



Feasibility Study of the Deferred and Routine Maintenance Dredging of the Odaw Drainage Basin in Ghana under a Performance Based Contracting Approach

Interim Report

RA19083

RVO

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Colophon

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Executive Summary

The consortium of IMDC, CDR International, Rebel Group and ADK has been awarded the Feasibility Study for Deferred and Performance Based Maintenance Dredging of the Odaw Drainage Basin, Accra, Ghana. The client is the Ministerie van Economische Zaken en Klimaat, Rijksdienst voor Ondernemend Nederland (RVO) and the Competent Authority is the Project Implementation Unit (PIU) in Ghana.

The study area consists of 4 main areas (as shown Figure 0-1 with further details of the area shown in Figure 0-2):

1. **Caprice – Abose Okai bridge:** Lined section of Odaw River channel with high sedimentation rates and the area that floods most frequently.
2. **Abose-Okai bridge – Interception weir:** Wider unlined section of the Odaw with fixed banks. The section runs through waste disposal areas and a large informal settlement called Old Fadama.
3. **Interception weir – Sea: “Korle Lagoon”.**
4. **Main Odaw River tributaries:** South Kaneshie (including Cemetery drain and Mataheko drain), Nima drain (first section), Agbogbloshie drain, and the Odawna drain.

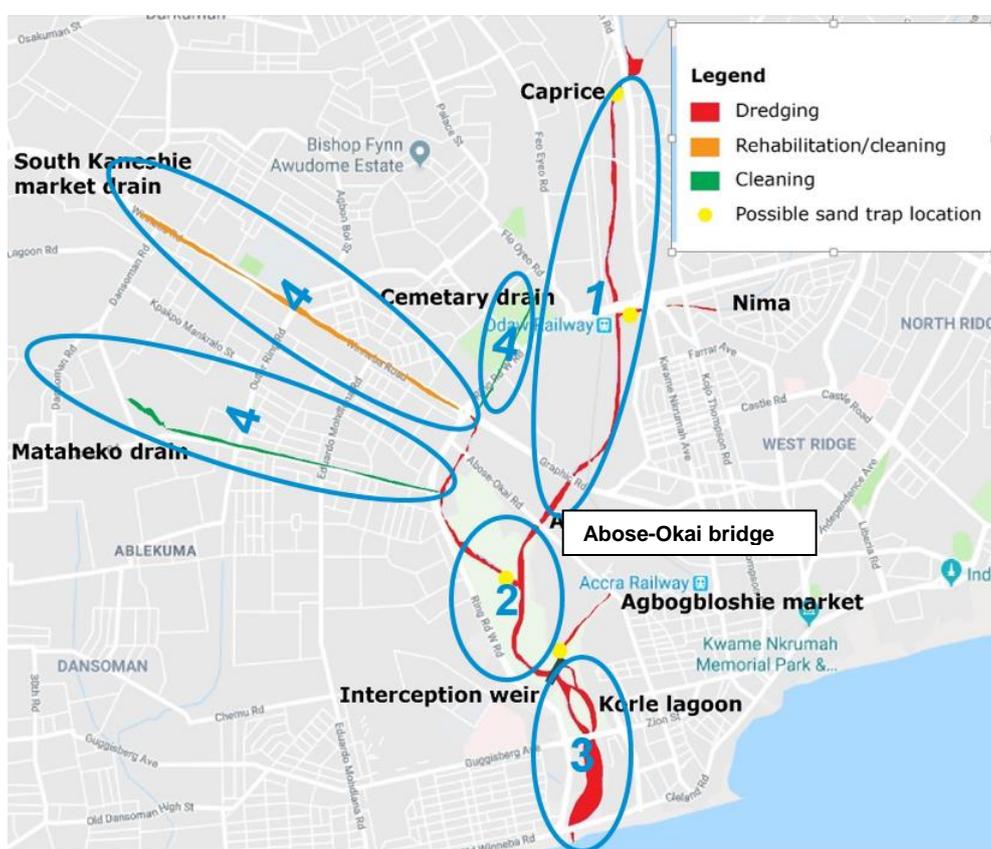


Figure 0-1: Project study area

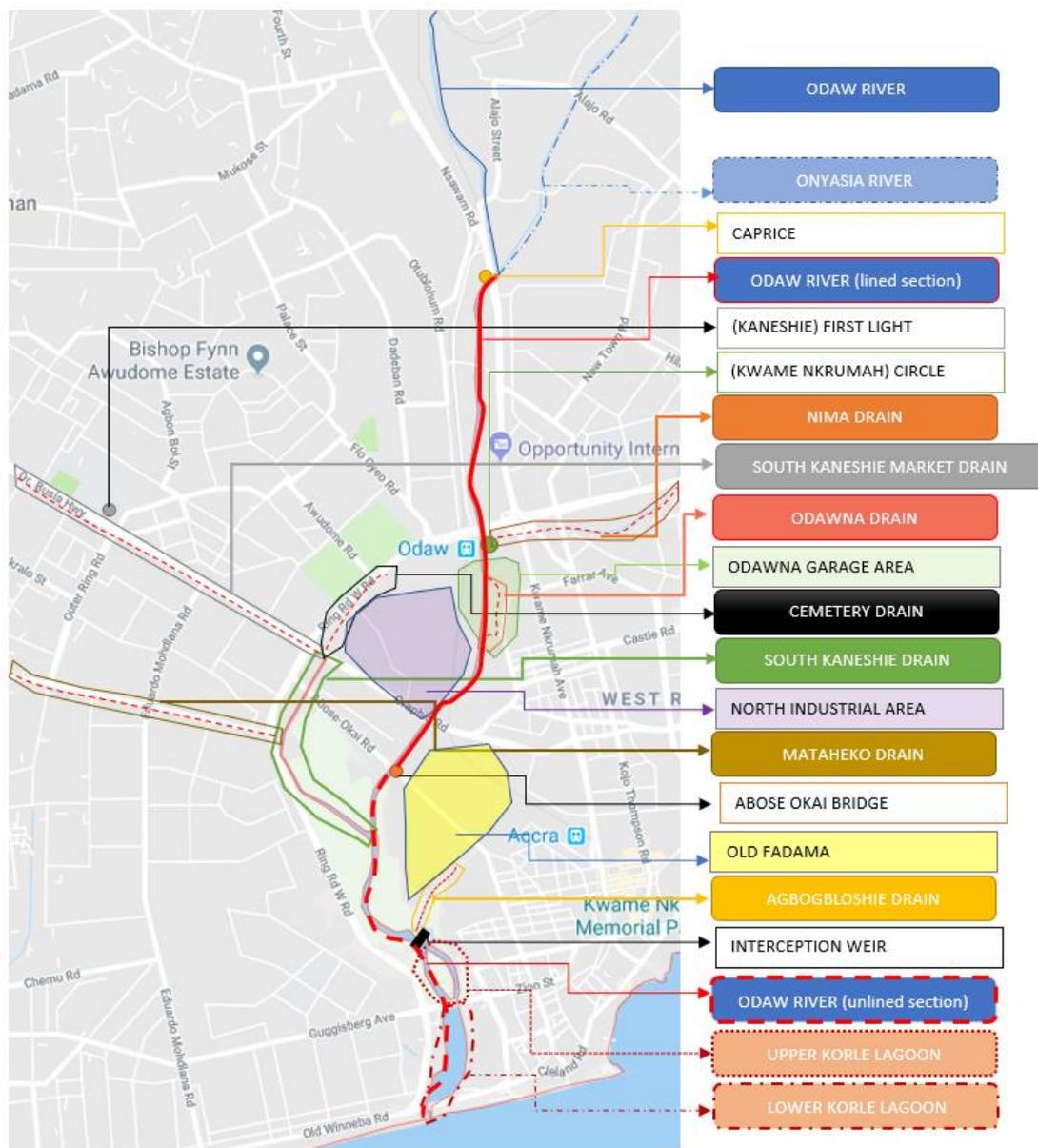


Figure 0-2: Location and names of key areas and drains

The overall objective is to contribute to achieving 1 in 10 years flood protection in the primary Odaw channel system, by preparing a ready-to-tender Performance Based Contracting (PBC) investment. The project will be financed as part of the broader World Bank GARID program.

The assignment consists of a feasibility study and preparations for a ready-to-tender Performance Based Contracting (PBC) document package. To achieve this, the study consists of the following tasks:

- Task 1: Dredged material assessment
- Task 2: Sediment handling and selection of deposit location
- Task 3: Cleaning and rehabilitation of tributary channels
- Task 4: Assessment of sand trap locations
- Task 5: Assessment of possibilities to give the interception weir a function (dredging purposes)

- Task 6: Institutional analysis
- Task 7: PPP and joint venture possibilities and risks
- Task 8: Capacity building and training needs assessment
- Task 9: Preparation of PBC tender and bidding documents

Task 1: Dredged material assessment

The dredged material consists of a mixture of gravel, sand, silt and clay. Based on sediment sampling the first 2 components form 75% of the material, and the remaining 25% is silt and clay. The total volume of material is split between 430,000m³ of deferred dredging and 85,000m³ of maintenance dredging. These numbers are based on calculations from bathymetric surveys.

The methodology to dredge this material is dependent on the location. In the drains it is most likely that it will be dredged by excavators. These can be equipped as long reach or with other supports for easy access to the site. In other locations a combination of mechanical dredging (excavators) and hydraulic dredging (with pumps) can be considered. Hydraulic dredgers seems to be preferred in the Korle Lagoon. The total cost for deferred dredging is estimated to be around €16 M.

Task 2: Sediment handling and selection of deposit location

Once the material is dredged, it must be disposed. In order to make the project as beneficial as possible, the reuse of the material was assessed. As Task 1 described, sand and gravel is the main components of the material and these can be used for a range of works such as construction works. However, the environmental sediment analysis showed a significant amount of contaminated material. This study concluded that all dredged material must be treated prior to reuse. For this treatment 2 sediment handling sites were identified. However, as the cost for such treatment is very high compared to the price of sand, this solution is deemed to not be an interesting incentive for the Performance Based Contract.

Therefore, the material needs to be disposed in designated areas. Three areas have been identified with a combined storage capacity of 990,000 m³, which is sufficient for storage of the deferred dredged material, and 6 years of maintenance dredging.

Task 3: Cleaning and rehabilitation of tributary channels

National experts and the models confirm that flooding is influenced by the drains. The Nima drain, Kaneshie drain, and the South Kaneshie market drain have the largest effect. It was assessed that these drains would also require remedial works (in addition to regular maintenance) as they were under capacity. It was recommended that a detailed design study should be undertaken that includes checking the influence over time with the incorporation of other flood alleviation measures i.e. by combining retention ponds with wider drains and as such avoiding high flows from all drains at the same time. Nonetheless, conceptual designs were assessed for these three critical drains.

The rehabilitation of Nima drain includes the construction of a 1 m high flood wall along the channel banks. The cost of this mitigation measure was calculated as around €1.5 M. For the South Kaneshie Market drain, an increase in capacity (by additional 3 additional culverts or 5 pipes of ϕ 1.8m) is recommended and is estimated to cost between €8.5M - €10.5M. for South Kaneshie drain the system is more complex with various options considered including the realignment of the 90° bend.

Task 4: Assessment of sand trap locations

Building sand traps may be an efficient measure to reduce the sediment load and dredging interval and increase the efficiency of the maintenance dredging. As such, several locations were investigated, and a multi-criteria analysis based on various factors was performed. This analysis which was shared with relevant stakeholders gave a clear outcome of the most preferred locations for sand traps namely: Kaneshie 2, Caprice and Nima 2 as presented in Figure 0-3.

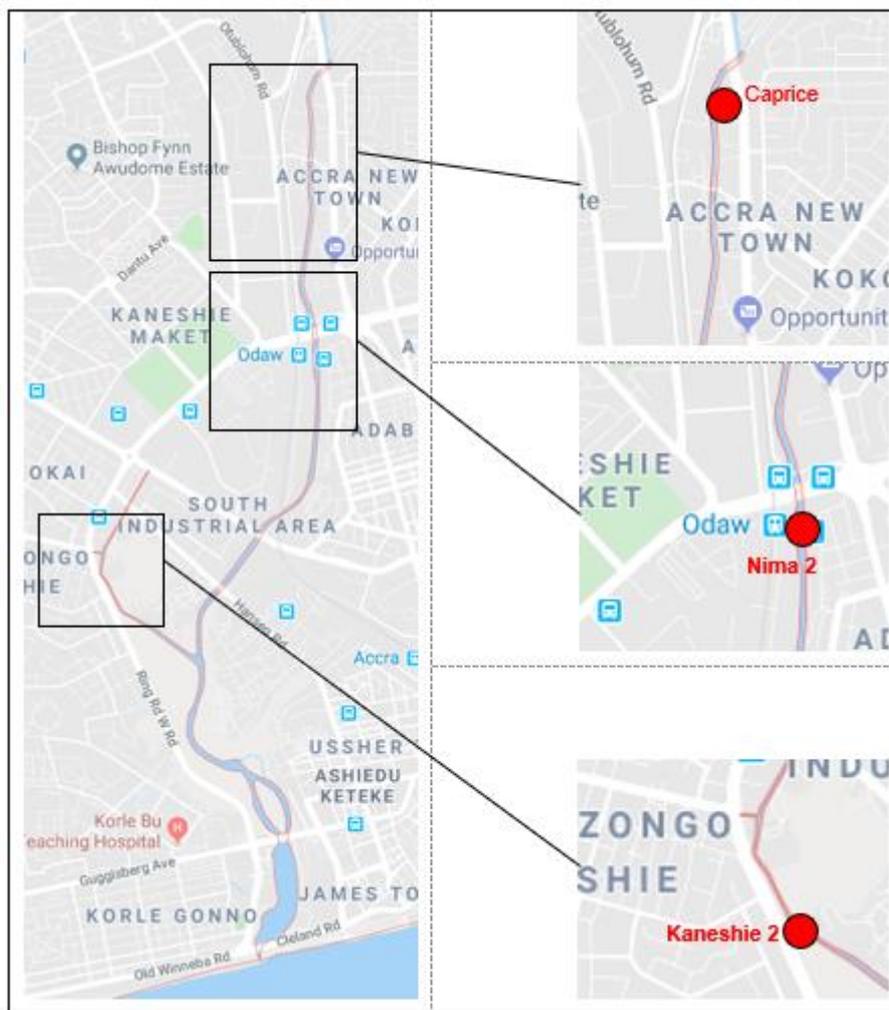


Figure 0-3: Selected sand trap locations after multi-criteria analysis

Task 5: Assessment of possibilities to give the interception weir a function (dredging purposes)

The concept of the interceptor weir was to prevent the heavily polluted dry weather flow of the upstream drainage system from entering the Korle Lagoon, which should have a positive influence of the quality of this water body. Clearly the interceptor weir is currently not functioning as originally intended, primarily due to a lack of proper maintenance. As a result, the structure may cause a negative impact on the flood safety of the upstream areas, primarily if gates are blocked or flow is obstructed due to floating debris that is retained and / or sedimentation of the bed.

Furthermore, it clearly blocks a lot of floating waste which is in fact good because this was one of the main goals of the KLERP system: to reduce the contamination in the lagoon area. However, the floating boom was installed to stop the floating waste and the waste was required to be regularly removed before arriving at the interceptor.

Task 6: Institutional analysis

A lot of institutions are involved for the maintenance of the Odaw and its tributaries: Central government; Ministry of Works and Housing; Hydrological Services Department; Ministry of Local Government and Rural Development; Accra Metropolitan Assembly; Drains Maintenance Unit; Environmental Protection Agency; Ministry of Sanitation and Water Resources; and National Disaster Management Organization. A desktop assessment and intake surveys revealed that alignment

between their different responsibilities is not clear and a lot of interactions between the different institutes is needed to ensure the maintenance works being efficiently executed.

Task 7: PPP/PBC and joint venture possibilities and risks

A well-structured PBC guarantees that the drains are, preventively, in good condition so that flooding is alleviated. PBC would be a good solution to address the present problems with the maintenance of the drains. However, there are still some challenges related to the PBC such as uncertainty about volume and debris, the lack of competition and the lack of experience in contract management. The latter one being tackled in Task 8 of this report. The outline of a PBC would consist of several items:

- The maintenance of primary, secondary and tertiary channels is bundled.
- This bundled project is tendered as a PBC under the public procurement framework.
- The contractor receives the right to develop commercial activities related the drains maintenance activities. If there is sufficient competition for the project, then the bidders will share the profits from these revenue-generating activities (in a lower bid price).
- A number of simple performance criteria is defined. design dimensions, waste parameters.

To reduce the uncertainty about the dredged volumes, a hybrid contract could be envisaged, in which the initial deferred maintenance is remunerated on the basis of volumes (prescribed in the contract on the basis of a hydrological survey conducted) and the maintenance dredging is remunerated through other systems.

Task 8: Capacity building and training needs assessment

Even though knowledge on procurement is available within the entities (mostly FIDIC), the knowledge on PPP and PBC contracts is limited and all institutions would require training. This training can be a multiple of combined options such as classroom training; on the job training; workshops/seminars; study visits and educational programmes.

As each department needs training throughout its entire organisation, it is suggested to train key figures who will be responsible for the training of their departments. Training must be conducted to the highest standards within the market and training abroad is therefore recommended.

Task 9: Preparation of PBC tender and bidding documents

HOLD – deliverable due 16th December 2019 and will be in a separate document following the World Bank procurement layout.

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0 Introduction

0.1 The assignment

The consortium of IMDC, CDR International, Rebel Group and ADK has been awarded the Feasibility Study for Deferred and Performance Based Maintenance Dredging of the Odaw Drainage Basin, Accra, Ghana. The client is the Ministerie van Economische Zaken en Klimaat, Rijksdienst voor Ondernemend Nederland (RVO) and the Competent Authority is the Project Implementation Unit (PIU) in Ghana.

The study area consists of 4 main areas (as shown Figure 0-1 with further details of the area shown in Figure 0-2):

1. **Caprice – Abose Okai bridge:** Lined section of Odaw River channel with high sedimentation rates and the area that floods most frequently.
2. **Abose-Okai bridge – Interception weir:** Wider unlined section of the Odaw with fixed banks. The section runs through waste disposal areas and a large informal settlement called Old Fadama.
3. **Interception weir – Sea: “Korle Lagoon”.**
4. **Main Odaw River tributaries:** South Kaneshie (including Cemetery drain and Mataheko drain), Nima drain (first section), Agbogbloshie drain, and the Odawana drain.

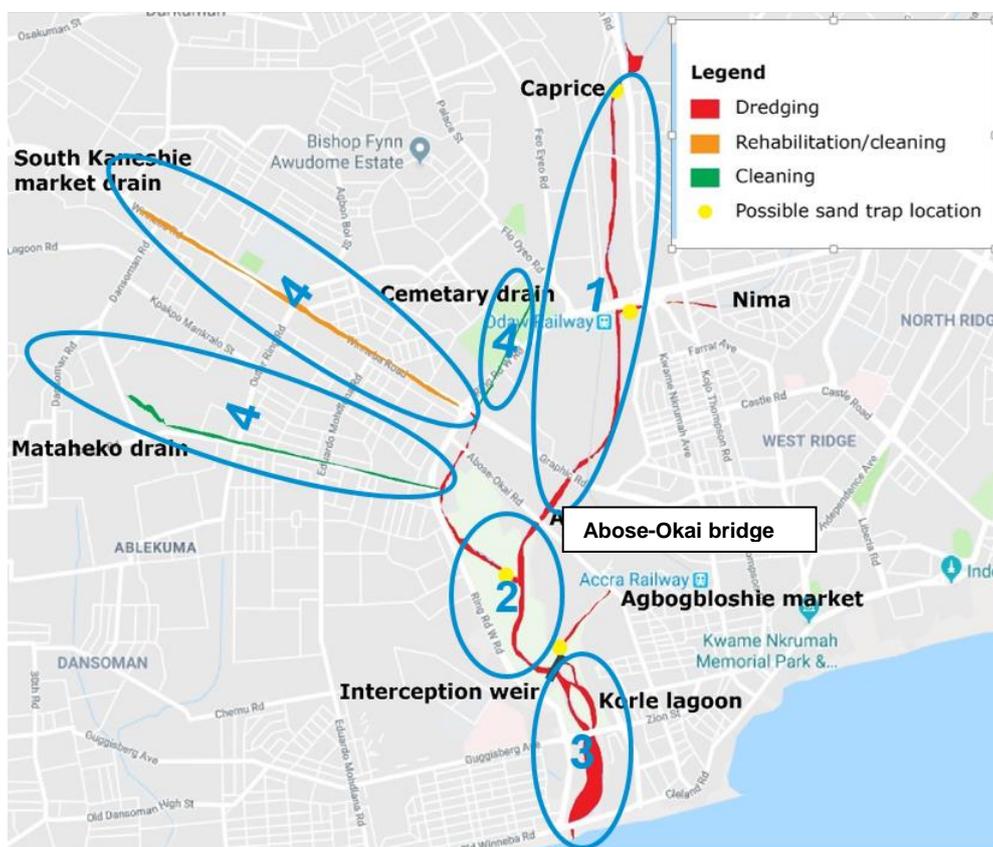


Figure 0-1: Project study area

The overall objective is to contribute to achieving 1 in 10 years flood protection in the primary Odaw channel system, by preparing a ready-to-tender Performance Based Contract (PBC) for the deferred and maintenance dredging. Maintenance dredging is dredging of the material that is settled annually. The amount of dredging is the same as the amount of settled material per annum. Deferred dredging is a requirement resulting out of lack of maintenance in the previous years and is therefore a

postponed maintenance dredging. This is different from capital dredging as capital dredging is removal of original material. Due to the lack of maintenance, piles of sediments have grown, which need to be removed in addition to the maintenance dredging. The determination of deferred and maintenance dredging requirements are the first steps of a range of other recommendations made in the prefeasibility report (HKV 2019), such as creating retention ponds, rising the bridge heights and other longer-term solutions such as widening the outlet. For this Feasibility Study, the focus is on the PBC for the deferred and maintenance dredging.

In order to proceed it is first required to have a clear definition of what is meant by deferred dredging, specifically what areas need to be dredged and to what depth/level. As such the following has been defined for the different sections of the study area based on the dredging flood alleviation solution in HKV, 2019:

1. **Lined Odaw River:** should be dredged down to concrete lining;
2. **South Kaneshie & Agbogbloshie drain:** should be dredged to the original cross-section design (from the KLERP study);
3. **Unlined Odaw River (Abosai Okai Bridge to interceptor):** should be dredged to the original cross-section design (from the KLERP study i.e. back to the gabions);
4. **Korle lagoon:** dredging a 60 m wide channel through the lagoon over a length of 1.5 km to at alleviate flooding (HKV, 2019).

For the purposes of this Feasibility Study, the volumes for the deferred and maintenance dredging have been calculated based on the above definition (in accordance with the terms of reference and requirements for the first phase flood alleviation recommendations of HKV 2019). The subsequent PBC documents are based on these calculations.

The defined overall objective to use a PBC for procuring and managing future dredging works for protection against flooding seems justified. All previous technical work by different consultants over many years has highlighted similar issues and proposed similar solutions: namely maintenance (via dredging and cleaning) of the main tributaries, drains, Odaw River and Korle Lagoon to allow for more water capacity and reduction in flood risk. The problem, however, stems from the required regular undertaking of such maintenance i.e. it has largely not been done in accordance with the recommendations of the previous studies. By implementing a PBC, the intention is to resolve this issue.

The assignment consists of a feasibility study and preparations for a ready-to-tender Performance Based Contracting (PBC) document package. The following reports will be delivered:

- D1 - Inception report;
- D2 - Interim report;
- D3 - Draft feasibility report;
- D4 - Draft PBC agreement;
- D5 - Final feasibility report.

This report is the Interim Report (D2) and is the second deliverable of the study.

For ease of reference, the work schedule for this study is summarised and reported in Table 0-1. This will be removed on submission of the final feasibility report (D5).

Table 0-1: Summary of work schedule of key dates for deliverables and meetings

No.	Deliverable / Milestone name	Date
1	Kick off Meeting and contract signing	15/05/2019
2	D1 - Inception report: Approach and Work plan, including the interface with the ESIA consultants	14/06/2019
3	Reference Group Meeting 1: Discuss inception report	02/07/2019
4	D2 - Interim report: including analysis, identification and assessment of both potential sediment handling and deposit locations and sand traps	14/10/2019
5	Reference Group Meeting 2: Discuss interim report	29/10/2019
6	D3 - Draft feasibility report: including analysis, identification and assessment of both potential sediment handling and deposit locations and sand traps	16/12/2019
8	D4 -Draft PBC agreement and WB tender evaluation protocol	16/12/2019
7	Reference Group Meeting 3: Discuss draft feasibility report and PBC agreement	10/01/2020
9	D5 - Final feasibility report	03/02/2020
10	Reference Group Meeting 4: Discuss final feasibility report	18/02/2020

0.2 Reading guidance

As the main outcome of the study is the provision of Performance Based Contract for dredging works, the first task is to assess the material that needs to be dredged. It analyses the locations where dredging works are required and the composition of the material. This is provided in Task 1, along with possible execution techniques of these dredging activities.

- Task 1 provides an answer to: What needs to be dredged and how.

As the material and the amount is determined, the material still needs to go to a final location. What can be done with the dredged material, and where it can be placed is described in Task 2

- Task 2 provides an answer to: What needs to be done with the dredged material.

As flooding is influenced by the tributaries/drains, their contribution and potential adjustments to avoid such flooding are assessed in Task 3. Sedimentation in the tributaries is one of the components that influence the flooding.

- Task 3 provides an answer to: In what way do the tributaries contribute to the flood risk and how can this be avoided.

Reducing sedimentation in the system by making sand traps to collect the sediments at strategical locations is done in Task 4.

- Task 4 provides an answer to where can sand-traps be strategically constructed to reduce the influence of sedimentation, and make the dredging works more structured/efficient.

As the tributaries contribute to the risk of flooding, so does the interception weir. Task 5 analyses what adjustments are needed to reduce the impact of the inception weir.

- Task 5 provides an answer to: what can be done at the interception weir from a dredging perspective.

By combining the first 5 tasks, there is a clear view on the technical requirements and challenges. The chapters deal with all contributors of the flooding: sedimentation, tributaries/drains, weir. This now has to result in a PBC. This PBC will have to be managed by the institutions responsible for the maintenance works. Task 6 provides a view on these institutions and their roles.

- Task 6 provides an answer to: which institutions are involved in the maintenance works.

One of the objectives of the feasibility study is to investigate the feasibility of the use of Performance-Based Contracts (PBC) in the procurement of dredging and channel maintenance works. In addition, other public-private partnership (PPP) and/or joint venture cooperation opportunities are addressed.

- Task 7 provides an answer to: is a PBC preferred above a PPP, what are its challenges, and how will it be structured.

Before drawing up a PBC, it is needed to verify whether such a new type of contract can be managed. Even though all technical requirements are stipulated, the risk and opportunities clarified, and the involved institutions identified, the success of the PBC will depend on the management of such a contract. Task 8 assessed whether sufficient familiarisation with PBCs are present in the different institutes to efficiently manage such contract set-up and what further training is required.

- Task 8 provides an answer to: who needs training and which training is needed.

The end result of this study consists of the concept of a PBC, which shall be delivered as part of the feasibility study.

0.3 Terminology

0.3.1 Abbreviations

A list of abbreviations used in this document is presented in Table 0-2.

Table 0-2: List of abbreviations

Abbreviation	Definition
AMA	Accra Metropolitan Assembly
BD	Backhoe Dredger
BOT	Build Operate Transfer
BOOT	Build Own Operate Transfer
CSD	Cutter Suction Dredger
DB	Design and Build
DBFMO	Design Build Finance Maintain Operate
DBFM	Design-Finance Build-Maintain
D2B	Develop 2 Build
DRF	Document Review Form
ESIA	Environmental & Social Impact Assessment
EPA	Environmental Protection Agency
FS	Feasibility Study
GIS	Geographic Information System

Abbreviation	Definition
GD	Grab Dredge
GARID	Greater Accra Resilient and Integrated Development Project
HSD	Hydrological Service Department
ITT	Information To Tender
IPC	Interim Payment Certificates
IPC	Interim Payment Certificates
JV	Joint venture
KOM	Kick off meeting
MSL	Mean Sea Level
MMDCE	Metropolitan, Municipal, and District Chief Executives
MSWR	Ministry of Sanitation and Water Resources
MWH	Ministry of Works and Housing
MCE	Multi-Criteria Evaluation
MDA	Municipal District Assemblies
NLD	National Level Datum
PBC	Performance-Based Contracts
PAU	PPP Advisory Unit
PFA	Project and Financial Analysis Unit
PIU	Project Implementation Unit
PIM	Project Information Memorandum
PID	Public Investment Division of the Ministry of Finance and Economic Planning
PPA	Public Procurement Authority
PPP	Public-private partnership
RTK GPS	Real-time kinematic Global Positioning System
RGM	Reference Group Meeting
RFQ	Request for prequalification
RFP	Request for Proposals
RVO	Rijksdienst voor Ondernemend Nederland
SPV	Special purpose vehicle
SDP	Submersible Dredge Pump
TOR	Terms Of Reference

1 Task 1: Dredged material assessment

Task 1 provides an answer to: What needs to be dredged and how.

1.1 Sediment composition

The composition and quality (contaminants) of the sediment to be dredged in the Odaw River system is important to know for both the Performance Based Contract documents and for identification of potential beneficial uses such as sand sales. This section describes the composition of the sediment, through analysis of historic and recent sediment sampling campaigns, and briefly covers the sediment quality, which is covered in more detail in the ESIA study.

1.1.1 2003 sediment sampling (KLERP)

The geotechnical investigation from the KLERP (Korle Lagoon Ecological Restoration Project) indicated that the sediment around the outlet of the Odaw River (based on 11 borehole samples) is composed of sand with a D_{50} between 0.40 mm and 0.45 mm (Dredging International, 2003). The grain size distribution showed that most of samples contained less than 10% clay and 10% to 30% silt (occasionally greater than 30% silt). The sand content averaged over all the samples was 72% (Figure 1-1).

The sediments were found to be slightly alkaline with a pH range of 8.3 to 8.5 and no differences were observed with an increase in depth. The Agbogbloshie area had the highest concentrations of sediment organic matter, nitrogen and phosphorus while the Abose-Okai Bridge had the highest levels of oil. Moreover, the study noted that, the dredged sludge from Korle Lagoon was generally classified as not contaminated.

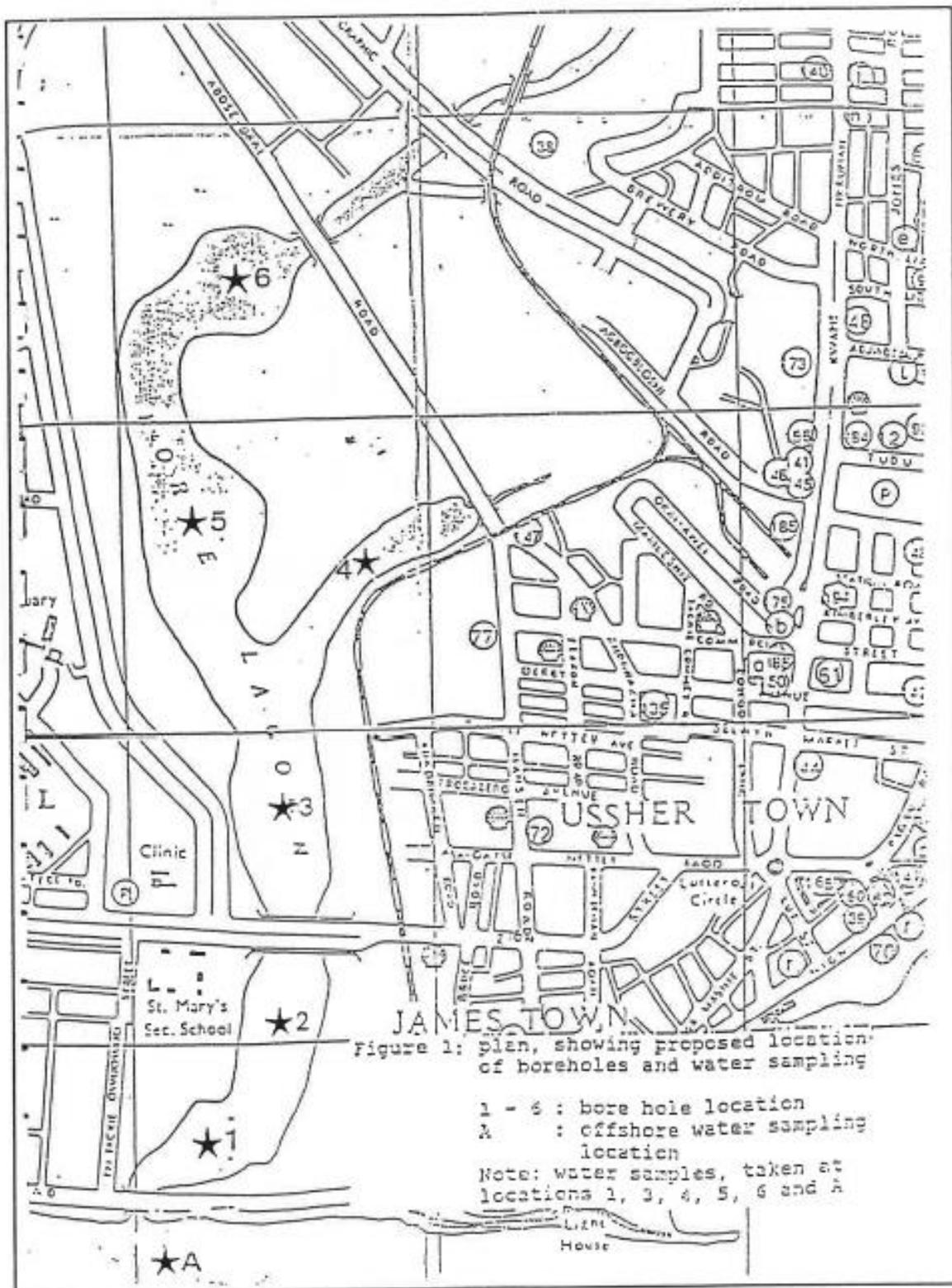


Figure 1-1: Sediment sampling locations during KLERP (Dredging International, 2003)

1.1.2 2018 sediment sampling (ESIA GARID study)

Sediment sampling was undertaken in December 2018 (Figure 1-2) as part of the ESIA GARID project. This sampling indicated that the sediment is mostly sandy (Table 1-1) with particles ranging from very fine sand to a composite of medium sand (SAL Consult, 2019). However, results showed higher percentages of clay and silt at sampling points 3, 6 and 7 (shaded in Table 1-1). Point 7 was at the mouth of the concrete lined drain whereas points 3 & 6 were sampled at the earth drains hence the increment in silt and clay deposition.

From the results, it was speculated by SAL Consult (2019) that the proposed dredge material sampled is less likely to be contaminated because sand material generally has a low capacity to retain pollution including heavy metals. Indeed, measurement of heavy metals in the samples indicated that only silver content was above the guidance level (SAL Consult, 2019). Pesticide and organic pollutants/polychlorinated biphenyls (PCBs) were also analysed and shown to be very low or non-detectable, despite the activities of the auto mechanic along the channel as well as the illegal e-waste processing activities around the Agbobloshie and Old Fadama areas (SAL Consult, 2019).

Table 1-1: Results of 2018 sediment sampling analysis (SAL Consult, 2019)

Sample ID	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Soil Texture	Comment
Point 1	2	2	95.82	0.31	Sandy	1.5 m depth cored with a composite of very fine sand at estuary
Point 2	4	5	90.91	0.41	Sandy	3m depth core to the earth storm drain with a composite of medium sand
Point 3	19	11	68.64	1.40	Sandy	Earth storm drain to 2.2 depth core with composite of fine sand
Point 4	1	2	96.65	1.10	Sandy	Earth storm drain to 2.8m depth cored with a composite of medium sand
Point 5	1	1	87.13	10.46	Sandy	2.7m depth core to the earth storm drain with a composite of medium sand
Point 6	17	16	65.84	0.60	Sandy	2.9m depth core to the earth storm drain with a composite of medium sand
Point 7	18	10	70.65	0.93	Sandy	1.6m depth core to the concrete storm drain liner with a composite of fine sand
Point 8	1	1	93.59	4.09	Sandy	1.2m depth core to the concrete storm drain liner with a composite
Point 9	0	0	82.51	17.04	Sandy	0.8m depth core to the concrete storm drain liner with a composite of medium sand
Point 10	1	1	96.79	1.47	Sandy	No sediment deposit, a scrapper was used to get sediment within a radius of 5m with a composite of medium sand

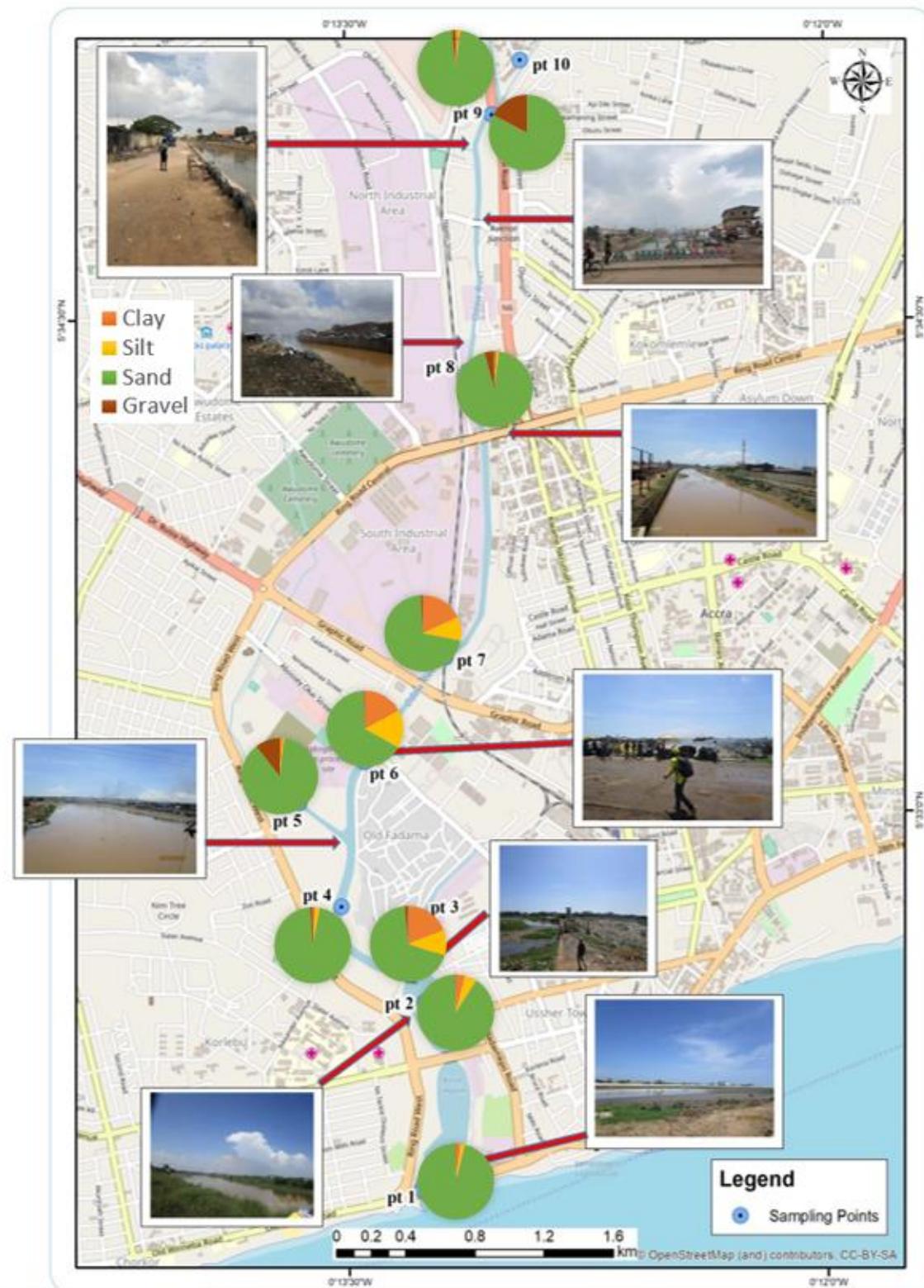


Figure 1-2: Location of Sampling Points (SAL consult, 2019)

1.1.3 2019 sediment sampling (feasibility study) and summary

For the characterisation of the dredged sediment a sediment sampling investigation was undertaken in May 2019 to obtain representative sediment samples along the entire study area. The location and results of the sampling points within the Odaw River and its tributaries are shown in Table 1-2. The sand and gravel content averaged over all the samples was 75%, with a range between 51 and 96%, although results showed higher percentages of clay and silt at sampling points 2, 3, 7, 12, 13, 14, 17, 18 and 20 (shaded in Table 1-2).

This average is lower than the results from the December 2018 sampling campaign which had an average sand content of around 88% with a range between 68% and 96% and the 2003 sampling campaign which had an average sand content of around 72%. It is also interesting to note that the gravel content from the May 2019 sampling is higher (19%) than the December 2018 sampling (4%). These differences may be a result of the differences in sampling techniques where the sampling of 2003 and 2018 were boreholes/cores and the 2019 were grab/surface sampling from the sediment that had been dredged and temporarily stored on the banks.

Overall there appears to be enough sand or gravel content to make sand and gravel sales for beneficial use an appealing incentive as part of the Performance Based Contract. However, sediment sampling undertaken as part of the ESIA study indicated high levels of pollution. This is discussed further in Task 2.

Table 1-2: Results of 2019 sediment sampling analysis

Sampling point	Particle size distribution (%)				ATTERBERG limits (%)			NMC %	Specific gravity
	Clay	Silt	Sand	Gravel	LL	PL	PI		
Point 1	2	18	70	10	No Plasticity			8.8	2.66
Point 2	11	24	46	19	34	27	7	10.9	-
Point 3	8	27	42	23	26	20	6	-	-
Point 4	-	5	81	14	No Plasticity			12.9	2.70
Point 5	-	9	79	12	No Plasticity			10.7	-
Point 6	4	17	70	9	23	21	2	10.4	2.65
Point 7	8	22	53	17	29	24	5	-	-
Point 8	16	12	50	20	40	32	8	12.4	2.68
Point 9	-	4	82	14	No Plasticity			15.6	-
Point 10	19	9	59	13	28	21	7	7.3	-
Point 11	4	10	62	24	No Plasticity			8.9	2.68
Point 12	15	34	35	16	36	28	8	10.7	2.67
Point 13	-	30	37	33	No Plasticity			12	2.66
Point 14	-	37	23	40	No Plasticity			-	-
Point 15	-	4	89	7	No Plasticity			9.1	2.56
Point 16	-	8	81	11	No Plasticity			-	-
Point 17	13	26	39	22	37	27	10	10.2	2.68
Point 18	-	41	27	32	No Plasticity			11	2.67
Point 19	2	11	40	47	No Plasticity			8.8	2.60
Point 20	10	39	35	16	43	33	10	12.2	2.70

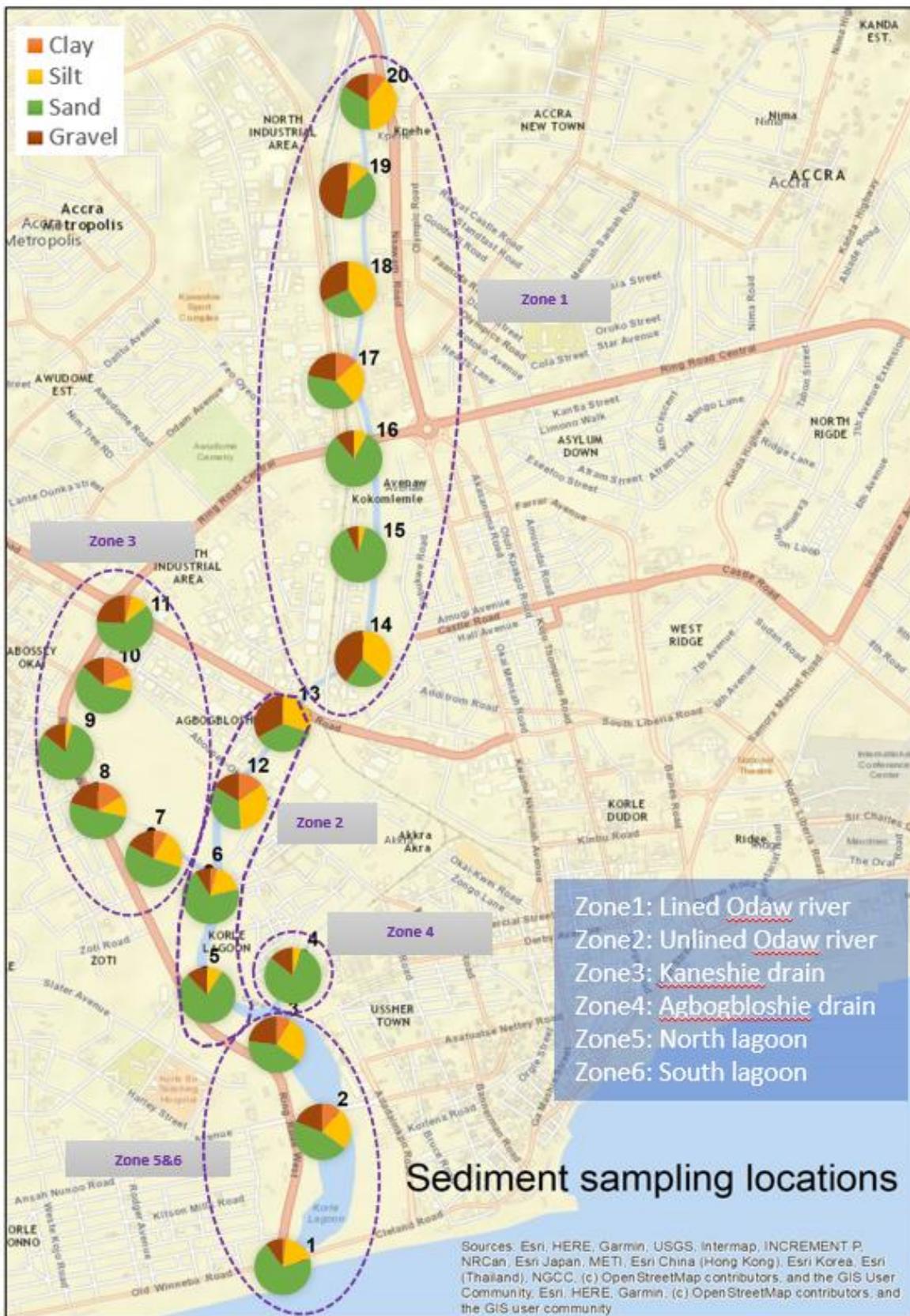


Figure 1-3: Sediment sampling results

1.2 Assessment bed level changes

Sedimentation of the Odaw River and its tributaries has a significant role in the reduction of the water capacity (as illustrated in Figure 1-4 and Figure 1-5), therefore increasing the risk of flooding.



Figure 1-4: South Kaneshie drain just after cleaning (May 2019)



Figure 1-5: South Kaneshie drain (July 2019)

This section therefore evaluates previous bathymetric surveys and available dredging records in order to have an insight into the sedimentation and expected dredging volumes. Due to several significant changes in the Korle lagoon, Odaw River and its tributaries, and in the surrounding urban areas, bathymetric data before 2015 are outdated and have not been evaluated. Data after this period has been analysed and is presented below.

