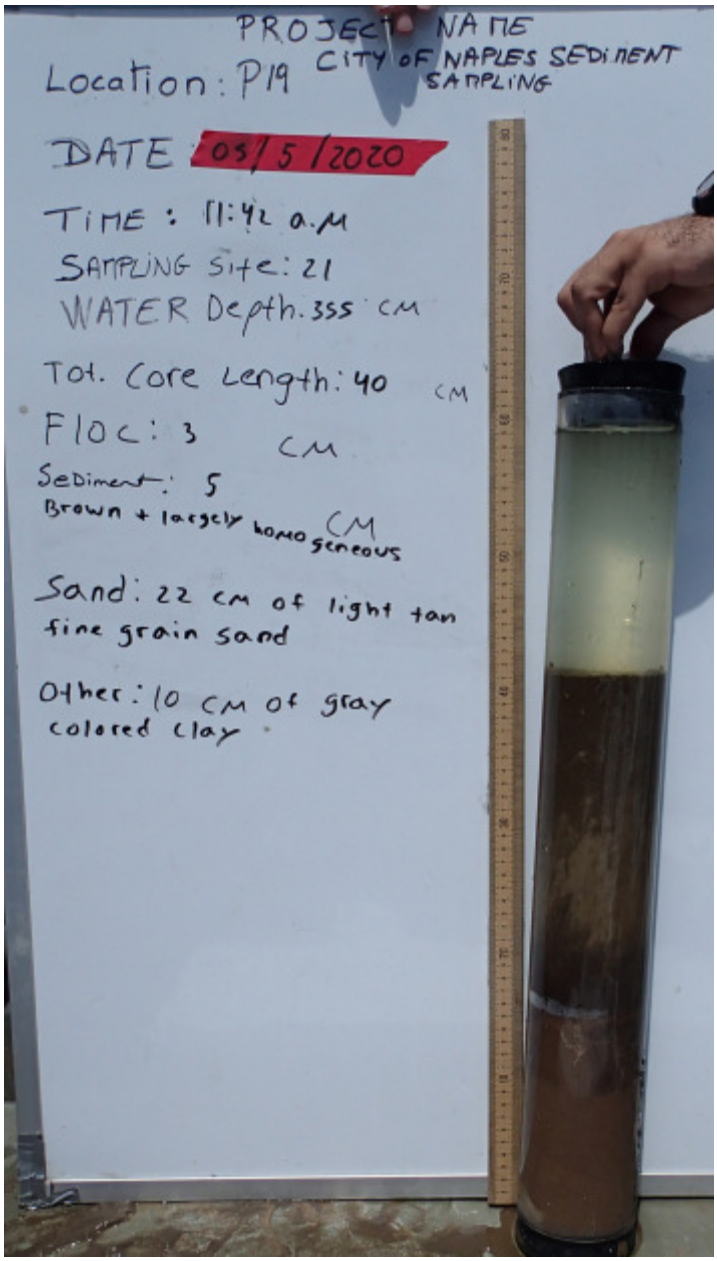
P19_S19


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 04/27/2020
TIME: 4:01 pm
SAMPLING Site: 19
WATER Depth: 336 CM
Tot. Core Length: 49.5 CM
Floc: 5 CM
Sediment: 42 CM
2.5 - Sand At Bottom Tan
Floc- Green
Sediment, Lighter Brown, Layered White Tan Clay into A Darker Brown