1.2.1 Bathymetric surveys

Several survey campaigns have been undertaken over the years and these have been analysed to assess the bed level changes and volumes. These can be split into 5 broad periods in 2015, 2016, 2017 and 2019 and is summarised in Table 1-3 and Figure 1-6. Additional surveys are being carried out during the Feasibility Study.

Table 1-3: Bathymetry surveys

Survey	Date	Areas surveyed	Purpose
Survey 1	6 December 2015 - 18 December 2015	Lower Korle Lagoon	Carried out by WCE & AESL subcontracted by DML to serve as the base data for the dredging
		Upper Korle Lagoon	
		Unlined Odaw River	
	6 February 2016 – 16 February 2016	Lined Odaw River	
		Agboglobloshe Drain	
		South Kaneshie Drain	
Survey 2	19 – 28 July 2016	Odaw River (lined + unlined) and Korle Lagoon	Carried out by WCE & AESL subcontracted by DML to determine the volume of dredging from December 2015 and 15 February 2016 to 28 July 2016
Survey 3	9 – 15 February 2017	Korle Lagoon	Carried out by WCE & AESL subcontracted by DML to determine the volume of dredging from 28 July 2016 to 15 February 2017
Survey 4	March 2019	Whole area	Carried out by WCE & AESL subcontracted by DML as a base data (in-survey) for the dredging activities currently being performed (April to July 2019)
Survey 5	Monthly during the FS study	Whole area	Carried out by ADK as part of the Feasibility Study as additional information on sedimentation

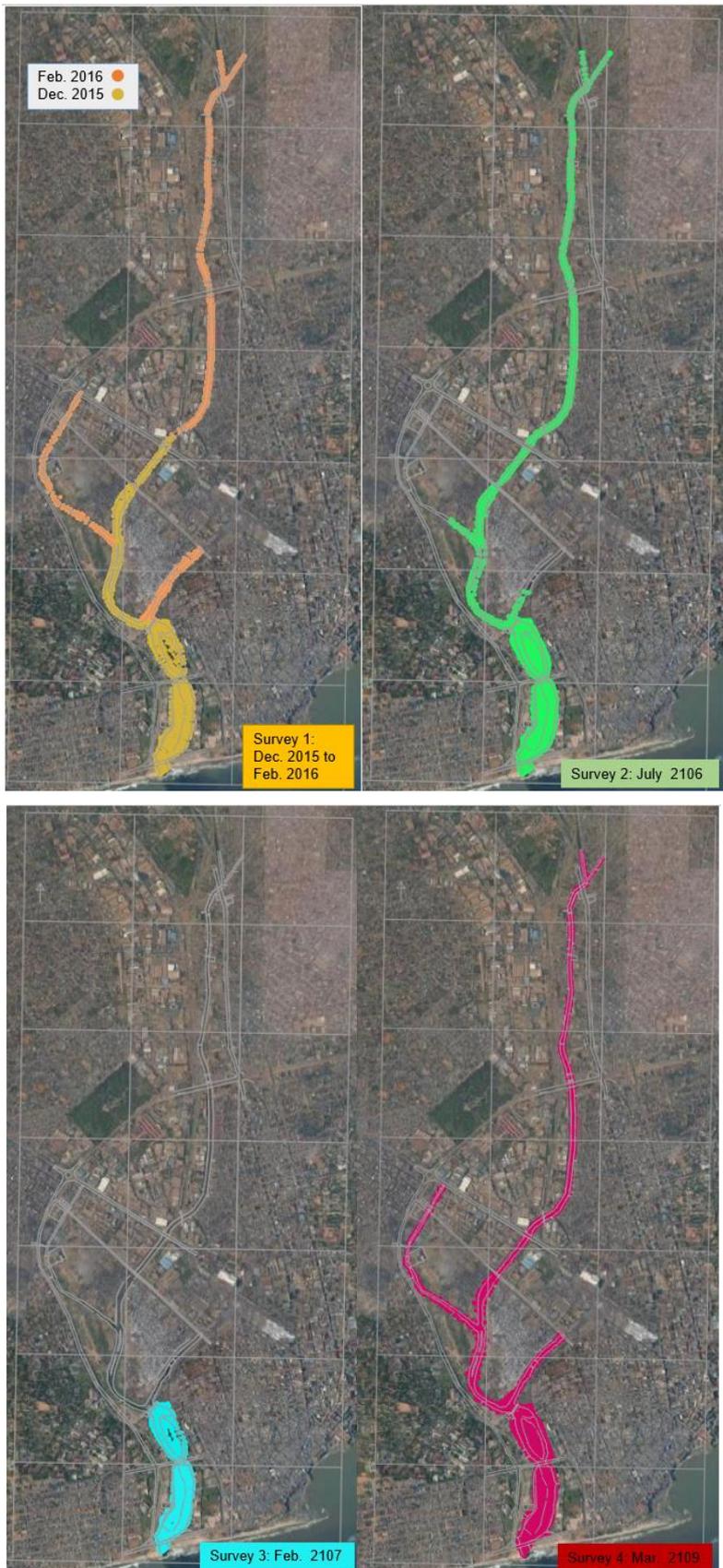


Figure 1-6: Bathymetric and Topographic Surveys (DML)

1.2.2 Dredging records

No official dredge records are available. However, it is understood that the more recent dredging activities that have been conducted since December 2015 can be split into 3 phases and consists of:

- **D1 = Korle lagoon, Unlined Odaw River, lined Odaw River.** According to DML (2016) the first dredging (D1) began end of December 2015 and was continued between February 2016 and July 2016 where the main Unlined Odaw River channel was dredged over a width of 20 m.
- **D2 = Korle Lagoon.** The second dredging (D2) has been conducted between 28 July 2016 and 15 February 2017. In the second dredging period activities were concentrated in the Korle Lagoon (DML, 2017).
- **D3 = No data available.** However, during the project site visit on 15-16 June 2019 it was observed that a new phase of dredging activities was ongoing. Activity was observed at the Lined Odaw River and South Kaneshie Drain at this period. Dredging began in April 2019 and is expected to finish in December 2019 and has so far covered Korle Lagoon, Unlined section of Odaw River, South Kaneshie Drain and Agbogbloshie Drain (personal communication with DML 23/09/2019). No volumetric data has been provided and may not even be available as no out-survey has yet been undertaken for the D3 dredging. DML are also removing the plastic waste using a big rake on the Water Master and then transported to Zoomlion to handle the plastic waste in the recycling plant adjacent to the interceptor.

1.2.3 Timeline of surveys and dredging

In order to provide a clear overview of what, where and when was done in terms of dredging and surveys, a timeline of activities has been summarised in Table 1-4. This allows easier interpretation of the results and calculation of deferred dredging for the PBC.

Table 1-4: Timeline of dredging and survey activities since 2015

Location	Activity	2015				2016				2017				2018				2019				2020
		Q1	Q2	Q3	Q4	Q1																
Korle lagoon	Dredging					D1	D1		D2										D3	D3	D3	
	Survey				S1			S2		S3									S4		S5	S5
Odaw River (unlined)	Dredging					D1	D1												D3	D3	D3	
	Survey				S1			S2											S4		S5	S5
Odaw River (lined)	Dredging						D1												D3	D3	D3	
	Survey					S1		S2											S4		S5	S5
South Kaneshie	Dredging																		D3	D3	D3	
	Survey					S1													S4		S5	S5
Agbogbloshie	Dredging																		D3	D3	D3	
	Survey					S1													S4		S5	S5
S1	First survey campaign executed by DML on 6 -18 December 2015 and 6- 16 February 2015																					
S2	Second survey campaign executed by DML between 19 – 28 July 2016																					
S3	Third survey campaign executed by DML between 9 - 15 February 2017																					
S4	Fourth survey campaign executed by DML in March 2019																					
S5	Monthly survey campaign executed by the Feasibility Study Team																					
D1	First dredging campaign executed by DML between December 2015 (according to second survey report) and then from February to July 2016																					
D2	Second dredging campaign executed by DML between July 2016 and February 2017																					
D3	Dredging campaign executed by DML between (April 2019 to December 2019 personal communication with DML on 23/09/2019)																					

1.2.4 Assessment of bed level and volume changes 2015- 2019

As described in the above sections, a number of surveys and dredging campaigns have been undertaken in the area by DML. To calculate the volume of dredging and sedimentation that has occurred over the timeframe December 2015 to March 2019, the collected bathymetric data has been assessed through creating the difference plots between different the bathymetric surveys and calculating the volumes. The main questions to be answered through this assessment were:

1. How much sedimentation has occurred ?
2. How much material was dredged?

1.2.4.1 Sedimentation volume calculations

To assess how much sedimentation occurred at different locations the bathymetry surveys were assessed and the volume differences between different surveys were calculated, after dredging had ceased. For example, for Korle lagoon the difference in bed levels between the March 2019 (S4) survey and the February 2017 (S3) survey was calculated and therefore the total volume is extracted from this difference plot. The same method was repeated for all the other areas using a combination of different surveys. The results are presented in Figure 1-7 and Table 1-5. The annual sedimentation was then calculated by dividing the volume by the time period. Based on this available data and an annual sedimentation for the whole area is around 210,000 m³, the majority of which is within Korle Lagoon.

Table 1-5: Calculation of sedimentation volumes

Location	Activity	2015	2016				2017	2019	Sedimentation volume calculations (Figure 1-7)	Annual sedimentation calculation
		Q4	Q1	Q2	Q3	Q4	Q1	Q1		
Korle lagoon	Dredging		D1	D1		D2			Volume difference between S3 and S4 =320,000 m ³	≈ 150,000 m ³ /yr
	Survey	S1			S2		S3	S4		
Odaw River (unlined)	Dredging		D1	D1					Volume difference between S2 and S4 =40,000 m ³	≈ 15,000 m ³ /yr
	Survey	S1			S2			S4		
Odaw River (lined)	Dredging			D1					Volume difference between S2 and S4 =70,000 m ³	≈ 25,000 m ³ /yr
	Survey		S1		S2			S4		
South Kaneshie	Dredging								Volume difference between S1 and S4 =30,000 m ³	≈ 10,000 m ³ /yr
	Survey		S1					S4		
Agbogbloshie Drain	Dredging								Volume difference between S1 and S4 =30,000	≈ 10,000 m ³ /yr
	Survey		S1					S4		
TOTAL										≈ 210,000 m³/yr

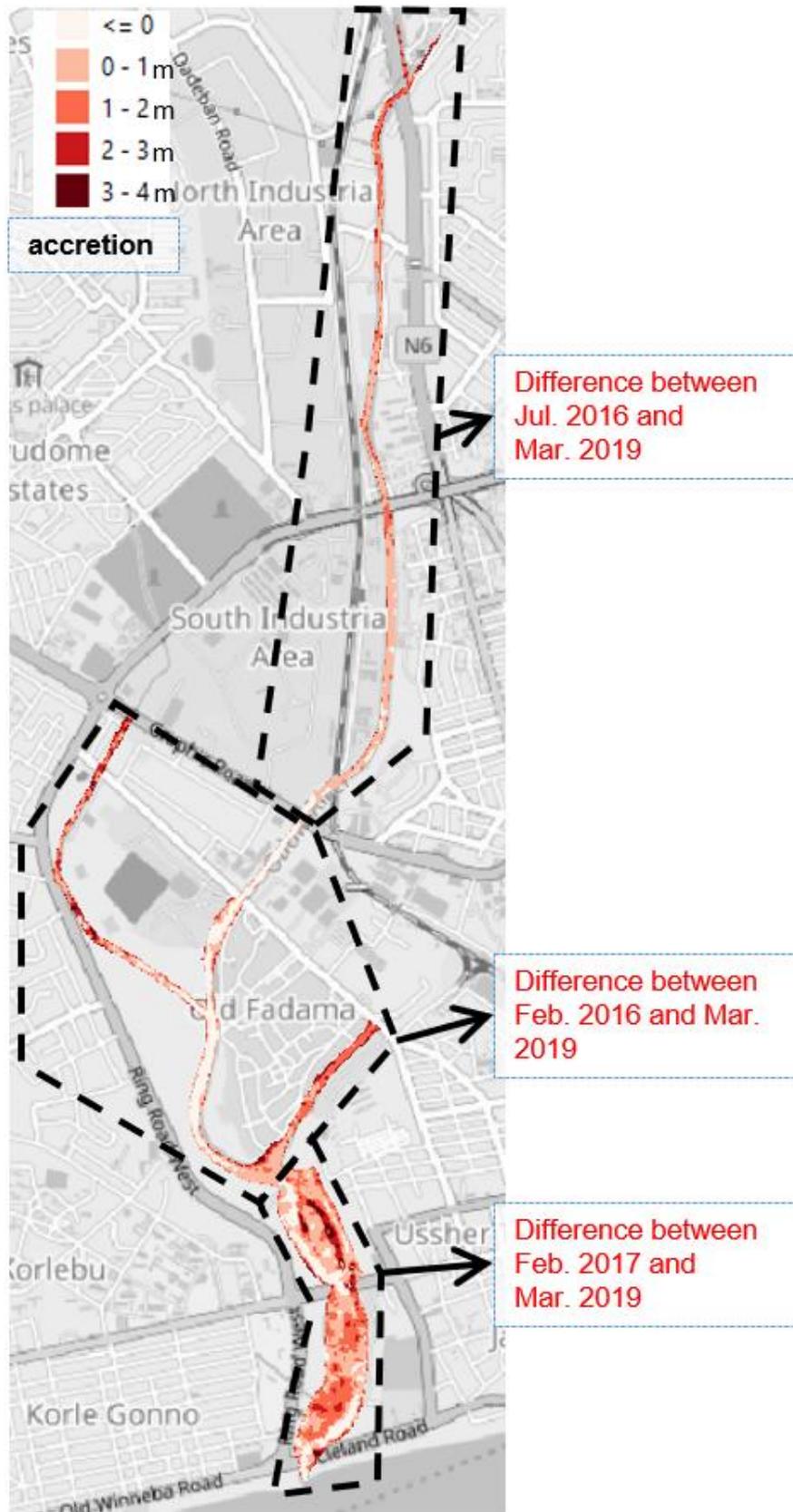


Figure 1-7: Bed level changes during different periods over the area of interest based on bathymetric surveys

1.2.4.2 Dredging volume calculation

To assess the volume of material dredged a difference plot between the different surveys was calculated, as shown in Figure 1-7 and Figure 1-8. This figure shows that the whole area has deepened, and this is a result of the dredging campaigns carried out over this time period (2015-2017). The table and figure also shows that no survey was undertaken of the entire South Kaneshie Drain or Agbogbloshie Drain after the dredging and therefore no volume calculations can be made for this area. Based on the available data, the volume of material dredged in this period was calculated to be 870,000 m³. Note that this calculation does not account for any potential sedimentation that may occur during or after the dredging campaigns.

Table 1-6: Calculation of dredged volumes

Location	Activity	2015	2016				2017	Volume calculations*
		Q4	Q1	Q2	Q3	Q4	Q1	
Korle lagoon	Dredging		D1	D1		D2		Difference between S1 and S3 = 450,000 m ³
	Survey	S1			S2		S3	
Odaw River (unlined)	Dredging		D1	D1				Difference between S1 and S2 =100,000 m ³
	Survey	S1			S2			
Odaw River (lined)	Dredging			D1				Difference between S1 and S2 =320,000 m ³
	Survey		S1		S2			
South Kaneshie	Dredging							No data available
	Survey		S1					
Agbogbloshie Drain	Dredging							No data available
	Survey		S1					
TOTAL								870,000 m³
*These figures don't account for any sedimentation that may have occurred during or after the dredging campaigns								

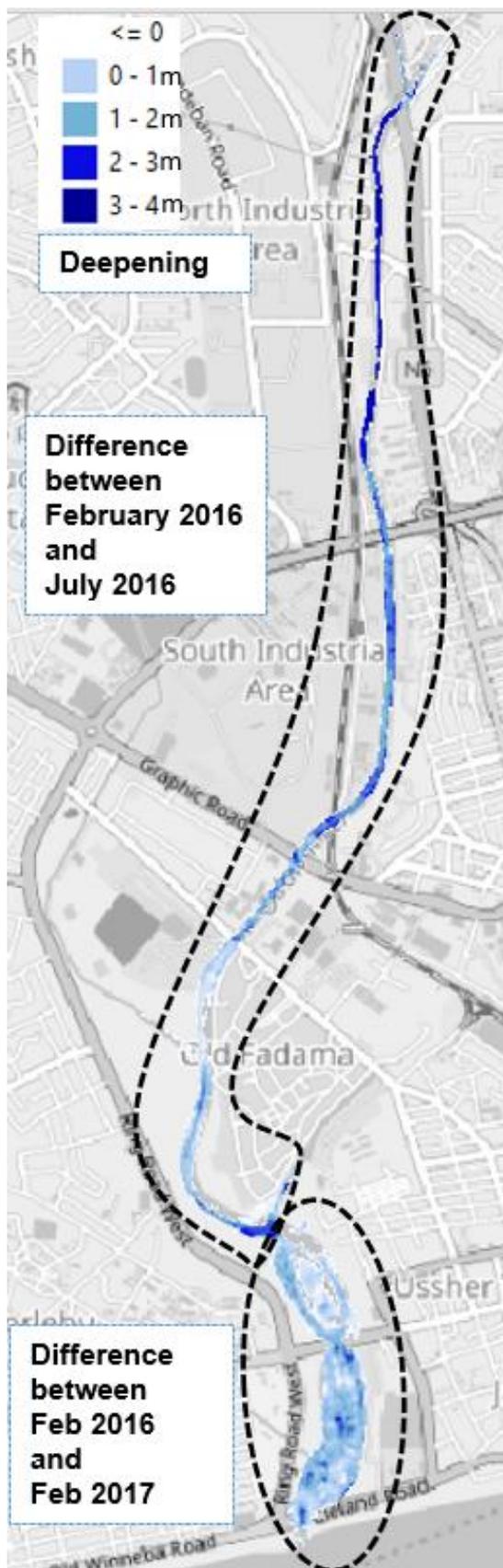


Figure 1-8: Bed level changes illustrating the dredging (no account for any sedimentation that may have occurred during or between Dredging campaigns)

1.3 Feasibility study (2019) bathymetric survey campaign

HOLD – Due 16 December 2019

1.4 Dredging volumes calculation

The Odaw River (and associated drains) from Caprice to the sea needs to be dredged, both initially (referred to as deferred dredging) to restore the design flow capacity and annually to maintain the design flow capacity (referred to as maintenance). As presented in the previous section, the Odaw River and part of the lagoon were dredged between 2016 and 2017 (and currently ongoing in 2019), but observations show already substantial increase in sediment layers, again reducing the flow capacity.

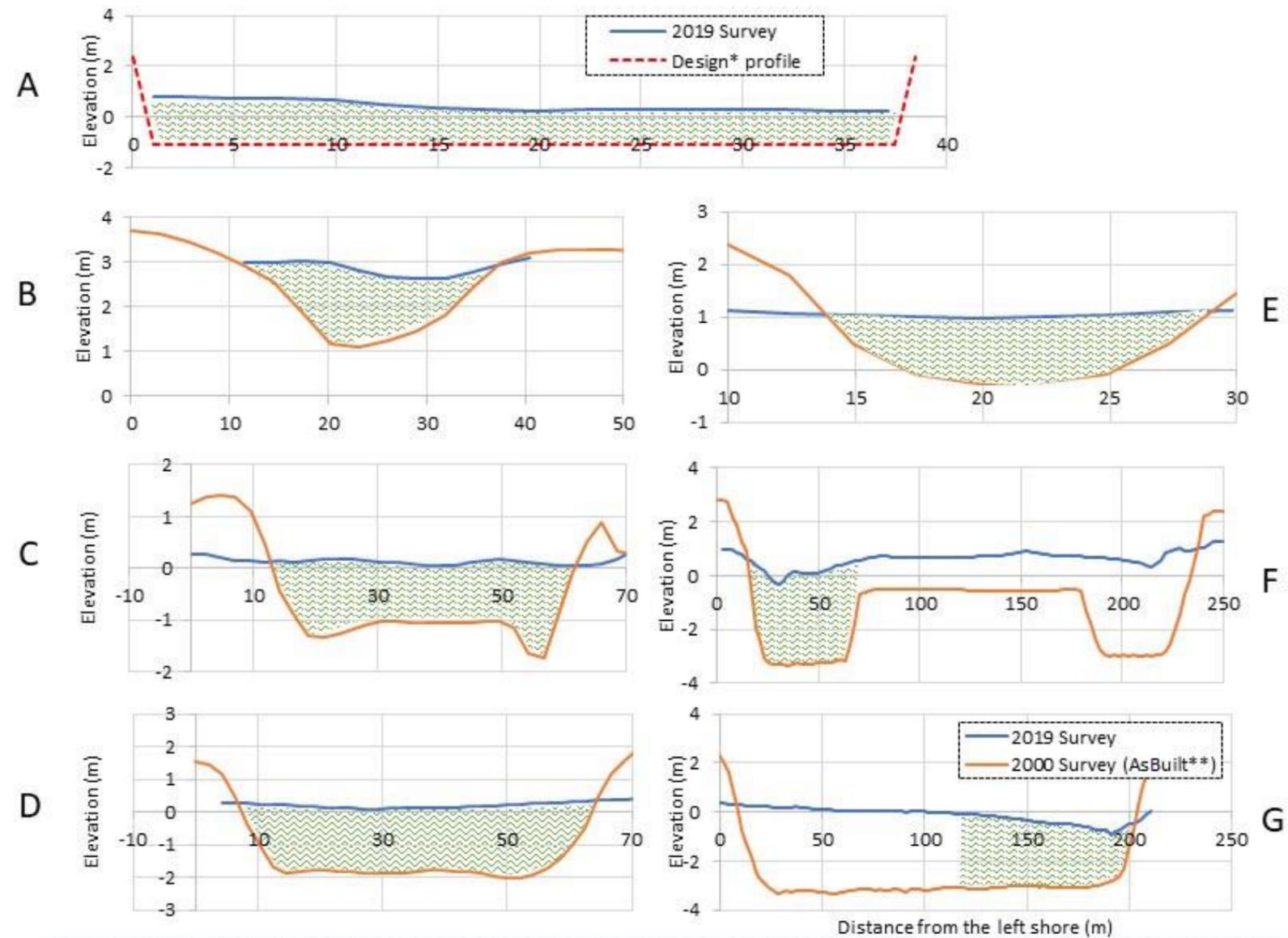
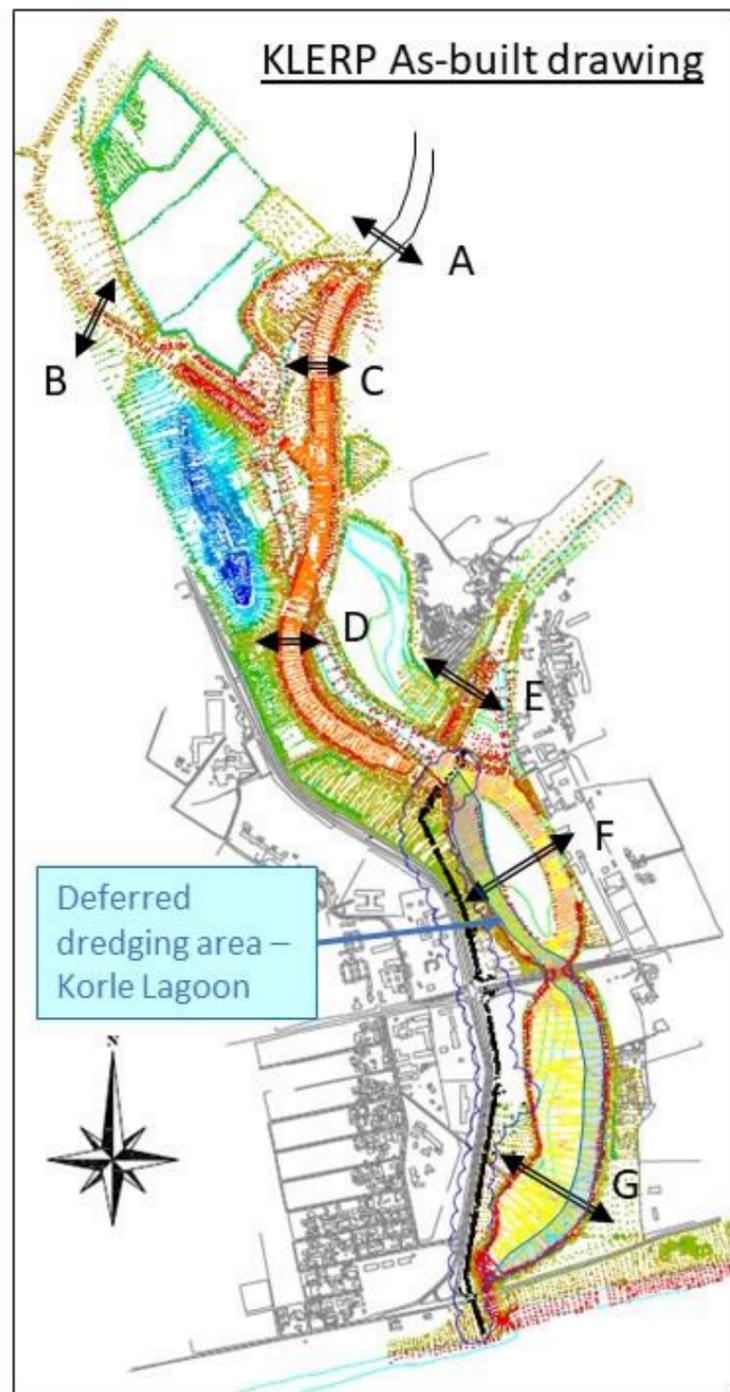
In order to calculate the volumes for the deferred dredging and subsequent maintenance dredging a combination of all the available data has been used. Most of the data used is historical surveys (December 2015 to March 2019) but these will be supplemented by additional topographic and bathymetric surveys over the course of the feasibility study.

1.4.1 Definition of deferred dredging

In order to proceed it is first required to have a clear definition of what is meant by deferred dredging, specifically what areas need to be dredged and to what depth/level. As such the following has been defined for the different sections of the study area:

1. **Lined Odaw River:** should be dredged down to concrete lining;
2. **South Kaneshie & Agbogbloshie drain:** should be dredged to the original cross-section design (from the KLERP study);
3. **Unlined Odaw River (Abosai Okai Bridge to interceptor):** should be dredged to the original cross-section design (from the KLERP study i.e. back to the gabions);
4. **Korle lagoon:** dredging a 60 m wide channel through the lagoon over a length of 1.5 km to at alleviate flooding (HKV, 2019).

The above is illustrated in Figure 1-9. For the purposes of this Feasibility Study, the volumes for the deferred and maintenance dredging have been calculated based on the above definition (in accordance with the terms of reference and requirements for the first phase flood alleviation recommendations of HKV 2019). The subsequent PBC documents are based on these calculations.



*Design profile is based on the designed dimensions of the concrete lining (red dashed line)
 **As-built survey (orange line) was completed for the Korle Lagoon Ecological Restoration Project (KLERP) PHASE II - Stage I - Dredging, Earthworks & Marine Works (Revision J; 15/10/2001)
 Deferred dredging

Figure 1-9: Schematic of deferred dredging areas and typical cross-sections

1.4.2 Calculation of deferred dredging volumes

The volumes for the deferred dredging have been made by calculating the difference in bed levels between the design levels and dimensions, and the bed levels measured in March 2019. The results are summarised in Table 1-7. A total of 430,000 m³ of deferred dredging is estimated. However, the PBC may not be based on volumes as a criterion for performance, but instead use dredging to the design cross-sections.

Table 1-7: Deferred dredging volumes

Location	Approximate Length (km)	Deferred dredging Volume (m ³)
Korle lagoon (section shown in Figure 1-9)	1.5	70,000
Odaw River (unlined)	2.0	150,000
Odaw River (lined)	3.6	140,000
South Kaneshie	1.7	47,000
Agbogbloshie	0.8	23,000
Total		≈ 430,000

1.4.3 Calculation of annual maintenance dredging

After the deferred dredging has been undertaken the area is subject to sedimentation, as discussed in section 1.2.4.1. Therefore, regular dredging will be required to ensure that the Odaw River, its Tributaries and the deferred dredging area of Korle lagoon is maintained to ensure the hydraulic capacity is met (for example by dredging to the design levels). Annual maintenance dredging has been calculated by using the method described in section 1.2.4.1 (volume differences between surveys), but in this instance the area of Korle lagoon is not the whole lagoon but the channel shown in Figure 1-9. The results are summarised in Table 1-7. However, the PBC may not be based on the volume to be dredged from the areas, but instead to maintain the bed levels to the design cross-sections. In this sense it is a better indicator of performance and provides more of a guarantee of flood alleviation. The calculated volumes will of course be additional useful information to be provided to the contractor as part of the PBC tender documents. In maintenance dredging, it shall also be ensured that the bed and bank protection / stability will not be affected.

Table 1-8: Annual maintenance volumes

Location	Approximate Length (km)	Annual maintenance dredging Volume (m ³)
Korle lagoon (section shown in Figure 1-9)	1.5	25,000
Odaw River (unlined)	2.0	15,000
Odaw River (lined)	3.6	25,000
South Kaneshie	1.7	10,000
Agbogbloshie	0.8	10,000
Total		≈ 85,000

1.5 Dredging methods and costs analysis

In general, the dredging method chosen is a result from the practical constraints (site conditions & materials), the specific needs of the Client, future maintenance, and the environmental requirements. Among those criteria disposal and the environment are major concerns and cost factors. As the disposal sites are part of Task 2 and the environmental criteria is being studied in another project, the following sections explain and justify the dredging methodology, and the possible alternatives.

1.5.1 Description of general dredging methodologies

1.5.1.1 Mechanical dredgers

Mechanical dredging removes sediment by capturing the sediment and then lifting the captured material to the surface. With this method the material more-or-less retains its in-situ composition and density. A mechanical dredge usually consists of the following:

- a bucket equipped with a cutting and grabbing edge;
- a crane or other means of lowering, manipulating, and retrieving the bucket (with the dredge material) through the water column;
- a means of transporting (usually a trucks/barge) the dredged material from the dredging site to a sediment handling and processing facility or a disposal facility.

A land-based excavator consists of a fully mechanical dredging technique. A bucket penetrates the soil and brings it towards the water surface. Note that in the Odaw River during the dry season excavation can be done in the dry. The material is discharged directly into trucks or is dumped on the shore. In the latter case, the dumped material is then reloaded with an excavator/loader into trucks which transport the material towards the disposal/sediment handling site.

Excavators can be upgraded for certain circumstances. If the location of excavation is difficult to access, the excavator can be equipped with long arms, which results in a long reach excavator. The long arm enables them to reach further. The further the reach, the lower the lifting capacity as a result of momentum forces. A typical diagram for long reach excavators is provided in Figure 1-10, which as a matter of illustration is applied to the Caterpillar 320D L excavator (Figure 1-11). This indicates that a bucket of 450 L can reach a depth of 11.88 m.

Another potential upgrade (mostly in addition to the long arms) is to equip the excavators with a different undercarriage. As such the caterpillars or the excavator can be made wider to decrease the pressure on the ground and be able to drive on less bearing surface (Figure 1-12). Another option is to put a spacer between the engine of the excavator and the undercarriage, and enable the excavator to drive into the water (Figure 1-13). Another potential upgrade is to place an excavator on a pontoon/barge. That way, the excavators can reach (depending on the draft of the pontoon/barge) all locations of a water influenced area (Figure 1-14).

As for transportation, the excavators generally loads trucks (Figure 1-15). Another option is that the excavator loads barges, but this is a site specific as the excavator should be able to reach the barge. Mostly barges will only be applied if the excavator is also positioned on a pontoon (Figure 1-16).

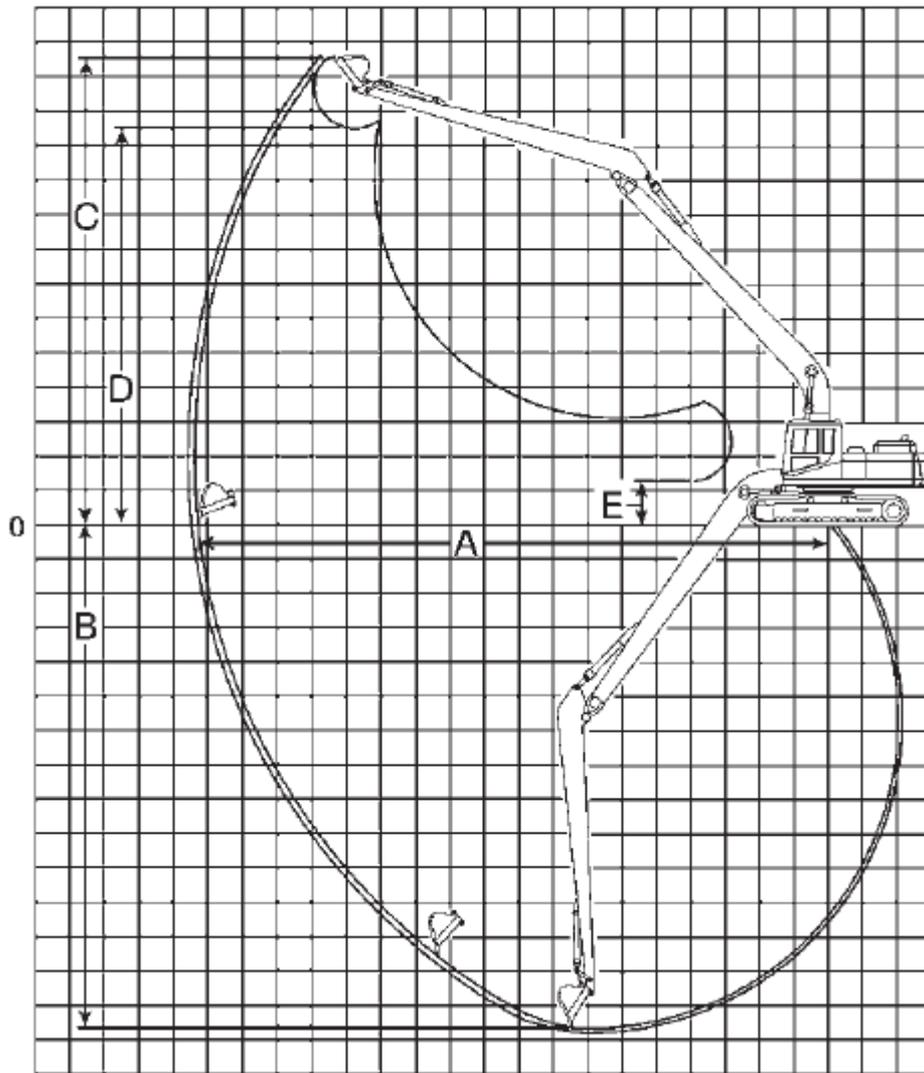


Figure 1-10: Long reach diagram

Long Reach, Range Dimensions	320D L	
	m	ft
A Maximum Reach at Ground Level	15.73	51'7"
B Maximum Digging Depth	11.88	39'0"
C Maximum Cutting Height	13.29	43'7"
D Maximum Dumping Height	11.01	36'1"
E Minimum Loading Height	1.97	6'6"

Long Reach, Bucket Information												
Model	Bucket Type	Bucket Width		SAE Heaped Cap.		Bucket Weight		No. of Teeth	Bucket Curl Force		Stick Crowd Force	
		mm	ft	L	yd ³	kg	lb		kN	lb	kN	lb
320D L	Excavation	810	2'8"	450	0.59	340	750	5	54	12,100	47	10,600

Figure 1-11: Application of load diagram to Caterpillar 320D L (as illustration only)



Figure 1-12: Excavator with wider tracks



Figure 1-13: Excavator with spacer



Figure 1-14: Excavator on pontoon



Figure 1-15: Excavator working in the dry and transport of material by use of trucks



Figure 1-16: Excavator loading barge

1.5.1.2 Hydraulic dredgers

Hydraulic dredgers remove sediment by fluidizing and pumping the material to the handling location. A hydraulic dredge usually consists of a dredge head and a hydraulic pump. The hydraulic pump may be deck mounted or submersible.

Because the sediment must be fluidized and pumped, large volumes of water are mixed and transported with the sediment. The volume of water added to create a slurry that can be pumped (referred to as carrier water) depends on the in-situ solids content of the sediment, sediment grain size, and pumping distance.

Cutter Suction Dredgers (CSDs) (Figure 1-17) are among the most popular type of hydraulic dredgers, available in a wide range of sizes ranging from the small portable units that fit on a large road trailer to ocean-going vessels of over 100 m long. A small CSD is able to handle small volumes of weakly cemented sediments, while full-size dredgers are commonly used for large-scale dredging operations, often in hard materials. The power cutter motors may range from 30 kW on the small and dismountable version, up to 8,000 kW on the largest models making them suitable for a wide range of sediments. These large sea-going cutters can dredge up to 35 m water depth and can operate in the intertidal zones as the cutter head (which is the dredge head of a CSD) is mounted at the bow. For this study, the smaller dredgers are further assessed as big dredgers are not able to enter the site location because of their size.

All CSDs are equipped with a rotating cutter head (Figure 1-18). The cutter head is a rotating mechanical device, mounted in front of the suction head and rotating along the axis of the suction pipe. It is used to 'cut' the soil, and 'disturb' the riverbed so the fluidization process can start. The cut (and fluidised) soil is sucked in by dredge pumps. CSDs cut the soil according to a pre-set profile. The dredged material can then be pumped ashore (to a reclamation site) using pumps and a floating pipeline or loaded into a barge moored alongside, which in turn can offload the dredged sediment at a designated location.

An advantage of CSD's is their ability to handle a wide range of materials, silts, clays, sand, gravel, cobbles, fractured and solid rocks. Normal working tolerance that can be achieved with a CSD are in general about ± 1 m in the horizontal plane and ± 0.3 m in the vertical plane. CSDs however are sensitive to rough seas and are not easily moved whilst working. For the dredging works in this situation, the dredgers are operating in a protected area (inland water) and are less influenced by the sea state. As the required dredging is limited, small CSDs could be applied for this project. These CSDs are generally dismountable for transport requirements, and are assembled on site. Table 1-9 presents a list of potential CSDs suitable for the (part of the) works required. Leaflets with a (*) are added in Annex A. Note that these are a non-exhaustive list and more dredgers able to execute the works are available. Furthermore, 2 fabricators of suitable dredging equipment are listed in the same table. These companies offer a wide range of smaller size dredgers, and multiple dredgers from their product range could be considered.

Table 1-9: List of potential CSD's (non-exhaustive list)

CSD	Owner	Leaflet
Seckin	DEME	https://www.deme-group.com/technology/se%C3%A7kin
Petrus Plancius (*)	Jan De Nul	https://www.jandenul.com/sites/default/files/equipment-item/pdfs/02.CSD_EN_-_V2014-1_-_Petrus_Plancius.pdf
Beaver Saint-Lawrence (*)	Boskalis	https://boskalis.com/about-us/fleet-and-equipment/dredgers/cutter-suction-dredgers.html
Ural River	Van Oord	n/a
IHC Beaver 65DDSP (*)	Dredgers can be purchased	https://www.royalihc.com/en/products/dredging/cutter-dredging/ihc-beaver-cutter-suction-dredger
DCSD500 (Damen) (*)	Dredgers can be purchased	https://products.damen.com/en/ranges/cutter-suction-dredger

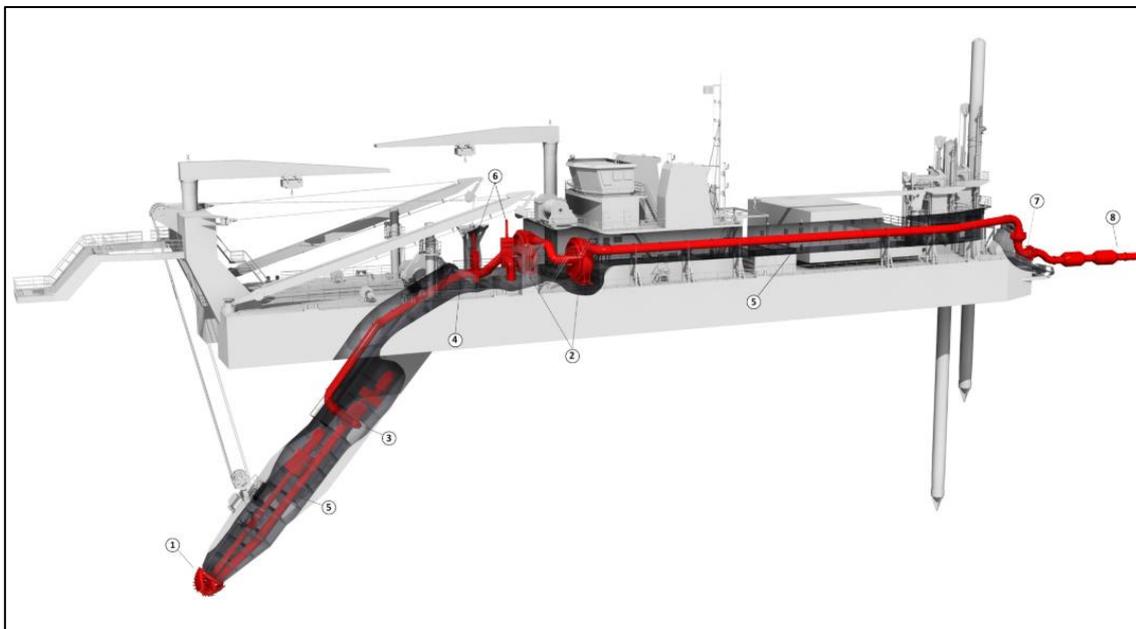


Figure 1-17: Cutter suction dredger



Figure 1-18: CSD cutting head Crown type – an example

1.5.1.3 Watermaster

Although this dredger is not a different method, it is mentioned as a separate chapter as it combines the mechanical and hydraulic dredging method. It’s a floating device with flexibility regarding the exaction method and is described by its fabricator as “THE AMPHIBIOUS MULTIPURPOSE DREDGER for all shallow water work” (Figure 1-19). A Brochure of Watermaster is added in Annex A. A watermaster is a floating dredging device with spuds in the back which are used to fix the vessel at its location, but also to push it forward. Arms are present to stabilize the dredger. The dredging arm is used to retrieve the material. This arm can be equipped with a bucket (for mechanical removal of material - Figure 1-20) or with a cutter head (for hydraulic removal of material - Figure 1-21). Other present components are the steering cabin and the engine.

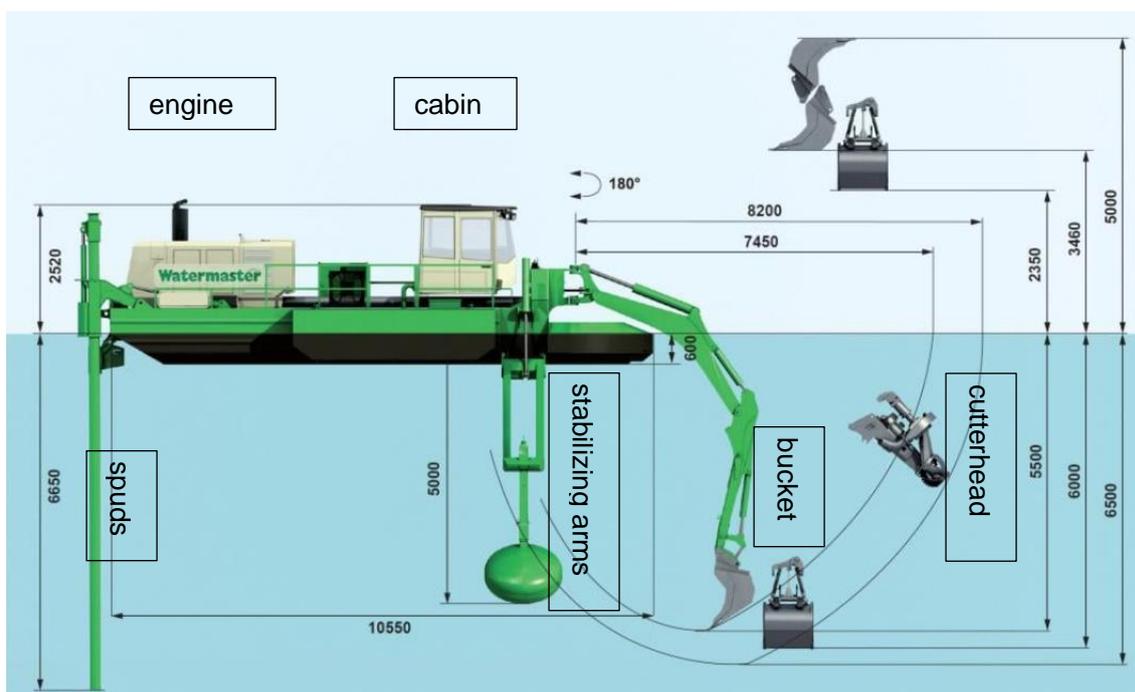


Figure 1-19: Components of the watermaster

The methodology of ‘mechanical material removal’ is similar to an excavator on a pontoon/berge. Due to the integrated construction, the efficiency on relocations and the ease of reaching certain locations, is an advantage over such excavator on a pontoon/berge.

For hydraulic removal of material, the draghead is installed on the dredging arm. This is connected to a discharge line that runs over the vessel and is connected to a floating pipeline to transport the material to the disposal area. Hydraulic removal is done by mixing the material (sand) with the present water. The mixture is pumped by the pumps on board of the vessel and as such transported to the disposal area, the reclamation area. As a reclamation is area is generally big, the speed of the water is reduced too. As such, the material can settle and the water again separated from the material.



Figure 1-20: Mechanical dredging with watermaster



Figure 1-21: Hydraulic dredging with water master

1.5.2 Current dredging methodology

Most dredging activities have been accomplished by Dredge Masters Ghana (DM). Their dredging fleet consists of:

- Excavators: Figure 1-22 (a);
- Long reach excavators: Figure 1-22 (b);
- Watermaster dredgers in hydraulic configuration: Figure 1-22 (c);
- Watermaster dredgers in hydraulic configuration: Figure 1-22 (d).

The Watermaster is applied in hydraulic configuration for dredging of the Korle lagoon area and also in the Odaw River Lined and Unlined sections. In the Korle lagoon a floating pipeline is leading to a temporary 'settlement area'¹ on the West of the lower Korle lagoon. However, this is not always possible, e.g. during low tide and/or high waste concentration, the cutter head gets stuck due to the plastic. In this situation the option has been to use the Watermaster in Backhoe Dredge mode, where self-propelled barges are first loaded and the offloaded using (long-reach) excavators near the temporary dump site next to the lagoon. Alternatively, DML use a Backhoe Dredge (essentially an excavator mounted on a pontoon/barge) for relocating the material from the centre of the river to the edge. On the side of the lagoon, the material is loaded for transport by use of (long reach) excavators.

¹ Note that it is a risk that a lot of material flows back into the channels in case there is no proper reclamation area. To avoid such flow back, a clear paragraph needs to be incorporated in the PBC.