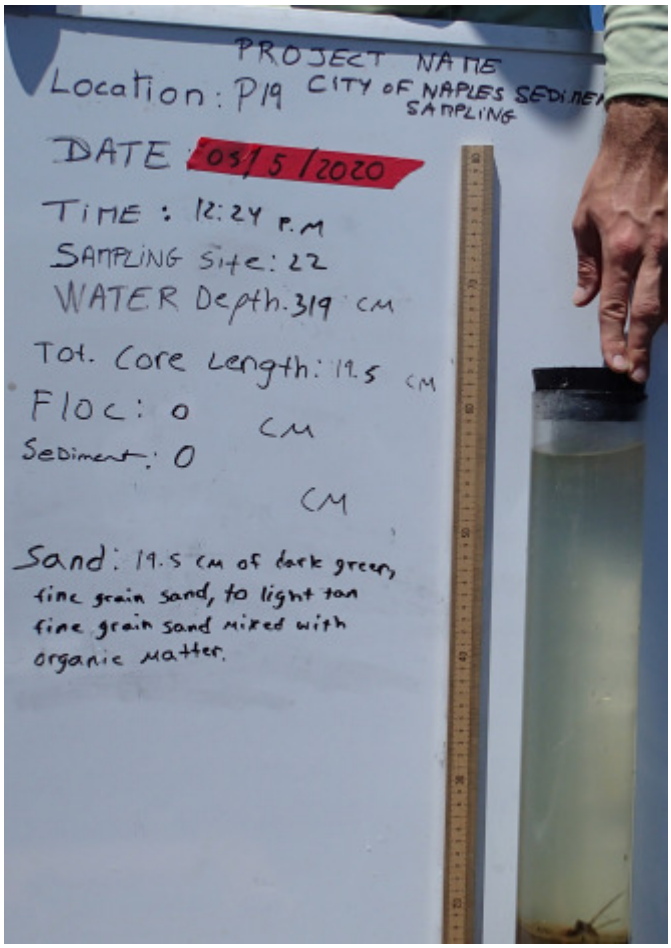
P19_S20


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 04/27/2020
TIME: 3:15pm
SAMPLING Site: 20
WATER Depth. 342 cm
Tot. Core Length: 32.5 cm
Floc: 6.5 cm
Sediment: 14 cm
Green to Brown - Sediment
Green/white CLAY
Green Brown floc
Light to Dark tan Sand mottled with leafy material.

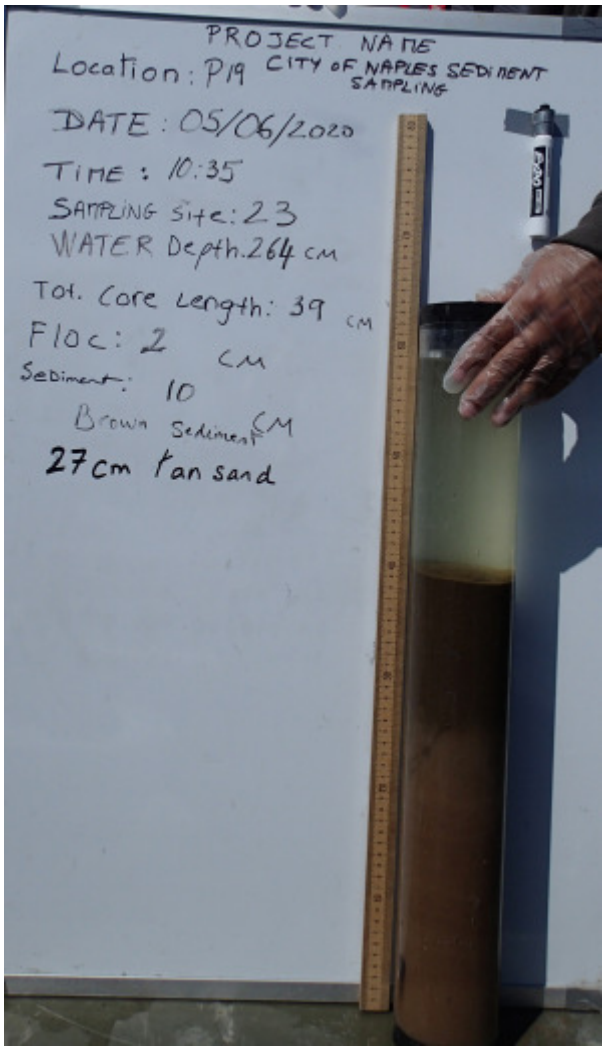
P19_S21


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE 03/5/2020
TIME: 11:42 a.m
SAMPLING Site: 21
WATER Depth. 355 CM
Tot. Core Length: 40 CM
Floc: 3 CM
Sediment: 5 CM
Brown + largely homogeneous
Sand: 22 cm of light tan fine grain sand
Other: 10 cm of gray colored clay

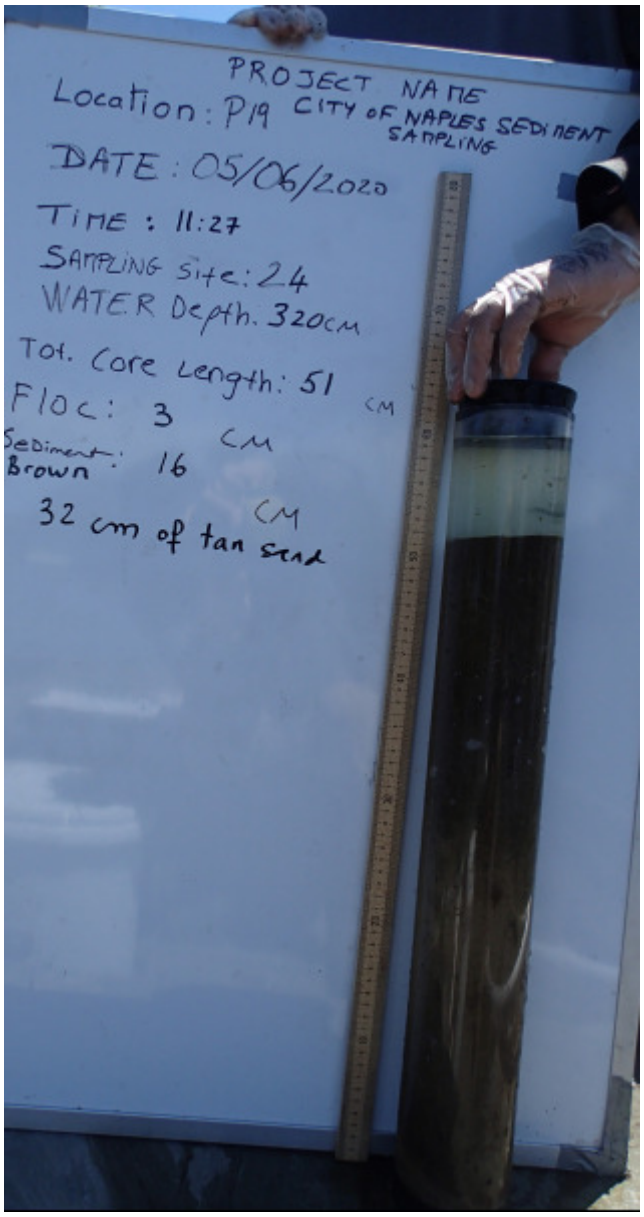
P19_S22 (core not fully showing on all three pictures taken)