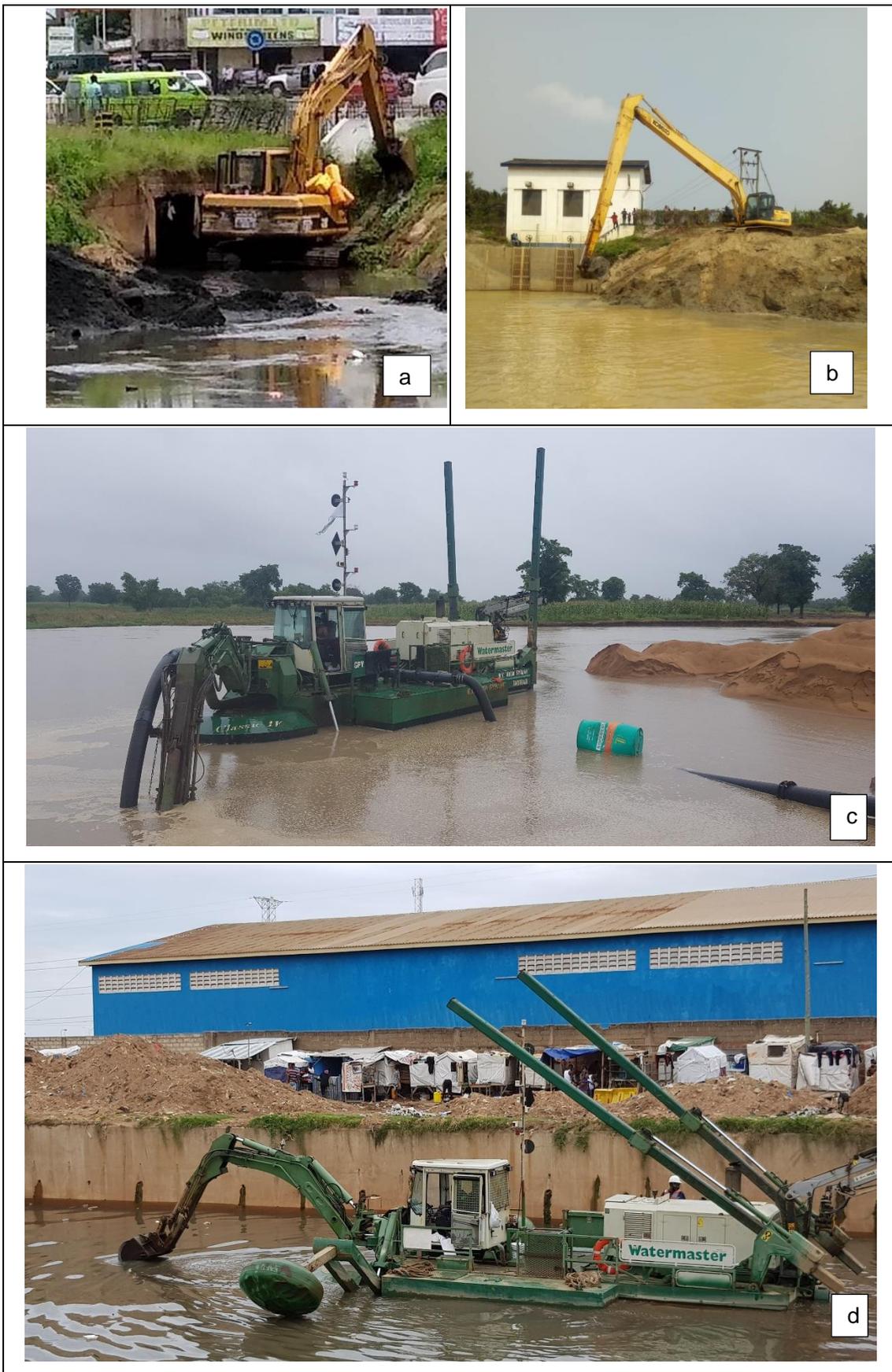


Figure 1-22: Dredge Master Limited, Ghana - Fleet extract

Along the Odaw River (lined and unlined), a combination of the excavators and long reach excavators is used together with the Watermaster (Figure 1-23). The excavator works in the middle of the channel (as well as the Watermaster in BHD mode) and both relocate material within the reach of the long reach. This results in re-handling in the wider sections of the river (Figure 1-23). The drains are dredged by use of long reach excavators which places the material on the side of the drains. From the side, they are loading onto trucks.

All dredging is undertaken during daytime hours. Haulage for disposal of material is undertaken after 9 pm.



Figure 1-23: Dredging method along the Odaw River (lined)

An overview of the dredging methodology is provided in Figure 1-24 according to the 5 zones required for the dredging volumes:

- Odaw River (lined) – Zone 1;
- Odaw River (unlined) – Zone 2;
- South Kaneshie drain – Zone 3;
- Agbogbloshe drain – Zone 4;
- Korle Lagoon - Zone 5 & 6.

All transportation is executed by trucks to the final disposal sites starting at 9 pm (for traffic restriction reasons). The location of these final disposal sites was not shared by DML. Note that these are currently not sites A or B² indicated on Figure 1-24, which are proposed sediment handling sites and are covered in more detail in Task 2.

² Sites A & B are the foreseen sediment handling sites as described in Task 2.



Figure 1-24: Dredging zones & current execution methods

1.5.3 Potential dredging methodologies for this project

Based on the above description of general dredging methods and the methods currently being used by Dredge Master Limited, several execution methods are feasible to execute the works. Table 1-10 presents the different execution techniques and relates them to their potential execution area. These will be the most likely methods applicable for the PBC deferred and maintenance dredging (although

this should not preclude contractors submitting alternative methodologies). It is also assumed trucks will be used to transport dredged material to the temporary handling sites and then onwards to the final disposal sites. As can be seen in Table 1-10 a lot of different options are available for the Contractors. In the future, the PBC methodology must be kept open. Each method has its advantages and disadvantages which are presented in Table 1-11. However, contractors are free to determine their most suitable and cost-effective method.

Table 1-10: Potential dredging methodologies

	Odaw River (lined) Zone 1	Odaw River (unlined) Zone 2	South Kaneshie drain Zone 3	Agbogbloshie drain Zone 4	Korle Lagoon Zone 5 & 6
CSD					x
Watermaster -BHD	x	x	x	x	x
Watermaster - CSD	x	x	x	x	x
Excavator + pontoon	x	x	x	x	x
Excavator	x	x	x	x	edges only

Table 1-11: Advantages and disadvantages per equipment type

	Advantages	Disadvantages
CSD	<ul style="list-style-type: none"> - High production rate - Low cost per m³ - Continuous operations - Less fines in material due to reclamation site (see task 2) 	<ul style="list-style-type: none"> - High mobilisation costs as not commonly available - Not very flexible movements in the dredging area - Reclamation area has high requirements to handle the mixture - Cannot dredge all locations i.e. in the drains
Watermaster -BHD	<ul style="list-style-type: none"> - Flexible use: easy movements through the dredging area 	<ul style="list-style-type: none"> - Lower production rate due to less efficient process - Very specific operations, and thus lower competition
Watermaster – CSD	<ul style="list-style-type: none"> - Flexible use: easy movements through the dredging area - continuous operation 	<ul style="list-style-type: none"> - Lower production rate due to less efficient process - Reclamation area has high requirements to handle the mixture - Very specific operations, and thus lower competition
Excavator + pontoon	<ul style="list-style-type: none"> - Can dredge all locations 	<ul style="list-style-type: none"> - Less flexible movements: requirement of assisting vessel
Excavator	<ul style="list-style-type: none"> - Worldwide availability and thus competitive market - Straight forward method 	<ul style="list-style-type: none"> - Cannot dredge all locations i.e. Korle Lagoon - Lower production rate

1.5.4 Dredging cost estimate

1.5.4.1 Deferred dredging cost estimate

The estimation of the costs for the deferred dredging works are provided in this section. However, it will not determine which methodology should be used. The cost for these operations and its related methodology is a result of a trade-off between availability of equipment; mobilisation cost and operational cost. The potential for market influence (have several competitors) should also be stressed in order be able to negotiate the best possible price.

Nonetheless an indicative price level is provided for the deferred dredging in Table 1-12. A distinction between mobilisation cost and operational cost is made. The first one is very dependent on the location of the equipment at the time of execution, whereas the latter one is subject to production/progress rates and optimisations. The variation of the first is not possible to determine as it cannot be predicted where the equipment will be. The mobilisation cost does not change when more, or less volume needs to be dredged. The variation of the operational cost will vary in the magnitude of +/-25% but is without any doubt mostly influenced by the volume. A total cost of €16 M (about 18 M USD) was estimated for the deferred dredging. Previous cost estimates were around 23 M USD (HKV, 2019). Therefore, it would be prudent to allow for a range between 18 -23 M USD

Table 1-12: Cost overview for deferred dredging works³

Volume [m ³]	Mobilisation Cost [€]	Operational Cost [€]	Total Cost [€]
430 000	4 M	12 M	16 M

1.5.4.2 Maintenance dredging cost estimate

The estimation of the costs for the maintenance dredging works are provided in this section. The same conditions related to methodology, operations and availability of equipment apply for the maintenance dredging as well. Furthermore, the cost of the maintenance dredging is estimated without taking any remedial actions (such as sand traps described in Task 4) into account. These measures will only have a beneficial impact on the total cost and can therefore be seen as an upper limit. Note that the mobilisation cost is very dependent on the used equipment. This is particularly important for the Korle Lagoon, where a wide range of equipment can be used. As maintenance is regular, the contractor is aware of it and can therefore more easily plan the operations to limit its mobilisation cost. As such the mobilization cost, compared to deferred dredging, is significantly lower. Nonetheless an indicative price level is provided for the deferred dredging in Table 1-13.

Table 1-13: Cost overview for maintenance dredging works

Volume [m ³]	Mobilisation Cost [€]	Operational Cost [€]	Total Cost [€]
85 000	1 M	1.7 M	2.7 M

³ Prices are based on European market conditions and mobilisation and are without costs for fuel.

2 Task 2: Sediment handling and selection of deposit location

Task 2 provides an answer to: What needs to be done with the dredged material.

2.1 Options for the dredged material: determination of use

There are two kinds of dredging activities in Odaw river and its tributaries which give rise to the need to the handling of the sediments:

- **Deferred dredging** (as explained in Task 1 the volume is approximately 430,000 m³);
- **Maintenance dredging** (as explained in Task 1 the volume is approximately 85,000 m³/year).

The identification of dredged material and management options needs to be carefully considered. It is well understood that disposal (whether to landfill or offshore at sea) is the least favourable option. However, elimination of disposal is also not a viable option for the Odaw river and its tributaries, as the flood risk will remain if no dredging is undertaken.

After these dredging activities several steps needs to be taken to handle the dredged material. The schematic procedure shown in Figure 2-1 illustrates the stages of the handling procedure and where important decisions should be made. First an assessment has to be made whether the material can be reused. This is firstly done based on the location where the material is dredged. Reference is made to the sediment sampling note (Royal Haskonnig, 2019) indicating that almost everywhere the sediments show an unavoidable presence of contaminated soil. Hence, if no actions are taken for purifying the dredged material, all dredged material should be disposed.

The second assessment is whether the dredged material at the contaminated locations can be reused. In order to make the dredged material re-usable, the contaminated parts have to be removed. By making the material re-usable, the final amount of material to be disposed can be reduced. Beneficial use of the dredged materials can play an important part of the overall reduction in sediment that has to be disposed. Sand and gravel are considered the most valuable materials that can be put to beneficial use (as demonstrated in Figure 2-2), with the remaining finer materials (clay and silt) having to be disposed in landfills. If both contaminated parts, and finer parts can be removed, the material will be suitable for re-use and the rest can be disposed at a designated disposal site.

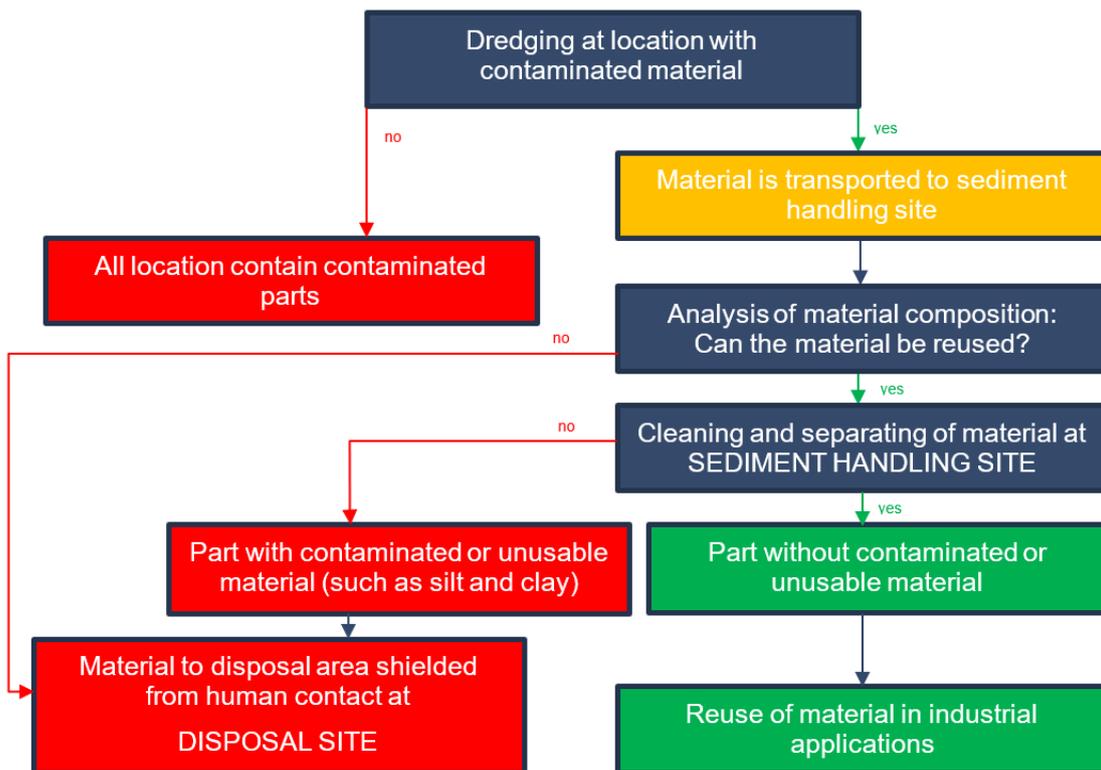


Figure 2-1: The sediment handling procedure



Figure 2-2: Example of sand mining from Accra beach

2.1.1 Dredged material characterisation: sediment composition

The composition of the material that is dredged from the Odaw River and its tributaries is presented in Task 1. Based on sampling of the dredged material in June 2019, it shows that the material contains on average around 55% sand and 20% gravel, giving a total of around 75% of material that can have a beneficial use. Sand and gravel are material which have a value and are used in all sorts of construction domains.

2.1.2 Dredged material characterisation: level of contamination

The potential for reuse of dredged sediments is influenced by levels of contaminants in the material. Laboratory analysis of the sediment sampled in December 2018 (SAL Consult, 2019) showed that the expected dredge materials are not contaminated with heavy metals and/or organic compounds. It was speculated that the proposed dredge material sampled is less likely to be contaminated as sand material generally has a low capacity to retain pollution, including heavy metals. However, based on the newly retrieved information described in the sediment sampling memo (Royal Haskoning, 2019), it has been indicated that the sediment samples show a significant amount of contamination. Nevertheless, the report states that:

“the sediments can be reused in industrial circumstances, under paved surfaces and after removal of plastics waste and aeration of the soil to enhance natural degradation of the mineral oil concentrations.” (Royal Haskoning, 2019)

This was further confirmed in the Meeting of 1st of October 2019, which states in the minutes of meeting

None of the material can be reused without any treatment. It is therefore advised that all dredged material is treated and disposed of in an industrial environment. (VV19026)

2.1.3 Identification of beneficial uses

As stated, the main portion of analysed material in Odaw river and its tributaries consist of sand and gravel. Sand and gravel are generally considered the most valuable materials for beneficial use. There are several different uses for sand and gravel obtained from dredging. Some international dredging companies pay for concessions to dredge sand and gravel directly from the sea for onward sales for everything from beach nourishment to construction uses.

Beneficial uses are mainly classified into two broad categories:

- **Engineering Uses** such as for construction materials, isolation, flood defence and beach nourishments.
- **Environmental Enhancement** including habitat creation and enhancement, maintenance of sediment supply, aquaculture and recreation.

To assess the reusability of the sediments dredged from the Odaw River and tributaries (as part of the PBC for deferred and maintenance dredging) an assessment of the composition and quality (contaminants) of the sediments has been undertaken in Task 1. However, due to the results of the sediment sampling (Royal Haskoning, 2019), the reuse of material is, if re-usable, is limited to industrial applications.

Based on the available information, a list of potential beneficial uses is identified below:

- Construction: concrete, brick making, road making etc.
- Reclamation or levelling (on the condition that no direct human contact is created, thus applicable for foundations etc.)
- Rehabilitation of (parts of) closed mining or quarry site(s)

In addition, plastics are prevalent in the Odaw River and tributaries and they can also potentially be reused/recycled. This is assessed in more detail in Task 5.

2.1.4 Calculation of volumes for beneficial use and final disposal

Based on the information described above, the volume of material that can be reused and which needs to be disposed of, has been calculated and presented in Table 2-1. Based on the results of (Royal Haskoning, 2019) all dredged material requires remedial treatment for eliminating the contaminated part. As for re-usable material, the coarser material (sand and gravel) described in Task 1 is considered as fully reusable. After cleaning around 320,000 m³ of the deferred dredging could have a beneficial use.

This information is used to assist in the selection of suitable sediment handling sites and final disposal sites, which is covered in the following sections.

Table 2-1: Calculation of volumes for beneficial use and final disposal

Parameter	Deferred dredging	Annual maintenance
Dredge volume	430,000 m ³	85,000 m ³
Percentage polluted	100%	100%
Percentage able to be treated and cleaned	100%	100%
Percentage sand and gravel	75% (55% sand and 20% gravel)	75% (55% sand and 20% gravel)
Volume sand and gravel (after cleaning)	320,000 m ³	65,000 m ³
Volume for final disposal	110,000 m ³	20,000 m ³

2.2 Site selection of sediment handling sites and final disposal sites

This section reviews the potential options for handling or disposal of dredged material from the Odaw river, tributaries and Korle Lagoon. The options will vary, depending on proximity to disposal site, sediment quantities, permit conditions, and dredging methods.

2.2.1 Sediment handling site

A sediment handling site is required to sort, clean and then redistribute any reusable sediment for beneficial use (such as sand sales). Any material that cannot be reused will then be transported to the final disposal site(s) as waste.

Identification of potential sediment handling sites has been based on the following elements:

- Observations based on the site visit (Annex A of Inception Report(IMDC, 2019));

- Preferred sites identified by PIU (including reference group) and RVO, during the 1st Reference Group Meeting;
- Analysis of the dredged volumes and composition;
- Results from the KLERP study;
- Satellite images and data review.

Based on the above information, 2 potential sediment handling sites have been identified and are shown in Figure 2-3. Site A is approximately 8 ha (see Figure 2-4). It is interesting to note that Site A is the same location as that identified by both the prefeasibility ESIA (SAL, 2019) and the ESIA Scoping Study (Royal Haskoning DHV and SAL Consult, 2019). Observations from the site visit, indicates that Site B could be a type of informal land fill and has approximately 14 ha of available land that could be used as a handling site (see Figure 2-4).

A brief description of these sites, together with photographs, is provided in the following sections.



Figure 2-3: Location of potential sediment handling sites



Figure 2-4: Surface calculation for sediment handling sites

2.2.1.1 Site A

One proposed sediment handling site for the dredged material, Site A, is located on the western bank of the Odaw channel along the Ring Road West and shares boundaries with the Agbogbloshe scrap yard (Figure 2-5). Currently, the area is used as an illegal waste dump site and usually there are scavengers found rummaging through the rubbish (Royal Haskoning & SAL, 2019). Part of the site is already used to process plastics (according to the open source map), scrap metal and urban waste. There is space available for sediment handling and has access to (Abose)Abossey-Okai Street.



Figure 2-5: Sediment handling site - Site A

2.2.1.2 Site B

Site B is situated on the western bank of the Odaw canal (Figure 2-3). Part of the area appears to be used as an informal (illegal) area for the disposal of waste, but space is available for sediment handling and the site has easy access to Ring Road West. The part of the site is covered by waste material could be capped by dredged material and then used as a sediment handling site; however further geotechnical assessment should be carried out to assure the stability of the site.



Figure 2-6: Sediment Handling site - Site B

2.2.1.3 Preferred handling site

Both sites A and B could be used as a sediment handling site and the selected contractor to undertake the deferred and maintenance dredging can use either or both at their discretion. However, for Site B parts would need to be capped before use and a geotechnical investigation would most likely to be needed to ensure the stability of the soil. For the ESIA, both sites should be assessed for potential impacts and benefits.

2.2.2 Final disposal sites

Despite best efforts to reuse as much of the dredged material as possible a certain amount will have to be disposed of in a final disposal site(s). Based on the assumptions presented in Section 2.1, this volume is estimated to be around 110,000 m³ from the deferred dredging and 20,000 m³/year resulting from maintenance dredging.

The disposal would be executed by trucks, as currently undertaken by DredgeMasters (see Task 1). Landfill disposal typically requires certain limits on free water in the waste. Therefore, the material will most likely need to be dewatered to a certain level before being taken to a landfill. This is already done on the sediment handling sites (see further section 2.3.1). After this procedure, the material can be transported to the final disposal sites (Figure 2-7):

- Ga West (5.678479°, -0.323032°) (source: *Ghanaian Government*);
- Ga East (5.706111° -0.197222°) (source: *Ghanaian Government*);
- Kpone Landfill, Tema (5.708106° - 0.021380°)(source: *Royal Haskoning & SAL, 2019*);
- Other existing land fill sites used for waste disposal in Accra (not disclosed);
- Existing final disposal site used by DML (not disclosed).

The last option on the above list is the location where DredgeMasters disposes of the dredged material as part of their current 2019 contract. As this location has not been disclosed, it has not been further considered in this report as an option. However, it is recommended that this site is disclosed so that we can consider it further as a potential option. In any event, it should be noted that as the ESIA report on the sediment composition mentions significantly polluted material, and human contact needs to be avoided, it is recommended to ensure that the currently used disposal site meets environmental regulations and there is no human contact.

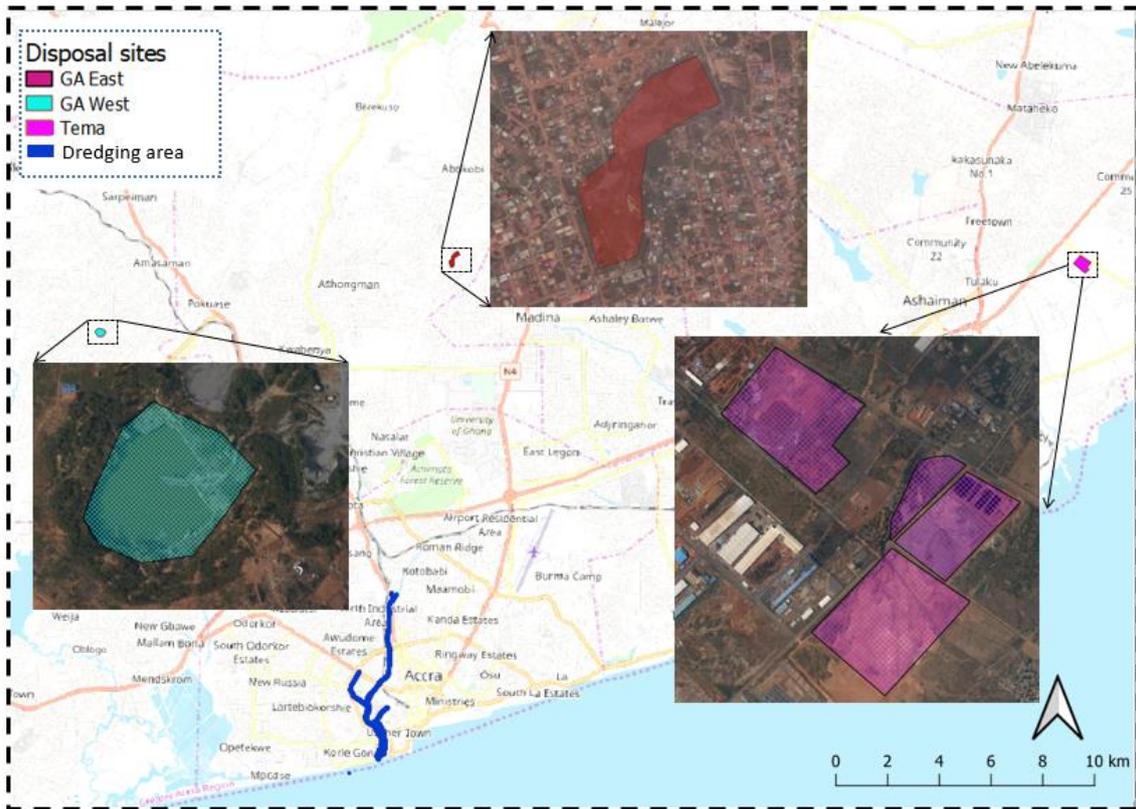


Figure 2-7: Available disposal sites

2.2.2.1 Ga West disposal site

The Ga West disposal site (5.678479°, -0.323032°) is located in the northwest of Accra in the suburb Pokoasi, about 25 km from the sediment handling sites (Figure 2-8). The site can be accessed preferably via Accra – Nsawam road, and take a left at Amasaman. According to the site visit on 09/10/2019, some construction will need to happen before this disposal site becomes operational. Moreover, according to Mr. Sampson this site is not yet fully acquired, however there would be options of disposing dredge material without a finalized acquisition. The area is proposed by Government of Ghana (GoG) and is shown in Figure 2-9 and is approximately 5 ha.



Figure 2-8 : GA West disposal site

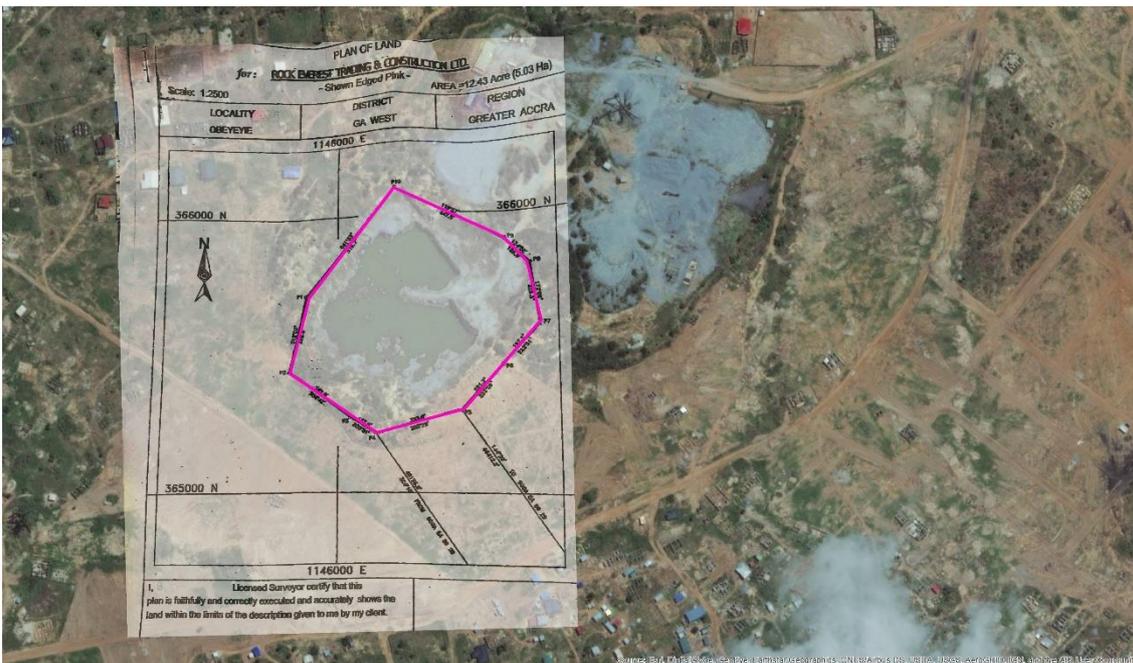


Figure 2-9 : Received map/location of GA West disposal site (source: PIU)

2.2.2.2 Ga East (Abokobi-Pantang landfill)

Ga East (5.706111° -0.197222°) is located in the northeast of Accra and is about 25 km from the sediment handling sites and can be accessed via the Legon E Road. The local press stated that the site was established in 2004 as a final disposal site (<https://www.todaygh.com/abokobi-landfill-soon-relocated/>). According to Cehrt (2019) the dumpsite has a surface area of 8 ha and consists of two separate dumps (Dumps 1 and 2, see Figure 2-10 and Figure 2-11). Dump 1 is about 4.5 Ha and is owned by GEMA, and managed by Waste Landfills Limited, on the Assembly’s behalf. Two other waste management companies (Honest Waste and Amanee Waste and General Services Limited) own and operate Dump 2 (3.5 ha). According to Mr. Sampson of MSWR, the plan is to decommission this landfill under GARID, however we would recommend keeping this operational to allow disposal of the dredge material.

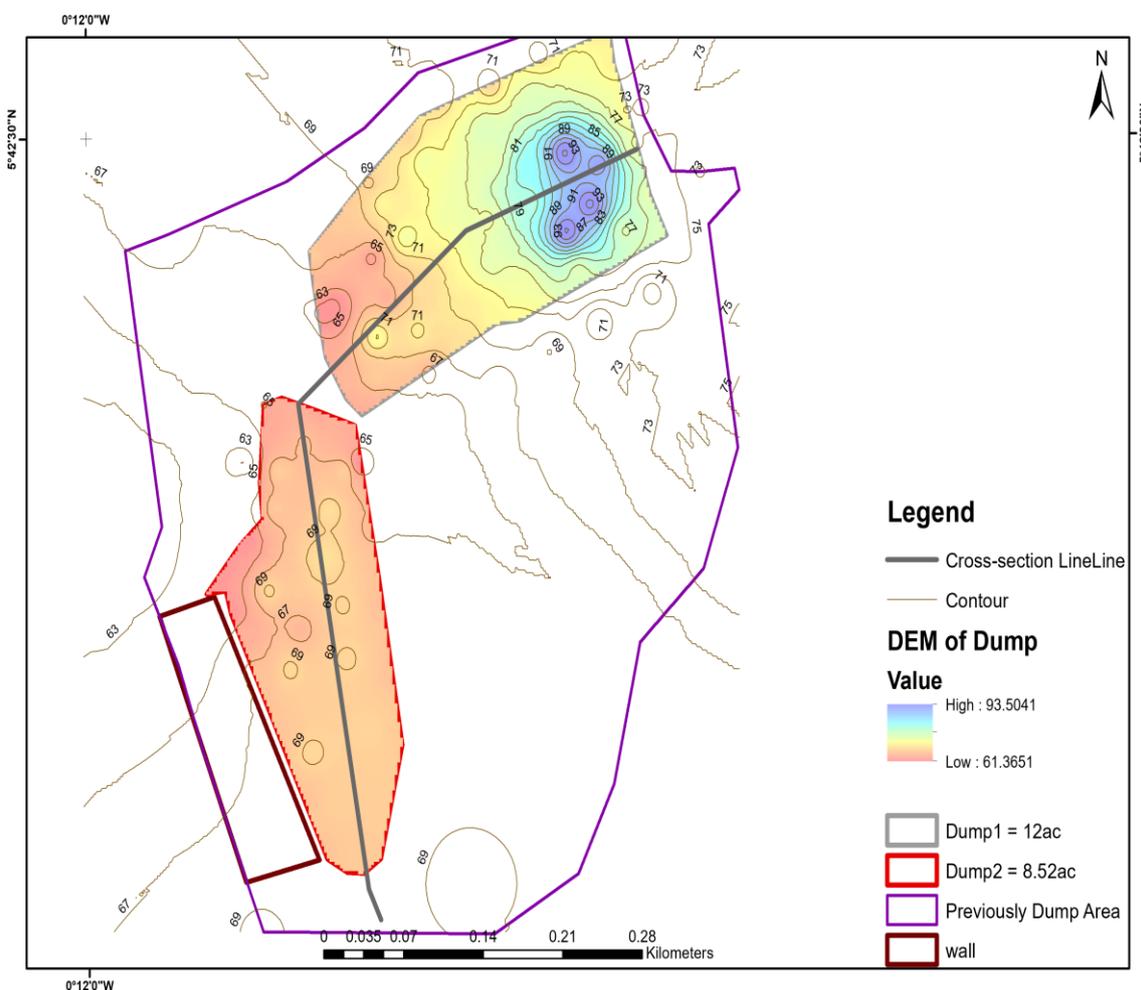


Figure 2-10 : Map/location of GA East disposal site (WasteCare Associates, 2019)



Figure 2-11 : Uncompleted Structures and current situation of the of the site (WasteCare Associates, 2019)

2.2.2.3 Tema (Kpone) landfill

The third potential disposal site is located in Kpone (5.708106° - 0.021380°), a suburb of Tema which is about 33 km from the sediment handling sites and can be accessed via the Accra –Tema Highway. The landfill was originally designed to serve the Tema Metropolitan Assembly. However, it currently serves a population of 1 million people, accepting 95% of waste generated in the Greater Accra Metropolitan Area.

According to WasteCare (2019), the engineered landfill was planned to be developed in two phases, as shown in Figure 2-12. The old landfill to the south (Phase I) is currently on fire and is out of service (Figure 2-13). Development of the overall site comprises the “Parcel A” and “Phase II” in Figure 2-12 and was reviewed by WasteCare (2019).

WasteCare (2019) recommended that Parcel A (Figure 2-12) should be legally acquired by the Government to facilitate the construction of additional cells.

Moreover, Phase II area could not be implemented as “the land demarcated for that purpose has been re-zoned by the TDC as an industrial area and has consequently been allocated to a private developer for the construction of a tile factory” (WasteCare Associates, 2019).

At the moment only a dump site just north of the old site where rubbish is permanently disposed is being used, as shown on the in Figure 3 12 (purple area) and Figure 2-14.

Currently there is no permanent site allotted for dredge materials. However, the dumpsite can take the dredge materials if the volumes and the composition are communicated. It is important to note that this is not an engineered landfill (e.g. no screens or protection on the “floor” of the dump site).

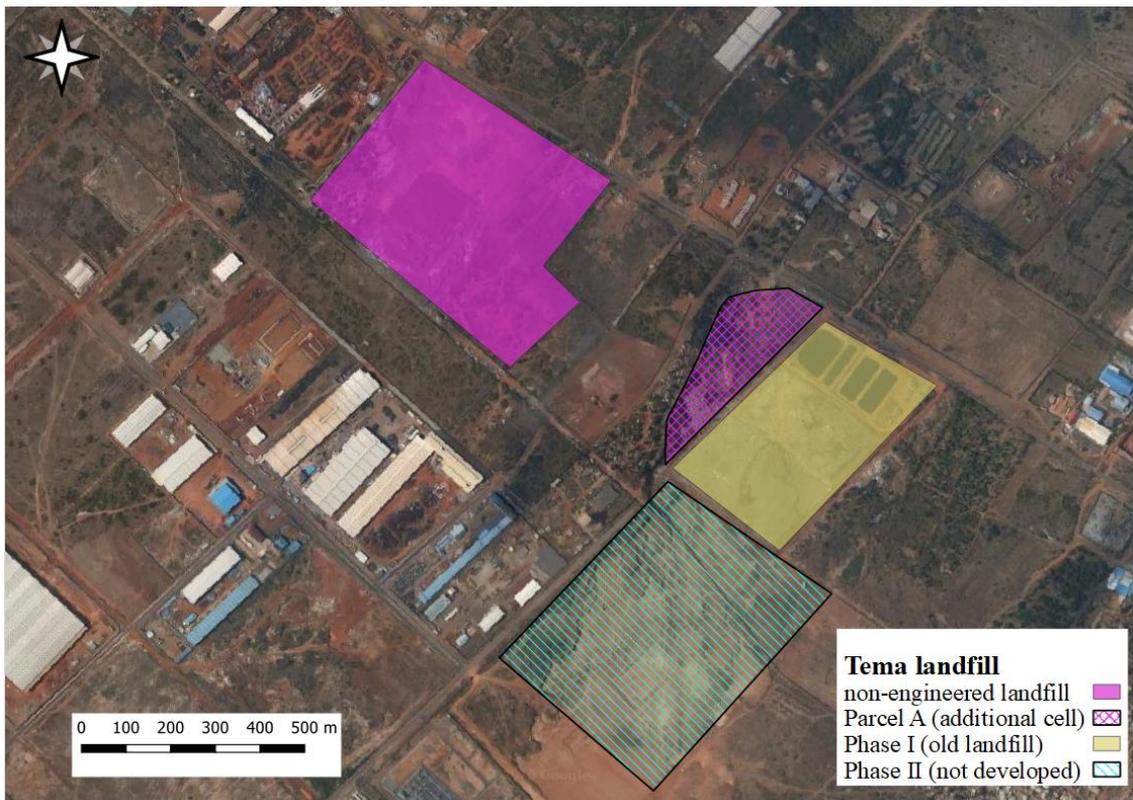


Figure 2-12 : Tema (kpone landfill) area



Figure 2-13 : Tema (kpone) old landfill (south)



Figure 2-14 : Collecting and storage of recyclables west in (North) Tema landfill (non-engineered landfill)

2.2.2.4 Summary of final disposal sites

Table 2-2 and Figure 2-15 summarises the site characteristics of all the disposal sites and shows that all sites could be used for disposal of non-reusable dredged material. For cost assessments, the travel time is important: the further the disposal site, the lower the production rate (longer travel), the higher the cost. It is also noted that trucks are currently only operating after 9:00pm (assumed contract restriction), as such the calculated travel time is based on a departure at 10:00pm. It is assumed that the existing disposal sites have been fully checked for geotechnical stability, local legislations and appropriateness to handle waste etc. and that the appropriate environmental assessment has been carried out.

Table 2-2 : Summary of disposal sites’ characteristics

Site	Distance from handling site B (Km)	Travel time* (min)	Available area (ha)	Limitations (environmental, ownership, limited capacity, etc.)
GA West	27	40-60	5	Currently an old quarry
GA East	25	40-60	8	Potential Ownership issue and potential plan to close under GARID project
Tema landfill	33	40-65	20	South is smoking and assumed to be on fire for the last year. North has potential limited capacity.
DML disposal site	?	?	?	??

*assuming departure time at 10pm



Figure 2-15: Traveling time and distances from handling site B to disposal sites (departure time at 10:00 p.m.)

2.3 Concept design of sediment handling site

As the material is assessed as generally polluted, it is proposed that all material is firstly transported to the sediment handling site, before being relocated to their final destination (disposal site or re-use). The process from dredging to final destination can be described in 3 steps:

1. Dredging
(transport)
2. Treatment at sediment handling site (site A or B described in section o)

(transport)

3. Final destination (re-use or disposal site described in section 2.2.2)

This chapter focusses on the second item. The volume of material that needs to be treated is presented in Table 2-2 and is about 430,000 m³ for the deferred dredging, and 85,000 m³ for the maintenance dredging.

The base technique for treatment of the contaminated soil is considered to be separation of the material, with an addition of landfarming to allow for aeration. This choice for separation is based on “the preferential adhesion of contaminant to the fine and cohesive fraction of sediments” as stated in “Dredging for a sustainable infrastructure” (CEDA, 2018). Thus, if the fines can be separated the remaining coarse fraction may be used.

In addition, the following statement from the sediment sampling report (Royal Haskoning, 2019) formed the basis to add the use of landfarming for the aeration:

“..and aeration of the soil to enhance natural degradation of the mineral oil concentrations” (Royal Haskoning, 2019)

2.3.1 Handling methodology

Based on these two statements, a separation technique followed by aeration could provide sufficient treatment for re-use of the dredged material, and the set-up of the sediment handling site is based on these two principles. Other methodologies such as chemical treatment or big dewatering basins (e.g. Amoras in Belgium Figure 2-16 a) or treatment plants (e.g. METHA plant in Hamburg Figure 2-16 b) are too complex and expensive for this type of project and thus analysed as non-sustainable solutions.



Figure 2-16: Plants for treatment of contaminated material

Separation techniques can be separation basins, hydro-cyclones, floatation and dewatering. For the project, the use of hydro-cyclones is most preferred as this is the most established (and easiest) form of processing (Bray *et al.*, 2008). A hydro-cyclone is a conical cylinder (Figure 2-17) with the point towards the bottom. At the top, there's a tangential entrance for a solid-water mixture. Furthermore, the hydro-cyclone has two exits: one on the top (for the fine material) and one on the bottom (for heavier material).

When the material enters the cyclone through the tangential feed, the combined influence of the tangential flow in the cylinder and the pressure gradient results in a falling spiral flow against the outer wall of the cylinder. Due to the centrifugal force, the heavier (coarser) particles are moved to the outside where they are absorbed in the spiral flow and move downwards. The lighter (finer) particles end up in the central part of the cylinder and move towards the upper exit (overflow). The coarser particles leave the hydro-cyclone via the lower overflow.

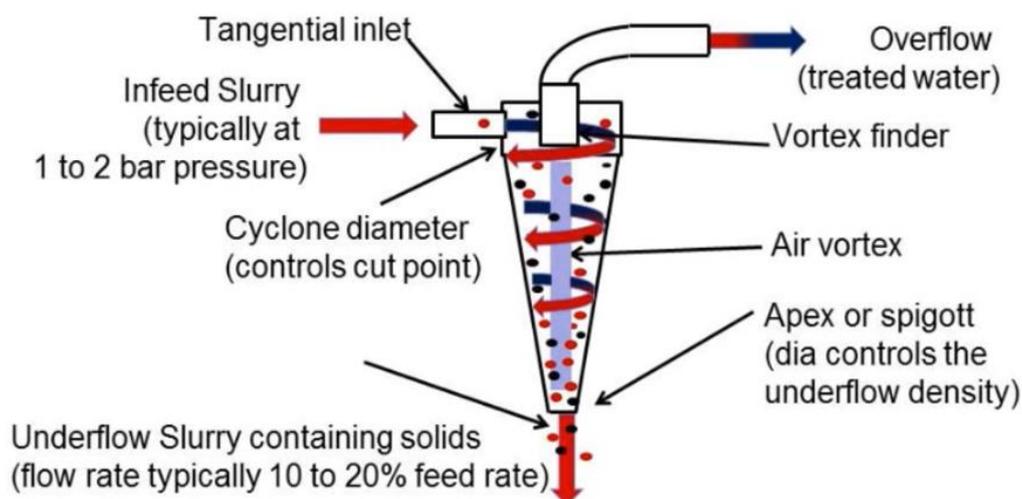


Figure 2-17: Working principle of hydro-cyclone

Hydro-cyclones can be adjusted to separate a certain grain size from the rest, for this application a grain size of $63\ \mu\text{m}$ is the separating factor i.e. smaller than $63\ \mu\text{m}$ should be disposed, bigger than $63\ \mu\text{m}$ can potentially be re-used. It has to be noted that the outcome of the hydro-cyclone is a mixture of sand and water. Hence the outlets have to go into a dewatering area, similar to a siltation area (Figure 2-19 to Figure 2-22). The principle of a siltation area is big surface with a low water speed to enable the sediment to settle and separate solid from water. For this a long trajectory of the sediment is needed. The re-usable part can be removed and transported for aeration at a reclamation site (Figure 2-23). As the water is not contaminated (separated into the finer section) the water can be repumped into the Korle Lagoon, and filtration into the bottom is not an issue. As for the contaminated fraction, an area also needs to be foreseen to separate the water from the fines in order to transport the fines to the disposal sites. The water can be reused for the hydro-cyclone. And the contaminated material can be loaded on to trucks. However, as the water cannot infiltrate into the ground, precautions (e.g. plastic bottom) needs to be taken. The fact that the material still contains some fines is not an issue as the hydro-cyclone will filter it out again. An example of a set-up is given in Figure 2-18.



Figure 2-18: Example of lay-out for sediment handling site

In order to get a good view on the process, a step-by-step approach is described below:

1. When material is dredged and loaded onto a truck, the truck drives to the sediment handling site.
2. It dumps the material at the “Area for trucks” location.
3. From of this area, the hydro-cyclones, which are located in the “Area for treatment of sediments”, are fed. The soil is thus fed from this area for trucks, and water is retrieved from the “Area with contaminated water for use in hydro-cyclone” to create the soil-water mixture for optimal use of the hydro-cyclone.
4. The top flow from the hydro-cyclone releases into the “Area for dewatering of contaminated material”,
5. the underflow is released into the “Area for dewatering of non-contaminated material”.
6. Both areas have the same function: dewatering of the soil by having a big surface for the particles to settle. The heavy particles settle at the beginning of the silt basin, resulting in an area where the particles can be removed by an excavator.
7. This area is indicated as “Area with non-contaminated material for transport to aeration area” for the useable fraction of the handled soil, and
8. “Area with contaminated solids to be transported to disposal area” for the non-useable material.
9. From this area, trucks are again loaded and the material is disposed at the disposal sites (described in section 2.2.2), for the contaminated fraction,
10. and to the Site A (2.2.1.1) for the non-contaminated area.
11. In the siltation basin, it is also possible to apply silt screens to further separate solids from water. This is particularly interesting for the contaminated parts, to ensure that the leftover water is as clean as possible. This is recommended as the rest water is reused to mix the dredge material with the dredged soil.



Figure 2-19: Siltation area (1)



Figure 2-20: Siltation area (2)



Figure 2-21: Siltation area (3)



Figure 2-22: Silt screen



Figure 2-23: Landfarming/aeration

2.3.2 Cost assessment

The size of hydro-cyclones are limited and thus perfectly suitable for this application. The cost of the treatment is estimated to be €25-€30 per dry weight ton (IMDC, 2002). In addition, the re-handling of the material (aeration) is estimated to be around €10 per dry weight ton which results in a handling cost of €35 per (dry weight ton) for the non-contaminated material, and €25 per dry weight ton for the contaminated material. The results are presented in Table 2-3. This cost is significant and therefore has been checked with the market value: whether the re-handling of such material is cost efficient i.e. what is the market value of sand compared to the cost of treatment. As local market price for sand is estimated to be around €12 per ton (2019), it is therefore unlikely that the re-use of the dredged material will be an interesting incentive for contractors bidding on the Performance Based Contract (PBC).

However, the PBC should allow for sufficient flexibility for the contractor and allow degrees of freedom. If an alternative suitable and cost-efficient treatment method is found, the benefits could be substantial for both the Government and Contractor.

Consequently, two options remain and should be freely explored:

1. Dredging of material + re-handling and market value is attributed to the contractor
2. Dredging of material + immediate disposal

For option 2, a check of the capacity of the disposal sites has been done. Based on the surfaces shown in Table 2-2, and an assumed disposal height of 3 m, the combined disposal sites have a capacity of 990 000m³, which is suitable for deferred dredging and 6 years of maintenance dredging.

Table 2-3: Cost for sediment re-handling

#	Parameter	Deferred dredging	Annual maintenance
1	Dredge volume	430,000 m ³	85,000 m ³
2	Ton dry weight	621,500 t	123,000 t
3	Percentage sand and gravel	75% (55% sand and 20% gravel)	75% (55% sand and 20% gravel)
4	Cost re-handling non-contaminated soil (€35/t)	€16 500 000 (€35* 621500*0.75)	€3 500 000 (€35* 12300*0.75)
5	Cost re-handling contaminated soil (€25/t)	€4 000 000 (€25* 621500*0.25)	€1 000 000 (€25* 12300*0.25)
6	Total costs to clean material for reuse (4+5)	€20 500 000	€4 500 000
7	Estimated benefit from sand sales/reuse (€12/t)	€6 000 000 (€12* 621500*0.75)	€1 000 000 (€12* 123000*0.75)
8	Cost(6)-Benefit(7)	-€14 M	-€3.5 M

Based on the above cost assessment, it can be concluded that re-use of material will most likely not be a strong incentive in the PBC.

3 Task 3: Cleaning and rehabilitation of tributaries

Task 3 provides an answer to: In what way do the tributaries contribute to the flood risk and how can this be reduced.

3.1 Assessment of occurrence and severity of floods

This task starts with an inventory of the main tributary drains to assess their relative impact on flooding. This has been done based on information gathered from the results of the hydraulic model (HKV, 2019), the site visits, and national and international expertise. The goal was to identify the drains that affect the floods due to potential capacity problems and to propose mitigation measures. The drains of interest are presented in Figure 0-2 and Figure 3-1, and are:

- Nima drain;
- Odawna drain;
- Agbogbloshie drain;
- Cemetery drain;
- South Kaneshie Market drain;
- Mataheko drain;
- South Kaneshie drain.

This section starts with an overview of the sources of information regarding the identification of the potential capacity problems and ends with an inventory of the drains studied.

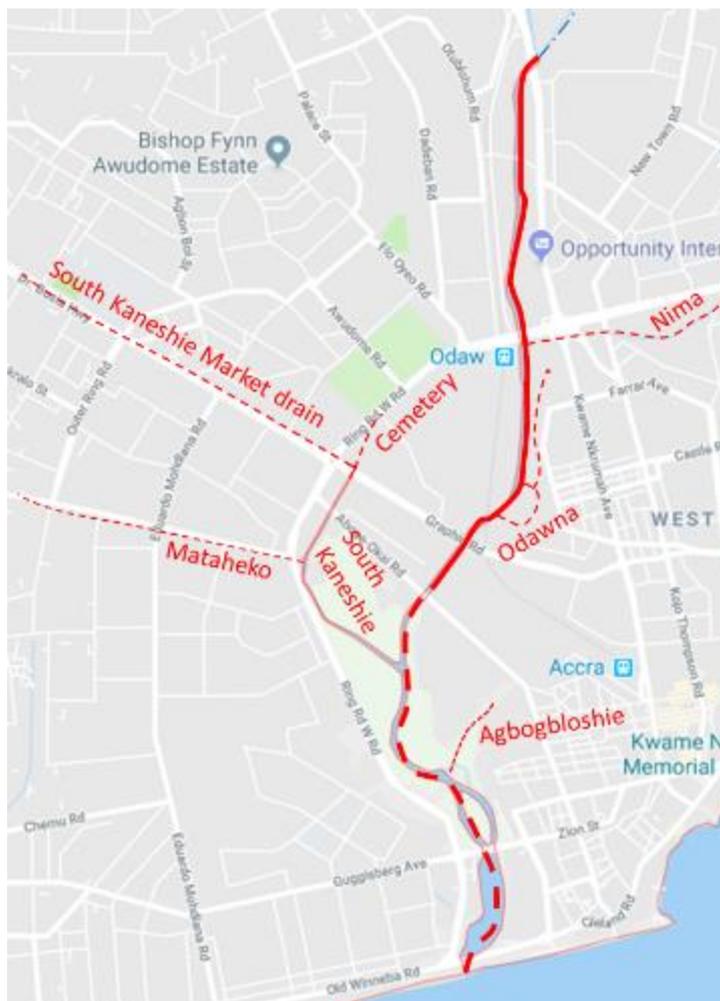


Figure 3-1: Overview of the main tributary drains of the Odaw River in Accra.

3.1.1 Information sources

3.1.1.1 Flood modelling results

As part of the HKV prefeasibility study (HKV, 2019), a flood model was developed in March 2018 to produce flood hazard maps for the Odaw basin. The simulated flood extent and the flood damage of the severe flood event of June 3rd 2015 are presented in Figure 3-2. Based on rainfall recordings in the southern part of the Odaw basin and the IDF curves⁴ at the airport of Accra, the corresponding return period was calculated as 10 years.

⁴ (Rainfall) Intensity/Duration/Frequency-curves are empirical curves that relate the rainfall intensity to the degree of aggregation (the duration) and the return period or the exceedance frequency (the inverse of the return period). These curves are obtained by extreme-value analyses done on rainfall intensity measurements aggregated to different aggregation levels (durations by which the data was averaged over).

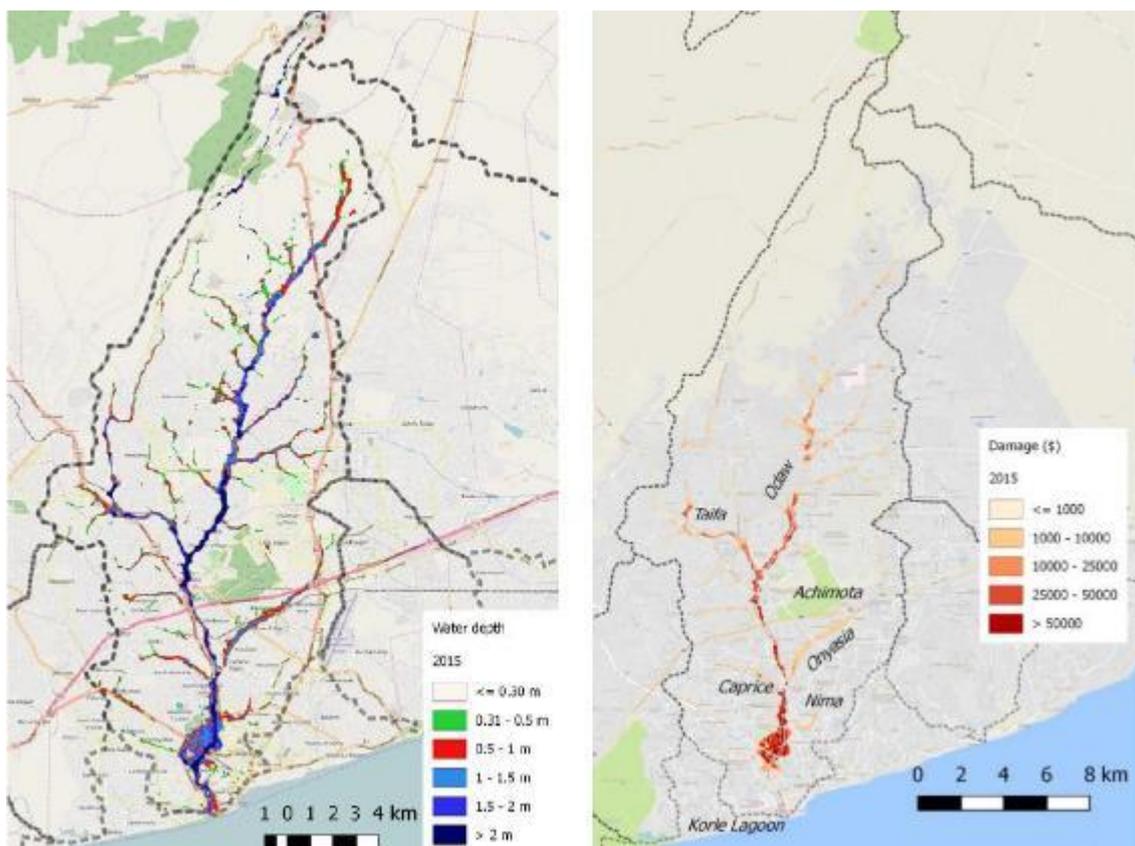


Figure 3-2: Simulated flood extent (left) and flood damage (right) of the flood of June 3rd 2015 in the Odaw basin [Figure 27 in (HKV, 2019)].

The HKV study (HKV, 2019) identifies the business and industrial area around (Kwame Nkrumah) Circle and Kaneshie, where economic activities are concentrated, as being heavily affected by the flood (Figure 3-3). The flood model report points out that the flood hazard and flood risk is the highest between Caprice and the Abose-Okai Bridge. Model simulations showed that flood waters accumulate here because of the downstream location in the Odaw Basin (all excess water must pass here), the flatness and low-lying nature of this area, and the lack of discharge capacity.

The capacity of the 35 m wide lined Odaw River section downstream of Circle was calculated as 600 m³/s, while the simulated peak flow was 620 m³/s (HKV, 2019), thereby indicating this section does not have enough capacity. Furthermore, at the time of flooding (June 2015) the lined Odaw River (among other parts) was heavily silted (likely due to a lack of maintenance dredging), which further reduced the discharge capacity and hence, the capacity of 600 m³/s was not even available. The flood was additionally worsened by the gates of the interceptor weir not being able to be opened due to sedimentation and lack of maintenance. Solid waste accumulating behind the weir (due to poor waste management) also contributed to rising water levels. The flood situation was further exacerbated due to debris accumulating against several bridges along the Odaw River, which resulted in the flow being blocked.

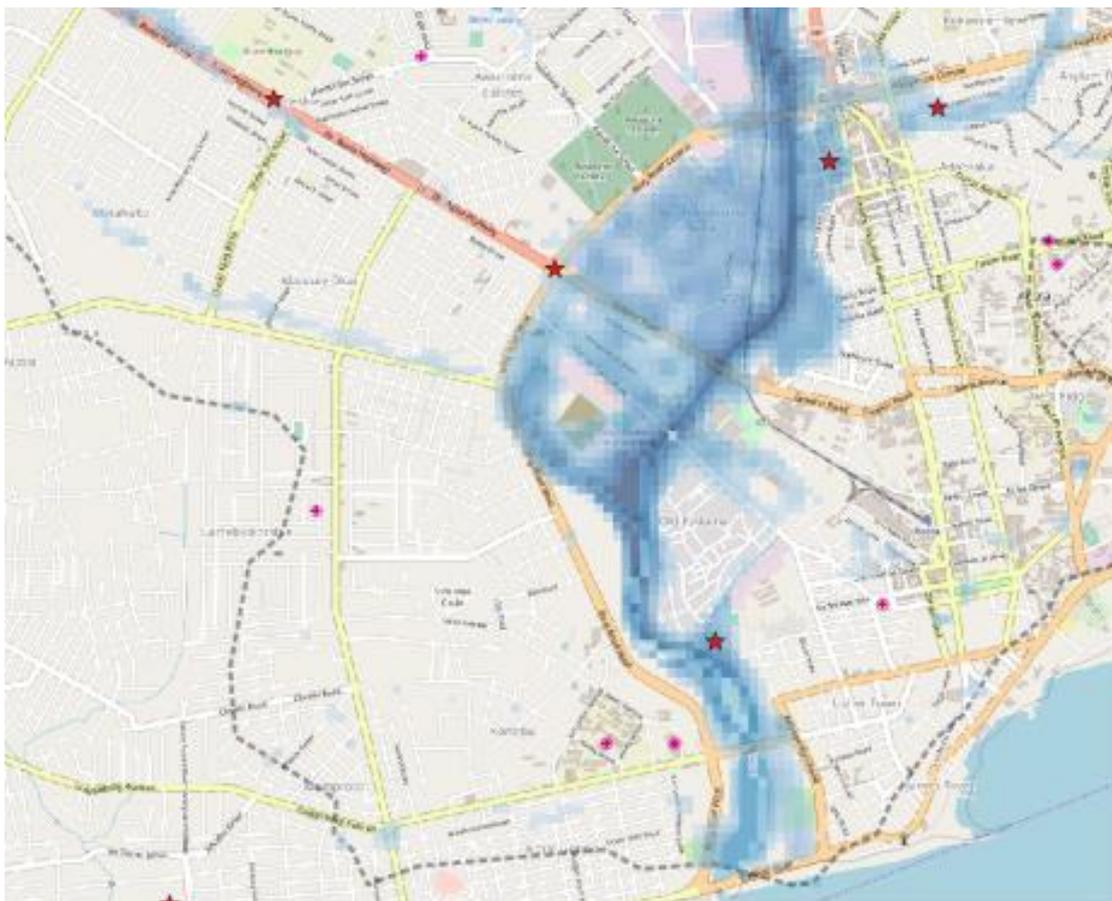


Figure 3-3: Simulated flood extent of the flood event June 3rd 2015, from Circle to Korle Lagoon [Figure 11 in (HKV, 2019)].

3.1.1.2 Site visits

A second source of information that was used to assess the occurrence and the severity of the floods, are the multiple site visits undertaken. Table 3-1 gives an overview of the drains visited. A summary of the consortiums’ first mission (15-16 May 2019) is provided in the Inception Report (IMDC, 2019c).

Table 3-1: Overview of the drains visited

Date	Drains visited
15-16 May 2019	Nima, Odawna, South Kaneshie Market drain, Cemetery drain, South Kaneshie drain
28 May 2019	Mataheko drain
3 July 2019	South Kaneshie Market drain, Cemetery drain
18 September 2019	Agbogbloshie drain

3.1.1.3 National and international experts

A third source of information makes use of the knowledge of national experts, who have been working for many years in the area and can provide useful insights into the history and current status of the drains. As part of this study several meetings and stakeholder engagements with different national experts such as Ing. Wise, drainage specialist from the Engineering Council and Ing. Seth Kudzordzi,

engineer at the Hydrological Services Department were held. This coupled with international experts from HKV and IMDC provided useful information regarding current capacity problems.

3.1.2 Inventory and effects of drains

This section provides an overview of the drains investigated and summarises all the data that has been collected on the drains during this Feasibility Study.

3.1.2.1 Nima drain

The Nima drain flows into the Odaw just downstream of the Ring Road Bridge (Figure 3-4). The drain runs underground at the Kojo Thompson Road, for around 500 m before its confluence with the lined Odaw channel.

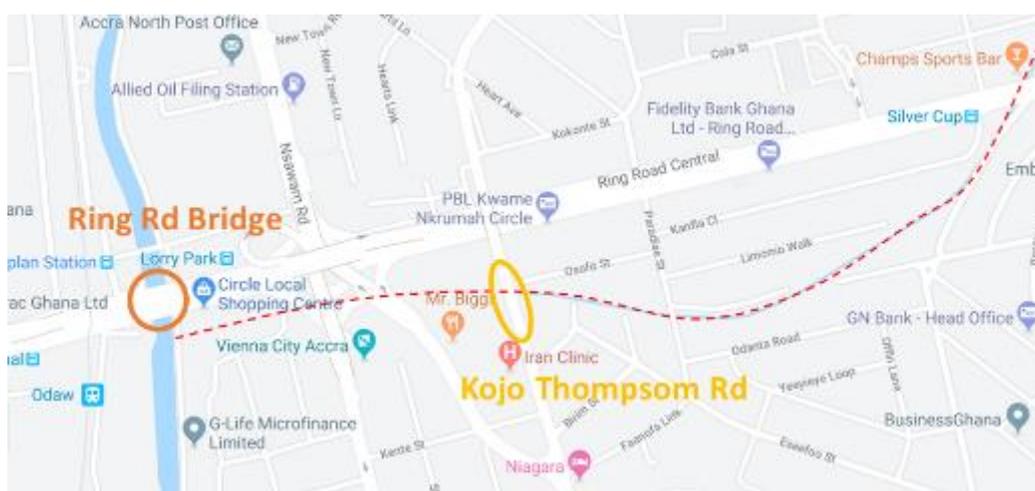


Figure 3-4: Location of Nima drain.

Figure 3-5 shows the cross-sections for both the covered and uncovered sections, as implemented in the Sobek model (HKV, 2019). The downstream part of the uncovered Nima drain is concrete lined (Figure 3-6).

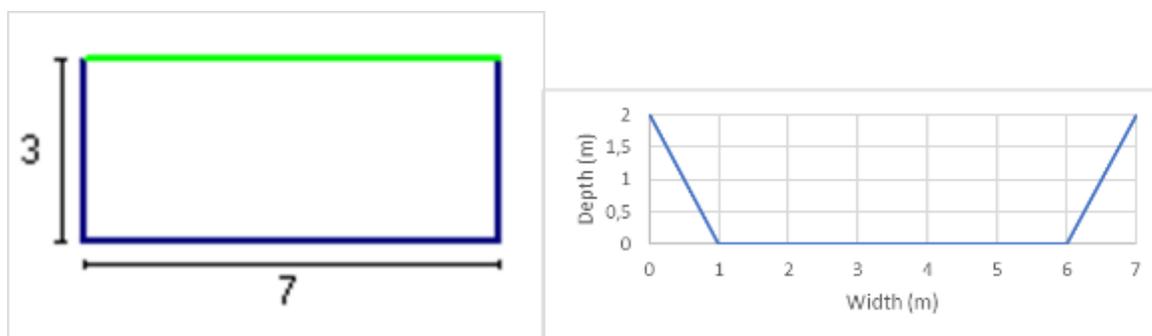


Figure 3-5: Nima drain design cross-sections from Sobek model (left: covered section, right: uncovered section).



Figure 3-6: Uncovered and concrete lined part of the Nima drain (HKV, 2019).

No information on dredging activities is available for the Nima drain and the figure above indicates only limited sedimentation. It can therefore be assumed that the need for dredging in this drain is rather limited. During the site visit of May, the drain outlet was visited (Figure 3-7). It should be noted that the partitions visible at the outlet reduce the flow capacity as there is more friction because of the larger contact surface.



Figure 3-7: Nima drain outlet to Odaw River, near Ring Road Bridge (above: 15 May 2019, below: 9 October 2019).

From witnesses and the flood modelling results by HKV (Figure 3-3), it is clear that the (Kwame Nkrumah) Circle area suffers from flooding. Although the inundations are mainly caused by a lack of capacity of the Odaw River, the model simulations show that the area first partially floods by an overflowing of Nima (indicated by the black arrow in Figure 3-8), before the Odaw River floods. The time lag is due to the fact that the Nima basin has a shorter concentration time⁵ than the Odaw basin. The Nima drain floods in the area where it goes underground, meaning that the culvert has not sufficient drainage capacity. HKV states that the flooding is the result of the combination of a too small downstream section and a full Odaw River (high water level) which causes a backwater effect to the Nima drain.

⁵ The time needed for water to flow from the most remote point in the drainage basin to the drainage basin outlet.

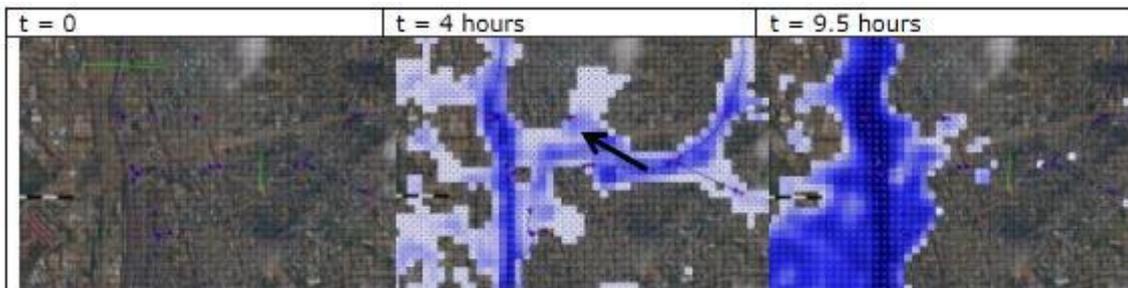


Figure 3-8: Flood simulations near Nima drain (HKV, 2019).

3.1.2.2 Odawna drain

The Odawna drain flows more or less parallel to the lined Odaw River, next to the Odawna Market, a valuable place for traders of Accra. Two outlets of the drain enter the Odaw in between the outlet of the Nima drain and the bridge of Graphic Road (Figure 3-9).



Figure 3-9: Location of Odawna drain.

Figure 3-10 shows typical cross sections for the drain, as implemented in the model. The drain is an uncovered ditch. Sedimentation can be seen when comparing photos from 2018 and 2019, both taken during one of the two rainy seasons (Figure 3-11).

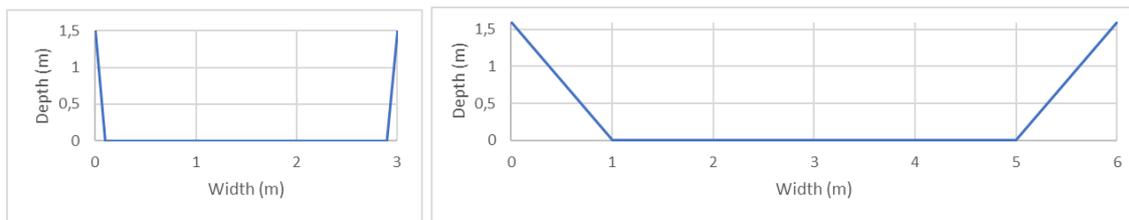


Figure 3-10: Odawna drain design cross-sections from Sobek model (left: two sections perpendicular to Odaw, right: section parallel to Odaw).



Figure 3-11: Odawna drain looking from the left bank of the lined Odaw River (middle: 22 Oct 2018, photo made by Job Udo, right: 16 May 2019 -IMDC).

The area around the Odawna drain has suffered from flooding in the past (Figure 3-3), which is mainly caused by the backwater effect from the lined Odaw River and/or from clogged drains in the area. Cleaning and maintenance of the Odawna drain and its banks is of importance to avoid waste and sediment accumulation. However, there is no indication that the drain itself affects the floods of the lined Odaw River.

3.1.2.3 Agboglobshie drain

The Agboglobshie drain is uncovered and unlined and flows inbetween the Agboglobshie district and the Old Fadama area (Figure 3-12). Figure 3-13 shows the design cross-section just downstream of the Hansen Road Bridge.

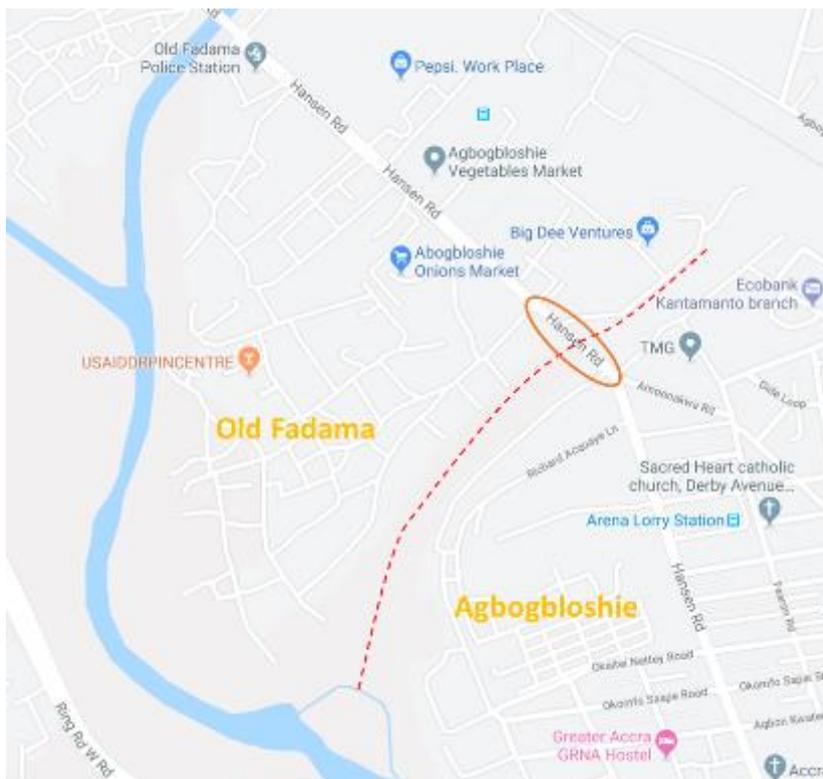


Figure 3-12: Location of the Agbogbloshie drain.

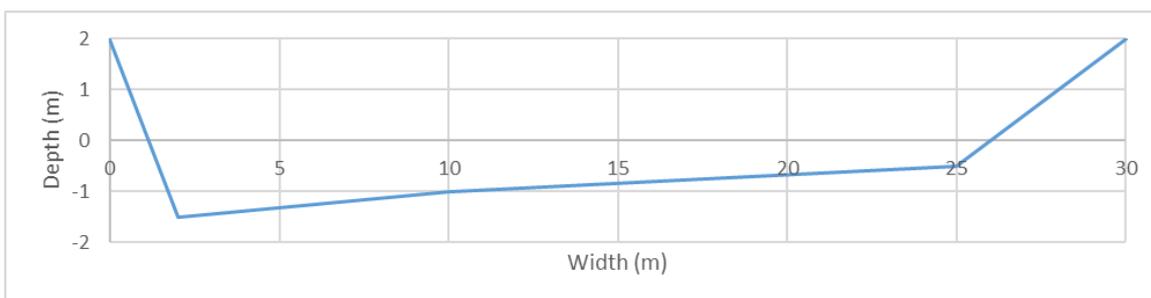


Figure 3-13: Agbogbloshie design cross-section from Sobek model, just downstream of the Hansen Road Bridge.

The site visit confirmed that the Agbogbloshie drain is heavily silted (Task 1). The drain and its banks are fully covered with garbage (Figure 3-14), which means that after each rainfall, a large amount of sediments and waste, will flow from the drain and its banks towards the lagoon. This material is blocked by the interceptor weir (Figure 3-15). As mentioned before in section 3.1.1, the waste accumulation at the weir contributed to the flood event of 3rd June 2015.

Capacity problems of the drain itself have not been reported. However, flooding (Figure 3-3) occurs in the downstream areas due to the backwater effect from the overflowing Odaw River.



Figure 3-14: Agbogbloshie drain at the Hansen Road Bridge (18 Sep 2019, top: looking upstream, bottom: looking downstream).



Figure 3-15: The interceptor weir blocking waste going into Korle Lagoon (15 May 2019).

3.1.2.4 Cemetery drain

The Cemetery drain is a small capacity drain flowing from the Awudome Cemetery into the South Kaneshie drain near Graphic Road (Figure 3-16). The drain is an uncovered ditch without concrete lining except at the end of the outlet (Figure 3-18)⁶. The cross-section used in the model is presented in Figure 3-17.



Figure 3-16: Location of Cemetery drain.

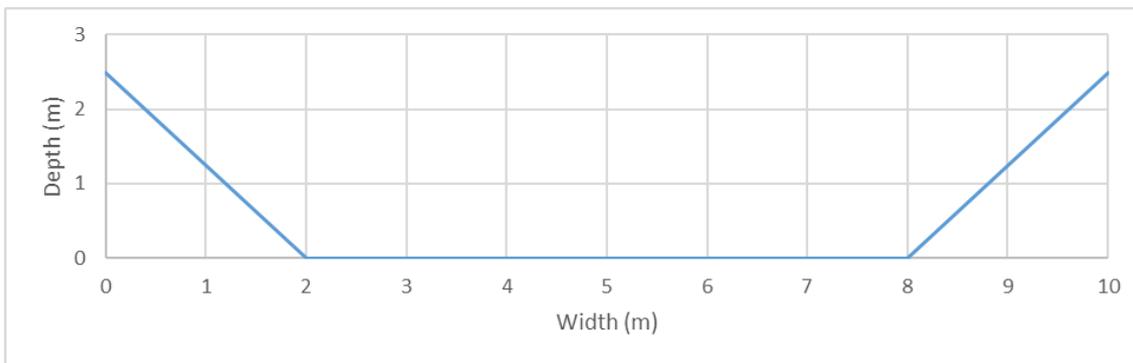


Figure 3-17: Cemetery drain design cross-section from Sobek model just upstream of its confluence with the South Kaneshie drain.

⁶ Upstream part has not been visited, but assumed that it is not hardened (concrete)



Figure 3-18: Downstream part of the Cemetery drain (top: 16 May 2019, bottom: 3 July 2019).

Capacity problems of the drain itself have not been reported. Figure 3-3 shows no signs of flooding in the Cemetery drain area. However, sedimentation is visible and regular maintenance is recommended.

The confluence zone of the Cemetery drain and the South Kaneshie drain, on the other hand, does suffer from flooding which is, according to the local drainage specialist, the result of a lack of capacity of the bend in the South Kaneshie drain (more details in Section 3.1.2.5). The waste trapped by the pipe and culvert under Graphic Road (Figure 3-18 b & c) demonstrates that high water levels occur frequently. The flood model shows inundations in the downstream part of the Cemetery drain.

3.1.2.5 South Kaneshie Market drain

The South Kaneshie Market drain runs mainly underground parallel to/underneath the Dr. Busia Hwy Road, until the Obetsebi Lamptey Circle after which it flows into an uncovered drain, referred to as the South Kaneshie drain (Figure 3-19). Upstream of the Accra Academy, the drain seems to be open.

The site visit confirmed that the upstream part of the South Kaneshie Market drain is open before entering a closed rectangular drain of approximately 4 m wide (Figure 3-20). Construction works were ongoing upstream of First Light showing the rectangular drain entering two parallel drains (Figure 3-22 and Figure 3-23). Because of the reinforcement on top of the side walls (Figure 3-23), it was assumed that this open drain will be closed in a later phase of the construction works. Aerial images (Figure 3-21) confirm that the drain is being covered.

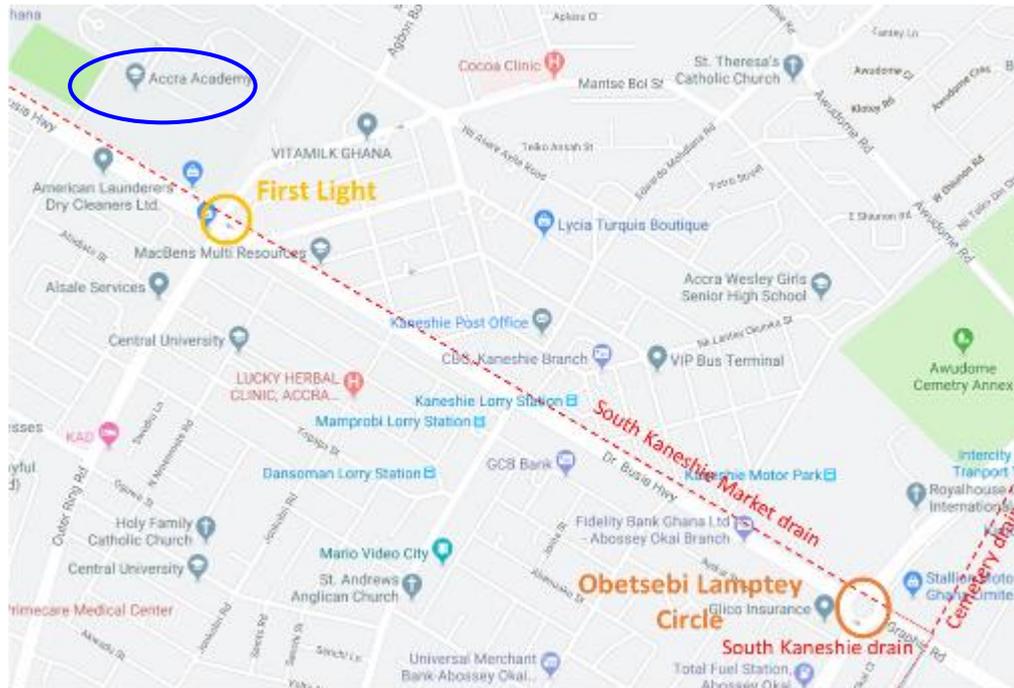


Figure 3-19: The location of the Accra Academy, First Light, and the Obetsebi Lamptey Circle, after which the South Kaneshie Market drain flows into the South Kaneshie drain.



Figure 3-20: South Kaneshie Market drain, upstream of the Accra Academy (3 July 2019).



Figure 3-21: Areal images of First Light area in 2013 and 2018 show that the drain is being lined and covered.



Figure 3-22: South Kaneshie Market drain, upstream of First Light, looking upstream (3 July 2019).



Figure 3-23: South Kaneshie Market drain, upstream of First Light, looking downstream (3 July 2019).

The two rectangular drains upstream of First Light (Figure 3-23) have quite similar dimensions to the ones seen at the South Kaneshie Market drain outlet (Figure 3-24), although not confirmed.



Figure 3-24: Outlet of South Kaneshie Market drain (3 July 2019).

According to Ing. Wise two drains join together into one smaller drain in the area around First Light (Figure 3-19). The dimensions of the drains, as described by Ing. Wise, are presented in Figure 3-25. The exact location of the confluence is unknown and no as-built drawings are available. The South Kaneshie Market drain is modelled as an open drain (Figure 3-26). The cross-sections found in the Sobek model are considered as simplifications of the actual drain, which is confirmed by HKV. Based on the different inputs (Ing Wise, site visits), a drainage configuration is assumed, as presented in Figure 3-27.

During the site visit of 3rd July 2019, Ing. Wise stated that the First Light area suffers from capacity problems and that this is caused by the two drains joining together in one. In addition to the existing problems of the drain, he explains that there are plans to build two flyovers over the Obetsebi Lamprey Circle which would involve driving piers (piles) through the ground and into the existing drain. This is unfortunate as the current limited capacity will further be reduced and hence, the flood risk will further be increased. It is recommended that this work is not undertaken or that the design is changed to ensure no reduction in the drain capacity. During the site visit, no construction of a new flyover was seen.

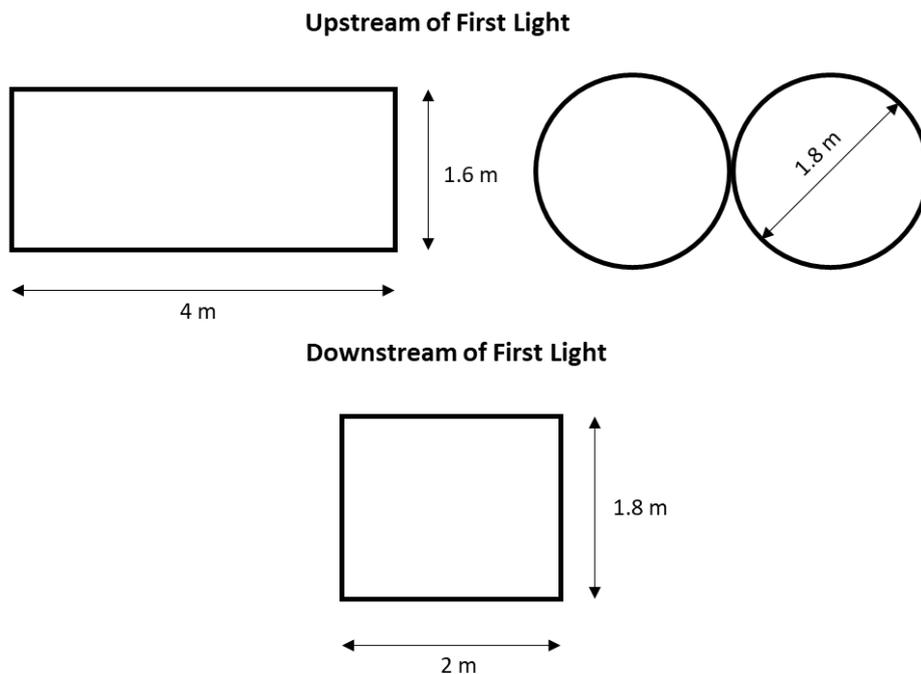


Figure 3-25: Dimensions of the South Kaneshie Market drain, as described by the local drainage specialist.

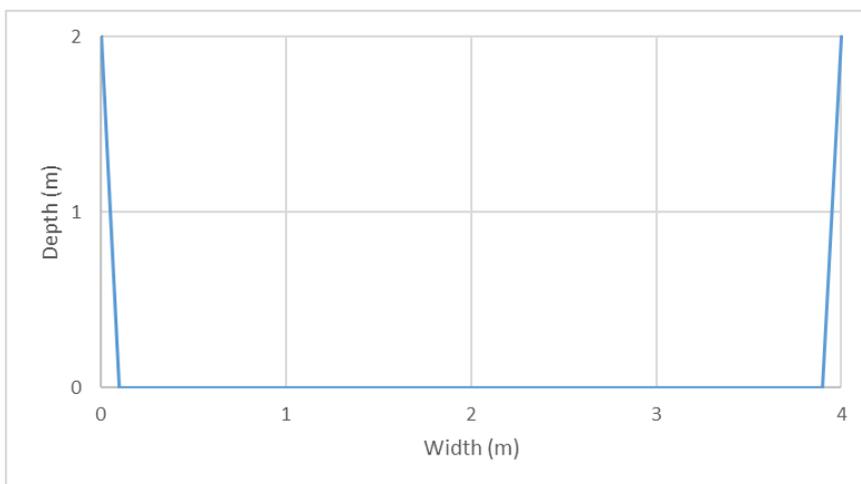


Figure 3-26: South Kaneshie Market drain design cross-section from Sobek model.

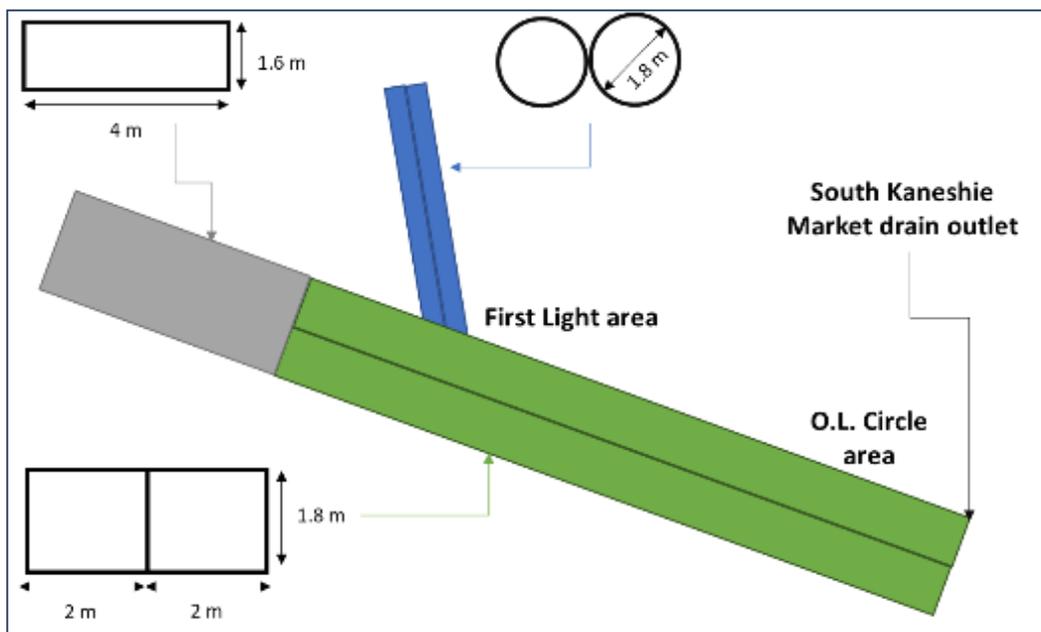


Figure 3-27: Assumed configuration and dimensions of the South Kaneshie Market drain based on the information of the local drainage specialist and site visits.

The flood map produced by the Sobek model (Figure 3-3), shows minor flooding at the South Kaneshie Market drain compared to the north industrial area. Nevertheless, the concerns of the national drainage specialist are considered as important.

3.1.2.6 Mataheko drain

Mataheko drain runs underneath the Oblogo Road and flows in an open drain not far from the South Kaneshie drain (Figure 3-28). No as-built drawings are available for the Mataheko drain. The underground cross-section found from the Sobek model is presented in Figure 3-29. The open drain appears to be concrete lined, at least along the edges, and is clearly suffering from sedimentation (Figure 3-30). No major capacity problems have been reported.



Figure 3-28: Location of Mataheko drain.

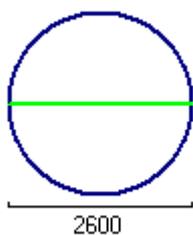


Figure 3-29: Mataheko covered cross-section from Sobek model (no as-built drawings available).



Figure 3-30: Mataheko drain, looking upstream (28 May 2019).

3.1.2.7 South Kaneshie drain

The South Kaneshie drain (Figure 3-31) starts at the outlet of the South Kaneshie Market drain. Approximately 100 metres further downstream, the Cemetery drain enters and the South Kaneshie drain makes a 90° bend southwards to flow underneath Graphic Road. The Kaneshie drain thereafter flows parallel to Ring Road West, after which it takes a bend to flow into the unlined section of the Odaw River. The drain has been visited multiple times. Figure 3-32 and Figure 3-34 show the section upstream of Graphic Road, including the 90° bend southwards. The cross-section implemented in the Sobek model is presented in Figure 3-33.



Figure 3-31: Location of South Kaneshie drain.

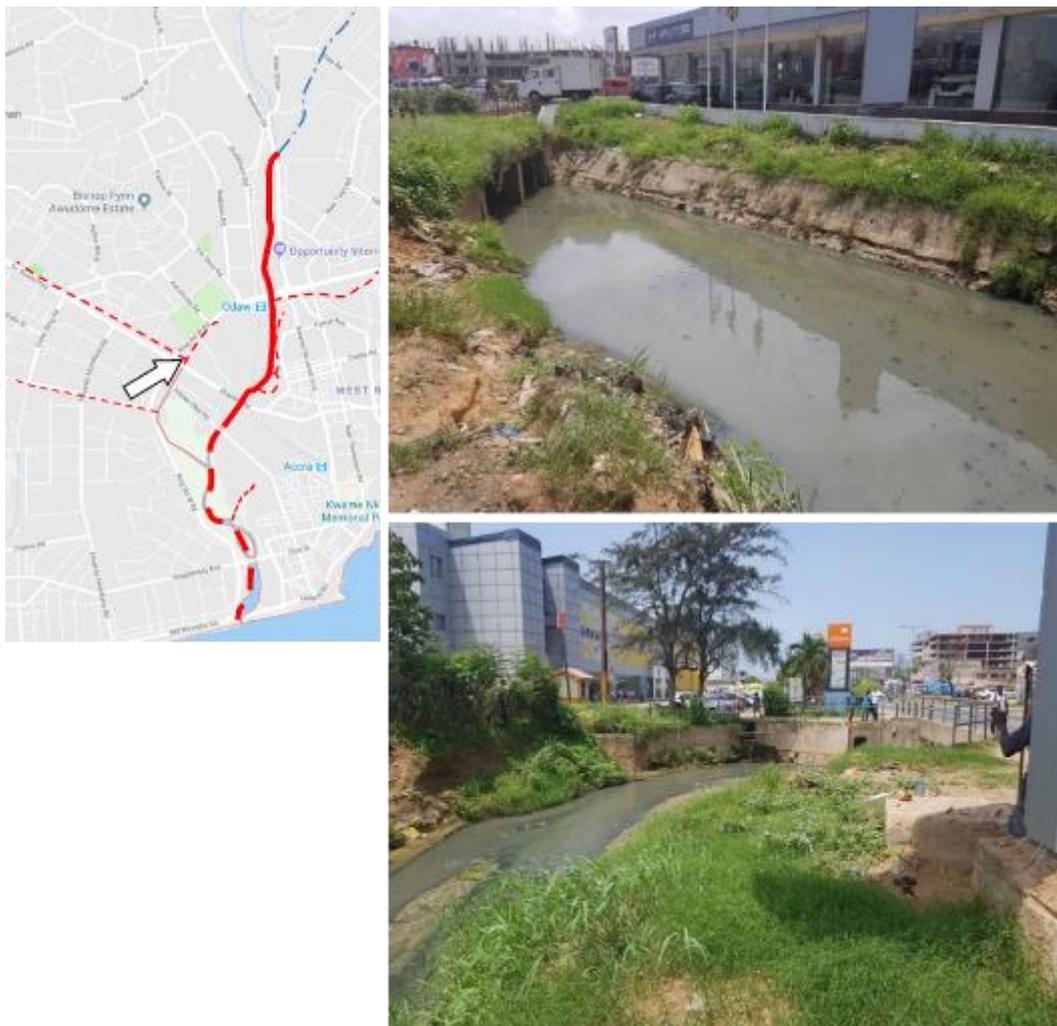


Figure 3-32: The South Kaneshie drain upstream of Graphic Road (top: the South Kaneshie Market outlet, 3 July 2019, bottom: just upstream of Graphic Road, 16 May 2019).

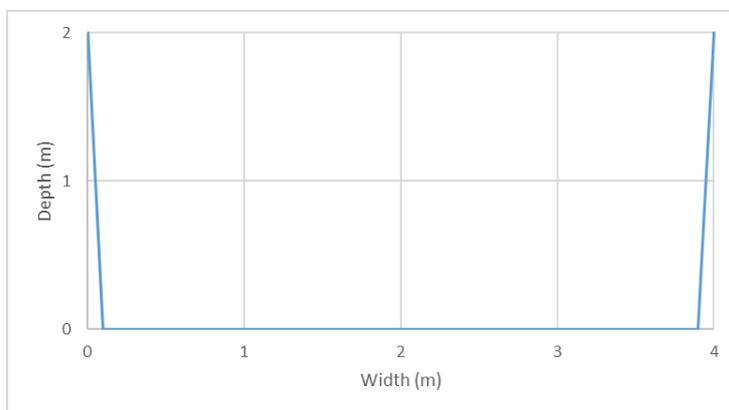


Figure 3-33: South Kaneshie cross-section (upstream Graphic Road) from Sobek model.



Figure 3-34: South Kaneshie drain at 90° bend, upstream of Graphic Road (top: 16 May 2019, bottom: 3 July 2019).

The comparison in Figure 3-34 shows that sedimentation clearly occurs on the inside of the 90° bend of the South Kaneshie drain. Dredging works were ongoing during the site visit of May. After removal the excavator placed the materials on the banks. It is noted that these sediments on the slopes of the banks can easily slip back into the drain following rainfall runoff. However, it is assumed that this is a temporary storage solution, and that this influence is undesirable but limited.

The first part of the Kaneshie drain downstream of Graphic Road is lined, but the banks are overgrown (Figure 3-36). The design cross-section implemented in the model is shown in Figure 3-35. During the site visit, the water depth was shallow and sediments were visible on the bottom of the drain. The waste trapped at the pipe illustrates that the water level rises and exceeds the bridge level.

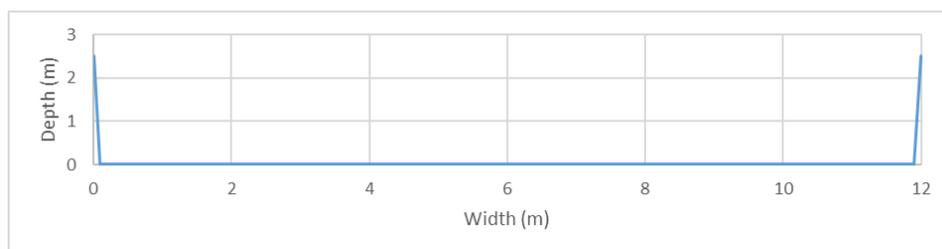


Figure 3-35: South Kaneshie cross-section from Sobek model near the Abose-Okai Bridge.



Figure 3-36: South Kaneshie drain at Abose -Okai Bridge (top: looking upstream, bottom: looking downstream, 16 May 2019).

Furthermore Ing. Wise identified a capacity problem of the drain at the 90° bend near Graphic Road. When the drain flows out of the covered area it faces directly towards the car dealership, which, according to Ing. Wise, causes frequent flooding because of the high flows during the rainy season. This is exacerbated due to the location of a current sand trap just downstream of the outlet of the South Kaneshie Market drain, which builds up sediments and causes blockages.