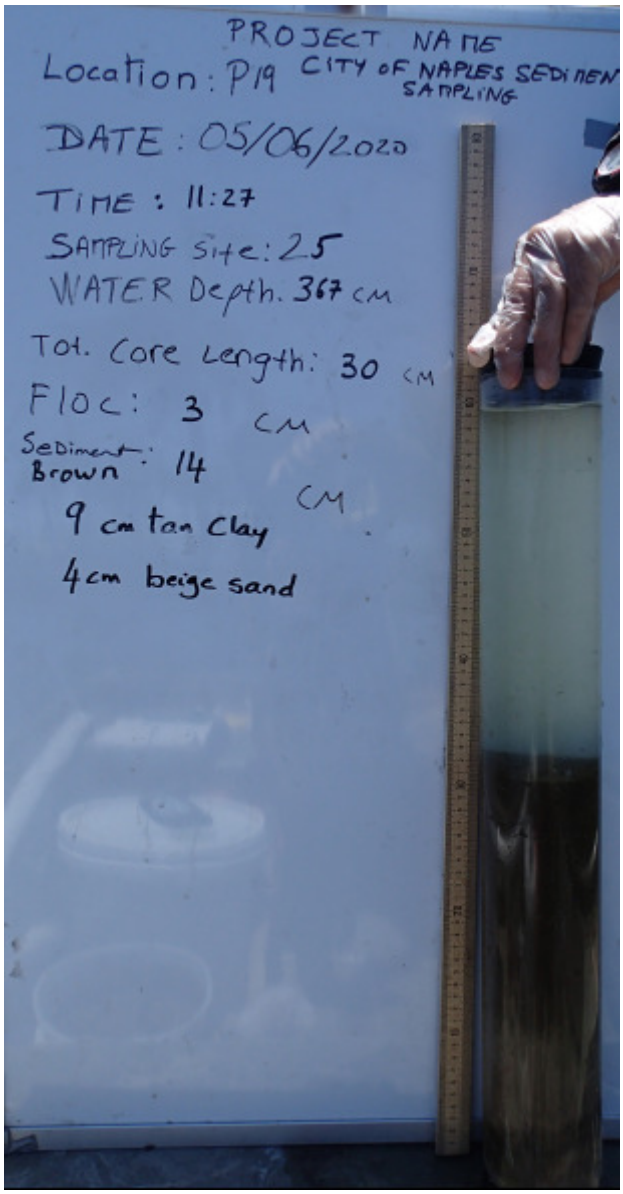
P19_S23


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 05/06/2020
Time: 10:35
SAMPLING Site: 23
WATER Depth. 264 cm
Tot. Core Length: 39 cm
Floc: 2 cm
Sediment: 10
Brown Sediment CM
27cm tan sand

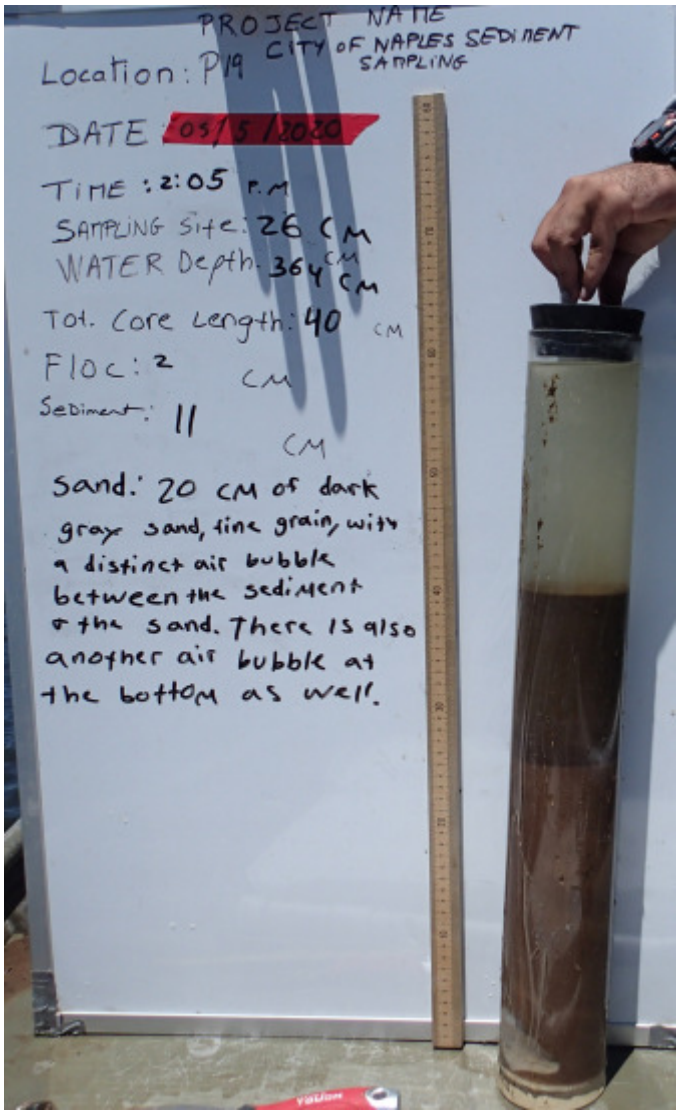
P19_S24


PROJECT NAME
Location: P19 CITY OF NAPLES SEDIMENT SAMPLING
DATE: 05/06/2020
TIME: 11:27
SAMPLING Site: 24
WATER Depth. 320cm
Tot. Core Length: 51 CM
Floc: 3 CM
Sediment: Brown 16 CM
32 cm of tan sand