The high flows that are not deflected but flow over the bend contribute to the major flooding in the North Industrial area (Figure 3-3). In addition, the flood model shows inundations in the downstream part of the drain.

Upstream of the confluence with the Odaw River, the Kaneshie drain runs freely (Figure 3-37). A small side drain near Market Lane was observed which needs to be maintained as well (Figure 3-38).



Figure 3-37: Looking upstream at Kaneshie 2 (16 May 2019).



Figure 3-38: Mouth of a smaller side drain at Market Lane (16 May 2019).

3.2 Assessment of needs & prioritisation for dredging, cleaning and rehabilitation of drains

Based on the inventory of the drains and their identified capacity problems, a prioritisation for dredging, cleaning and rehabilitation measures is made in order to efficiently mitigate future flooding in the project area. This chapter starts with the prioritisation and ends with the concept designs of proposed mitigation measures.

3.2.1 Prioritisation of measures

Table 3-2 shows an overview of the prioritisation of the drains. The main issues of the tributary drains are the capacity problems of the South Kaneshie Market drain near First Light and the 90° bend of the South Kaneshie drain. The rehabilitation of both drains therefore gets high priority.

In addition, the flood modelling results indicate capacity problems of the downstream part of the Nima drain (regardless of the low sedimentation rate), from which it is concluded that the rehabilitation of the Nima drain gets high priority as well.

For all three high priority drains, adjustments are proposed and discussed in sections 3.2.3 to 3.2.5.

No major capacity problems have been reported in the other drains and hence, a low priority is assigned. However, this is only valid on the condition that the drains and their banks are regularly cleaned and maintained. As already stated by HKV, without maintenance, other measures make no sense.

The Agboglobshie drain gets medium priority as it has a high contribution to the waste blocking the flow at the interceptor weir. A maintenance plan is proposed in section 3.2.2.

Figure 3-39 shows an overview of the measures for rehabilitation and cleaning of the drains in plan view.

Table 3-2: Prioritisation of measures for the tributary drains.

Drain	Flood description	Priority Level	Measure(s)
Nima Drain	High	High	Dredging and cleaning, Adjustment of downstream part
Odawna Drain	Low	Low	Dredging and cleaning
Agboglobshie drain	Medium	Medium	Dredging and cleaning
Cemetery drain	Low	Low	Dredging and cleaning
South Kaneshie Market drain	High	High	Dredging and cleaning, Adjustment near First Light
Mataheko drain	Low	Low	Dredging and cleaning
South Kaneshie drain	High	High	Dredging and cleaning, Adjustment of bend and downstream culverts

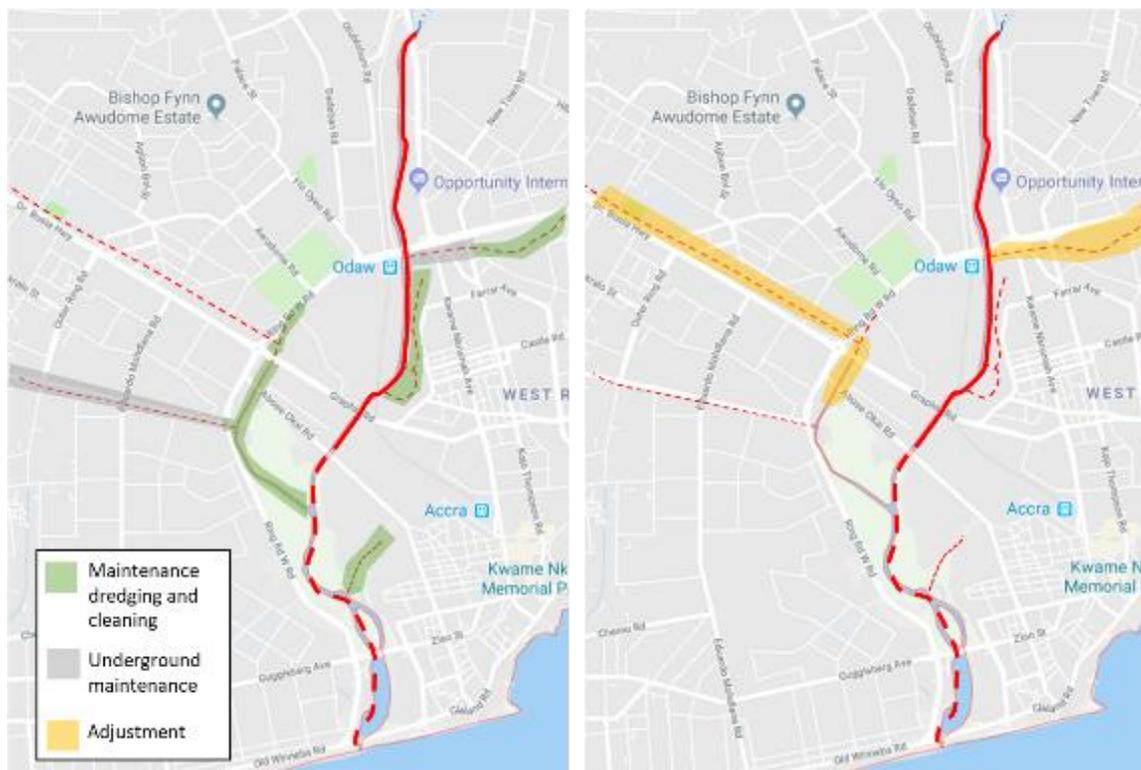


Figure 3-39: Overview of measures for the rehabilitation and cleaning of tributary drains.

The proposed solutions of course must be sustainable and at two levels: the concept as such must be sustainable (i.e. no excessive operational cost, e.g. a solution in which the lagoon should be dredged every week is not sustainable), and the execution and operation must be done in a sustainable way (e.g. storing removed sediment sufficiently far from the bank to avoid re-entrance in the system by rain erosion).

Solutions not sustainable by concept have been rejected or mitigating measures have been defined to increase sustainability. To guarantee “operational sustainability” the type of solution must comply with certain constraints and requirements. Each solution is accompanied by a list of guidelines and directives, based on current best practice.

3.2.2 Maintenance plan

The drainage capacity of the current draining system should be retained and clogging of drains should be avoided at all time by a sensible maintenance plan. It is strongly recommended to establish a maintenance programme of the Korle Lagoon, the surrounding drainage system of the Odaw Basin and its tributaries, such as the one developed by IMDC for the KLERP. The proposed plan should include the following aspects regarding the drains:

- The drainage system should be dredged regularly in order to maintain the design cross-sections and to retain the initial drainage capacity. Sufficient personnel and equipment should be provided for this work. An optimisation of dredging frequency should be considered. It is recommended to invest in a Performance Based Contracting instead of a volume based to ensure frequent and optimized dredging (Task 1).
- The drains have to be inspected frequently (e.g. weekly depending on the season) to ensure that all grit and rubbish are removed from the trash rack grill and weir inlets. Open channels and culverts leading to Korle Lagoon should be cleaned of all rubbish and other obstructions on a regular basis. A combination of manual labour and light machinery should be employed effectively. Sufficient personnel and equipment are to be provided. Disposal of the rubbish and other waste must be

undertaken by the Waste Management Department as a matter of routine and obviously it is always better to collect waste before it enters the drains. All metal fittings and drain gates are to be kept in good order at all times.

It is proposed to build on these recommendations and work together with the results of the institutional analysis and capacity building to ensure a workable maintenance plan, because it is clear that the previously proposed plan was not implemented and has led to the subsequent degradation of the area.

The preliminary costing of maintenance dredging and cleaning of the Agbogbloshie drain and the South Kaneshie drain has already been estimated in Task 1. Because of the limited information on sediment and waste volumes, a contingency budget of 10% is recommended, to include the maintenance and cleaning of the other drains.

3.2.3 Adjustment of South Kaneshie Market drain near First Light

Ing. Wise explained that the area of First Light suffers from a capacity problem because of the two drains joining together in one smaller capacity drain.

The hydrological discharge of the 2015 storm (calculated as T10 by HKV) in the South Kaneshie Market drain (Figure 3-40) has been retrieved from the Sobek model and is approximately equal to 49 m³/s.

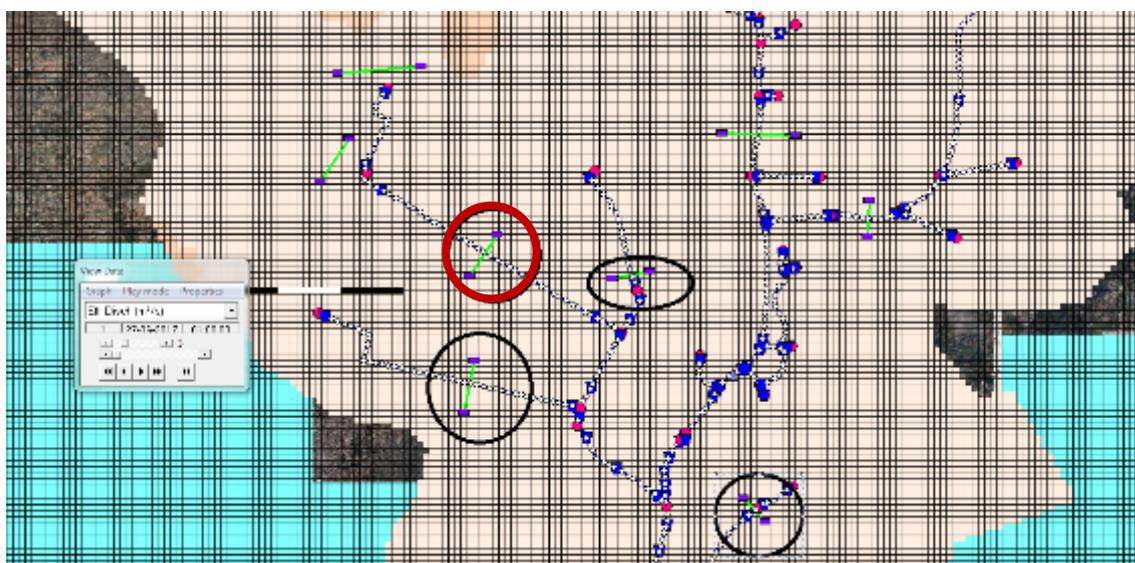


Figure 3-40 : Discharge location in South Kaneshie Market drain

Using a bottom slope of 0.0056 m/m (estimated from the model) and a Manning's roughness of 0.02 (extracted from the model), it is concluded that the capacity of the main drain (open channel, width x height 4 m x 1.6 m) is already too small to drain the T10 flow of 49 m³/s. The capacity of this drain equals (only) 22 m³/s.

The culvert (covered part of the drain) being under pressure and the fact that the flow is divided over 2 parallel drains (2 x 2 m x 1.8 m) causes severe setup. The presence of the intermediate wall also reduces the total capacity of the drain by 2 m³/s.

- Capacity of a single culvert width x height = 2 m x 1.8 m, $Q_c = 9.96 \text{ m}^3/\text{s}$. The available capacity of the 2 parallel drains is therefore 19.92 m³/s.
- Capacity of a single culvert width x height = 4 m x 1.8 m, $Q_c = 21.95 \text{ m}^3/\text{s}$.

Both values are way below the expected design flow of 49 m³/s. The entire drain from upstream of the Accra Academy to the outlet near Graphic Road (a stretch of over 3 km) therefore needs to be upgraded.

The connection near First Light between the main drain and the two pipes coming from the north needs to be evaluated in more detail in a separate study. This should be based on hydraulic calculations with reliable design flows, and the division of the upstream discharges over the two parallel culverts has to be checked and guaranteed.

The flooding problem as a whole is however related to insufficient capacity of the drain over the whole stretch. Additional capacity should be created by providing additional culverts. In order to be able to evacuate the design discharge of 49 m³/s 5 parallel culverts of 2 m x 1.8 m (the height is a fixed constraint for evacuation reasons) would be needed. These might be divided over different drains and be constructed on either side of (or under) the Dr. Busia Highway before being connected to the open drain (south Kaneshie) downstream of Graphic Road.

A direct result of this capacity increase also means the capacity of the culverts under Graphic Road and under Abose-Okai Road needs to be reviewed and increased in order to avoid new or additional flooding problems around and downstream of Graphic Road. See also section 3.2.4.

Alternative solutions could consist of uncoupling certain upstream areas and evacuate the runoff via other routes to the main Kaneshie drain more downstream or providing (a number of) storage basins or retention ponds near or upstream First Light and the cemetery. Neither of these alternatives seems to be viable however, as available space is extremely limited, and in order to be able to evacuate the T10 runoff through the available drains a surface of around 2 km² would be needed to be able to store the actual flood volume (based on the HKV model results).

Additional relief on the downstream stretch of Kaneshie drain, in order to lower the water levels and thus facilitating the flow in South Kaneshie drain near Graphic Road and Abose-Okai Road, could be created by providing storage basins along Odaw River upstream from Caprice. These would reduce or slow down the flow in the Odaw River. This way the storm runoff wave coming from the Kaneshie drain area could be disconnected in time from the storm runoff wave coming from the Odaw River area.

A first rough cost calculation of the necessary capacity increase along Dr. Busia Hwy (i.e. for building 3 additional culverts), results in a total cost of around €8.5 M. This cost includes all ground and material work (concrete, steel). The cost does not include any cost related to traffic organisation or road construction works (e.g. no breaking up and restoring of road pavements).

In case circular conducts would be preferred over rectangular culverts, a total of 5 pipes with an internal diameter of 1.8 m, would be needed for evacuation of the extra discharge. It is estimated this would cost around €10.5 M.



Figure 3-41: Upgrade of the South Kaneshie Market drain.

During the site visit, it was noted that open land nearby First Light, owned by the Accra Academy (Figure 3-42), could be a potential site for a retention pond, whereby excessive flood water could be retained and then slowly released in order not to overload the capacity of the drains and therefore reduce flooding. However, from our understanding, the school is not willing to use the site as a retention pond and wants to surface the area instead as it wishes to expand. This is unfortunate as the surfaced area would increase the runoff towards the drain and would further worsen the flooding in the area. Freeing up land to “make space for water” (“building with nature”) is something that has been carried out recently in several northern European countries and has also been highlighted as an option by HKV. Sacrificing some land for flooding, would protect other more vulnerable land. These aspects can be thought of during the planning and permitting process for future construction works (both road and buildings).



Figure 3-42: Open land nearby First Light, owned by the Accra Academy.

3.2.4 Adjustment of South Kaneshie drain at 90° bend

Ing. Wise identified a capacity problem at the 90° bend in the South Kaneshie drain. The lack of capacity can potentially be due to the sharp bend not allowing the high and strong flows to move sufficiently or efficiently towards the culvert of the Graphic Road Bridge and instead passing straight on to garages area. The sand trap just downstream of the (covered) South Kaneshie Market drain worsens the water level increase. One option suggested is to realign the channel to a more natural alignment (i.e. not 90°) and to move the sand trap downstream of the bridge (Task 4). Such realignment would entail the installation of a new culvert under Graphic Road (Figure 3-43).

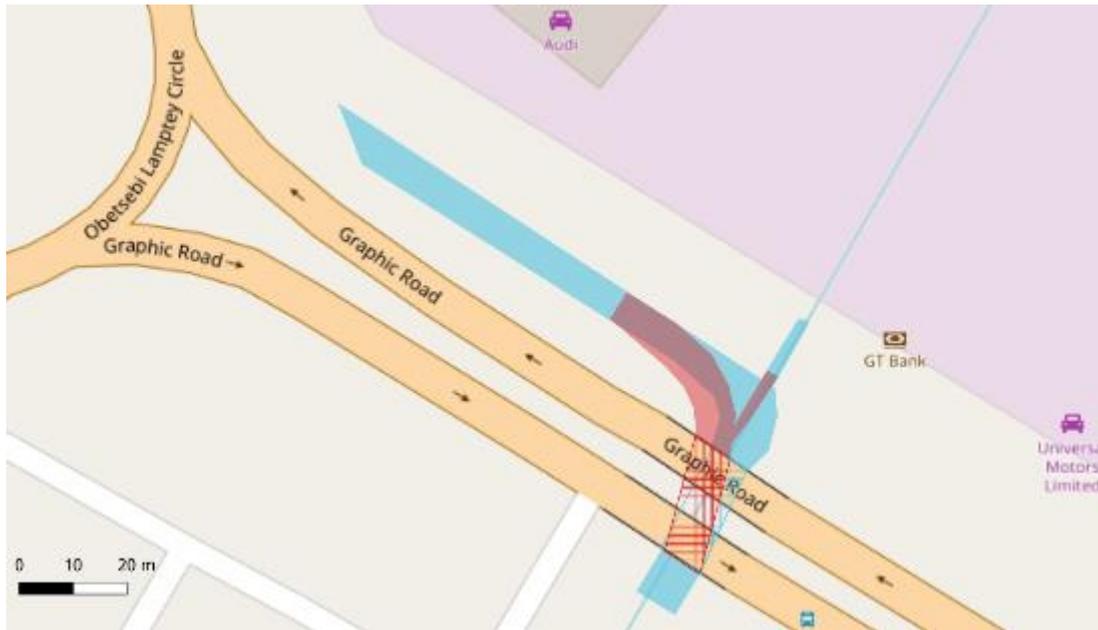
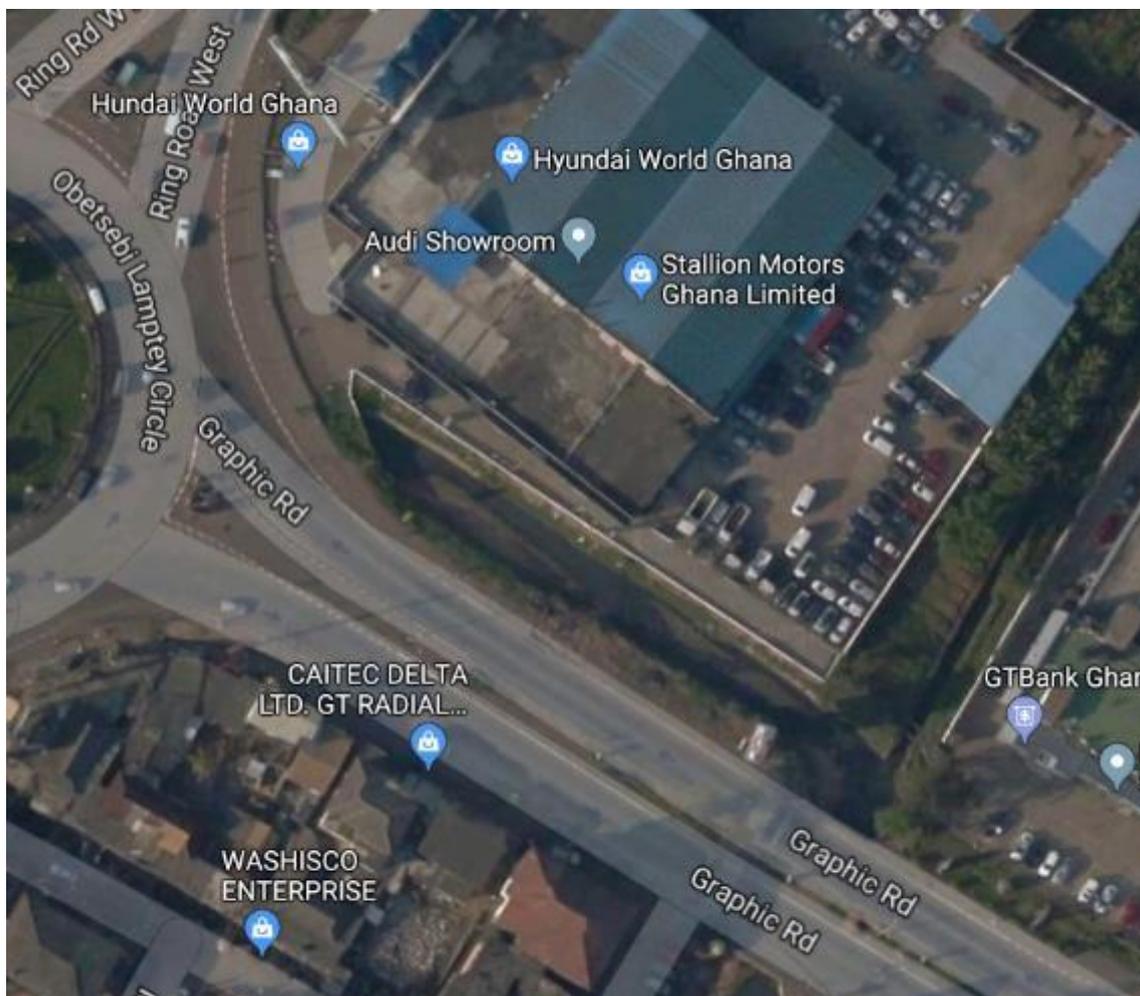


Figure 3-43: Concept design of the realignment of the 90° bend of the South Kaneshie drain [blue: current drain, red: realigned drain].



This measure in the complex area of Graphic Road requires detailed modelling with data on discharges of the many different drains in the area, including road drains, as the influence on the waterflow of every drain needs to be studied in order to design a sensible realignment. Such detailed design is out of scope for the feasibility phase study. Either way, the adjustment needs to be accompanied with maintenance dredging and in the culvert as well. The water flow will always be slowed down in the inner bend and the low velocities can cause sediments to settle down and to block the flow. This reduces the capacity and hence, the efficiency of the current/new culvert (Figure 3-44).



Figure 3-44: South Kaneshie culvert underneath Graphic Road (16 May 2019). The inner bend is blocked by sediments.

It needs to be understood that an increase in the capacity of the South Kaneshie drain near Graphic Road has its effects downstream, as the realignment will allow more water to be discharged efficiently. The capacity of the downstream South Kaneshie drain, however, is also constrained by the low Abose-Okai bridge (Figure 3-45). The realignment near Graphic Road will thus likely result in flooding further downstream. It is therefore suggested that this option is looked at during a later stage of the project (GARID) when the bridges are studied. The Abose-Okai bridge over the Odaw River was already identified as an issue by the HKV pre-feasibility study (HKV, 2019). A raising of the Abose-Okai bridge over the South Kaneshie drain should be included in the study as well.

Because there are still many aspects that need to be studied in more detail in order to design a sensible realignment, a cost estimation is not included.



Figure 3-45: South Kaneshie culvert underneath Abose-Okai Road (16 May 2019).

3.2.5 Adjustment of the downstream part of Nima drain

The flood model shows that the downstream part of the Nima drain starts flooding because of a lack of capacity of the drain itself.

Capacity calculations over Nima drain indicate the following:

- For the downstream, covered part (Figure 3-5), a capacity of the culvert (3 x 2.6 m wide x 2.75 m high) is 54.8 m³/s (Manning coefficient 0.03, slope 0,007 m/m).
- For the upstream, uncovered part (trapezoidal section, Figure 3-5), the cross-section changes frequently (from a rectangular section to a trapezoidal section with variable bottom width and slopes, see figures below). The capacity of the uncovered section as implemented in the model lies between 20 and 30 m³/s, depending on the roughness coefficient that is adopted. A complete cleaning and rehabilitation, as suggested by HKV (HKV, 2019), will have a direct positive effect on this capacity.



Figure 3-46 : Start of the uncovered section of Nima Drain at Kojo Thompson Road (left: google maps, feb 2016, right photo HKV)



Figure 3-47 : Nima drain at Paradise Street (260 m upstream from Kojo Thompson Road (left: looking downstream, right: looking upstream)



Figure 3-48 : Nima drain at Paloma Bridge (Ring Road Central, 950 m upstream from Kojo Thompson Road (left: looking downstream, right: looking upstream)

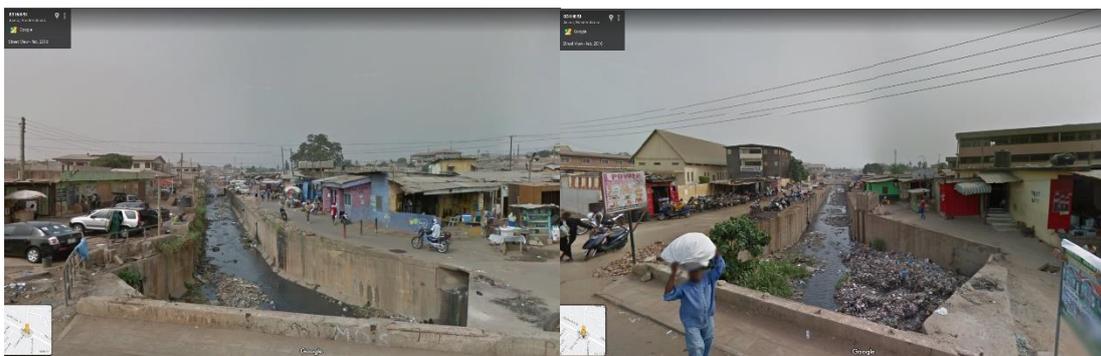


Figure 3-49 : Nima drain at Hill Street (850 m upstream from Ring Road Central) (left: looking downstream, right: looking upstream)

As model results indicate that even the downstream covered section is too small to evacuate the discharge from a T10 rainfall event, it is clear that a capacity increase is needed. HKV therefore recommends to rehabilitate the drain by an increase of the capacity (from trapezoidal to rectangular) of the uncovered sections over a length of almost 900 m, from Kojo Thompson Road to Ring Road Central (Figure 3-50). The suggested rehabilitation by HKV does not incorporate an upgrade of the underground drain in order to minimize installation costs. This means that the culvert will still cause a backwater effect and raise water levels in the uncovered part. The rehabilitation therefore includes the construction of a 1 m high flood wall along the channel banks. The cost of this mitigation measure was calculated by HKV as €1.5 M (HKV, 2019).

As execution of these measures are already foreseen, rehabilitation of Nima drain is not further elaborated as part of this feasibility study. However, it needs to be clear that even after the implementation of these measures, flooding will most probably still occur for a flow event with a return period of 10 years and that maintenance of the drain (garbage cleaning as well as reparations to the concrete lining), even upstream from Paloma Bridge, as well as looking for additional retention or storage capacity upstream, needs to stay a constant point of concern.



Figure 3-50: Area of rehabilitation of Nima drain, as proposed by HKV (HKV, 2019).

3.3 Summary

In order to provide an overview of the descriptions in section 3.1.2 and the possible adjustments described in section 3.2, Table 3-3 is presented and in addition provides an overview of the costs per drain.

Table 3-3: Summary of drains with their measures

Drain	Problems	Measure	Cost
Nima Drain	Capacity of the drain is too small for the flow at a T10 return period.	Adjustments to the Nima drain as proposed in Chapter 8 of (HKV, 2019)	Not applicable: adjustment works already being funded
		Maintenance dredging	Included in contingency budget of 10% for dredging (Task 1)
Odawna Drain	None	-	-
Agbogbloshe Drain	Limited	Maintenance dredging and cleaning of the drain	Included in maintenance dredging budget of €2.7M
Cemetery Drain	Limited	Cleaning of the drain	Included in 10% contingency budget of maintenance dredging
South Kaneshie Market Drain	Constant flooding due to lack capacity	Increase drain capacity by increasing the amount or the size of culverts	€8.5M – €10.5M
		Uncoupling upstream areas	
		Storage/retention basins upstream of Caprice	
		Maintenance dredging	Included in maintenance dredging (Task 1)
Mataheko Drain			Included in 10% contingency budget of maintenance dredging (Task 1)
South Kaneshie Drain	Flooding at the 90° bend and Abose-Okai Road	Realign the bend	Requires detailed study
		Move sand trap downstream	
		Increase drain capacity at Graphic Road and Abose-Okai Road	
		Maintenance dredging	Included in maintenance dredging budget of €2.7M

4 Task 4: Assessment of sand trap locations

Task 4 provides an answer to where can we strategically construct sand-traps to reduce the sedimentation, and make the dredging works more structured.

The Assessment of sand trap locations consists of two main parts:

- Part 1 – Site Selection;
- Part 2 – Conceptual design of sand trap.

4.1 Site selection of sand trap locations

According to the pre-feasibility study by HKV (April 2019) it is mentioned that next to maintenance dredging, “Building sand traps” may be one of the best measures to “reduce the sediment load and dredging interval”. For example, HKV (April 2019) state that downstream of Caprice the channel slope reduces significantly and flow velocities drop, resulting in sedimentation. It is therefore recommended to construct a sand trap directly downstream of Caprice bridge, where in the past a sand trap existed. National experts (not stated who in HKV report) estimate that this sand trap will reduce the sedimentation of Odaw downstream by 50%, leading to a residual sedimentation rate of 10-12.5 cm per year from 20-25 cm (HKV, 2019). Indeed, previous studies have also recommended and installed sand traps along the river for the same purpose. Therefore, as part of this Feasibility Study, a site selection has been undertaken to assess suitable locations for new sand traps. At these sand traps sediment can accumulate and then be easily extracted, cleaned and potentially used for sand sales or for other beneficial use (described more in Task 4). As discussed in Task 1, there is a suitably high content of sand and gravel to make it appealing for such reuse, which is beneficial for a Performance Based Contract.

4.1.1 Shortlisting of locations

The first task of the site selection was to identify potential sand trap locations which can then be assessed in a multi criteria assessment. Various data sources were consulted to help identify potential sand trap locations and these included the following:

- Original sites identified in the Information To Tender /Terms of Reference documents;
- Locations identified by the PIU;
- Locations identified by experts (national (HSD & Ing Wise) and international);
- Natural areas of sedimentation (output from Task 1, see Figure 1-7);
- Existing sand traps (from previous studies);
- Results of former projects;
- Previous modelling results and discharge rates.

Based on information gleaned from these sources, potential sand trap locations have been identified and are presented in Figure 4-1

A brief description of the potential sites is provided below.

1. **Caprice**, downstream of the confluence of the Odaw and Onyasia streams. National experts (Ing Wise and Ing Seth from HSD) both agree that there should be a sand trap here and mentioned that in the past (before the concrete lining) this was already a sand trap and worked very effectively. However, according to HSD, it might be needed to shift it somewhat downstream, as both the Odaw and Onyasia tributaries are now lined, have a steep slope and have very high velocities: a sand trap immediately downstream of the confluence would not be very effective because of these high velocities. This was also observed during the site visit and is in line with the recommendations of HKV (2019) who also state that downstream of Caprice the channel slope reduces significantly and flow velocities drop, resulting in sedimentation. This location is shown in Figure 4-2.

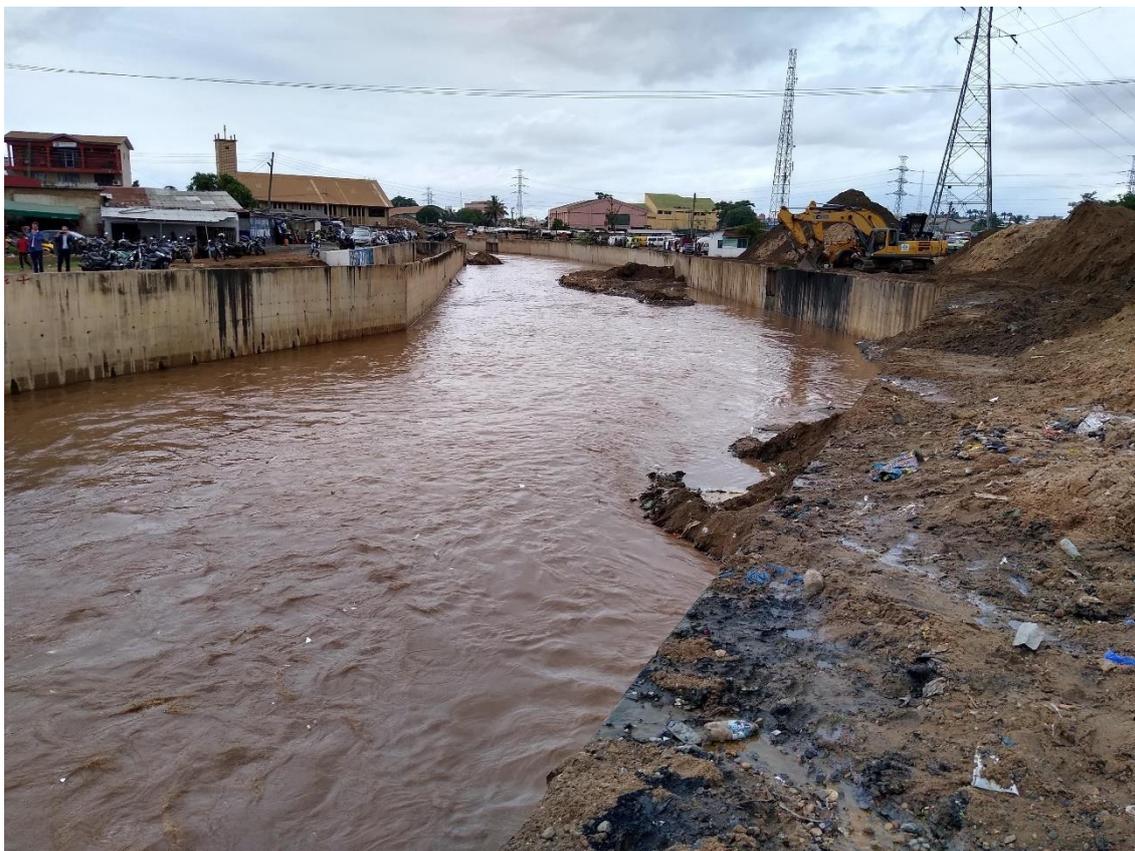


Figure 4-2: Photo of potential sand trap location at Caprice.

2. **Nima**, at the confluence of Nima drain and Odaw. According to the Hydrological Services Department (HSD), the Nima drain could be realigned under the GARID program, although Ing Wise did not mention this. According to HSD this program would kick off only somewhere in September 2020. HSD also recommended to locate the sand trap in the Odaw itself, just downstream of the (new) confluence with the realigned Nima drain (**Nima 2**), whereas Ing Wise advised to construct a sand trap at the end of the (existing) Nima drain, just before entering the Odaw (**Nima 1** - Figure 4-3). The Nima drain is currently covered in this location, however, a small section just before confluence with Odaw could be opened, and therefore be suitable for sand trap installation and maintenance. In the past, there used to be a (very effective) sand trap at that location, just before confluence with Odaw. It is uncertain whether this is the same location as the one located at **Kwame Nkrumah circle** (Figure 4-1), which is no longer in operation as the drain is now covered there.



Figure 4-3: Photo of potential sand trap location at Nima 1.

3. **Kaneshie 4.** According to National expert Ing Wise there is an existing sand trap immediately downstream of where Kaneshie drain transitions from a closed drain to an open drain, as shown in Figure 4-4.



Figure 4-4: Photo of existing “sand trap” location at Kaneshie (4).

4. **Kaneshie 3.** According to Ing Wise and HSD, the 90-degree bend in the South Kaneshie drain (where it meets the Cemetery drain) could be realigned, also under the GARID program, in order to reduce flood risk. This South Kaneshie drain carries a lot of sediments, which was confirmed by Ing Wise and HSD. It would therefore make sense to have a sand trap downstream of the new bend in this drain (confirmed by Ing Wise and HSD, 9 July 2019). Figure 4-5 below shows existing area downstream of the bridge.



Figure 4-5: Photo of potential sand trap location at Kaneshie 3.

- 5. **Kaneshie 2.** The Mataheko drain, flowing into the South Kaneshie drain, does not carry too much sediment. However, another drain which was observed during the site visit of 15 May 2019, appeared to carry some sediment but, according to Ing Wise, is not significant (Figure 4-6). This drain was located just downstream of the Mataheko drain and is shown in the photo below. When placing the sand trap as indicated in Figure 4-1, a sand trap at location Kaneshie 1 (in the Kaneshie drain just upstream of the confluence with the Odaw) would not be needed according to Ing Wise. Indeed, a sand trap at location Kaneshie 3, would also not be needed if one was installed at Kaneshie 2.



Figure 4-6: Sedimentation where smaller drain enters Kaneshie drain (downstream of Mataheko).

- 6. **Kaneshie 1.** As part of the KLERP project a sand trap constructed with gabion baskets was installed at this location. Figure 4-7 shows the sand trap in May 2019 and Figure 4-8 was just after it was built in October 2001.



Figure 4-7: Location of existing sand trap near the Odaw-Kaneshie confluence in 2019.



Figure 4-8: Existing sand trap near the Odaw-Kaneshie confluence in 2001.

- 7. Downstream of Kaneshie-Odaw confluence.** Ing Wise advised a sand trap downstream of the confluence of Kaneshie and Odaw, just before entering the lagoon (Figure 4-9). This should trap sediments from Odaw between Caprice and that location. HSD does not believe this is needed.



Figure 4-9: Location of potential sand trap downstream of Kaneshie-Odaw confluence.

8. **Agbogbloshie drain.** Ing Wise and HSD advise a sand trap here, however, they also say that the Agbogbloshie drain does not carry too many sediments and is essentially a dead-end tributary. Although this may be true, the bathymetric report from Dredge Masters (DML, 2017) states “The Agbogbloshie drain is heavily silted and its banks serve as the garbage hub for people living within the area. Any rainfall within the area results in the flow of large volumes of silt towards the lagoon.” The high sedimentation can be seen Figure 1-7 and Figure 4-10. Sediment sampling in the area (ADK, 2019) indicates mostly sand while older sediment samples indicates a higher silt content. Nevertheless, the Ing Wise and HSD consider this sand trap location as optional, because they consider any sand trap at the downstream end of the Agbogbloshie drain as being part of the dredging operations inside the lagoon. It can be considered a natural sediment trap and should be part of the maintenance dredging works regardless and no actual design or construction would be needed.

9. **Interceptor weir.** As the interceptor weir is already trapping sand mostly on the upstream side but there are some areas of high sediment on the right-hand side downstream, as shown in red in Figure 4-10. Its future use in terms of dredging is being studied as part of Task 5, it seemed prudent to include it in the list of potential locations.

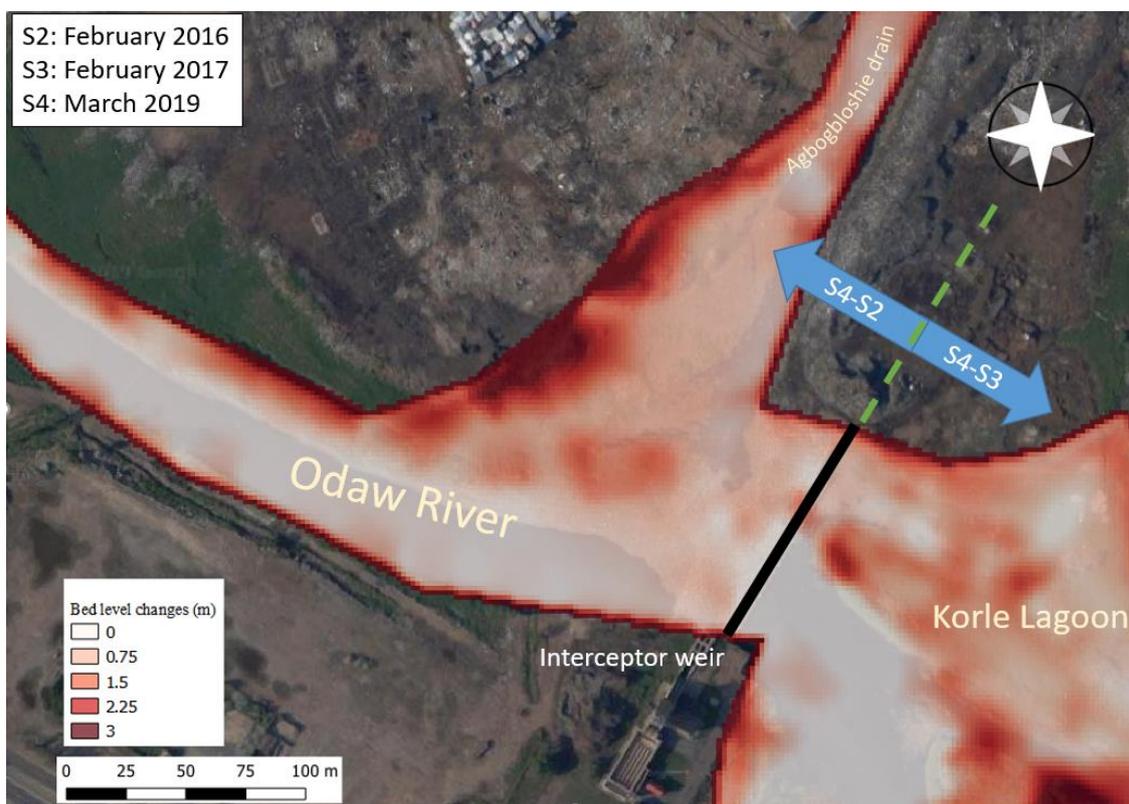


Figure 4-10: Sedimentation around the Interceptor weir and Agbogbloshie drain.

Some of these potential locations can now be carried forward to the multi criteria assessment to enable a selection of the most suitable locations for sand traps. The following sites can already be discounted: **Kwame Nkrumah** circle (as it no longer exists and is covered); and **Kaneshie 4** (as it is partly the cause of flooding at this location and all experts agree it is not a suitable site). This leaves a total of 9 potential locations.

4.1.2 Assessment criteria

The consultant followed its internal procedure for site selection, which has been proven as a suitable basis for previous Projects. Before the site selection exercise was undertaken the criteria to be used for the assessment was discussed and agreed upon together with the client. The list below is considered to contain the most appropriate parameters to use for the assessment of each potential site:

Contribution of the upstream drain to sediment load (sediment/sand load in the drain) is the indicator directly linked to the actual incoming flow of sediment (volume/concentration of sediment) and is therefore an indicator of the possible effectiveness of a sand trap. The more sediment transported through the drain (in absolute volume), the more effective a sand trap can be.

Proximity to sediment handling site (Task 2) i.e. market proximity gives an indication of both the efficiency of the dredging/cleaning activities and the handling/transport of the sediments to the handling site. The closer the sand trap is to a handling site, the less intermediate actions have to be organised, the shorter the transport distances and therefore the lower the transport costs. These costs are included here as a criterion, and not in the construction cost of the sand trap. Social or environmental impact of transportation activities are also not included in this criterion.

Available space to build a functional/effective sand trap relates to the degree of freedom (available space) in choosing an appropriate and efficient sand trap design. More open space to widen and deepen the drain/river (primary criteria in a sand trap design) at the location, and to create (additional) easy access if necessary, allows a more efficient design and thus receives high scores. It would therefore be preferred over a location where the drain is already lined with vertical slopes or where no open space is available on one or both banks.

Accessibility to sand trap (in order to maintain, clean and recover the sediment) is related to maintenance costs. Maintenance is only possible and can only be guaranteed on the long term, if the sand trap is easily accessible (during dry periods) for dredging or removing of deposited sediments. A sand trap in open terrain can be made easily accessible by building a cheap slope towards or into the sand trap. Side slopes behind the vertically lined walls of a drain can make the drain easily accessible. Existing slopes along the Odaw River can therefore make sand trap locations along these lined stretches as attractive as locations in open terrain as long as the distance is short. Locations which have difficult access receive low scores.

Environmental impact is the measurement tool of the positive or negative impact (other than sediment collection) on the environment in the vicinity of the sand trap location. This criterion also reflects the environmental impact during the construction phase of the new sand trap (excavation work, demolition and construction etc.).

Cost (material cost, demolition, construction etc. as a function of the type of sand trap) reflects only the actual construction costs of the newly designed sand trap at a certain location. As the actual design is not done during site selection stage, it is assumed that the costs will be higher the more existing infrastructure exists at (or in the proximity of) the location (e.g. housing, roads, bridges, concrete vertical slopes, concrete bottom etc.) or the more precautions that have to be taken during construction works.

Social impact (expropriation, transport etc.) reflects the direct impact on people. Certain locations may be very well located in terms of technical efficiency but may need permanent or temporary expropriations, transportation restrictions, noise, pollution etc.

% of sand (from samples) or beneficial usefulness of sediment (i.e. does the sediment collected at this site score well in terms of beneficial use). Sand and gravel are considered to be the beneficial or useful component of the sediment load that can be collected for reuse. It is considered as a separate criterion (compared to the first, which reflects the total volume of sediment) because a sand trap on a smaller drain may be technically very efficient, have little environment or social impact, etc. but may

not be attractive from the point of view of possibilities of usefulness of the collected sediment (e.g. too much silt).

4.1.3 Ranking of short list sites

The site selection has been conducted using a Multi Criteria Assessment (MCA). The governing parameters/criteria described above are summarised in Table 4-1. The MCA was carried out by assigning a score to each criterion between 1 and 5, where:

- 5 = Excellent
- 4 = Very Good
- 3 = Good
- 2 = OK
- 1 = Not good
- 0 = Very Bad

Any “0” in a column will automatically discard the related site. “0” scoring is therefore carefully analysed. These scores were then weighted according to importance of a particular criteria. The weightings sometimes vary owing to the nature of various projects, but this is standard industry practice and is the most commonly followed approach. The total score for a site is calculated by multiplying the scores with their weighting per criteria and adding them up, resulting in an overall percentage. The MCA used for each short-listed sand trap site is presented in Table 4-1.

Table 4-1: Multi Criteria Assessment (MCA) – Case 0 Baseline

[A] Criteria/Parameters to assess	[B] Weighting	[C] Score	[B] * [C] Weighted Score
Contribution of the upstream drain to sediment load (suspended sediment/sand load in the drain)	12.5%		
Proximity to sediment handling site (Task 2) i.e. market proximity	12.5%		
Available space to build a functional/effective sand trap	12.5%		
Accessibility to sand trap (in order to maintain, clean and recover the sediment)	12.5%		
Environmental impacts	12.5%		
Cost (material cost, demolition, construction ... as a function of the type of sand trap)	12.5%		
Social impact (expropriation, transport etc.)	12.5%		
% of sand (from samples) or beneficial usefulness of sediment	12.5%		

4.1.4 Results of MCA

The summary of the MCA results for the base case (Case 0) is presented in Table 4-2. This indicates that Kaneshie 2 scores the highest, followed by Caprice, Kaneshie 1. Locations, Nima 1, Downstream Kaneshie-Odaw and Agbogbloshie score the lowest. However, this only reflects an equal weighting for each criterion. The next step was to repeat the exercise applying different weightings to the criteria to see how this influenced the result. This is described in the next section.

Table 4-2: Results of Multi criteria assessment (Case o)

Criteria/Parameters to assess	Weighting	Caprice		Nima2 (N-Odaw)		Nima 1		Kaneshie 3		Kaneshie 2		Kaneshie 1		Downstream K-O		Agbogbloshie		Interceptor	
		Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Contribution of the upstream drain to sediment load (sediment/sand load in the drain)	12.5%	5	0.625	3	0.375	2	0.25	4	0.5	4	0.5	2	0.25	1	0.125	2	0.25	4	0.5
Proximity to sediment handling site (Task 2) i.e. market proximity	12.5%	2	0.25	3	0.375	3	0.375	4	0.5	5	0.625	5	0.625	4	0.5	1	0.125	3	0.375
Available space to build a functional/effective sand trap	12.5%	3	0.375	3	0.375	1	0.125	2	0.25	4	0.5	5	0.625	5	0.625	1	0.125	4	0.5
Accessibility to sand trap (in order to maintain, clean and recover the sediment)	12.5%	4	0.5	4	0.5	3	0.375	4	0.5	3	0.375	2	0.25	1	0.125	1	0.125	3	0.375
Environmental impacts	12.5%	4	0.5	4	0.5	4	0.5	4	0.5	4	0.5	4	0.5	4	0.5	4	0.5	4	0.5
Cost (material cost, demolition, construction, etc. as a function of the type of sand trap)	12.5%	2	0.25	2	0.25	1	0.125	3	0.375	4	0.5	3	0.375	2	0.25	4	0.5	2	0.25
Social impact (expropriation, transport, etc.)	12.5%	4	0.5	4	0.5	1	0.125	2	0.25	3	0.375	4	0.5	4	0.5	2	0.25	3	0.375
% of sand (from samples) or beneficial usefulness of sediment (i.e. does the sediment collected at this site score well in terms of beneficial use)	12.5%	5	0.625	5	0.625	5	0.625	5	0.625	4	0.5	4	0.5	3	0.375	3	0.375	5	0.625
TOTAL WEIGHTED SCORE		3.625		3.5		2.5		3.5		3.875		3.625		3		2.25		3.5	
% Suitability of Site		73%		70%		50%		70%		78%		73%		60%		45%		70%	

4.1.5 MCA Sensitivity analysis

In order to tackle the issue of MCA being subjective and not aligning with the different stakeholders preferences (i.e. RVO, PIU including Reference Group, ESIA Team.), the exercise was deliberately transparent, and could be repeated to assess the sensitivity of the comparisons using different weightings reflecting the importance of the various criteria. Each of the criteria were therefore given different weightings in order to provide a **sensitivity** analysis and this is shown in Table 4-3. The blue figures indicate changed weighting with reference to Case 0- Baseline.

Table 4-3: Weightings for the Multi Criteria Assessment (MCA).

Criteria/Parameters to assess	Case 0 - Baseline	Case 1 -FS consultants	Case 2 - RVO	Case 3 - PIU	Case 4 - Environmental/ Social
Contribution of the upstream drain to sediment load (sediment/sand load in the drain)	12.5%	30%	25%	15%	25%
Proximity to sediment handling site (Task 2) i.e. market proximity	12.5%	15%	5%	10%	15%
Available space to build a functional/effective sand trap	12.5%	15%	10%	10%	5%
Accessibility to sand trap (in order to maintain, clean and recover the sediment)	12.5%	10%	10%	15%	10%
Environmental impacts	12.5%	10%	15%	10%	15%
Cost (material cost, demolition, construction, etc. as a function of the type of sand trap)	12.5%	10%	15%	15%	5%
Social impact (expropriation, transport etc.)	12.5%	5%	15%	10%	20%
% of sand (from samples) or beneficial usefulness of sediment	12.5%	5%	5%	15%	5%

The results of the sensitivity analysis to the different weightings for the criteria is presented in Table 4-4. Despite varying the weighting of the different criteria, the sand trap at location Kaneshie 2 consistently scored the highest. As only one sand trap would be necessary to cover the sediment within the Kaneshie Drain this location would be the most appropriate. Caprice also consistently scored highly, followed by the Interceptor and Nima 2.

Conversely, Agbogbloshie consistently scored the lowest but appears to naturally accumulate sediment, potentially a lot from the sea via Korle Lagoon.

Table 4-4: Results of sensitivity analysis on MCA.

Sand Trap	Case 0 - baseline	Case 1 - FS Team	Case 2 - RVO	Case 3 - PIU	Case 4 - Environmental / Social	Notes
Caprice	73%	74%	76%	76%	74%	
Nima2 (N-Odaw)	70%	65%	67%	67%	70%	
Nima 1	50%	46%	44%	44%	51%	
Kaneshie 3	70%	71%	68%	68%	72%	1
Kaneshie 2	78%	80%	76%	76%	77%	
Kaneshie 1	73%	68%	66%	66%	69%	
Downstream K-O	60%	54%	54%	54%	55%	
Agbogbloshie	45%	41%	48%	48%	46%	2
Interceptor	70%	71%	69%	69%	70%	3

Notes

1. Select one for Kaneshie Drain
2. Natural sedimentation appears to occur here (potentially from the sea).
3. As part of Task 5: the use of interceptor for dredging purposes, this would be an option and a full sand trap would not need to be developed

4.1.6 Selected sand trap locations

Based on the above selection procedure which involved interaction with key stakeholders, the following locations have been selected for sand traps to be installed:

1. Kaneshie 2
2. Caprice
3. Nima 2 – back up

However, in addition to the construction of specifically designed sand traps, both the Agbogbloshie drain and area beside the interceptor weir are areas sediment naturally accumulates (some of which from the sea). Therefore, although not specifically designed as sand traps they should still be dredged as part of the deferred and maintenance PBC dredging.

4.2 Conceptual design of sand trap

HOLD – completion after acceptance of site selection. Part of D3, due 16 December 2019

5 Task 5 Assessment of possibilities to give the interception weir a function (dredging purposes)

Task 5 provides an answer to: what can be done at the interception weir in terms of dredging purposes.

This section provides insight about the past and present situation of the interception weir. It discusses the origin and design of the structure (Figure 5-1), and describes the way towards the present state of the weir (Figure 5-2).



Figure 5-1: Interceptor weir during construction.



Figure 5-2: Interceptor weir in 2015 approx. 10 years after construction.

5.1 Origin of the interceptor weir

The interceptor weir is a concrete weir of about 75m long with 20 steel flap gates. It is located in Accra (Ghana) between the Odaw River and the (Upper) Korle Lagoon, as shown in Figure 5-3. Next to the weir, a pumping station for primary water treatment was constructed.



Figure 5-3: Location of the interceptor weir.

The interceptor weir was built as part of the Korle Lagoon Ecological Restoration Project (KLERP). The aim of this project was to restore the ecological value of the heavily polluted Korle Lagoon, as well as providing an upgrade to the surrounding natural drainage system in general.

The KLERP was led by IMDC from 1998 to 2010 and can be subdivided into three large project phases:

- **Phase 1:** Dredging works + disposal of material, removal of mangrove area, rehabilitation of stormwater canals;
- **Phase 2:** Construction of interceptor weir, pumping station and primary sedimentation basin and (gravity) outfall pipe to the ocean +infrastructural works;
- **Phase 3:** Dredging, slope protection works, installation floating boom at the interceptor weir and a gentle slope to allow excavators to clear the floating waste in front of the beam.

The most relevant maps of the KLERP project are shown in Annex B.

The interceptor weir was constructed in 2006 and put into operation in 2009, after the work of phase 3 was largely finished. Currently, the interceptor weir is not functioning properly mainly due to lack of maintenance after the initial period and handover. In this memo, the design of the interceptor weir and its intended functions are first described. After that, a timeline of events from the moment of construction to the present situation is given. The memo is concluded by an assessment of the current state and functioning of the interceptor weir, which will be the baseline situation for successive studies.

5.2 Functions and Design

5.2.1 Functions

For decades, the water flowing into the Korle Lagoon is heavily polluted, as the primary (Odaw River), secondary and tertiary drains in the surrounding area are generally used as open sewers and disposal site for all kinds of solid and liquid waste (Figure 5-4).



Figure 5-4: Garbage in tertiary (left) and secondary (right) drains in Accra (HKV et al (2019)).

The concept of the interceptor weir was to prevent the dry weather flow of the upstream drainage system from entering the Korle Lagoon, which should have a positive influence of the quality of this water body. The dry weather flow is diverted around the Lagoon by means of a $2\text{m}^3/\text{s}$ pumping / pre-treatment station connected to a gravitational outfall pipe that discharges the wastewater in a diffused way into the ocean.

The dry weather flow of the upstream drainage system flows via the Odaw River towards the interceptor weir and the Korle Lagoon. At the interceptor weir, the flow is blocked by 20 steel flap gates (non-return valves), each installed in individual segments with a width of 3 m (Figure 5-5), which were designed to function automatically without or at least minimal human interference .



Figure 5-5: Steel non-return valves during construction of weir (circa 2006).

The gates are naturally pushed open by the hydraulic forces if the upstream water level is about 0.10 m higher than the water level in the (upper) Korle Lagoon (<http://klerp.tripod.com>). During high discharges and peak flows due to heavy rainfall the flap gates thereby enable water to pass the interceptor weir increasing the hydraulic capacity and limiting the water level increase due to the weir (back water effect). In addition, the gates prevent the (tidal) water of the Korle Lagoon from entering the river/drainage system upstream of the interceptor (and mixing with the contaminated water).

The opening of the flap gates therefore depends on the downstream water level of the Upper Korle Lagoon (which is influenced by the tide), in combination with the upstream water level (which is influenced by the discharge of the Odaw River and the heavy rainfalls). The flap gates are designed to withstand extreme high tides at the downstream side while the upstream riverbed is dry (SBE (2003)).

The interceptor weir was designed in a way that the obstruction during flood events, with discharges up to 500m³/s to 700 m³/s and reasonably high flow velocities, is reduced to a minimum (IMDC (2003)). The weir therefore should not cause a significant increase in the upstream flood levels except a small backwater effect. Regular peak flows are important for the functioning of the weir, as it flushes out the silts that have settled behind the steel flap gates (IMDC (2003)). During extreme flooding conditions water can spill over the structure if necessary (IMDC (2003)) as the water level rises above the structure.

Main function: Prevent the heavily polluted dry weather flow from entering the Korle Lagoon

Additional (functional) requirements:

- Allow high discharges and peak flows to pass through the weir;
- Minimise the flow obstruction by the interceptor weir during high discharges, so the structure does not cause a large backwater effect;
- Prevent the tidal water of the Korle Lagoon from entering the upstream channels (and get contaminated);
- The weir / environment / maintenance plan should be designed such that blockage of the weir by siltation and floating waste is prevented;
- Water spilling over the weir during extreme flood events should not harm the structure;
- No seepage of water directly underneath or along the structure..

5.2.2 Design

During the KLERP, several designs with multiple hydraulic structures were discussed before ending up at the current design of one large interceptor weir (based on technical and economical justifications). In this memo only the final design is elaborated, which schematically looks like Figure 5-6. Detailed drawings are included in Annex B.



Figure 5-6: Artist impression of the interceptor weir.

The concrete structure of the weir has a length of 77.5 m, is 8.5 m wide and has a height of 4.85 m. Because of the poor soil conditions and to prevent seepage, the structure is founded on a double row of steel sheet piles.

The weir is divided into 20 compartments, each accommodated with a steel flap gate. The flap gates have a width of 3.1 m and a height of 3.7 m. If closed, they block the dry weather flow from the upstream Odaw river, as well as the downstream tidal flow from the Korle Lagoon (Figure 5-7).

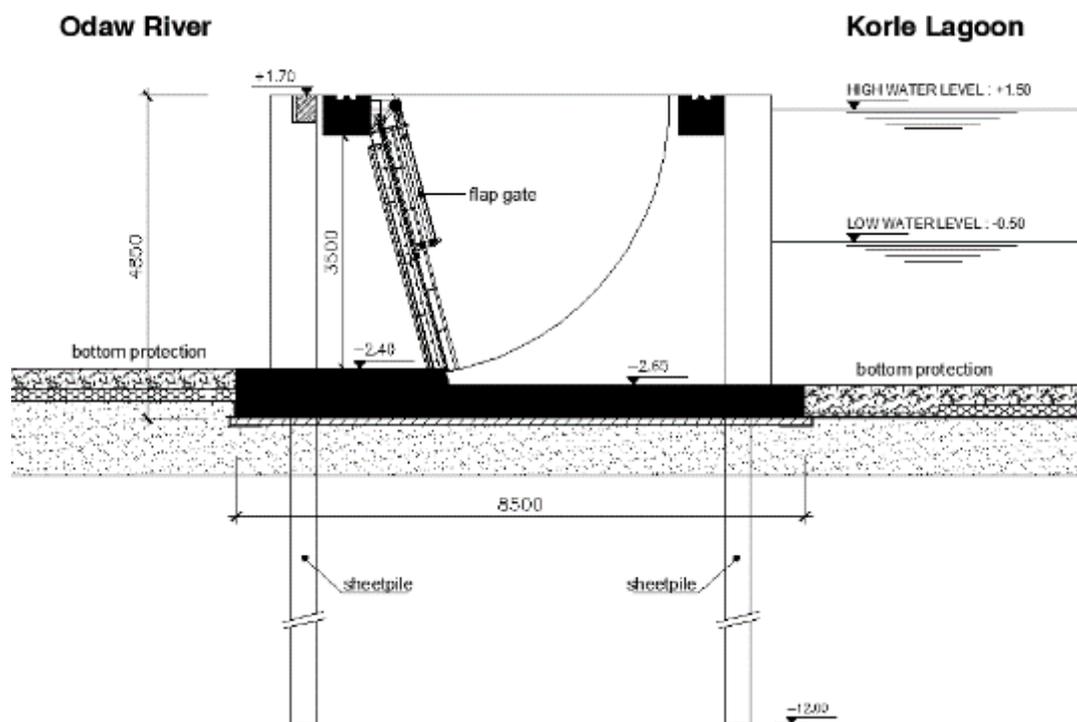


Figure 5-7: Cross-section of a steel flap gate (w.r.t. NLD).

The heights in the cross-section of Figure 5-7 are referenced to National Level Datum (NLD). NLD is equal to the tidal level Mean Lower Water Neap (MLWN) in front of the Ghanaian coast. Mean Sea Level (MSL) is at +0.34 m NLD (see Figure 5-8).

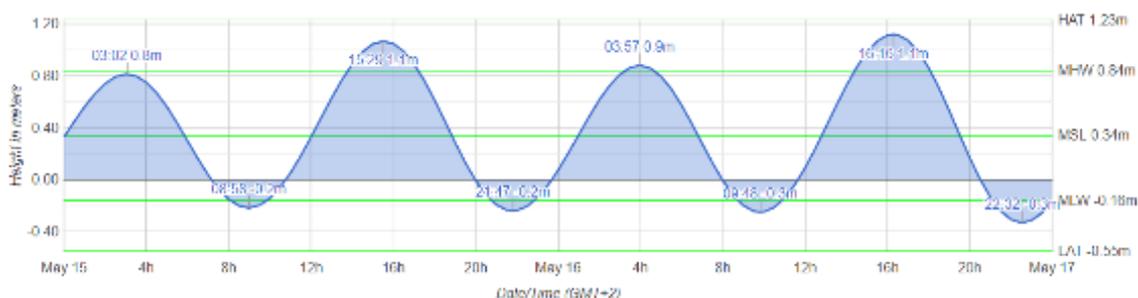


Figure 5-8: Tidal levels at Accra, Ghana with respect to MLWN (= NLD) (source: <https://www.worldtides.info/>).

During dry weather conditions, the design high water level of the Upper Korle Lagoon is taken as +1.5 m NLD. The design low water level is set to -0.5 m NLD. The exact derivations of these downstream design water levels are not found in the available reports about the KLERP. At the time, the bottom of the Korle Lagoon near the interceptor weir was dredged to a level of -2.65 m NLD. For the structural calculations, the water levels at the upstream side (Odaw River) of the weir varies between -2.4 m NLD (= bottom level / completely dry) and +1.7 m NLD.

However, during extreme conditions the structure can become fully submerged, as water levels of the Korle lagoon rise above the top of the weir (+1.70 m NLD). The exact level to which the water of the

Korle lagoon can rise is uncertain at this moment as it depends on the situation of the lagoon, the lagoon mouth and the tide. More about this is written in section 5.5.1.

To treat and redirect the dry weather flow around the Korle Lagoon into the ocean, a pumping station is installed at the upstream western side of the interceptor weir. The water is pumped by an Archimedes screw with a capacity of 2 m³/s. This type was selected because of high reliability (>95% up time) long lifetime and low maintenance requirements. The water then flows towards the ocean through a gravitational outfall pipe, the wastewater is pre-treated by 2 screens (50 mm coarse and 6 mm fine), a settling basin and an oil skimmer. In the ocean the water will be discharged in a diffused way to minimise the ecological impact. This (basic) treatment process was selected as it is the basic option with a limited operational cost.

The four centre gates are fitted with electronic limit switches. These switches are set to detect the opening of the flap gates during events of heavy rainfall. The detection will automatically stop the pump operation, as it is not appropriate to pump during high discharge conditions.

A timber (azobé) beam was placed at the upstream crest of the weir, to protect the structure from collisions with floating objects during high discharges. Furthermore, on top of the weir a rail was placed which can be used by a trolley for inspection and maintenance purposes of the flap gates. At each flap gate, a steel frame was cast in the concrete to minimise the leakage in case they are closed.

Upstream and downstream of the interceptor weir, a rock bed protection was applied to prevent scour holes developing too close to the structure. Furthermore, sheet piles were applied to close the gap between the weir and the crest of the bank at the east and west side of the structure. Flow velocities near the weir can become quite high, i.e. in SBE (2003) a maximum design velocity of 2.7 m/s was assumed for an extreme discharge between 500 m³/s to 700 m³/s. Therefore, the banks near the weir are protected against erosion by Reno mattresses or rip-rap placed on a suitable geotextile (IMDC (2003)).

A boom was installed across the Korle watercourse in an attempt to prevent unsightly floating debris passing through and/or over the weir during high flow conditions as well as to facilitate the work of removing floating material during dry weather flows (Figure 5-9).

The boom was designed to move up and down with the level of the river. Floating material is caught by the boom and either will be swept along the boom by the current or can be swept along manually by an operator with a rake or by means of the 2 long reach excavators.

The boom consisted, according to the design (IMDC (1998)), of the following equipment: boom (wooden floats, ropes and net) and two steel anchoring columns at both sides of the river. According to IMDC (2010), an 80 m long, 800 mm diameter HDPE pipe was used as the floating boom, just upstream of the interceptor. The pipe was anchored to the bottom of the river and the floating boom follows the level of the water in the river. It was repositioned during the maintenance and operation period to simplify the waste collection.



Figure 5-9: Floating boom trapping floating debris.

5.2.3 Maintenance and Operation

To achieve the goals of the KLERP, the canals, lagoon and structures should be monitored, maintained and operated. In the Maintenance and Operation Manual (IMDC (2010)) the relevant information is stated. The operation and maintenance manual describes in detail the mechanical and electrical installations, like the pump, screening plant, outfall pipe etc. It also describes how the steel flap gates can be opened or removed individually - if necessary - with the trolley mounted on the rails.

Regarding the functioning of the weir itself, it is further mentioned that siltation at both the upstream and downstream side of the gates should be monitored and removed if necessary. Siltation can cause blockage of the flap gates and a reduction of the flow capacity of (some of the) segments, resulting in increased upstream water levels (backwater effect) and therefore an increased flood risk. With regard to the upstream flood risk (open gates), leakage and pollution of the lagoon (“closed” gates), also blockage of the gates by floating rubbish shall be monitored and removed if necessary.

The aim of the floating boom was to trap the floating debris that is carried towards the interceptor weir by the Odaw river. The repositioned boom was set to direct the debris towards a platform on the western riverbank, from where the debris can be easily collected by means of a long-reach excavator. The Operation and Maintenance Manual encourages “regular removal of the trapped garbage and certainly after rainy event is necessary to ensure the efficiency of the boom”.

5.3 Timeline

5.3.1 Historical development of the project and status of the interceptor

1998: Start preparation construction works of the Korle Lagoon Ecological Restoration Project (KLERP) by IMDC (Bosch Stabbers (2018))

2000 – 2002: KLERP phase 1 (IMDC (2010)).

2003 – 2006: KLERP phase 2. In this project phase the interception weir is constructed (IMDC (2010)).



Figure 5-10: Picture during end of phase 2, construction of outfall pipe (from: presentation KLERP IMDC).

2006 – 2009: KLERP phase 3. Largest part of the remaining dredging and construction works finished. Mainly dredging of the lagoon and opening of the lagoon mouth that was silted up, to stimulate the tidal exchange and improve the ecological quality of the lagoon. Interception weir put into use.

2009 – 2010: One year maintenance and operation period by the contractor for the interceptor weir and pumping station. The project was successful as the pump station operated on a 24/7 basis and waste was removed continuously in front of the weir. Based on the findings during these 12 months period, an updated version of the Operation and Management Manual (IMDC (2010)) was provided.

October 2011: A flash flood due to heavy rainfall coincided with high tidal levels in the Upper Korle Lagoon (Bosch Stabbers (2018)).

April 2012: The need for removal of silt and waste at both sides of the interceptor is identified in the Accra Sanitary Sewer and Stormwater Drainage Alleviation Project (Conti, 2012). This is briefly elaborated in section 5.5.4.

June 2015: Severe flood due to heavy rainfall, corresponding to a 1/10 years event (HKV et al, 2018). Amongst others, the flood levels were increased because the flap gates of the interceptor weir did not open automatically as a result of siltation at the downstream side of the weir (HKV et al, 2018). After this severe flood, the flap gates were opened permanently, whereby the weir basically lost its functionality (HKV et al, 2018). According to HKV et al, 2018, the malfunctioning of the flap gates (blocked gates due to siltation and poor maintenance) together with siltation of the upstream drains, caused a water level increase of about 1.0 m at the Aboosse-Okai Bridge (located about 1.5 km upstream of the interceptor weir).

Site visit 2017: Figure 5-11 is a picture of the interceptor weir, taken during a site visit on the 19th of January 2017. From this picture it is clear that the structure already suffered severely from the lack of maintenance.



Figure 5-11: Picture site visit 19-01-2017.

Amongst others, the following can be seen:

- All gates are open (in agreement with “June 2015”);
- No rails on top of the structure for the maintenance trolley;
- No timber (Azobé) beams to protect the structure against floating objects;
- No floating boom to catch waste (already burned down before 2017?);
- Floating waste is not collected / removed at all.

April 2019: Final report “Greater Accra Flood Risk Mitigation Strategy”. In this report, several options are presented for the future of the interceptor weir, which are listed below:

- *“Keep the weir clean on a daily basis. It is noted that the weir can still cause a major obstruction during a flash flood as debris will likely block the weir, even when it is completely clean before the flood occurs.*
- *The interception weir is a location where most of the waste from the main drains in the basin ends up. A perfect place for a waste or plastic collector, including a recycling facility. A pedestrian bridge could also be considered.*
- *The most logical measure from flood safety point of view, is to remove the weir completely and prevent obstruction of flow.*
- *Fully rehabilitate the weir and pump installation, after a thorough feasibility study focussing on sustainability“(HKV et al, 2019).*

May 2019: Based on the reference group meeting the following information is known:

- According to the PIU, operational costs of the interceptor weir appear to be too high and there were no funds to maintain the pump station and keep the weir free from waste (Bosch Stabbers (2018), PIU (2019)). This resulted in a fast degradation of the structure and its functionalities. However, it should be noted that the weir operates automatically under natural forces (provided the silt is removed regularly and the floating debris as well). Only the pumping stations required a bit more maintenance and the bill for the electricity has to be paid: this was the main reason why the system was stopped only months after the contractor left the site.
- Boom to catch plastics burned down (PIU (2019))

5.3.2 Satellite images information (Google Earth)

Information extracted from Google Earth satellite images also contribute to the understanding of the historical and present situation of the KLERP and in particular the situation around the interceptor weir.

	
<p>2000: Before start KLERP.</p>	<p>2008: Canalizing and interceptor in progress.</p>
	
<p>2009: New land being occupied, some waste upstream of interceptor.</p>	<p>2014: Further occupation of lands and siltation and / or floating debris upstream of interceptor.</p>
	
<p>2015: Flooded lands unoccupied, floating waste upstream of interceptor.</p>	<p>2018: Lands re-occupied, no floating waste.</p>

5.4 Present situation: Baseline

Compared to Figure 5-11 of January 2017, the deterioration of the interceptor weir only worsened as the structure is not maintained. The flap gates are still permanently opened, although some of these steel gates seem to be subsided, broken or totally lost (Figure 5-12). The pumping station and water treatment installation is not functioning for many years and parts may be defect or missing.



Figure 5-12: Picture of current state interceptor weir. Some gates seem to be subsided, broken or lost.

The open gates are covered with waste and soil on which even some grass is growing (left Figure 5-13). Also the concrete structure is damaged at some locations (right Figure 5-13), probably as a result of collisions with floating objects or during cleaning operations by excavator.



Figure 5-13: Grass growing on open flap gates (left). Concrete structure is damaged (right).

Clearly the interceptor weir is currently not functioning as originally intended. The structure does not prevent any interaction between the upstream drainage channels and the tidal Korle Lagoon and, as mentioned in HKV *et al* (2019) as the gates are opened in present situation. In addition to this, the structure may cause a negative impact on the flood safety of the upstream areas, primarily if gates are blocked or flow is obstructed due to floating debris that is retained and / or siltation of the bed.

In Figure 5-12 and Figure 5-14, people are walking over the interceptor weir. The structure therefore does seem to fulfil a function as pedestrian connection between the western and eastern bank of the Odaw River / Korle Lagoon. Next to the interceptor, local sedimentation is observed. Furthermore, it clearly blocks a lot of floating waste which is in fact good because this was one of the main goals of the KLERP system: to reduce the contamination in the lagoon area. However, the floating boom was initially intended to stop the floating waste and to remove it before arriving at the interceptor.



Figure 5-14: The structure blocks a lot of floating waste and is used by pedestrians.

5.5 Technical assessments

In this chapter a number of assessments are performed to investigate the behaviour of the interceptor weir and the surrounding drainage/lagoon system.

5.5.1 Earlier hydraulic studies concerning the interceptor weir

As part of the design process for the KLERP, a hydraulic study was performed which is described in section 7 of IMDC (1998). In this study, the initial design of the interceptor weir was included with a fixed crest. Later in the process the weir has been designed and built as a flap gate structure. However, the original study does provide information about several important characteristics of the drainage/lagoon system. In 2019, a new hydraulic study was performed to investigate new strategies to mitigate the flood risk of Accra, in particular around the Odaw drainage system. This study is described in HKV *et al* (2019). In this section, these studies are used to investigate the behaviour of the hydraulic system around the interceptor weir.

Extreme conditions

For the interceptor weir, extreme conditions are events with heavy rainfall and high discharges that are expected to occur once every 10, 25, 50 or even 100 years. The longer the return period, the more “extreme” (or severe) the event will be.

In the study of IMDC 1998, two extreme conditions were taken into account. An event with a return period of 25 years, for which a discharge of 368 m³/s was assumed, and an event with a return period of 50 years, for which a discharge of 446 m³/s was assumed. These numbers are relatively low

compared to the discharges mentioned in later design reports and studies. For example, in IMDC (2010) it is stated that the weir is designed based on extreme discharges of 500 m³/s to 700 m³/s. Differences may have been caused by fact that in the initial design several weirs were planned more upstream and due to the changing situation, such as increased rainfall and significant growth / urbanisation of Accra resulting in higher run-off and higher discharges.

In the study of **HKV et al 2019**, an extreme discharge of 600 m³/s is mentioned for an event with a return period of 10 years. In the model, this discharge is representative for a location more upstream of the interceptor weir. The discharge at the interceptor weir therefore might be even larger, but for now a discharge of 600 m³/s is considered representative at the location of the interceptor weir as well.

In general, the discharge at the interceptor weir may have increased over time, amongst others due to the following reasons:

- Fast growth of Accra. Therefore, fast growth of paved and built-up areas, which results in higher run-off and higher peak discharges.
- Increased rainfall intensities.

Lagoon's water level during extreme conditions

During dry weather conditions, the water level in the Korle lagoon is mainly influenced by the tide. For these conditions, the design high water level downstream of the interceptor is shown as +1.50 m NLD in the “as-built” drawings of the interceptor weir (Annex B), and the design low water level is shown as -0.50 m NLD.

As stated earlier, the water level in the Korle lagoon can rise to much higher levels during periods of heavy rainfall and large discharges (extreme conditions) of the Odaw. Moreover, the lagoon's water levels can increase over time due to siltation of the lagoon and especially its outlet towards the ocean.

The exact water level of the Korle lagoon during extreme conditions is unknown, but the order of magnitude can be derived from IMDC (1998) and HKV et al (2019). The hydraulic study of **IMDC 1998** mentions lagoon water levels of +2.47 m NLD (1/25 years) and + 2.75 m NLD (1/50 years) during extreme conditions before the KLERP was executed. After relining the Odaw river, these water levels are expected to increase to +2.58 m NLD and +2.78 m NLD respectively. Due to dredging measures of the KLERP, these extreme water levels can be lowered towards +2.13 m NLD and +2.35 m NLD. In case in addition the lagoon's outlet is re-dredged towards the second dredging campaign of KLERP to a depth of -4.0 m NLD, then the extreme water levels could be decreased to +1.43 m NLD (1/25 years) and +1.52 m NLD (1/50 years), according to the model (IMDC (1998)).

The hydraulic study of **HKV 2019** mentions lagoon water levels during extreme conditions of +2.75 m NLD for a “baseline situation” in which the drainage channels and weir structure are maintained as originally intended. Without maintenance (referred to as “situation flood June 2015”), the water level just downstream of the weir is increased towards +3.60 m NLD, mainly because the lagoon's outlet towards the ocean is not maintained properly.

Backwater effect of interceptor weir

The backwater effect means an increase of the upstream water levels due to an obstruction in the flow (decrease of the flow area). It is therefore expected that the interceptor weir will cause a certain backwater effect, especially if (some) gates are closed. During dry weather conditions this is not problematic, as the upstream water levels will still be lower than the those during events with heavy rain and high discharges. However, during extreme conditions like the situation of June 2015 (when the weir had not been maintained for a significant period of time), a backwater effect of a few decimetres can make a large difference in the area that is flooded.

In the hydraulic study of **IMDC 1998** several alternatives for the interceptor weir were assessed briefly, however these were all fixed weirs (no flap gates) at different locations than the weir that is finally built. An order of magnitude for the backwater effect of these weirs can be derived from the Table 5-1.

Table 5-1: Water levels for alternative weirs at different locations (IMDC (1998)).

	no weir	weir 1,4 x 60	weir 1,1 x 80	weir 1,1 x 80	weir 1,4 x 60	bank level
Weir position wrt bridge	-	upstream	upstream	downstream	downstream	after relining
3125	2.64	3.27	2.90	2.76	3.36	2.94

From this table it can be derived that the backwater effect of these weirs is in the order of 0.12 m to 0.72 m depending on the dimensions and location of the weir.

In the hydraulic study of **HKV 2019** the effect of some flood mitigation measures are assessed with a numerical model of the Odaw drainage system and the Korle lagoon. In this model, the backwater effect of for example the Korle lagoon’s outlet towards the ocean is clearly visible (see Figure 5-15). However, although in the text of HKV *et al* (2019) it is stated that the difference between maintenance (baseline) or no maintenance (flood June 2015) of the interceptor weir is included in the model, this is not (directly) visible in the graphs of the modelled results. For both situations, the backwater effect seems in the order of 0.10 m to 0.15 m. These values are expected to be too low in case the weir is partly blocked. Therefore, the order of magnitude of the expected backwater effect is calculated in the next section.

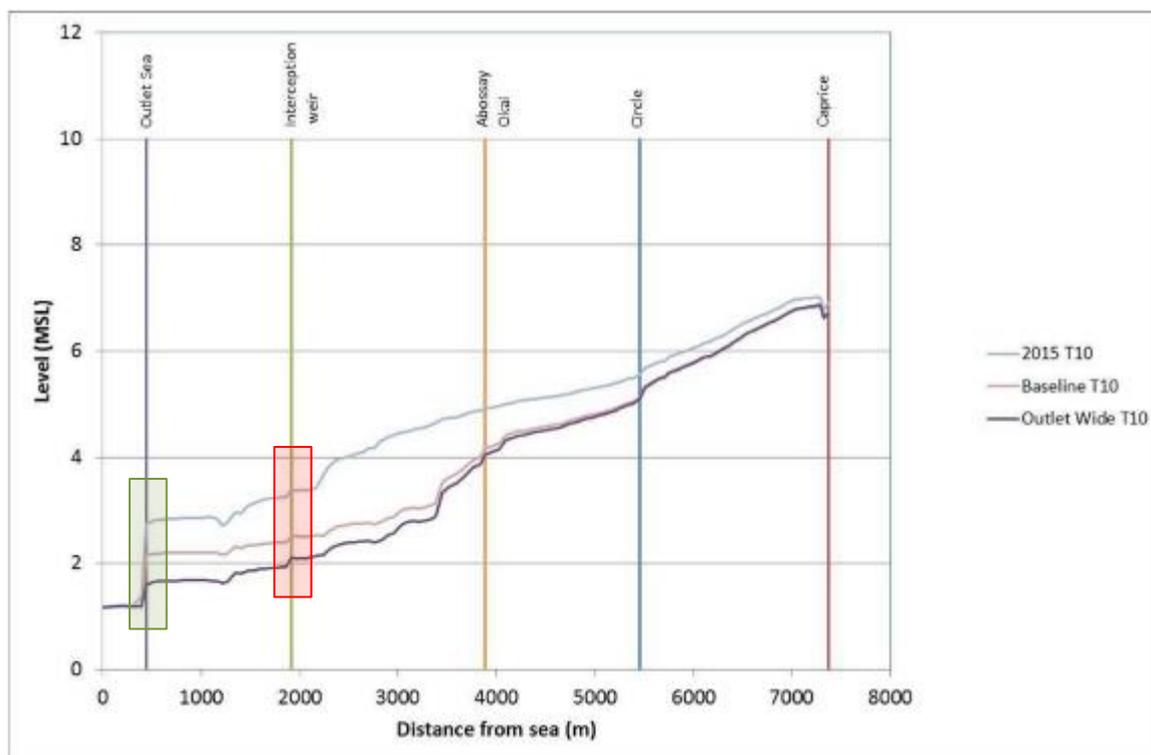


Figure 5-15: One of the modelled results of HKV 2019 (HKV *et al* (2019))
 In green the backwater effect of the outlet towards the ocean for different scenarios
 In red the backwater effect of the interceptor weir for different scenarios.

Outlet Korle lagoon towards the ocean

In both hydraulic studies, the outlet of the Korle lagoon towards the ocean is mentioned as an important bottleneck, on which the upstream water levels (especially of the lagoon itself) are very dependent. As especially stressed in the next section, the lagoon’s water level is directly influencing

the functioning of the interceptor weir and backwater effect it may cause. For relatively low water levels of the lagoon, most of the water will flow through the gates of the interceptor weir during high discharges. For relatively high water levels, part of the discharge will flow over the weir. The future situation of the outlet towards the ocean should therefore be taken into account, when assessing the future situation of the interceptor weir.

According to the model used in the hydraulic study of **IMDC (1998)**, the extreme water levels could be lowered to +1.43 m NLD (1/25 years) and +1.52 m NLD (1/50 years) in case the lagoon's outlet is dredged towards a depth of -4.0 m NLD.

According to the model used in the hydraulic study of **HKV 2019**, the water level at the outlet reached towards a height of +3.10 m NLD during the 2015 flood. In case the outlet would have been maintained as originally intended, this water level was about +2.50 m NLD. In the situation the outlet will be widened in the future, the water level during extreme conditions may drop towards +1.95 m NLD. These numbers are all derived from Figure 5-15.

5.5.2 Opening of the gate

As part of the design, it was intended that the flap gates will open automatically by the hydraulic pressure in case the upstream water level is 0.10 m higher than the downstream water level (IMDC (2010)). A quick check based on the hydrostatic pressures, is carried out below to verify this.

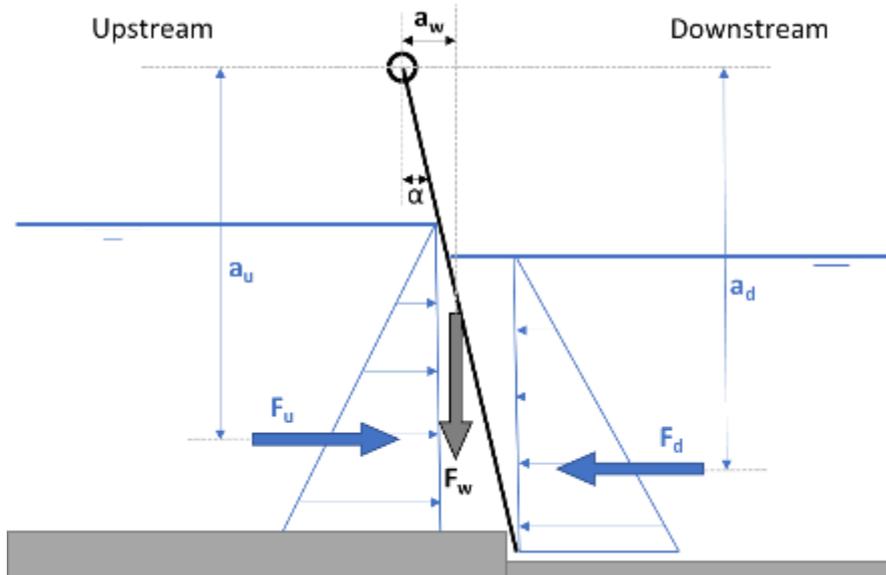


Figure 5-16: Balance of moments around the hinge of the flap gates.

For this assessment, the gate weight is assumed similar to a steel plate with a thickness t_s of 2 cm. The downstream water level is assumed equal to MSL and the upstream water level is 0.10 m higher. The bottom is assumed horizontal at a level of -2.40 m NLD on both sides. The upstream water depth d_u therefore will be 2.85 m. The hinge is located at +1.70m NLD, which is equal to +1.35m MSL. The rotational friction of the hinge itself is neglected. If the balance of moments is larger than 0, the gate will open provided that the rotation of friction is not too large.

$$\Sigma M_{hinge} = +F_u a_u - F_d a_d - F_w a_w$$

- $F_u = \frac{1}{2} \rho g d_u^2 = \frac{1}{2} * 9.81 * 1000 * 2.85^2 \approx 39841 \text{ N}$
- $a_u = \frac{2}{3} d_u + (4.10 - d_u) = \frac{2}{3} * 2.85 + (4.10 - 2.85) = 3.15 \text{ m}$
- $F_d = \frac{1}{2} \rho g d_d^2 = \frac{1}{2} * 9.81 * 1000 * 2.75^2 \approx 37094 \text{ N}$
- $a_d = \frac{2}{3} d_d + (4.10 - d_d) = \frac{2}{3} * 2.75 + (4.10 - 2.75) = 3.18 \text{ m}$
- $F_w = l * w * t_s * (\rho_s - \rho_w) * g = 3.5 * 3.0 * 0.02 * (7850 - 1000) * 9.81 \approx 14112 \text{ N}$
- $a_w = \sin(\alpha) * \frac{1}{2} l = \sin(15^\circ) * \frac{1}{2} * 3.5 \approx 0.45 \text{ m}$

$$\Sigma M_{hinge} = +F_u a_u - F_d a_d - F_w a_w \approx +1.02 \text{ kNm} > 0$$

In reality, hydrodynamic forces will also “help” to push the steel gate open. On the other hand, the rotational friction of the hinge will cause extra resistance, but this is expected to be less than the hydrodynamic forces.

From this assessment, it can be concluded that it is plausible that the steel flap gates are pushed open if the upstream water level is 0.10 m higher than the downstream water level. However, it is not ruled out that the level difference needs to be larger, as the current calculation is an indicative

estimate only. In case the head difference needs to be larger to push the gates open, the backwater effect will be larger as well.

Moreover, if the gate is pushed open, the arm of the weight towards the hinge will increase. In case a similar calculation is performed with an increased angle $\alpha = 25^\circ$, this results in $M_{\text{hinge}} = -3.02 \text{ kNm}$. This shows that if the gates is pushed open for a water level difference of 0.10 m, it might only be for a small bit.

It makes sense that the limits between opening and closure of the gates are small in case the upstream water level is only 0.10 m higher than at downstream side of the gate. However, this also shows why this equilibrium is very sensitive to forces that are not taken into account, as for example the additional resistance caused by accumulated sand behind the gate.

5.5.3 Calculated backwater effect during extreme conditions

An increased flood level of a few decimetres can make a large difference in the area that is flooded during an extreme event with heavy rainfall and high discharges. In this section the order of magnitude of the backwater effect is calculated that can be expected during extreme conditions. The backwater effect is determined for two states of the weir:

1. Current state: All gates fully open (or absent).
2. Weir not functioning properly: Gates partly open (gates half open or half of the gates fully open and half of the gates fully closed).

Remaining assumptions are listed below based on several sources as indicated in the reference list.

- Extreme discharge $Q = 600 \text{ m}^3/\text{s}$ (return period $T = 10$ years);
- Increased bed level due to siltation is not taken into account;
- Flow contraction is not taken into account;
- Water levels Korle lagoon during extreme conditions: +2.0 m NLD, + 2.5 m NLD, + 3.0 m NLD;
- The flow area is based on the cross-section of Figure 5-17.



Figure 5-17: Cross-section of the weir.

The following aspects shall be realised regarding the cross-section of Figure 5-17:

1. Even if all gates are fully opened, the weir structure (concrete pillars, top beam, sheet piles at the both sides) occupies a considerable part of the total cross-section, especially with relatively low water levels in the lagoon. However, it shall also be taken into account that at the weir location, the section was widened compared to further upstream. The upstream profile is about 60 m wide around MSL. Compared to that upstream profile, the 20 openings of 3 m wide are in same order, but the concrete beam and the head loss to open the gate can cause a backwater effect. To overcome this effect, the lagoon was widened at the weir location before the construction. It can be imagined that in case (some) gates are closed, the blocked part of the total cross-section will be larger, which causes a larger backwater effect.
2. For all assessed water levels during extreme conditions, the weir is fully submerged. This means that water does not only flow through the structure, but also over it. Higher water levels and/or more closed flap gates means relatively more water is flowing over the weir instead of through the gates.

- In case the calculated water level is higher than +3.0 m NLD, the cross-sectional area is expected to increase significantly (flooding), based on Figure 5-17. However, in reality there may be obstructions on the land side. Therefore, the calculated backwater effect for these cases is based on the assumption of continuous slopes. In reality the calculated backwater effect may therefore be somewhat less.

The backwater effect is calculated based on a one-dimensional situation (Figure 5-18) in which the percentage of the blocked cross-section is chosen similar to the percentage blocked in the two-dimensional cross-section of Figure 5-17. In this assessment of the backwater effect, it makes no difference if the water is flowing through or over the structure.

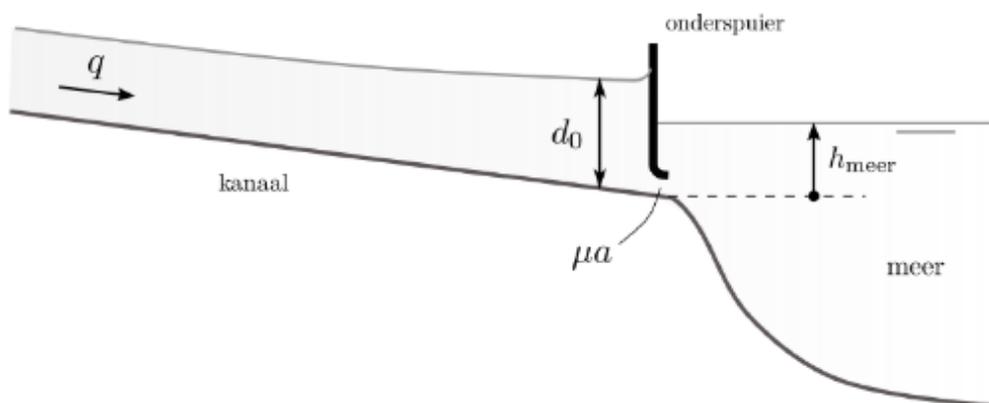


Figure 5-18: one-dimensional backwater calculation.

In Table 5-2, the results are shown for the situation in which all flap gates of the interceptor weir are all fully opened (current situation). According to the information and previous analysis, the flap gates open with a difference of 10 cm to a certain extent (angle). It is likely that the difference will need to increase further to open the flap gates further.

Table 5-2: Gates fully opened.

Water level Korle lagoon [m +NLD]	Total potential flow area [m ²]	Flow area over weir [m ²]	Flow area through weir [m ²]	Area blocked by the weir [%]	Upstream water level [m +NLD]	Backwater effect [m]
2.0	447	29 (6.5%)	210 (47%)	47	+2.50	0.50
2.5	506	77 (15.5%)	210 (41.5%)	43	+2.85	0.35
3.0	566	127 (22.5%)	210 (37%)	40.5	+3.25	0.25

These calculations show that even in case all gates are opened, the interceptor weir causes a backwater effect in the order of 0.25 m to 0.50 m, depending on the downstream water level in the Korle Lagoon. However, it should be noted that these are indicative calculations not fully taking into account all aspects. Based on all considerations, a backwater effect of 0.20 m to 0.35 m is deemed to be a realistic value (the lower the Lagoon level, the larger the impact of the weir).

In case some gates are closed (as noted for the 2015-flood), this backwater effect will be even larger. The results for these calculations are shown in Table 5-3.

Table 5-3: Gates half open, or half of the gates fully opened and half of the gates fully closed.

Water level Korle lagoon [m +NLD]	Total potential flow area [m ²]	Flow area over weir [m ²]	Flow area through weir [m ²]	Area blocked by the weir [%]	Upstream water level [m +NLD]	Backwater effect [m]
2.0	447	29 (6.5%)	105 (23.5%)	70	+2.95	0.95

Water level Korle lagoon [m +NLD]	Total potential flow area [m ²]	Flow area over weir [m ²]	Flow area through weir [m ²]	Area blocked by the weir [%]	Upstream water level [m +NLD]	Backwater effect [m]
2.5	506	77 (15.5%)	105 (21%)	64	+3.10	0.60
3.0	566	127 (22.5%)	105 (18.5%)	59	+3.30	0.30

The results of this calculation clearly show that the backwater effect can be significant in case (some) gates are malfunctioning, especially for low water levels of the Korle lagoon when the discharge goes through the flap gates. In case higher water levels during extreme conditions, the part of the discharge over the weir (over the crest) increases and therefore malfunctioning of the gates has less impact on the backwater effect.

As mentioned before, it should be noted that these are indicative calculations not fully taking into account all aspects. Based on all considerations, a backwater effect of 0.25 m to 0.50 m is deemed to be a realistic value (the lower the Lagoon level, the larger the impact of the weir).

5.5.4 Sedimentation (at the interceptor weir)

HOLD - Part of D3, due 16 December 2019

5.6 Future Options Interceptor

5.6.1 Introduction

Based upon the (original) intended function, the present situation / condition of the interceptor and the present overall situation of the project, the potential future options can be determined.

For this determination of future options, it is important to consider the following questions:

- How has the interceptor functioned during the last 10 years?
- What are the reasons for this functioning as observed?
- Was the interceptor successful for improvement of the eco system in the lagoon?
- Is there an intention to start the dry weather flow pumping and treatment again in relation to the water quality and eco system of the lagoon?
- Are the (design) conditions still similar as used originally or could these, meanwhile, be significantly different? For example, peak discharges of the river at the location of the interceptor and water levels in the lagoon influenced by the outlet?
- How significant is the potential water level increase due to the interceptor (in case of blockage) compared to other 'bottlenecks' like the lagoon outlet or bridges?
- Has the bed level at the location of the interceptor be maintained (dredged) at the original level of -2.40 m NLD to ensure sufficient hydraulic discharge capacity? Or could the bed level be increased to higher levels, assuming that the interceptor gates are removed?
- Can the interceptor be used for other purposes?

The answer to question d) is most relevant. If there is no intention to pump, then the interceptor does not need to stop the dry weather flow and the flap gates do not need to close. However, if there is an intention to use the pump and water treatment, then the dry weather flow from upstream shall be

blocked and tidal inflow from downstream as well for which the flap gates shall be functioning, or other solutions be determined.