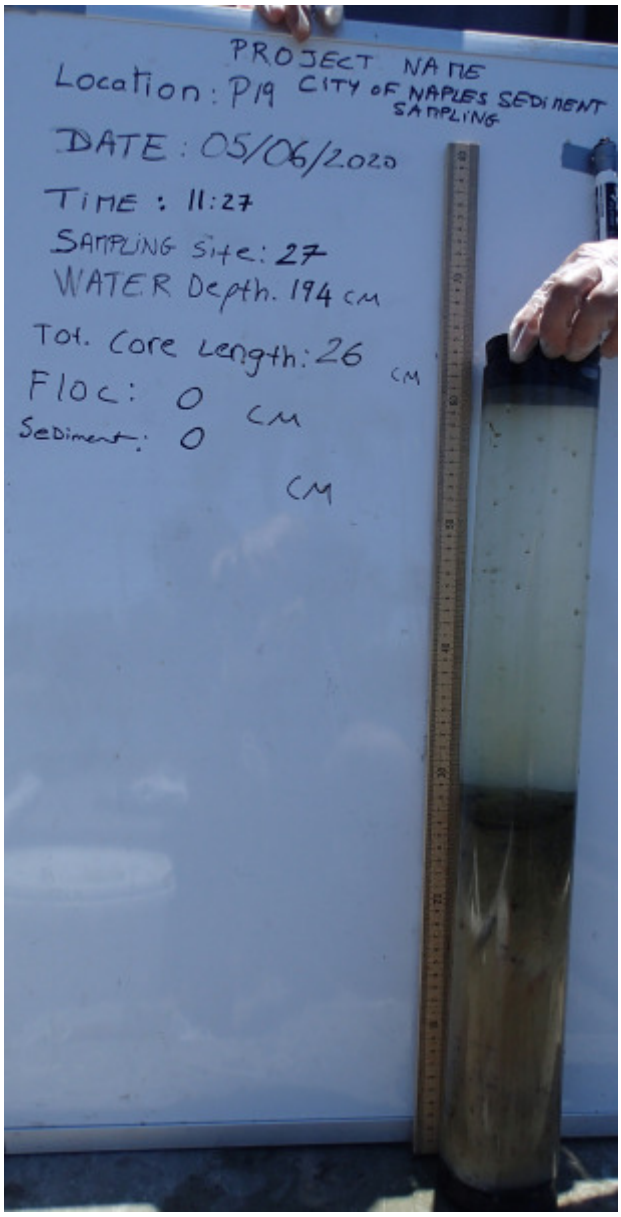
P19_S25


PROJECT NAME
Location: P19
CITY OF NAPLES SEDIMENT SAMPLING
DATE: 05/06/2020
TIME: 11:27
SAMPLING Site: 2.5
WATER Depth. 367 cm
Tot. Core Length: 30 cm
Floc: 3 cm
Sediment: Brown 14 cm
9 cm tan Clay
4 cm beige sand