As per the Final report “Greater Accra Flood Risk Mitigation Strategy” (April 2019) several options were presented for the future of the interceptor weir, which are listed below:

- *“Keep the weir clean on a daily basis. It is noted that the weir can still cause a major obstruction during a flash flood as debris will block the weir, even when it is clean.*
- *The interception weir is a location where most of the waste from the main drains in the basin ends up. A perfect place for a waste or plastic collector, including a recycling facility. A pedestrian bridge could also be considered.*
- *The most logical measure from flood safety point of view, is to remove the weir completely and prevent obstruction of flow.*
- *Fully rehabilitate the weir and pump installation, after a thorough feasibility study focussing on sustainability (HKV et al (2019))”.*

As per Inception Report, the following potential options will be checked:

- Continued cleaning and functioning of the flap-gates as intended;
- Combining with a new bridge deck as additional connection over the lagoon and to ensure maintenance (cleaning) and opening of gates during flood;
- Re-design of weir in relation to dredging (removal, part of the weir passable for dredging equipment, controllable gates instead of flap gates to influence water level upstream, etc.).

One of the scenarios will be the re-design of the cleaning system to capture plastic. Based on the first evaluation of the initial design and the history of the operation and maintenance, it is observed that the design was focussed on keeping the inflow of the Archimedes screw pump free of waste. This was successful, but at the same time, caused a problem of large areas of floating waste collecting in front of the floating boom. In later years, when the floating boom was not functioning, the waste flow directly into the structure, blocking the gates and / or still passing into the lagoon.

5.6.2 Basic options

The basic options are presented in the table below.

	Rehabilitate pumping station, treatment and outfall	Bed level dredging	Remove weir	Remove gates	Adjust structure	Use for waste / plastic collection
Without pumping	No	Optional	Optional	Optional	Optional	Optional
With pumping	Yes	Yes	No	No	Optional	Optional

6 Task 6: Institutional analysis

Task 6 provides an answer to: which institutions are involved in the maintenance works

Institutions refer to cultural values, legal frameworks, market mechanisms and political processes. The task will help us think critically about how different aspects of institutions influence project preparation and implementation. It is important to note that there are no other ‘widely accepted’ tools for analysing institutions despite the fact that the concept of institution is so important to project development.

The goal of the institutional analysis is to analyse the potential institutional set ups for the project to be implemented. This analysis aims to ensure that:

- The existing capacity and technical framework of the institutions is adequate for the project’s successful implementation;
- The institutional arrangements are effective and sustainable for the operation and maintenance of the project’s facilities;
- The institutions’ monitoring and key performance indicators are measurable.

The institutional analysis describes and scrutinizes the institutional set-up for the Stakeholders involved in dredging and maintenance works of the Odaw Drainage Basin. The analysis also identified the major structural variables present in all institutional arrangements and how the values differ from one type to the other. It aims to ensure that the proposed PPP/PBC management system is:

- institutionally sound and adequate capacity exists for a successful implementation;
- the institutional arrangements are effective and sustainable for the operations and maintenance of the project.

To ensure a successful project planning and implementation of PPP/PBC, this task focused on the suitable institutional and project/contract management arrangements. These arrangements need to provide for :

- ease of project preparation by all relevant Stakeholders and authorities;
- a strong contract management framework and monitoring system during the implementation of the project;
- an assurance that the implementing agencies are set up to effectively discharge their responsibilities for the implementation of the components for which they are responsible;
- a clear definition of the implementing agencies’ responsibilities and their relationship with other agencies and entities involved in project implementation;
- an efficient future operation and management of the project facilities to ensure sustainability in terms of finance and service provision;
- capacity building based on the specific features of the project and recognition of the to-be-newly-established PPP/PBC.

6.1 Identification of the institutions

The following institutions have been identified as the key ones relevant to the dredging, drainage and maintenance works:

- Ministry of Works and Housing
- Ministry of Sanitation and Water Resources

- Accra Metropolitan Assembly
- Environmental Protection Agency
- Hydrological Services Department
- Public Investment Division (PPP Unit)
- Public Procurement Authority

The institutions are divided into 3 types, each with their specific relation in the planning and execution of the drainage maintenance works:

- Contracting Authorities;
- Implementing entities;
- Auxiliary Agencies.

The institutions have been further grouped into primary and secondary, depending on their influence on the stages of project planning, implementation and support (Table 6-1).

Table 6-1: Key institutions relevant for the dredging and maintenance activities

Type	Institutions	Group	Mandate
CONTRACTING AUTHORITIES	Ministry of Works and Housing, MWH	PRIMARY	This Ministry has its main function as the central management agency responsible for initiating and formulating policies for the Works and Housing sector.
	Ministry of Sanitation and Water Resources, MSWR		This Ministry is responsible for policy formation and direction for waste management implementation and sustainability.
IMPLEMENTING ENTITIES	Hydrological Services Department, HSD	SECONDARY	HSD is an autonomous body under the MWH, responsible for the programming and coordination of construction of drainage and maintenance and monitoring of water bodies in respect of floods.
	Accra Metropolitan Assembly, AMA		AMA is also responsible for the formulation and execution of plans, programmes and strategies for the effective mobilisation of the resources necessary for the overall development of the district.
	Environmental Protection Agency, EPA		The EPA is dedicated to improving and promoting the environment and striving for environmentally sustainable development. It oversees the implementation of the National Environment Policy.
AUXILIARY AGENCIES	Public Procurement Authority, PPA		The PPA is the regulatory body responsible for the effective implementation of the Public Procurement Law. PPA also make proposals for the formation of policies on procurement.
	Public Investment Division (PPP Unit)		Their role is to serve as the PPP Advisory Unit to support and build the capacity of the relevant Ministries, Department and MMDCEs in the development and management of prospective PPP transactions.

6.2 Institutional assessment

In order to assess and analyse the policies and governance issues of the various institutions, the Water Governance Centre’s three-layer model was adopted as the framework for this task. The core element of this approach is that good water management comprises three layers (Table 6-2):

- a content layer;
- an institutional layer;
- a relational layer.

First, the “**content**” layer looks into the substance of adaptation policies. Through this layer, adaptation policies are characterized by their degree. In addition, the content layer assesses the available expertise and skills needed to develop relevant adaptation policies in a governance context.

Second, the “**institutional**” layer deals with the organizational aspects that support the effective implementation of designed adaptation policies. In the three-layer framework (TLF), good institutional capacities entail clear and legally anchored divisions of responsibility, strong legal and administrative capacities (which, for example, includes workforce, management and supervisory qualities, implementing capacities, monitoring capacities) and a robust financing structure.

In the third “**relational**” layer, the TLF makes a distinction between culture and ethics, communication and cooperation and participation in this regard. Important elements of this layer are communication and cooperation between different actors (i.a. MWH, MSWR, the Environmental Protection Agency (EPA), AMA, Hydrological Services Department (HSD), Water Resources Commission, Mineral Commission and other relevant local authorities) and with the public, stakeholder participation, transparency and trust.

Table 6-2: The three-layer model of water governance with related example questions.

Three-layer model		Example Layer/Question
CONTENT Layer	Clear policy	Is there a clear policy and planning for the project in your region/institute?
	Information (Basic data and information)	Is there sufficient and relevant information available?
	Knowledge and skills (Knowledge of the water systems and of the nature of the problems; Experience and skills to be able to solve the problems)	Are the necessary knowledge and skills available?
INSTITUTIONAL layer	Organization (Organizational framework)	Are the roles and responsibilities clear?
	Legislation → Administration resources (Legal instruments and other tools)	Are the necessary tools available?
	Financing (Financing structure)	Is functioning of the financing system ensured?
RELATIONAL Layer	Communication and cooperation (Communication and cooperation between different actors and with the public)	Is the project policy well connected with other policy fields (e.g. spatial planning)?
	Participation (Stakeholder participation)	Are all stakeholders involved in decision making for water management?
	Culture, ethics (Transparency and trust, ...)	Is there transparency in project management?
		Is there enough confidence to work together?

In assessing the institutions, intake interviews were conducted together with expert consultation with key staff of the various institutions. This approach was to get an intuitive and a broader understanding on the set up of the institutions. This method was backed up by a desk study into their mandates and the roles/responsibilities of the institutions in the area of drainage maintenance works. An overview of these intake interviews in relation to the three-layer model is presented in Table 6-3 and a more detailed assessment is provided in the following sub-sections, which is based on the framework of action, association, meaning and association, and about how they interact and often reinforce each other.

Table 6-3: Overview of institutions in relation to the three-layer model.

THREE LAYER MODEL		LAYER/QUESTION	STATUS
CONTENT	Clear policy	<i>Is there a clear policy and planning for the project in your region/institute?</i>	Each institution has a policy framework with which they are expected to implement and manage drainage maintenance works and waste management.
	Information (Basic data and information)	<i>Is there sufficient and relevant information available?</i>	Information is believed to be available but assessing the information is always the issue. Challenge here is the information appears to be in the wrong places.
	Knowledge and skills (Knowledge of the water systems and of the nature of the problems; Experience and skills to be able to solve the problems)	<i>Are the necessary knowledge and skills available?</i>	There is knowledge and skills available to an extent. At least for the fundamental execution of the respective mandates. However, the use of innovative and technological approach to work is lacking due to lack of in-service/on-the job training.
INSTITUTIONAL	Organization (Organizational framework)	<i>Are the roles and responsibilities clear?</i>	There appears to be conflicting or overlapping roles for the various institutions involved in planning and implementation of drainage maintenance works. There are also gaps in the roles of the different institutions
	Legislation → Administration resources (Legal instruments and other tools)	<i>Are the necessary tools available?</i>	There is more room for improvement here. Some key Entities will need legislative backing to strengthen their structure. Example is the passing of the PPP Law to institute the PID (PPP Unit) and the legal instrument to make HSD an Authority to enforce their rules and regulations.
	Financing (Financing structure)	<i>Is functioning of the financing system ensured?</i>	No institution appears to have adequate and regular funding for the continuous maintenance of the drains. This one major bottlenecks for the implementation of all nicely crafted policy statement and directions.

THREE LAYER MODEL		LAYER/QUESTION	STATUS
RELATIONAL	Communication and cooperation (Communication and cooperation between different actors and with the public)	<i>Is the project policy well connected with other policy fields (e.g. spatial planning)?</i>	<p>Communication is One key element that is lacking. Knowing that all these institutions are interrelated in various ways. In addition, not all institutions are aware of what other institutions are planning or executing.</p> <p>Example: Spatial Planning is overwhelmed by activities of squatters and unapproved settlers within the corridors of the waterway. This is a massive drawback for policy plans for Drainage maintenance works and waste management.</p>
	Participation (Stakeholder participation)	<i>Are all stakeholders involved in decision making for water management?</i>	Various institutions are concerned with different aspects. There is however no comprehensive coordination of all relevant institutions in the decision making process in the management of the drainage basins.
	Culture, ethics (Transparency and trust, ...)	<i>Is there transparency in project management?</i>	There is limited information on the project management and administration
		<i>Is there enough confidence to work together?</i>	<p>There is the need for proper and well-defined structure to identify the specific role for each institution.</p> <p>Most institutions appear to work in isolation and the lack of training is a contributing factor.</p>

6.2.1 Ministry of Works and Housing (MWH)

Meaning

This ministry as a Contracting Authority exist to formulate, monitor and evaluate the implementation of policies, plans and programmes for the sustainable management of drainage and coastal protection, operational hydrology by using technical expertise and innovative methods.

Control

MWH has the mandate to ensure that projects are identified, planned and implemented well, to ensure that drains are well maintained and water bodies well protected. As a ministry of works, their policy direction should be geared towards controlling how projects are scoped, constituted and managed to get the desired results.

Association

As a contracting authority, the ministry is the central hub to harmonize coordination and proper stakeholder engagement with subsidiaries, agencies and other implementing agencies who have specific roles on implementation and management. The ministry is expected to coordinate with the Hydrological Services Department, Municipal District Assemblies (MDA's), Ministry of Sanitation and Water Resources and Environmental Protection Agency and Public Procurement Authority from Project Planning to Completion.

Action

MWH is expected to make inputs in the contract management framework as a contracting authority. In the areas of monitoring and evaluation, the ministry is expected to be the main backstopping stakeholder in the vetting and verify work done before approval is given for payment. The ministry's action is to ensure that there is a smooth running of the projects. Their action is to ensure that all players are functioning.

6.2.2 Ministry of Sanitation and Water Resources (MSWR)

Meaning

The Ministry as a Contracting Authority has the goal to improve the sanitation conditions of drains through hygienic and environmentally accepted standards of waste management and its sustainability. They are also responsible for the disposal of waste material and creation of waste disposal sites.

Control

MSWR main role is to formulate policies and direction for waste management and the enforcement of the policies' implementation. Their mandate cuts across the provision of a drainage sanitation framework and direction to ensure waste management of all drains and disposal sites.

Association

Implementation of sanitation policy is done by the Municipal District Assemblies such as Accra Metropolitan Assembly for the Odaw Drainage Basin. The ministry also collaborate with the Environmental Protection Agency in ensuring that the environment is protected from the waste management interventions and that waste management systems impact on the environment and aquatic life. MSWR also works with the Water Resources Commission.

Action

It is expected of the ministry to provide an administrative and management guide to waste management projects and implementation ideologies to ensure that it follows the Environmental Sanitation Policy. As the ministry is tasked to ensure drainage sanitation, their action point is to enforce implementation and monitoring of the projects smooth running and management.

6.2.3 Hydrological Services Department (HSD)

Meaning

The main implementing entity responsible for the planning and implementation of drainage and coastal protection projects. Under the National Flood Control Programme, HSD is expected to maintain all primary and key secondary drains.

Control

HSD has the mandate to ensure that all primary and key secondary drains are maintained and functioning properly. HSD is expected to make inputs into prioritizing drainage maintenance works by keeping a database of all primary and key secondary drains. HSD should be the technical expert in project identification and scoping to feed the ministry to package. They are also currently responsible for managing the dredging contract of Odaw River and Korle Lagoon.

Association

As an autonomous body under the Ministry of Works and Housing, HSD works together in close coordination with the Ministry's Works Department in the execution of their mandate. HSD is expected to also work with the MDA's who are mandated to work on most of the secondary and all tertiary drains. Since the secondary drains feed into the primary, it is preferable to collaborate with the Accra Metropolitan Assembly's Drainage Maintenance Unit.

Action

HSD is the main entity tasked with the day-to-day monitoring of the drainage maintenance works. It is expected that they initiate to closely monitor and evaluate the performance of Contractors engaged to undertake drainage maintenance works. With their technical expertise, they are expected to manage frameworks and strategies in the project implementation and execution.

6.2.4 Accra Metropolitan Assembly (AMA)

Meaning

Accra Metropolitan Assembly is the political and administrative authority for the City of Accra. They are responsible for the overall development of the District. AMA is also responsible for the formulation and execution of plans, programmes and strategies for the effective mobilisation of the resources necessary for the overall development of the district.

Control

AMA is mandated to implement projects with regard to sanitation, waste management and the maintenance of most secondary and tertiary drains. The Assembly has a Drainage Maintenance Unit who is the implementing entity in the drainage maintenance whereas the waste management department is responsible for environmental sanitation.

Association

The AMA is expected to work together with the Ministry of Sanitation and Water Resources who is the environmental sanitation policy formulator. The AMA and EPA must work together well on issues of environmental sanitation and environmental protection respectively. The AMA Drainage Maintenance should be in constant cooperation with HSD to also see how they can best engage on the maintenance of primary and secondary drains.

Action

The Drainage Maintenance Unit, just as HSD, has the oversight and monitoring action on the implementation of drainage maintenance works for the secondary and tertiary drains. The Waste Management is also responsible for engineering strategies for waste collection and disposal. They are expected encourage the public to not dump waste into drains.

6.2.5 Environmental Protection Agency (EPA)

Meaning

The Environmental Protection Agency is a subsidiary of the Ministry of Environment, Science Technology and Innovation. The agency is dedicated to improving and promoting the environment and striving for environmentally sustainable development. It oversees the implementation of the National Environment Policy.

Control

The Environmental Protection Agency is responsible for the assessment of the dredged material and its impacts on the Public and Aquatic Life. Also maintaining water bodies is part of their jurisdiction. EPA policy states that an Environmental Assessment Permit must be obtained before dredging works start. Law clarifies that before the permit is given an Environmental Impact Assessment must be conducted.

Association

The EPA is expected to work closely with the MSWR and MDA's in finding an environmentally conducive final dumpsite for sediment from drainage maintenance works. EPA must also be in close contact with the Contractors on dredging and drainage maintenance to ensure that their work methodologies and practices does not breach the environmental impact assessment, and protection polices and laws.

Action

EPA has the mandate to halt any practices that is contrary to their environmental mandate. The EPA must demand that an environmental impact assessment and scoping reports is completed, and permit issued before dredging of drains can commence. EPA also is expected to inspect and approve both temporary and permanent handling of sediments.

Occasionally, EPA must test and analyse constituents of sediments dredged to ensure they do not contain harmful metals which is health detrimental and then advise on interventions. Currently they are unsure of where the dredged material is being disposed of. Given that Royal Haskoning (2019) state that the material is contaminated, the location of the disposal site should be closely followed up by EPA.

6.2.6 Public Procurement Authority (PPA)

Meaning

The PPA is the regulatory body responsible for the effective implementation of the Public Procurement Law. The Authority seeks to ensure fairness, transparency and be non-discriminatory in

public procurement in order to promote a competitive local industry and increase stakeholder confidence in public procurement processes.

Control

PPA is made to define rules, method and law to use to acquire goods, services, mandates processes and procedures by which government institutions and works using public funds. PPA also make proposals for the formation of policies on procurement. The Law governing procurement in Ghana is the Public Procurement Law, 2003, ACT 663.

Association

PPA works with the various procurement units in the various institutions. They work in close collaboration with all government institutions.

Action

PPA ensures that all public procurement for works is in accordance with their processes and procedures. Regulations stipulated for restrictive tendering and single sourcing tendering for project is strictly approved by the PPA. Though funding like the World Bank is not expected to adhere to the PPA regulations, PPA will be expected to be on board as an important stakeholder for sustainability if the PBC management is implemented.

6.2.7 Public Investment Division (PPP Unit)

Meaning

The PPP Unit of the Public Investment Division is under the remit of Ministry of Finance and has to oversee PPP Programmes in Ghana.

Control

Their role is to serve as the PPP Advisory Unit to support and build the capacity of the relevant Ministries, Department and MMDCEs in the development and management of prospective PPP transactions. This PPP Unit has the technical and financial expertise on PPP project development and is rolling out training packages to help equip the major players in policy and project implementation circles.

Association

The PPP Unit also develops nodal units in the MDAs with the skills set and knowledge on PPP. Thus, their work is to associate with the entire relevant stakeholder in the PPP Programme and project implementation.

Action

The PPP Unit is expected to support contracting authorities to identify scope, and then implement and manage PPP projects. Capacity Building plans include joint reviews with contracting authorities and appraisals as well as political input for PPP projects. The Unit is currently rolling out a training programme for key staff of the various institutions to aid them in PPP project appraisal and planning. The PPP Unit is also working to put together a standard Request for Proposal document for PPP to be used.

6.2.8 Summary of institutions

The above descriptions and discussion have been summarised in Table 6-4.

Table 6-4: Summary of institutions relevant for the dredging and maintenance activities and current situation.

INSTITUTION	MEANING	CONTROL	ASSOCIATION	ACTION	RECOMMENDATIONS / COMMENTS
MINISTRY OF WORKS AND HOUSING	Contracting Authority – Policy and direction formulation for drainage maintenance works	Mandate to ensure the identification, planning and implementation of drainage maintenance works per policy direction	HSD, AMA, MSWR, PPA	To oversee the implementation of a contract management framework for the monitoring and evaluation of drainage maintenance works	MWH should include HSD (Implementing Agency) in Project Planning and contracting
MINISTRY OF SANITATION AND WATER RESOURCES	Contracting Authority – Policy and direction formulation to improve sanitation and waste Management sustainability	Mandate to ensure the implementation of Environmental Sanitation Policy direction.	AMA, EPA & MWH	To enforce and monitor the sanitation and waste management systems by providing administrative and management guide	No define dumpsite for dredged material. Possess a health risk
HYDROLOGICAL SERVICES DEPARTMENT	Implementing Entity – Planning and Implementation of Drainage Maintenance works	Mandate to ensure maintenance of all primary and key secondary drains and their adequate functioning.	MWH, AMA & Contractors	Technical Monitoring and performance evaluation of drainage maintenance works.	HSD need legal backing to enforce laws and regulations
ACCRA METROPOLITAN ASSEMBLY	Implementing Authority – Political and Administrative Authority in Execution, Planning etc of Projects	Mandated to implement waste management projects and the maintenance of secondary and Tertiary drains	MWH, AMA, MSWR, EPA, PPA, Contractors	Oversight and Monitoring for all Secondary and Tertiary drainage maintenance. Waste Collection and Disposal.	The Drainage Maintenance Unit need appropriate resources, equipment and machinery The Waste Management should have more Engineers to offer solutions not health administrators

INSTITUTION	MEANING	CONTROL	ASSOCIATION	ACTION	RECOMMENDATIONS / COMMENTS
ENVIRONMENTAL PROTECTION AGENCY	Implementing Entity – improve and promote environment and striving for sustainable development	To oversee implementation of National Environment Policy. Protection of environment and aquatic life.	AMA, MSWR, Contractors	Issuance of environmental permit for dredged sediments handling and disposal. Testing and analysis of sediments	EPA must do better in ensuring the handling and dumping of sediments is done right
PUBLIC PROCUREMENT AUTHORITY	Auxiliary Entity – Regulatory Body for public procurement	Define rules, methods and laws for public procurement	ALL	All procurement to be in accordance with processes and procedures of procurement laws	Monitoring of the procurement process and procedure for contract award to be intensified
PUBLIC INVESTMENT DIVISION (PPP Unit)	Auxiliary Entity – Subsidiary to MOF to oversee PPP Programmes	Advisory Unit to support and build PPP Capacity	ALL	Train Stakeholder to appraise, identify, scope and implement PPP project	PPP law should be passed to pave way for PPP nodal units in the various institutions

6.3 Summary of current situation

Following the analysis of the institutions, it has been deduced that the mandate and roles of the various institutions is well defined on paper. The Contracting Authority has a policy statement and framework in place to be implemented at any given time to improve drainage situation to avert flooding.

However, implementation of these policy frameworks and structures is the major challenge. It appears that the institutions seem to overlap each other in implementation. This overlap has caused neglect of the core duty of some institutions.

Lack of coordination is also a major bottleneck for the clear implementation of institutional mandates. The poor communication and low or no inter-institutional engagement is a major issue that must be addressed. If PBC is to work in the current institutional set-up there must be better communication between the various institutions. For instance, the Ministry of Works and Housing cannot identify a priority drain and scope it on their own without the input of Hydrological Services Department, the technical expert and the implementing entity. In the same vein, HSD should work out the contract management framework with the Ministry as the Contracting Authority.

AMA must coordinate better with the EPA, especially as their roles in waste management is very much related. AMA should always ensure that they are in constant communication with EPA on waste management collection, handling and disposal. EPA must also work hand-in-hand with the AMA or any Contractor who is on board to undertake Drainage maintenance works and Dredging to ensure proper adherence to regulations

Due to poor waste management systems within the communities along the Odaw basin and its major tributaries, this major drainage channel has huge volumes of waste entering it. In addition, silt from upstream sources most of which are unlined and from unpaved surfaces. These have contributed to reducing the drainage capacities of these channels. The challenge is defining which institution has the final responsibility to maintain these channels. No specific institution has the exclusive responsibility to undertake maintenance works in the Odaw/Korle. For example, after the June 3rd, 2015 flooding, the Drains Maintenance Unit of the Accra Metropolitan Assembly was the first institution to respond by starting the maintenance of the Odaw, before the government -through the Ministry of Works and Housing- awarded it to Dredge masters.

Funding is the biggest challenge facing the institutions. Inadequate funding at all levels contributes to the poor implementation and monitoring of drainage works and waste management projects. Lack of resources always hampers the frequency of monitoring that is expected. Prior to the current (2019) dredging works by DredgeMasters, maintenance of the waterway has been undertaken by the department which received funding, therefore there has been no continuous maintenance program.

6.4 Next steps

HOLD - The next deliverable will further capture information, detail the interventions, and present the changes to be made to restructure the various institutions in readiness for the implementation of a PBC. Due 16 December 2019.

7 Task 7: PPP and joint venture possibilities and risks

Task 7 provides an answer to: is a PBC preferred above a PPP, what are its challenges, and how will it be structured.

This chapter presents the PPP Background report. It is divided into the following sections:

- background on PBC and PPP;
- legal and institutional framework for PBC and PPP in Ghana;
- stakeholder views and capacity regarding PBC and PPP;
- preliminary conclusions with respect to the outline of a preferred contracting solution.

7.1 Background on PBC and PPP

7.1.1 Definitions of PBC and PPP

One of the objectives of the feasibility study is to investigate the feasibility of the use of Performance-Based Contracts (PBC) in the procurement of dredging and channel maintenance works. In addition, other public-private partnership (PPP) and/or joint venture cooperation opportunities have been looked at. However, it is useful to first clarify the definitions of PBC and PPP.

In the terms of reference of this feasibility study a PBC was defined as:

“a contract where the contractor is responsible for the guaranteed performance of infrastructure for a longer period. PBCs are a form of outsourcing for a mix of technical services and civil works, but with three primary distinguishing features that create incentives for efficient, high quality work:

- i) *payment to the contractor based on achieving results rather than on the cost of inputs;*
- ii) *the contractor ideally has flexibility and discretion regarding how the results will be achieved, including the organization of teams and technology; and*
- iii) *the contractor ideally has a stake in the upside that would come from exceeding the targets.*

The contract records agreements based on performance (output or outcome) rather than agreements based on activities (input). The maintenance component entails the maintenance dredging period which will start after the deferred dredging has been completed.”

The first sentence of the PPP Reference Guide of the World Bank reads: *“There is no single, internationally accepted definition of Public-Private Partnership.”* Therefore, the Reference Guide adopts a broad definition of PPP: *“A long-term contract between a private party and a government entity, for providing a public asset or service, in which the private party bears significant risk and management responsibility and remuneration is linked to performance.”*

Although not the same, PPP and PBC share a number of key characteristics. The most important common feature of PPP and PBC is that the remuneration of the contractor is not based on the cost of inputs but on performance, i.e. the achievement of outputs and results. This in turn entails a substantial transfer of responsibilities, freedom of approach and risks to the contractor.

PPP arrangements in general involve private financing of the investments in the asset. Although private finance is not mentioned in the World Bank definition of PPP cited above, it is included in a list of common features of PPP projects in another section of the PPP Reference Guide.

The Odaw basin dredging project will be financed by a loan of the World Bank, so there is no need for private financing. There is, however, a potential for extending the role of the contractor beyond the provision of a public service under a publicly financed PBC arrangement. This potential may lie, for instance, in the development and operation of complementary, privately financed commercial

activities, the revenues of which can contribute to covering the costs of the public drainage service (e.g. re-use of dredged materials, recovery and recycling of plastic waste and sand exploitation are being considered in this regard).

We follow the World Bank in adopting a broad definition of PPP. Therefore, the objective of Task 7 is **the analysis and definition of the most efficient way of procuring and managing the dredging project**, which takes into account:

- the incentives for cost efficiency and quality throughout the entire duration of the project;
- the incentives to develop ancillary commercial, revenue-generating activities;
- the competences and constraints of the public and private stakeholders (including contracting authority and eligible contractors);
- the ability to attract interest from international bidders for possible cooperation agreements with local partners.

7.1.2 Range of procurement options

PBC and PPP belong to a range of options (Figure 7-1) to organize the delivery of public assets and services, varying from conventional works and services contracts to privatization.

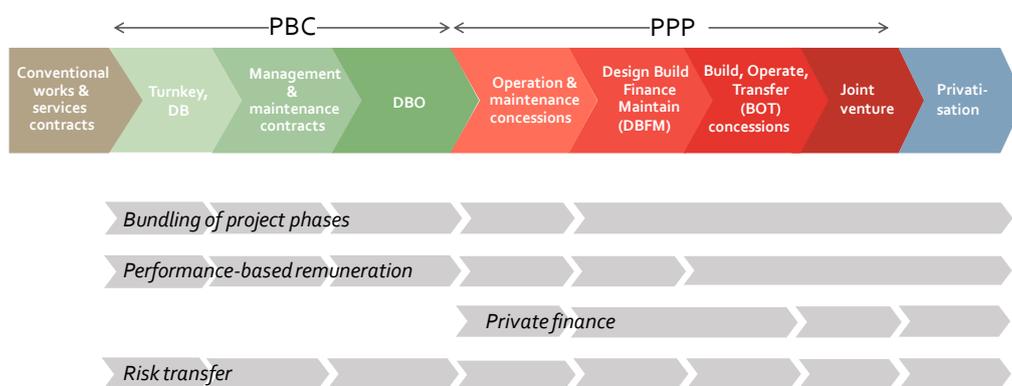


Figure 7-1: Procurement options.

Compared to conventional works and services contracts, PBCs and PPPs have a number of distinguishing characteristics.

- **The bundling of project phases.** In the conventional model of public service delivery, every phase of the project is procured separately. In the conceptual phase several consulting firms are hired to perform technical, environmental and economic feasibility studies. Next an engineering firm is contracted to design the facilities and draw up detailed terms of reference for the construction (bill of quantities). The works are then outsourced to a construction company. Maintenance and operations may be carried out by the contracting authority itself, but may also be partially or wholly outsourced through short-term maintenance contracts. In PBC and PPP the contracting authority remains responsible for the definition of the concept. However, the design, construction, maintenance and operational activities are outsourced in a bundled contract. The degree of bundling depends on the contract type. In a Design and Build (DB) contract only the design and construction are included in the contract scope. A Design-Finance Build-Maintain (DBFM) contract, on the other hand, covers all phases of the project lifecycle.
- **Performance-based remuneration.** In conventional works and services contracts, the contractors are largely paid in function of inputs. In contractor specifies in his proposal

which inputs (manpower, equipment time, materials) are needed to complete the design, construction or maintenance activities and submits a price for the supply of these inputs. The contractor is paid in regular instalments during the contract in function of the progress of the activities. A small amount (generally 5 to 10 %) is withheld until the successful completion of the project. However, while the contractor must carry out their activities according to the state of the art and the terms of reference, he is not ultimately responsible for any shortcomings in performance that may occur in spite of the diligent execution of the terms of reference. In PBC and PPP contracts the contractor is paid upon achieving contractually specified performance targets (for instance the timely completion of a building according to specifications, or the good maintenance condition of an asset). If the performance is not achieved the payment is reduced in function of the severity of the shortcoming.

- **Risk transfer to contractor.** Because of the performance-based payment the contractor assumes a higher level of construction and operational risks than in a conventional services contract. In PPP contracts, with private finance and user revenues, financial and commercial risks are also transferred to the contractor.
- **Private financing.** PPPs involve private financing of assets. In the case of operating concessions, the private financing is restricted to the equipment and superstructure owned and used by the contractor. In DBFM and BOT concession contracts, the contractor finances public infrastructure, such as roads or port terminals. Although the infrastructure is privately financed, it remains government owned. Alternatively, the infrastructure may be in private ownership during the contract period but is then transferred to the government on the end date of the PPP agreement. The (eventual) public ownership of the infrastructure is what distinguishes PPP from privatisation. PBCs don't involve private financing, or at most for a short period between the execution of the works and the performance-related payment.
- **User revenues.** Within PPPs two groups can be distinguished: government-pays PPPs and user-pays PPPs.⁷ In government-pays PPPs the contractor is remunerated for his investments and services by the government. The payment takes the form of a periodical service fee or an availability fee, which is paid in full when the infrastructure is available in good condition, in compliance with the contractual specifications. In user-pays PPPs the contractor is directly remunerated by the user of the infrastructure or the service (for instance the user of a toll road, or an airport). In both cases the contractor uses the revenues to repay the investment costs (with interest and dividends) and to cover operating and maintenance costs. PBCs are always government-pays arrangements.
- **Joint ventures** are a particular form of PPPs. In a joint venture a government entity and a private partner establish a jointly owned enterprise to undertake a project. Both the private and public partner contribute equity to the enterprise. Often the government's contribution is in-kind in the form of the land that is required to realise the project. Joint ventures are sometimes called "institutional PPPs", while the PPP arrangements described above are "contractual PPPs" since the cooperation is governed by the PPP agreement.

Table 7-1 summarises the key features of the various PBC and PPP options.

⁷ Hybrid forms also exist, for instance a user fee topped up by a government subsidy to make the project financially viable.

Table 7-1: Contract types

Contract types	Conventional works & services contracts	Turnkey, DB	Management and Operating contracts	DBO
		PBC	PBC	PBC
Length of contract	1-3 yrs	1-3 yrs	2-5 yrs	10-15 yrs
Ownership of asset	Public	Public	Public	Public
Bundling				
Finance	Unbundled			
Design/Build	Unbundled	✓		✓
Maintain/Operate	Unbundled		✓	✓
Payment by	Contr. Auth.	Contr. Auth.	Contr. Auth.	Contr. Auth.

Contract types	Operating concession, lease, affermage	DBFM, DBFMO, BOT, BOOT, BTO, BLT, ROT,...	Concession, BOT, BOOT, BTO, BLT, ROT,...	Joint venture	Sale, BOO
	PPP	PPP	PPP	PPP	
Length of contract	10-15 yrs	20-30 yrs	20-30 yrs	In perpetuity or fixed duration	In perpetuity
Ownership of asset	Public	Public (or private transferred to public)	Public (or private transferred to public)	Public/private	Private
Bundling					
Finance		✓	✓	✓	✓
Design/Build		✓	✓	✓	✓
Maintain/Operate	✓	✓	✓	✓	✓
Payment by	User	Contr. Auth.	User	User	User

It should be noted that the terms BOT, BOOT, DBFMO, concession, etc. are often used interchangeably. When confronted with a BOT, DBFMO or similar contract, the characteristics of the arrangement (scope, private financing, government-pays or user-pays) should be checked, rather than trust the label at face value. The strictness of the definition of PBC and PPP also varies between sources. Some sources would, for instance, not regard an operating concession as a PPP (because the extent of private finance is limited), or a DB contract as a PBC (because it does not include operating or maintenance activities).

The term “maintenance contract” may also be misleading. It is important to distinguish short term contracts for specific maintenance activities (for instance desilting a drainage channel) and maintenance management contracts under which the entire responsibility for the maintenance during 2 to 5 years (or longer) is outsourced to a contractor (i.e. keep all drainage channels in good condition according to contractually determined performance standards). The former is a conventional services agreement, while the latter is a PBC.

7.1.3 Benefits of PPP/PBC

Experience across the world has shown that PPP and PBC can contribute to achieving service delivery with a better price-to-quality ratio (“value-for-money”) than traditional public works and service contracts.

The efficiency and quality gains of PPP and PBC are the result from a number of specific characteristics of PPP and PBC arrangements. The Figure 7-2 shows an overview of the driving factors behind the “value-for-money”. Each of the drivers is further discussed in the paragraphs following the figure.

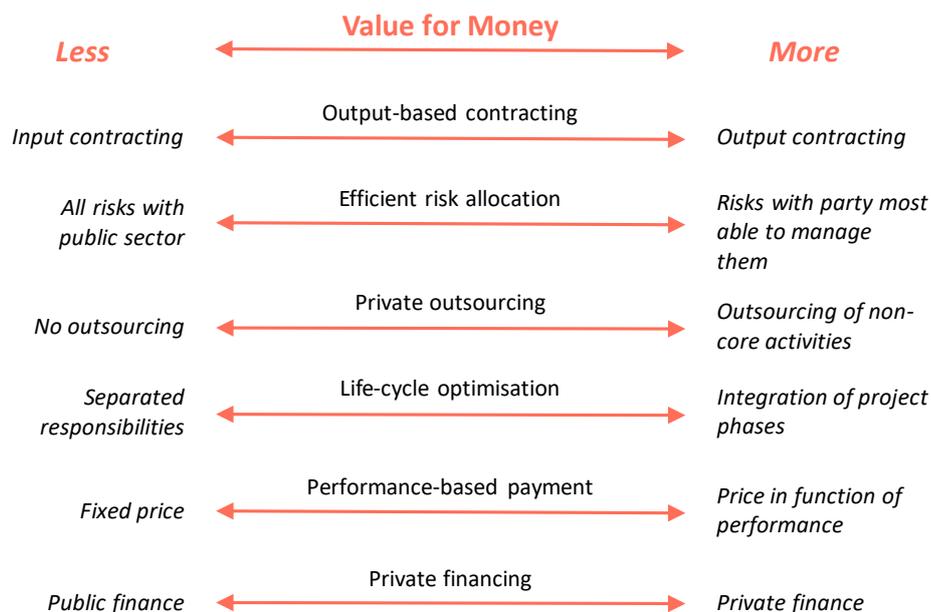


Figure 7-2: Value for Money drivers.

Output-based contracting

The use of performance-oriented (or outcome-based) specifications is an important lever for creating value in PPP and PBC contracts. In conventional procurement contracts, specifications are defined in terms of inputs and activities that need to be delivered by the contractor. The technical solutions as well as the engineering and design are imposed. In a PPP or PBC project, on the other hand, the specifications are more general. They are focused on desired outcomes (minimum performance required) rather than on how to design the goods or services. In other words, the contracting authority specifies what must be done by the private contractor, but not how. Consequently, the contractor has a degree of flexibility in deciding how best to provide the requested services, allowing it to deploy unique technical skills or creative methods that offer better value for money than the proposals of the competitors. Performance-oriented specifications enable the contracting authority to harness the innovative and creative capabilities of the private sector, resulting in the delivery of public services at a lower cost to the user or at the same cost with better quality.

Efficient risk allocation

The basic principle of efficient risk allocation is that risks should be held by those parties best able to manage them. For instance, the building contractor has the strongest control over the management of construction activities ensuring a delivery on time and within budget. Therefore, the contractor should assume the construction risk and receive a financial penalty in case delivery is late or over budget. However, the risk of delays in the securing of planning approvals (if not due to negligence of the private contractor) or of changes in the law having a negative impact on project profits should be allocated to the contracting authority because they are outside the influence of the private partner.

If the risk allocation is efficient then all contract parties have maximum incentives to control risks (i.e. to reduce the likelihood and/or the consequences of risks), resulting in lower project costs. In the conventional public procurement model, most of the project risks are in the hands of the contracting authority. In PPP and PBC projects, most risks (in particular design and construction risks, operating risks and, in revenue-generating PPP projects, also financial and revenue risks) are transferred to the private contractor. Since the private sector is indeed best placed to manage these risks and should therefore assume them, PPP and PBC achieve a risk allocation that is more efficient than in the case of classic procurement.

Private outsourcing

Through PPP and PBC the contracting authority can mobilize the human and technical resources of the private sector in order to complement the resources of the public sector. This creates various benefits:

- The private sector may have skills and expertise that is not available within the contracting authority.
- One of the main strengths of the private sector is its business process management skills, which enable it to implement projects effectively and efficiently, thus saving costs for the government and/or the end-user. PPP and PBC introduce private sector management skills and competencies in the provision of public infrastructure and services.
- By outsourcing the design, construction, maintenance and operation of specific projects to the private sector, the contracting authority frees up its own resources to pursue other projects. In this way, PPP and PBC increases the speed of implementation of projects.
- Private companies are in general better able and more strongly incentivised than public authorities to pursue revenue-generating opportunities and synergies, which help to defray the costs of the public infrastructure.

Lifecycle optimization

Integrating the design, construction and operating stages of public infrastructure reduces interface problems. A contractor who is responsible for all stages of the project life-cycle has an incentive to minimize life-cycle costs. In contrast, if several contractors are each responsible for a single stage, they tend to minimise their own costs or maximise their own revenues, even if this behaviour increases costs/lowers revenues in other stages. For instance, the building contractor has no incentive to spend resources on higher quality resulting in lower maintenance costs, because he will not benefit from cost savings in maintenance. In contrast, if the project stages are bundled in a single PPP or PBC, the contractor in charge of construction who decides to skimp on quality in order to compress costs will suffer the consequences during the maintenance phase. The contractor of a PPP or PBC project will therefore have an incentive to balance quality and costs across the entire lifecycle of the project.

Performance-based payments

In PPP and PBC projects the contractor is only paid upon delivery of the service. This is obvious in the case of user-pays PPPs. However, in government-pays PPPs and PBCs the payment of the availability or service fee is also conditional on the infrastructure being available in good condition and the services being provided in the agreed quantities and according to the agreed quality standards.

Through the performance-based character of the payments the private contractor is strongly incentivised to complete the infrastructure on time and deliver the services according to the contractually specified output specifications and quality standards. In this way PPPs and PBCs ensure timely delivery with consistent quality. They also create a strong maintenance discipline.

Private financing

Private financing does not apply to PBCs, only to PPPs. Private financing has a similar effect as performance-based payments. It sharpens the incentives by increasing the financial stakes and in this manner, pushes private contractors to deliver on time and according to specifications. Private financing provides especially strong incentives for timely delivery of the infrastructure. Every delay increases the financial costs of the project because the revenues needed to service the debt are postponed.

Secondly, private finance brings forth additional project monitoring capacity. The private financiers have strong incentives and are often better placed to monitor the operational and financial performance of the project than the contracting authority. If the private financiers detect shortcomings in performance, they will request the contractor to take remedial actions in order not to endanger the debt service payments.

Finally, private financing mobilizes additional financial resources for public resources, thus accelerating project implementation.

7.1.4 Drawbacks of PPP/PBC

PPP and PBC also come with some drawbacks.

Higher transaction costs

Setting up a PPP or PBC entails higher transaction costs than traditional procurement, both for the procurement agency and the private contractor. Due to the transfer of risks to the private sector and the larger scope and longer duration of PPP and PBC arrangements the contracts are more complex. They must allow for a far larger set of contingencies than traditional procurement contracts. The preparation and negotiation of these contracts are time-consuming and labour intensive. PBCs are in this respect less onerous than PPPs, which also involve private financing.

Higher financing costs and risk premia

Because of the greater transfer of risks to the private contractor, the latter will add a risk premium to their price. In the case of PPPs (with private financing) the risk is also reflected in higher financing costs.

Risk premia and higher financing costs are the price to pay to achieve the benefits of efficient risk allocation (see above), so the government gets something back in return. Financing costs and risk premia are mainly a problem if the private contractor is required to take on risks that he cannot manage, avoid or mitigate. In that case there are no benefits from efficient risk management, but only extra risk premia.

Lower flexibility

A PPP generally has a long duration, during which the contracting authority has less influence on the provision of the service. All performance requirements that the private partner must satisfy are specified in the contract. Once the contract has been signed it is possible to change the requirements, but only by way of negotiations with the contractor. This limits the ability of the contracting authority to respond quickly and flexibly to changes in the external environment. PBCs, generally having a shorter duration than the PPPs, are less affected by this drawback.

Less competition

PPP and PBCs are more complex and have a larger scope than conventional works and services contracts. As a result they give an advantage to larger contractors, who are more likely to possess the managerial, technical and financial capacity that is needed to undertake the project.

7.1.5 Experiences with PPP and PBC in dredging

One of the first sectors in which PBC was widely applied was road maintenance. The use of PBC in road maintenance is facilitated by the availability of well-known and well-defined performance indicators for road conditions (roughness, cracking, incidence of potholes, rutting and ravelling, cleanliness, etc.).

A review of road PBCs by the World Bank drew the following lessons:⁸

- The contracting authority spends less efforts on the management of the road maintenance. The management and monitoring of the contractor is made easier by the

⁸ César Queiroz, Recent Experience and Lessons Learned with the Use of Performance Based Contracts (PBC) and PPP, Performance Based Contracting and PPP Seminar, Stockholm, Sweden, November 6, 2007.

use of performance indicators. There is no need to continuously determine and change quantities of inputs and activities.

- The transfer of the risks and responsibilities to contractors stimulates innovative methods.
- On the negative side, the tendering of a PBC requires more efforts and takes a longer time than a conventional maintenance contract. Smaller contractors are often unable to compete and can only participate as subcontractors to larger, more capable firms.
- Some road agencies perceive a loss of control and flexibility. Where performance standards are unclear or lacking the outcomes may fall short of expectations.
- Adequate supervision arrangements are essential for the success of PBC. If needed an external consultant must be hired for the supervision, or contracting authority staff must be trained and coached on the job. Terms of reference for the supervision must be established.
- Credible budgetary commitments must be in place for the duration of the PBC contract.

In the dredging sector PBCs and PPPs also have a long history, although their use is less common than in other sectors. One of the oldest PBCs for dredging concerns the maintenance of the navigation channel to the **Port of Bahia Blanca** in Argentina.⁹ Since 1999 a minimum draft of 13.7 m (45 feet) has been maintained under successive 5-year PBC and PPP agreements. The initial government-pays PBC was converted into a concession agreement with the remuneration of the contractor paid entirely by tariffs levied on each ship that uses the channel. The contractor is paid upon achieving the channel specifications, and not in function of the dredged volume. The contractor thus assumes the risk of the degree of sedimentation. It is able to do so because of the availability of detailed hydrodynamic data collected over a period of 20 years by the port authority. Furthermore, in the beginning of each five-year contract period the channel is fully surveyed (bathymetry) to establish the pre-dredging conditions, and the volume dredged to achieve the channel depth is measured. This volume is taken as a reference for the level of payments in the remainder of the contract.

Before the use of PBCs the port authority tendered dredging contracts based on pre-fixed volumes. However, these pre-fixed volumes did not guarantee that the channel had the required depth to allow the passage of vessels without grounding. The use of PBC allowed to optimize the dredging (resulting in lower costs) while ensuring the minimum draft at all times.

While building up experience with the PBC the port authority learned that lower bid prices were obtained if the PBC had a duration of at least five years (giving the contractor more opportunities to optimize dredging fleet deployment), and if the port authority guaranteed the monthly payments (giving the contractor more financial certainty).

A still older dredging PBC/PPP, also in Argentina, was concluded for capital dredging and subsequent maintenance dredging of the **Rio Plata and the Rio Parana** (as well as installation and maintenance of navigational aids). The contract lasted from 1995 to 2013. The contractor is remunerated by tolls collected from vessels using the channel. The contractor therefore assumed sedimentation and commercial risk.

Since about ten years, **Rijkswaterstaat** (Dutch Public Works Agency) procures most maintenance dredging with PBCs. Several reasons underly this choice.

- Rijkswaterstaat is relieved from the task of preparing weekly or monthly dredging plans, but only needs to verify that performance targets are met.

⁹ Prieto-Portar, L., Prins, J. and Prieto y Muñoz, L., *Contractual Model for Dredging Projects to Avoid Disputes: Case Studies of the application of Performance Based Contracts in dredging projects around the world*, PIANC-World Congress Panamá City, Panamá, 2018

- The cost of dredging is fixed during the contract period (except for price adjustments in function of a fuel cost index), which is easy for budgeting.
- The contractor is incentivised to use innovative methods and has opportunities for optimizing fleet deployment, resulting in lower costs.