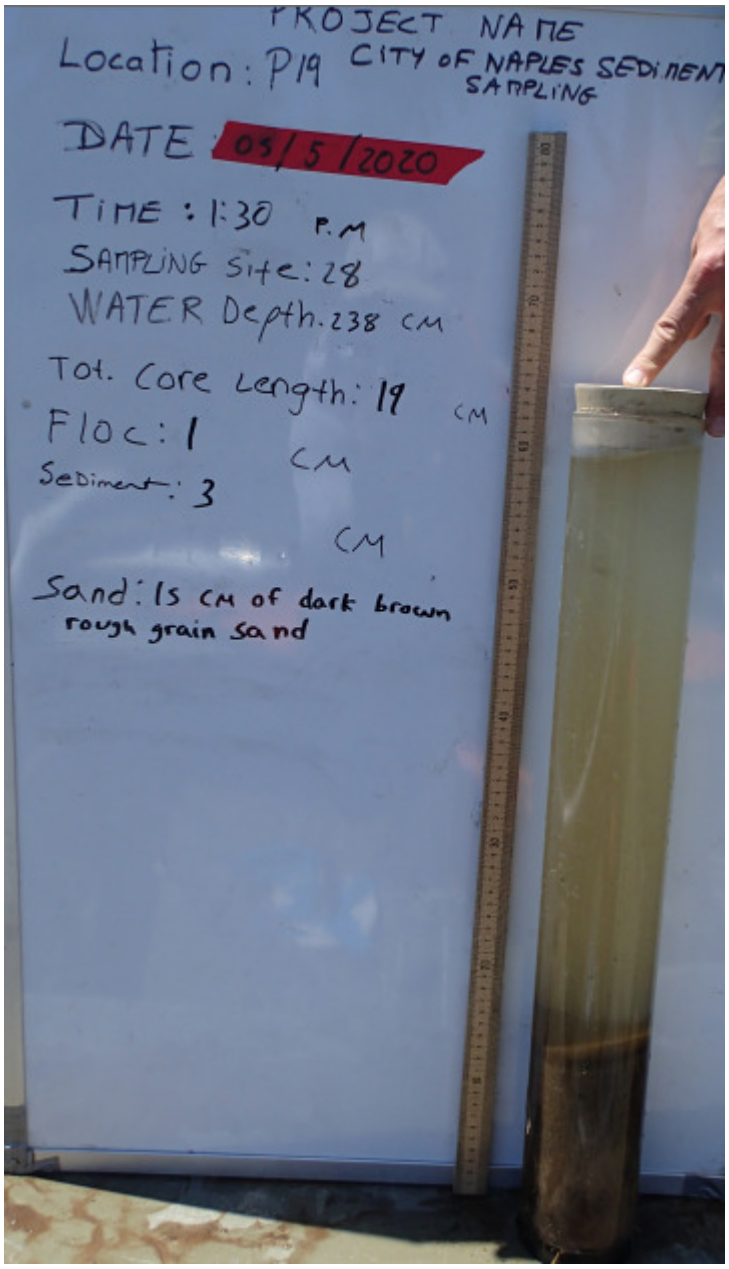
P19_S26


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 03/5/2020
Time: 2:05 P.M
SAMPLING Site: 26 CM
WATER Depth: 364 CM
Tot. Core Length: 40 CM
Floc: 2 CM
Sediment: 11 CM
Sand: 20 CM of dark gray sand, fine grain, with a distinct air bubble between the sediment & the sand. There is also another air bubble at the bottom as well.

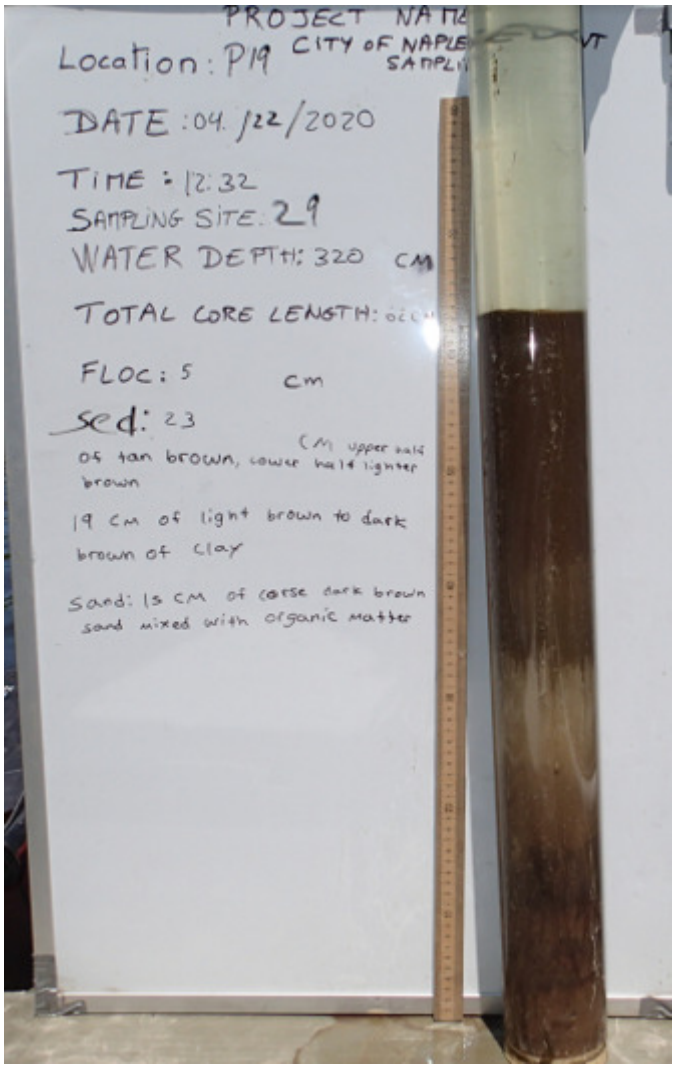
P19_S27


PROJECT NAME
CITY OF NAPLES SEDIMENT SAMPLING
Location: P19
DATE: 05/06/2020
Time: 11:27
SAMPLING Site: 27
WATER Depth. 194 cm
Tot. Core Length: 26 cm
Floc: 0 cm
Sediment: 0 cm

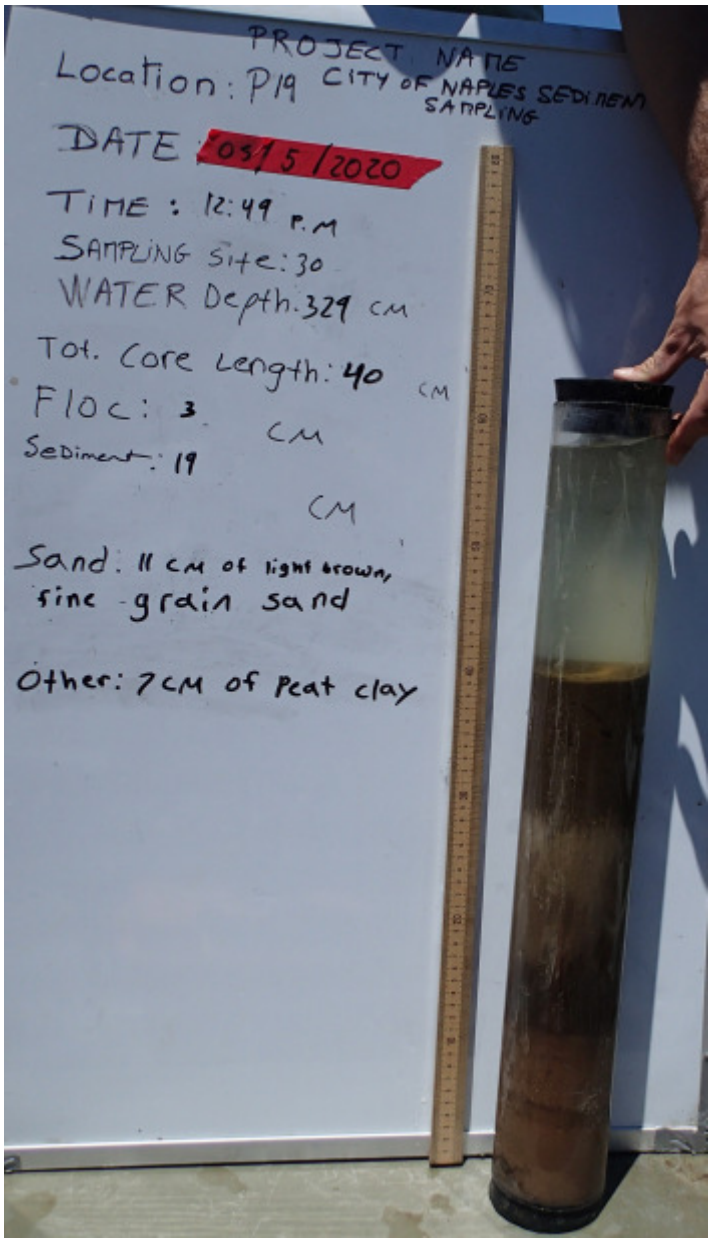
P19_S28


PROJECT NAME
Location: P19
CITY OF NAPLES SEDIMENT SAMPLING
DATE 03/5/2020
TIME: 1:30 P.M
SAMPLING Site: 28
WATER Depth. 238 CM
Tot. Core Length: 19 CM
Floc: 1 CM
Sediment: 3 CM
Sand: 15 CM of dark brown rough grain sand

P19_S29


PROJECT NA
CITY OF NAPLE
Location: P19
DATE: 04/22/2020
TIME: 12:32
SAMPLING SITE: 29
WATER DEPTH: 320 CM
TOTAL CORE LENGTH:
FLOC: 5 cm
sed: 23
CM upper half of tan brown, lower half lighter brown
19 CM of light brown to dark brown of clay
Sand: 15 CM of corse dark brown sand mixed with organic matter

P19_S30


PROJECT NAME
Location: P19 CITY OF NAPLES SEDIMENT SAMPLING
DATE: 03/5/2020
TIME: 12:49 P.M
SAMPLING Site: 30
WATER Depth: 329 CM
Tot. Core Length: 40 CM
Floc: 3 CM
Sediment: 19 CM
Sand: 11 CM of light brown, fine grain sand
Other: 7CM of Peat clay