However, in Belgium the maritime waterways authority decided not to use PBCs, but to stick with conventional volume-based contracts. The authority was concerned about the risk premiums in the bid prices to compensate for fluctuating sedimentation levels. Furthermore, it is not possible everywhere to verify whether performance targets have been met.¹⁰

7.2 Legal and institutional framework

7.2.1 PPP legal and institutional framework

The current PPP framework in Ghana is established by the National PPP policy adopted in 2011.¹¹ The policy defines:

- the concept and guiding principles of PPP;
- the roles and responsibilities of the key institutions and parties;
- the PPP project preparation and approval process;
- the PPP contract management tasks and process.

In the policy PPP is described as follows:

“A PPP is a contractual arrangement between a public entity and private sector party, with clear agreement on shared objectives for the provision of public infrastructure and services traditionally provided by the public sector. Usually, in a PPP arrangement, the private sector party performs part or all of a government’s service delivery functions and assumes the associated risks for a significant period of time. In return the private sector party receives a benefit/financial remuneration (according to predefined performance criteria) which may be derived:

- *entirely from service tariffs or user charges;*
- *entirely from government budgets, which may be fixed, partially fixed, periodic payments (annuities) and contingent;*
- *a combination of the above.”*

The Figure 7-3 shows the PPP approval process. This approval process is in place and is currently used for all PPP projects in Ghana.

¹⁰ *Baggerwerken in Vlaanderen*, Verslag van het Rekenhof aan het Vlaams Parlement, Brussel, maart 2016

¹¹ Government of Ghana, Ministry of Finance and Economic Planning, *National policy on public-private partnerships (PPP)*, June 2011

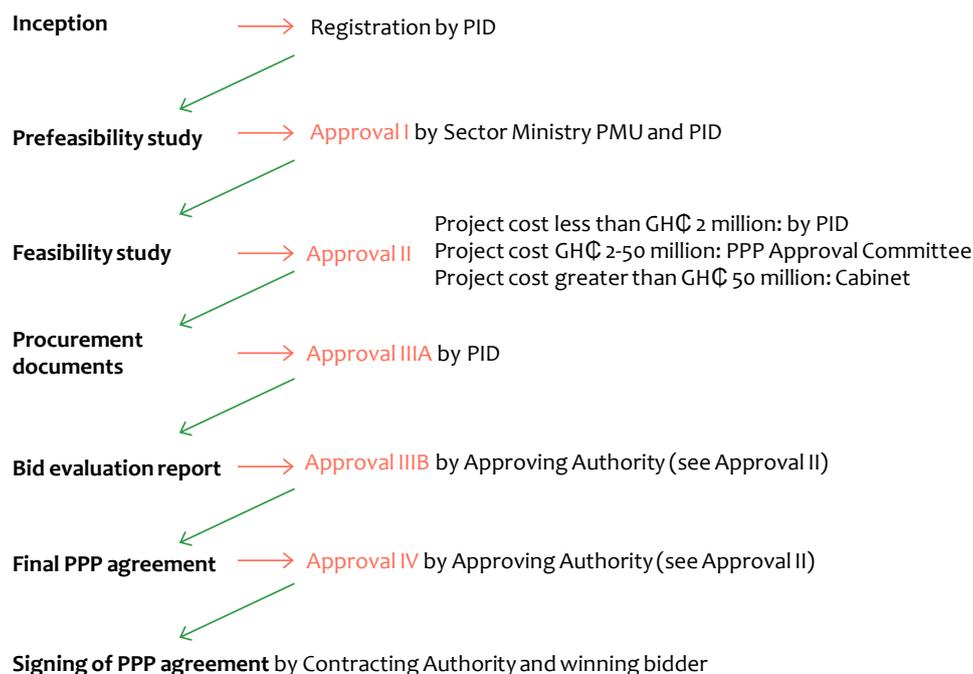


Figure 7-3: PPP preparation and approval process in Ghana.

A key institution in the PPP process is the Public Investment Division (PID) of the Ministry of Finance and Economic Planning. Within the PID, the Project and Financial Analysis (PFA) Unit and the PPP Advisory Unit (PAU) have been established. The PFA Unit is responsible for the general and financial analysis of PPP projects. The unit serves as the secretariat of the PPP Approval Committee and coordinates all activities that are required for the review and approval process. The PAU has a support role. It can assist contracting authorities in the preparation and procurement of PPP projects. It is also responsible for capacity-building and the drafting of manuals and standard procurement and contracting documents. Through the PFA Unit and the PAU, the PID thus fulfils both a gatekeeper function and an advisory and support role in the area of PPPs.

Depending on the value of the project cost the PPP project must be approved at key steps in the project preparation process by the PID (project costs less than GH¢ 2 million, as estimated in the prefeasibility study), the PPP Approval Committee (project costs between GH¢ 2 and 50 million) or the Cabinet upon the recommendation of the PPP Approval Committee (project costs more than GH¢ 50 million).

Since 2013 a PPP Bill has been in preparation. The Bill is presently in the final stages before its final adoption as an act. Depending on the speed of the remaining steps (among others, review by the Attorney General) the PPP bill may come into force near the end of 2019 or early 2020.¹² The PPP Bill further elaborates the legal and institutional framework for PPPs in Ghana. In particular, it:¹³

- defines the various types of PPP arrangements that may be concluded by a contracting authority and a private entity;¹⁴

¹² Oral communication of Mr. David Klotey Collison, Director of PID.

¹³ N. Dowuona & Company, *PPPs: Panacea to Ghana's infrastructure malaise?*, Newsletter 23 October 2018. Elizabeth Ashun, *PPP Bill Expected In Ghana This Year*, Mondaq, 7 June 2018. Pinsent Masons, *PPP Bill expected in Ghana this year*, OUT-LAW Analysis, 28 Sep 2017.

¹⁴ Including many of the contract types cited in

- defines the type of projects that are eligible for PPP (in principle projects from the National Infrastructure Plan, the Public Investment Plan or other government plans. However, grants of mineral rights, the procurement of goods, works and services primarily with the use of public funds and procurement contracts where the term is less than 15 years would be excluded from the scope of the PPP Act);
- establishes a PPP Fund in order to provide financial support to infrastructure PPPs partnership agreements for the development of infrastructure in Ghana;
- establishes the Ghana Partnerships Agency for the promotion and regulation of PPPs in Ghana (and which will also take over the role of the PPP Approval Committee);
- requires every contracting authority undertaking a PPP project to designate a dedicated unit for coordinating and supervising the project;
- requires contractors to establish a special purpose vehicle (SPV) under Ghanaian law to carry out the PPP project (this SPV can be majority-owned by foreign entities, but in that case it would not benefit from the margin of preference that a contracting authority may grant to an SPV in which Ghanaians hold a majority);
- allows contracting authorities to participate in the equity of SPVs (thereby allowing PPPs by means of a joint venture);
- makes provisions for complaint and dispute settlements procedures.

The Bill also sets a threshold of the project cost below which article 181 of the Constitution would not apply. This resolves one of the uncertainties in the current PPP framework. Under article 181 (5) of the constitution, Parliamentary approval is required for “an international business or economic transaction to which the Government is a party”. This article has been interpreted as being applicable to any PPP agreement involving a foreign entity, regardless the project cost. This requirement is very onerous and creates uncertainty about the legal validity of PPPs involving foreign entities.

The lack of a PPP Act has not prevented the undertaking of PPP projects in Ghana. The current PPP pipeline shown on the PPP web portal (accessed September 2019) of the Ministry of Finance and Economic Planning¹⁵ has 32 projects in pre-procurement and procurement phases. The World Bank database of closed PPP projects since 1990 includes 26 projects for Ghana.¹⁶ Some of these projects predate the National PPP Policy of 2011, or even the National PPP Policy of 2004 (which was never operationalised).

This fact demonstrates that the lack of a PPP Act does not constitute in itself obstacle to the implementation of PPPs. Nevertheless, the legal framework for PPP in Ghana has some uncertainties.

- The National PPP Policy of 2011 clearly defines the PPP approval process (except for unsolicited proposals). This process has been followed in recent PPP projects, and provides contracting authorities and private partners with a clear roadmap for the preparation and procurement of PPPs. However, the National Policy PPP is not an Act of Parliament and therefore does not actually constitute a legal framework. The authority of contracting authorities to engage in PPPs is derived from other legislative documents, such as the Constitution, the Public Procurement Act and the Financial Administration Act. This sometimes leads to unexpected and undesirable developments, such as challenging the validity of some PPP agreements with foreign entities before the Supreme Court because of a violation of article 181.

Table 7-1 above.

¹⁵ <http://ppp.mofep.gov.gh/>. The projects include public markets and shopping malls, sports facilities, cultural facilities, roads, seaport terminals and bulkwater supply.

¹⁶ <https://pppknowledgelab.org/countries/ghana> (mainly energy, transport infrastructure and ICT).

- The PPP Bill contains a number of valuable additions to the legal framework for PPP, such as the provisions regarding dispute settlement and joint ventures. These useful elements are lacking as long as the Bill has not been enacted.
- The PPP Bill has a retroactive impact on existing PPP projects. PPP agreements concluded after the issuing of the National PPP Policy (June 3, 2011) and which are deemed to be not in accordance with the Policy will have to be regularised. This retroactive effect creates legal uncertainty for every PPP project concluded before the adoption of the PPP Act.

7.2.2 Public procurement legal and institutional framework

The legal and institutional framework for procurement is defined by the:

- Public Procurement Act of 2003, amended by the Public Procurement (Amendment) Act of 2016; and the
- Public Procurement Act Regulations of 2006.

The Public Procurement Act and Regulations define in detail the process for the procurement of goods, services and works. The procurement activities are fully the responsibility of the contracting authority. There is no external approval process, as with PPPs, except for the approval of the budget for the project expenses.

The procurement process provides for internal checks and balances within the contracting authority. Several departments and committees within the contracting authority are responsible for distinct parts of the procurement process.

- Each contracting authority must establish a **tender committee**. The tender committee consists of senior staff of the contracting authority (the chairperson is the head of the department and agency, and the members are heads of divisions and units). The tender committee approves the procurement plan.
- For large projects a **tender review committee** is established. The threshold varies between types of government agencies and type of procurement. For works carried out by a Ministry the threshold equals GH¢ 15 million. The tender review committee is composed of eminent persons from outside the contracting authority. The chairperson is appointed by the Minister of Finance. Other members are appointed by the Public Procurement Authority, the Attorney General, the Institute of Engineers, the Institute of Chartered Accountants, etc. The tender review committee must review and approve all activities and decisions in the procurement cycle. The tender review committee also intervenes in complaints.
- The actual evaluation of the bids is entrusted to a **tender evaluation committee**. The members must have the necessary expertise to evaluate the tenders. The tenders are evaluated according to the evaluation criteria specified in the bidding documents.
- Finally, the procurement unit of the contracting authority is responsible for the management of the tender process and all decisions not explicitly allocated to one of the above entities.

The Public Procurement Authority is not directly involved in the tender process. It has a monitoring and support role, including:

- checking compliance with the provisions of the Public Procurement Act and Regulations;
- formulate procurement policies;
- develop manuals and standardized bidding and contracting documents;
- develop and promote training and capacity building programs;

- collect and publish data on ongoing tenders;
- advise contracting authorities on procurement issues;
- organize and participate in complaints procedures.

The website of the Public Procurement Authority contains a large set of downloadable manuals and standardized bidding and contracting documents.¹⁷ Last year the Public Procurement Authority issued a series of manuals on contract administration, a known weakness of contracting authorities in Ghana.¹⁸

The use of these standard documents is optional. In fact, Section 96 of the Public Procurement Act provides for procurement arising from any grant or concessionary loan to the government to be conducted in accordance with the terms of the grant or loan.

The default procurement mode is competitive tendering. Projects with a contract value exceeding GH¢ 15 million (works) or GH¢ 5 million (technical services) international competitive tendering with prequalification of bidders is required.

The Public Procurement Act also provides for a two-stage tendering procedure. In this procedure the bidders first submit technical bids (without price). The contracting authority enters into negotiations with the bidders who have submitted a valid technical bid. The negotiations concern one or several aspects of the bid. In the second round the bidders submit a complete proposal, containing a (revised) technical proposal and a price proposal. The two-stage tendering procedure is intended for situations where the contracting authority is unable to formulate complete specifications for the works or services, or where there are various alternative solutions.

Under limitative conditions, restrictive tendering (invitations to shortlist of bidders) or even single source procurement are permitted. The motivation for the use of these procurement methods can be the fact that only a few or one potential contractor are able to carry out the project (because of compatibility with earlier projects, exclusive technology, etc.), or urgency. The use of restrictive tendering or single source procurement must be approved by the Board of the Public Procurement Authority.

7.2.3 Sectoral legal and institutional framework

Drains maintenance

The Accra Metropolitan Assembly's (AMA) Drainage Maintenance Unit is responsible for the construction and maintenance of secondary and tertiary drains in the Accra Metropolis and some of the municipalities within the Greater Accra Region.

Hence AMA acts as the contracting authority for drains maintenance. However, there is no clear policy on the maintenance and desilting of drains. Short term maintenance contracts are bid out in function of apparent needs. No special permits are used to undertake the maintenance and deposit the silt. The desilting of secondary and tertiary drains is carried out by excavators. No dredging vessels are needed.

Exceptionally the central government (Ministry of Works and Housing) has contracted drains maintenance activities following the flood of 2015. The reason is that the maintenance was very urgent, and the central government had obtained funds.

A particular problem for drains maintenance is littering and the dumping of rubbish in the drains. The Environmental Protection Agency has launched a collaborative effort with the Metropolitan, Municipal, and District Chief Executives (MMDCEs), the Ministry of Sanitation and Water Resources and the Ministry of Works and Housing to address the issue.

¹⁷ <https://ppa.gov.gh/online-documents/standard-tender-documents/>

¹⁸ Verbal communication of Ms. Lesley Doodoo, legal director of Public Procurement Authority.

Dredging

The primary drains are maintained by the Ministry of Works and Housing. These maintenance works require dredging. The Hydrological Services Department within the Ministry of Water and Sanitation conducts surveys to determine the dredging locations and volumes. The Ministry of Works and Housing bids out a volume-based dredging contract using the analysis of dredging needs by the Hydrological Services Department. After the completion of the dredging works the Hydrological Services Department conducts a new survey to verify that the dredging activities have been successfully completed and to determine the dredged volume. On the basis of these data the contractor is paid. However, it is noted from the survey data received that these surveys are currently carried out by a subcontractor working for the company undertaking the dredging (DredgeMasters) and not directly for the Hydrological Services Department.

The dredging works and the disposal of the sediments requires an Environmental Permit. Prior to the works an Environmental Impact Assessment must be carried out and submitted to the Environmental Protection Agency (EPA). The EPA is responsible for the assessment of the quality of the dredged material and its impacts on public health and aquatic life. The EPA has the necessary skills and knowledge to execute its mandate but effective implementation is lacking. The EPA is, for instance, not aware of the current dumpsite for ongoing dredging works or it seems the contamination levels of the material which according to the Royal Haskoning (2019) report states it is polluted.

Re-use of dredged material

The opportunities for the reuse of dredged material has been assessed in Task 2 and the opportunities to re-use material heavily relies on the contamination levels of the sediment and the subsequent acceptance of the EPA for re-use. If such opportunities turn out to exist, the question is whether the Minerals Commission would be involved. According to the Minerals and Mining Act of 2006 (amended in 2015) the minister responsible for mining grants mineral rights upon the recommendation of the Minerals Commission. The Act covers “every mineral in its natural state in, under or upon land in Ghana, rivers, streams, water-courses throughout the country, the exclusive economic zone and an area covered by the territorial sea or continental shelf.” The list of industrial minerals in the Act includes sand and other building materials. However, dredging is not explicitly mentioned in the Act or on the website of the Minerals Commission. Whether the Commission has authority over the re-use of dredged materials remains to be determined.

7.3 Stakeholder views and capability

As mentioned above, the lack of a PPP Act has not stopped contracting authorities and contractors from engaging in PPPs. However, the large number of projects in the pre-procurement and procurement phases and the relatively small number of closed projects in the last years suggests that the implementation of PPP is slow-going.

Most observers agree that, while the legal framework for PPP could be improved and that that the adoption of the PPP Bill is urgent, the key obstacle to PPP development is the lack of project preparation and management skills within contracting authorities.¹⁹

However, both the PID and the Public Procurement Authority (PPA) say that PPP or PBC options should be pursued and are feasible provided that sufficient technical support is arranged for the contracting authority and other key public stakeholders (Hydrological Services Department). The PID

¹⁹ Osei-Kyei Robert and Albert P. C. Chan, “Implementing public–private partnership (PPP) policy for public construction projects in Ghana: critical success factors and policy implications”, in *International Journal of Construction Management*, July 2016. Osei-Kyei Robert, Albert P. C. Chan and Ayirebi Dansoh, “Public-Private Partnership in Ghana”, in A. Farazmand (ed.), *Global Encyclopedia of Public Administration, Public Policy, and Governance*, Springer International Publishing, 2017. This view was confirmed by oral communications from Ms. Lesley Dodo, legal director of Public Procurement Authority, and Mr. David Klotey Collison, Director of PID.

and the PPA have different views on whether the project should be tendered as a PBC (under public procurement framework) or as a PPP (government-pays PPP with possible a small revenue-generating concession).

The present contracting authority (Ministry of Works and Housing) has nothing against PPP or PBC, but points out that this is only feasible if structural funding for the dredging and drains maintenance is arranged. The present contractor (DredgeMasters) shares this view and claims that, in fact, they are already operating under a PPP mode since they pre-finance all works and are only paid afterwards, sometimes with large delays. However, it appears that neither Ministry of Works and Housing nor DredgeMasters has a firm idea about how a PBC/PPP would concretely look like.²⁰

7.4 Conclusions with respect to PBC and PPP options

7.4.1 PBC: a good idea?

PBC would be a good solution to address the present problems with the maintenance of the drains (unstructured, reactive approach after floods). A well-structured PBC guarantees that the drains are, preventively, in good condition so that flooding is alleviated.

Despite the challenges of undertaking a PBC (see below), the directly involved stakeholders think it is feasible with sufficient technical support. The World Bank funding addresses one important obstacle pointed out by the stakeholders: the lack of budgetary commitments.

7.4.2 PBC of PPP?

The assessment of revenue-generating activities (reuse of dredged materials, plastic recycling) has not yet been fully completed. We believe that revenues (if any) from these activities will only cover a small part of the total dredging and drains maintenance costs. The reason is that the development of revenue-generating activities itself involves investment and operational costs.

Therefore, the project is largely a PBC, which, under the definition of the PPP Bill, would probably fall outside the scope of PPP (being a publicly funded project). The small revenue-generating component will not be large enough to change the qualification of the project.

The only way for the project to fall under the PPP framework is to structure it as government-pays PPP in which the private contractor would pre-finance the deferred dredging and be repaid over the duration of the maintenance period. However, this would imply that the World Bank funds would be unused in the initial years and kept on an account from which the availability payment is paid. That is an inefficient use of funds.

7.4.3 Main challenges of PBC

The main challenges of implementing a PBC are the following.

- **Uncertainty about the dredged volume.** In other PBC dredging contracts this uncertainty is reduced by a statistical analysis on a vast amount of data about the past behaviour of the system. With lower levels of knowledge the bidders will factor in a risk premium in their bid prices, making the project more expensive.
- Another source of uncertainty about the workload of the contractor is the **debris in the drains**. The private contractor has now an effective influence on the behaviour of residents littering and dumping waste in the drains. EPA has launched a program in

²⁰ Verbal communication from representatives of PID, PPA, Ministry of Works and Housing and DredgeMasters.

cooperation with other public stakeholders to address this issue. But the effectiveness of this initiative is, as yet, unknown.

- The **lack of project development and contract management capacity** within the contracting authority and other key public stakeholders (Hydrological Services Department, EPA, AMA).
- **Lack of competition.** Only one firm in Ghana possesses dredging equipment and expertise. This firm has been awarded all dredging contracts since the floods of 2015. Moreover, this contract was extended in April 2019 for another two year (to April 2021).

The lack of budgetary commitment is not added in the list of challenges because the World Bank loan should address this issue.

7.4.4 Extent of bundling

The project has a number of distinctive parts with different features.

- First the maintenance of the primary drains, which requires dredging.
- Secondly the maintenance of the secondary and tertiary drains, which makes use of excavators.
- Thirdly, one or more revenue-generating activities.

In principle these components of the project could be spread over various contracts: a PBC each for the maintenance of primary drains and secondary and tertiary drains, and a PPP for the revenue-generating activities. Unbundling the maintenance of the maintenance of primary drains and secondary and tertiary drains would open up the market for smaller contractors that don't possess dredging technology. However, unbundling would create interface problems (the workload of the downstream dredging contractor depends on the performance achieved by the contractors responsible for the maintenance of the secondary and tertiary drains. It would also take away opportunities for optimization of the drains maintenance across the whole system. There is a plan to concentrate the responsibility for all drains within the Hydrological Services Department. AMA, currently responsible for the secondary and tertiary drains, supports this consolidation.

7.4.5 Outline of PBC solution

From the above, the outline of a preferred solution becomes apparent.

- The maintenance of primary, secondary and tertiary channels is bundled.
- This bundled project is tendered as a PBC under the public procurement framework.
- The contractor receives the right to develop commercial activities related the drains maintenance activities (such as re-use of sediment, plastic recycling, etc.). If there is sufficient competition for the project, then the bidders will share the profits from these revenue-generating activities (in a lower bid price).
- A number of simple performance criteria is defined. For instance (to be elaborated):
 - Minimum channel dimensions (depth, intersection, etc.)
 - Cleanliness of tributaries (maximum thickness of sediment, maximum area of vegetation)
 - Maximum water area covered by debris
 - Unobstructed and functioning gates in the weir
 - Sediment disposal in compliance with environmental standards.
 - Minimal fraction of sediment that must be treated for reuse (instead of disposal)

- The contract contains a general requirement that the contractor must comply with all relevant environmental rules and regulations (possibly extended by specific World Bank rules in this regard).
- To reduce the uncertainty about the dredged volumes, a hybrid contract could be envisaged, in which the initial deferred maintenance is remunerated on the basis of volumes (prescribed in the contract on the basis of a hydrological survey conducted by the contracting authority), and maintenance dredging is performance-based.
- During the project preparation phase and the contract phase the contracting authority is respectively supported by a transaction advisor and an independent consultant. This addresses the problems with the lack of capacity within the contracting authority. The independent consultant (paid jointly by the contractor and the contracting authority) will be responsible for the performance monitoring and evaluation. An independent consultant is expensive, but worth the expense to make the PBC feasible. The cost of the consultants can be partially recovered by inserting in the consultant agreements provisions with respect to knowledge transfer and on-the-job training. In this way the consultants also contribute to capacity development.

8 Task 8: PBC Capacity building and training needs assessment

Task 8 provides an answer to: who needs training and which training is needed.

8.1 Approach and methodology

The purpose of Task 8 is to assess the current capacity of the various players involved with the project preparation and implementation. Based on the findings, the capacity building needs have been outlined and a training plan to help bridge the knowledge gaps for the proposed PBC/PPP project procurement and implementation. The focus is on the main stakeholders, implementing entities, government agencies and contracting authorities involved with dredging, drainage and maintenance works. The purpose of the assessment was to identify the skills available against the skills required and analyse the gaps and two main topics are covered:

- Current Capacity Assessment;
- Needs Assessment and Training Plan.

Data was primarily gathered via intake interviews with key staff from the various departments and units of the stakeholders, entities and authorities as tabulated (the interviewed stakeholders are presented in Table 8-1). In addition, a desk study on the various agencies and their mandate, capacity and existing policies and framework has been undertaken. This was the surest approach to significantly generate insights into the realities and the needs for capacity building. Another approach initially identified was to obtain information and data from past and present projects to which would be reviewed, and information obtained on the capacity. However, obtaining those documents have proven futile.

In order to garner enough information to make a good assessment the Contractor undertaking dredging on the Odaw Drainage Basin and Korle Lagoon was engaged. The idea was to get their inputs on the project preparation and tendering process before the award of their dredging contract and contract management framework for the implementation stage as well as handling and disposal of sediments.

Table 8-1: List of interviewed stakeholders.

STAKEHOLDERS/ENTITIES	INTERVIEWEE
MINISTRY OF WORKS AND HOUSING	Ing Thomas Donkor, Deputy Director of Works
MINISTRY OF SANITATION AND WATER RESOURCES	Henrietta Osei-Tutu, Public Health Engineer
HYDROLOGICAL SERVICES DEPARTMENT	Ing Hubert Owusu Ansah, Director Ing Seth Kudzordzi, Senior Engineer
ACCRA METROPOLITAN ASSEMBLY	Graham Sarbah, Head of Drainage Maintenance Unit, AMA Godfred Fiifi Boadi, Public Health Engineer, Waste Management Department, AMA
ENVIRONMENTAL PROTECTION AGENCY	Kwabena Badu Yeboah, Director of Environmental Assessment
PUBLIC INVESTMENT DIVISION, MOF	David Klottley Collison, Director of PID, PPP Unit
PUBLIC PROCUREMENT AUTHORITY	Lesley Dodoo, Head of Legal and Policies
DREDGE MASTERS LIMITED	Samuel Borquaye, Project Director Capt Khan, Project Director

8.2 Current capacity and gap assessment

The capacity assessment has been done for the different stakeholders (described in Task 6, and listed in Table 8-1), and is based on the following 3 step approach (see also Table 8-2):

- Project Preparation and Tendering;
- Project Implementation;
- Sediment Handling, Sampling, Analysis and Testing.

All the entities are further described in the following sections.

Table 8-2: Involvement of project stakeholders through project phases.

SCOPE OF ASSESSMENT	STAKEHOLDER	UNIT/DEPARTMENT
PROJECT PREPARATION AND TENDERING	<ul style="list-style-type: none"> • Accra Metropolitan Assembly (AMA) • Hydrological Services Department (HSD) • Ministry of Works and Housing, (MWH) • Ministry of Sanitation and Water Resources (MSWR) • Public Procurement Authority (PPA) 	<ul style="list-style-type: none"> • AMA Drainage Maintenance Unit • Works Department, MWH
PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> • Accra Metropolitan Assembly • Hydrological Services Department • Ministry of Works and Housing 	<ul style="list-style-type: none"> • AMA Drainage Maintenance Unit • Works Department, MWH
SEDIMENT SAMPLING, ANALYSIS AND TESTING	<ul style="list-style-type: none"> • Ministry Sanitation and Water Resources • Environmental Protection Authority • Accra Metropolitan Assembly 	<ul style="list-style-type: none"> • Environmental and Health Management Department, MSWR • Environmental Assessment Department, EPA • Waste Management, AMA

8.2.1 Ministry of Works and Housing (MWH)

8.2.1.1 Overview

The Ministry of Works and Housing is the main entity responsible for policy formation in the planning and implementation of the construction and maintenance of drains. They coordinate all the other agencies and stakeholders in the country.

Project identification

To identify drainage maintenance projects, the Ministry depends on the Hydrological Services Department (HSD) to advise them on the priority drainage maintenance works that needs urgent

attention. The Ministry, the main Contracting authority through their works department, proceeds to do the necessary due diligence.

Project scoping

Based on the funding available, the Ministry further engages HSD on scoping the project. The project scope per the ministry, outlines the objectives of the project and the goals to be satisfied, which includes tasks, deliverables, cost, deadlines through terms of reference and statement of works. The project timelines and durations for deliverables is finalized under the scoping phase.

Tendering and selection criteria

Depending on the complexity of the drainage project identified, the Ministry decides the procurement process to adopt. The current procurement method used is the conventional procurement system of Open or Selective Tendering. The Ministry decides to adopt the selective tendering if the drainage maintenance works needs urgent attention.

A shortlist of competent Design Consultant or Contractors and all relevant information on the project which includes scope, cost, funding, location etc. is forwarded to the Public Procurement Authority (PPA) for evaluation and approval. The Ministry then proceeds to request for Technical and Financial proposals. Open Tendering advertises the drainage projects and invites prospective tenderers to apply. After, responsive Bidders are shortlisted for proposals for further evaluation and selection. Selection and Award Criteria according to the Ministry is primarily based on:

- Experience in similar assignment;
- Key Expertise;
- Equipment Holding;
- Credit Worthiness;
- Financial Muscle;

This is evaluated with the financial proposals to undertake the project and a Design Consultant or Contractor is selected.

Contract management framework

The MWH is responsible for the framework of the contract management, which details the fundamental operational activities to be undertaken during the project implementation phase of the contract. It is usually enshrined in the contract agreement documents sent to the Design Consultant or Contractors upon award of the contract. Issues of risk management is normally brought up here to be agreed on before the project is implemented.

Monitoring and performance indicators²¹

HSD is mandated to manage and supervise all primary drainage dredging and maintenance projects. Monitoring is essentially done on the stretch allotted for dredging and maintenance works.

According to Dredge Masters Limited, dredging works is currently ongoing from the Odaw Caprice enclave through to the Graphic Road to Agbogbloshie and downstream to the Lower and Upper Korle Lagoon.

Evaluation and payments

Based on evaluation reports from HSD, the MWH also vets and approves the payment based on the volumes dredged. MWH through the Bathymetrical survey data also reviews and vests Interim Payment Certificates (IPC) from the Contractors and onward to the Ministry of Finance for payments. In cases

²¹ HSD intake Interview will detail the monitoring and performance indicators.

where a Monitoring and Evaluation Consultant is procured, they will be expected to vet and approve IPCs.

General impression on PPP/PBC proposal

A PPP contract option is good if the Government can also be committed. The current dredging contract management can be classified as PPP since the Contractor is pre-financing before the Government reimbursement.

A PBC based project can be implemented though it is complex due to the rate of siltation. It may be contentious since siltation can happen in a matter of days. PBC can still be implemented but certain conditions should be well described and agreed with the Contractors.

8.2.1.2 Capacity assessment and gap analysis (MWH)

The results of the capacity assessment and gap analysis is presented in Table 8-3.

Table 8-3: Capacity assessment and gap analysis MWHR.

TASK	CURRENT CAPACITY AS ASSESSED	GAPS IDENTIFIED
PROJECT IDENTIFICATION	<ul style="list-style-type: none"> MWH depends on HSD to provide them with information on priority drainages that need maintenance or dredging. 	<ul style="list-style-type: none"> No existing plan to periodically maintain and dredge drains.
PROJECT SCOPING	<ul style="list-style-type: none"> Project scoping is done based on engagement with HSD. 	<ul style="list-style-type: none"> No existing policy framework on the goals and objectives of drainage maintenance works.
SELECTION CRITERIA AND AWARD	<ul style="list-style-type: none"> Selection based on key expertise, experience, equipment holding, credit worthiness and financial aspects. 	<ul style="list-style-type: none"> Proposal documents and Terms of reference too generic and duplicated.
CONTRACT MANAGEMENT FRAMEWORK	<ul style="list-style-type: none"> MWH puts together the contract management structure through the project implementation phase. 	<ul style="list-style-type: none"> No clear detail on contract risk management.
MONITORING AND PERFORMANCE INDICATORS	<ul style="list-style-type: none"> HSD mandated to conduct monitoring and set performance parameters. Monitoring on water levels, drainage capacity and rate of siltation through bathymetrical surveys. MWH reviews. 	<ul style="list-style-type: none"> Effectiveness of the reviews of performance as against parameters, indicators and specifications.
EVALUATION AND PAYMENT	<ul style="list-style-type: none"> MWH vets and approves IPCs for payment through the MOF based on the submission from the Contractor through HSD. Dredged volumes ascertained from Bathymetric surveys is the basis of evaluation of work done and payment. 	<ul style="list-style-type: none"> Payment is always an issue. Source of funding (mostly GOG) not reliable for most dredging and maintenance. Bathymetric surveys and volume calculations are undertaken via a subcontractor of Dredge Masters and are not witnessed.

8.2.2 Accra Metropolitan Assembly (AMA)

8.2.2.1 Overview

Accra Metropolitan Assembly is the political and administrative authority for the City of Accra. They are responsible for the overall development of the District. AMA is also responsible for the formulation and execution of plans, programmes and strategies for the effective mobilization of the resources necessary for the overall development of the district.

The assessment of the capacity of the AMA was done via intake interviews with two Units under the Assembly's Departments, namely:

- Drainage Maintenance Unit;
- Waste Management Department.

8.2.2.1.1 Drainage Maintenance Unit

The Accra Metropolitan Assembly's Drainage Maintenance Unit is responsible for the construction and maintenance of secondary and tertiary drains in the Accra city and some of the municipalities within the Greater Accra Region.

Project identification

The AMA Drainage Maintenance Unit has an inventory of all secondary and tertiary drains under the remit in the city of Accra and the sub metro divisions. The Unit has a monitoring mandate to check, desilt and maintain all drains within the environments. For smaller desilting works, the unit has sufficient capacity, whereas for larger works they need to procure Contractors to undertake the desilting and maintenance works under their supervision.

Project scoping

Scoping is done by the Drainage Maintenance Unit before procurement of Contractors is done. The scoping of projects and all relevant detailing is prepared by the Unit before the project procuring process commences.

Tendering and selection criteria

The AMA Drainage Maintenance Unit falls on a list of Contractors from Urban Roads Department under the Ministry of Roads and Highways. Most of the desilting and Maintenance works is done via Restrictive/Selective Tendering.

Shortlisted Contractors are invited to tender for identified projects. The Unit is involved in selecting the Contractor capable of executing desilting and drainage maintenance works. There is no documented criteria, but the Unit is aware of the Contractors who have the capacity to undertake the assignment.

Contract management framework

The contract is time-based and managed by the Drainage Maintenance Unit. They supervise the works, vet the Contractors IPCs, and approve for payment. Issues of risk management is agreed during the contract negotiations.

Monitoring and performance indicators

The Unit has the capacity to supervise and monitor all desilting and drainage maintenance works on secondary and tertiary drains. At implementation stage, the Unit monitors the Contractor and ensures that work is executed within the project catchment. Monitoring is done to ascertain the methodology of desilting, equipment used, and the volumes desilted.

Evaluation and payment

The executed work is evaluated based on the volumes desilted or dredged material over a certain period. Methods of evaluation includes the measuring of the invert levels of culverts before and after desilting (to ascertain the volumes desilted). Capturing the number of truck trips of the sediment volumes is the easiest method used. It is somewhat contentious. Bathymetry survey is the best option, but it is very expensive.

Sediment handling, sampling and analysis

Sediments which have been removed (desilted) are transported to the temporary dumpsite on the Ring Road West, G1. Disposal of the sediment is currently not correctly undertaken. A permanent site should be assigned as dumpsite for dredged sediments.

No Analysis is done to ascertain the constituents/contamination of the sediments.

General impression on PPP/PBC

PPP arrangement may be difficult to implement for drainage maintenance works. The Private sector may not see any return in profit or advantage. It can be looked at as a social corporate responsibility but may not be sustainable. However, if the private sector is willing to collaborate with the government on drainage works it should be welcomed.

PBC management will be very important if it can be implemented and sustained as it could solve issues with payment and will push Contractors to perform well. It will however depend on commitment from both parties (Client and Contractor) and most importantly reliable funding (which is assumed to come from the World Bank).

8.2.2.1.2 Waste Management Department

The AMA has the mandate to manage the waste (solid and liquid). It is the mandate of AMA to ensure that solid waste is not dumped in the drains. AMA is guided by the Environmental Sanitation Policy, which deals with waste management.

Project identification

Annual and ad-hoc plans are submitted to the Local Government Ministry and the main Assembly office for funding and implementation. AMA coordinates with the Ministry of Sanitation and Water Resources (MSWR) on identifying projects to help in the management of waste generation and the mitigation of refuse dumping into drains.

Project scoping

Scoping is essentially on the management of waste generation and disposal. Goals and objectives for scoping is drawn from the Sanitation policy as framed by the Ministry of Sanitation and Water Resources. Project scoping also covers sensitization and engagement of the Public and educating them on waste management, generation and the prevention of disposal into drains.

Tendering and selection criteria

Procurement is done at the Procurement Unit of the AMA in collaboration with the Ministry of Sanitation and Water Resources. The Department do not have any input on the procurement of contractors for projects.

Contract management framework

The AMA secured funding to undertake dredging of the Odaw Basin and Korle Lagoon after the June 2015 flood in Accra. Funding of the dredging was a problem and it marred its sustainability. The AMA is not involved in the current dredging works and is not aware of the contract details and information on Dredge Masters Limited. The drainage maintenance works under the ambit of the AMA is on the desilting of secondary and tertiary drains, which the AMA Drainage Maintenance Unit handles.

Monitoring and performance Indicators

Monitoring and performance indicators for waste management projects is basically on the volumes collected.

Evaluation and payment

Payment is made based on the volumes collected by Contractors and Evaluated by the Assembly.

8.2.2.2 Capacity assessment and gap analysis

The results of the capacity assessment and gap analysis is presented in Table 8-4.

Table 8-4: Capacity assessment and gap analysis AMA.

TASK	CURRENT CAPACITY AS ASSESSED	GAPS IDENTIFIED
PROJECT IDENTIFICATION	<ul style="list-style-type: none"> The Drainage Maintenance Unit has the mandate to check, desilt and maintain all secondary and tertiary drains. The Waste Management puts together a programme annually to get funding for project. 	<ul style="list-style-type: none"> No existing plan to periodically desilt and clean drains. No Funding to undertake projects identified.
PROJECT SCOPING	<ul style="list-style-type: none"> Project scoping is done by the Drainage Maintenance Unit. Goals and Objective is to clean secondary and tertiary drains. Waste Management Department scope project based on the Environmental Sanitation Policy on waste collection and proper disposal. 	<ul style="list-style-type: none"> Weak coordination and collaboration among sector institution on goals and objectives. No framework for research and development to track waste generation.
SELECTION CRITERIA AND AWARD	<ul style="list-style-type: none"> Selection based on key expertise, experience, equipment holding, credit worthiness and finances. 	<ul style="list-style-type: none"> Proposal documents and terms of reference too generic and duplicated.
CONTRACT MANAGEMENT FRAMEWORK	<ul style="list-style-type: none"> The Drainage Maintenance Unit manages contract for projects to be implemented. 	<ul style="list-style-type: none"> No clear contract management structure.
MONITORING AND PERFORMANCE INDICATORS	<ul style="list-style-type: none"> Monitoring is done by the Drainage Maintenance Unit. Performance Indicators are based on time, quality and volumes. Waste Management Dept Performance is measured based on the volumes of waste collected and disposed/recycled. 	<ul style="list-style-type: none"> Monitoring is ineffective. Funding is the largest reason. Performance measurement parameters not entirely reliable and may be contentious.
EVALUATION AND PAYMENT	<ul style="list-style-type: none"> Evaluation and payment based on volumes desilted. Waste management evaluation and payment is based on the volumes of waste collected. 	<ul style="list-style-type: none"> Payment is always an issue. No reliable source of funding for waste collection and disposal.

8.2.3 Hydrological Service Department (HSD)

8.2.3.1 Overview

The Hydrological Services Department is an autonomous body of the Ministry of Works and Housing (MWH) responsible for the planning and implementation of drainage and coastal protection projects. Under the National Flood Control Programme, HSD is expected to dredge all primary drains. HSD has the mandate to ensure that all primary and key secondary drains are maintained and functioning properly.

Project identification

HSD is expected to have data on all drains and water bodies. Periodic monitoring informs the department on the priority drains and water bodies that need urgent attention. HSD is expected to plan and implement projects such as dredging and maintenance.

Project scoping

HSD does the project scoping for drainage dredging and maintenance works. Scoping is done based on the goals and objectives of the department coupled with the funding available

Tendering and selection criteria

Dredging and maintenance works is procured through restrictive and single sourcing tendering due to the limited capacity. Selection drawn out of the database of the department with information on the competencies and expertise of contractors.

Contract management framework

HSD has the mandate to implement and manage dredging and maintenance works. HSD is mandated to make significant inputs in the contract management structure to ensure that the project is completed within the time frame, and quality assurance.

Monitoring and performance indicators

HSD supervises the dredging works to be done and set the performance measurement parameters and indicators for evaluation.

Evaluation and payment

Evaluation is done based on the measurement of dredge volumes. Joint bathymetrical surveys are conducted to get data on the sedimentation and dredged volume, although it is unclear if the bathymetry surveys are verified or witnessed by HSD. The current contract is based on the pre-financing of the dredging works by the Contractor, which are reimbursed by the Government.

General impression on PBC/PPP

It may generally be difficult to get PPP patrons since work associated with drainage and maintenance is often seen as social responsibility more than a sustainable revenue mobilization venture for the private sector to buy into.

PBC is the best way in terms of project implementation and contract management. Current maintenance of sand traps is managed similarly to PBC terms.

8.2.3.2 Capacity assessment and gap analysis (HSD)

The results of the capacity assessment and gap analysis is presented in Table 8-5.

Table 8-5: Capacity assessment and gap analysis HSD.

TASK	CURRENT CAPACITY AS ASSESSED	GAPS IDENTIFIED
PROJECT IDENTIFICATION	<ul style="list-style-type: none"> • HSD monitors and catalogues data on all primary drains, key secondary drains and tributaries and water bodies. • HSD plans and implements drainage maintenance projects. 	<ul style="list-style-type: none"> • Monitoring of drains is not well funded.
PROJECT SCOPING	<ul style="list-style-type: none"> • HSD puts together the scoping detail for projects based on the monitoring data of drains. • Scoping is done per the overall goals and objective for primary drains and key secondary drains and tributaries. 	<ul style="list-style-type: none"> • Scoping structure for drainage maintenance not well defined.
SELECTION CRITERIA AND AWARD	<ul style="list-style-type: none"> • Selection is done through the MWH which is the Contracting Authority for Drainage Maintenance currently. 	<ul style="list-style-type: none"> • HSD do not have a project procurement unit.
CONTRACT MANAGEMENT FRAMEWORK	<ul style="list-style-type: none"> • HSD makes an input in building the Contract Management Framework with the MWH. 	<ul style="list-style-type: none"> • HSD not fully equipped to manage contract as they are the implementing entity for Drainage maintenance.
MONITORING AND PERFORMANCE INDICATORS	<ul style="list-style-type: none"> • Monitoring is done by HSD. Performance Indicators are based dredged volumes and time. 	<ul style="list-style-type: none"> • No Independent verification of data on dredged volumes.
EVALUATION AND PAYMENT	<ul style="list-style-type: none"> • Evaluation and payment based dredged volumes ascertained from a joint Bathymetrical survey with contractors. • Payment done after IPCs are approved and vetted by MWH. 	<ul style="list-style-type: none"> • HSD do not conduct independent bathymetrical surveys • Government funding is not reliable and can affect performance

8.2.4 Environmental Protection Agency (EPA)

8.2.4.1 Overview

The Environmental Protection Agency is a subsidiary of the Ministry of Environment, Science Technology and Innovation. The agency is dedicated to improving and promoting the environment and striving for environmentally sustainable development. It oversees the implementation of the National Environment Policy.

EPA policy states that an Environmental Assessment Permit must be obtained before dredging works start. The law stipulates that before the permit is given an Environmental Impact Assessment must be conducted.

The EPA is responsible for the assessment of the dredged material and its impacts on the Public and Aquatic Life. Maintaining water bodies is also part of their job jurisdiction.

Sediments sampling and analysis

As per the Environmental Assessment policy, the EPA must sample and analyse dredged materials to ascertain its constituents/contamination levels to deduce its impact on the surroundings. The EPA has its own laboratory and can undertake the necessary tests and analysis of the sediments to be dredged.

Sampling testing

Further tests and sediment analysis is also done to explore the potential of re-cycle and re-use of the sediment and its constituents.

Sediments dumpsite

EPA must assess and approve the dumpsite for the dredged materials. Whether temporary or permanent. Approval must be sort from the EPA. Currently, the EPA in collaboration with the Ministry of Sanitation and Water Resources has approved of a permanent dumpsite and a landfill near Tema in Kpone.

General impression on PBC/PPP

The PBC contract management system is good if it is well structured and both parties are committed and satisfied.

8.2.4.2 Capacity assessment and gap analysis (EPA)

The results of the capacity assessment and gap analysis is presented in Table 8-6.

Table 8-6: Capacity assessment ad gap analysis EPA.

TASK	CURRENT CAPACITY AS ASSESSED	GAPS IDENTIFIED
ENVIRONMENTAL ASSESSMENT PERMIT	<ul style="list-style-type: none"> • EPA has the mandate to assess the environmental impact and give the necessary permit before dredging starts. • Assessment is done to ascertain the impact on the public and aquatic life. 	<ul style="list-style-type: none"> • EPA granted the permit for the current dredging works but is not following up to periodically monitor and does not know where the material is being disposed.
SEDIMENT SAMPLING AND ANALYSIS	<ul style="list-style-type: none"> • EPA has the capacity to conduct sediment sampling and analysis 	<ul style="list-style-type: none"> • No clear structure and schedule to undertake sediment sampling and analysis.
SEDIMENT TESTING	<ul style="list-style-type: none"> • EPA has its own laboratory internally to test sediments to determine the properties of the sediment and any other harmful constituents • Sediment testing and further analysis can deduce if the sediments can be recycled or has other reuse potential. 	<ul style="list-style-type: none"> • EPA has no clear schedule to periodically test samples to obtain data on the sediments.
SEDIMENT DUMPSITE	<ul style="list-style-type: none"> • EPA collaborates with the MSWR to approve and permit a permanent dumpsite and landfill for waste and dredged materials. 	<ul style="list-style-type: none"> • EPA is not aware of the temporary dumpsite for dredged materials.

8.2.5 Ministry of Sanitation and Water Resources (MSWR)

8.2.5.1 Overview

The Ministry has a policy in place for sanitation and waste management. The policy is being implemented with the various Municipal Assemblies. An environmental master plan for liquid and solid waste management is currently being developed for implementation by close of the year.

The Ministry's main role is to formulate policies and direction for waste management. Policy implementation is done with the Local Government Waste Management Departments, Environmental Management Department, Water Resources Commission, and Public Health Units of the Assemblies etc.

MSWR also coordinates with AMA (Drainage Maintenance Unit), HSD and MWH on Drainage maintenance works. They focus mainly on primary and secondary drains.

Project implementation

MSWR is to ensure that projects on sanitation and waste management is implemented by the Districts Assemblies to ensure that issues with dumping of refuse in drains is mitigated.

Sediments dumpsite

MSWR has a dumpsite in Kpone near Tema where rubbish is permanently disposed. Currently there is no permanent site allotted for dredge materials. However, the dumpsite can take the dredge materials if the volumes and the composition are communicated.

General impression on PBC/PPP

PBC is a good contract management option to implement. Ministry is open to PPP arrangement, but it may be challenging because PPP will require a scheme to mobilize revenue to incentivize the private partnership.

8.2.5.2 Capacity assessment and gap analysis (MSWR)

The results of the capacity assessment and gap analysis is presented in Table 8-7.

Table 8-7 : Capacity assessment and gap analysis MSWR.

TASK	CURRENT CAPACITY AS ASSESSED	GAPS IDENTIFIED
PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> MSWR is expected to initiate and direct the District and Municipal assemblies in the implementation of waste management projects. 	<ul style="list-style-type: none"> Funding is a major challenge. Non-existence of an effective and efficient waste management system.
SEDIMENT DUMPSITE	<ul style="list-style-type: none"> MSWR is responsible for the provision of a permanent dumpsite for waste. 	<ul style="list-style-type: none"> No existing dump site for sediment for ongoing dredging.
SOLID WASTE MANAGEMENT POLICY FRAMEWORK	<ul style="list-style-type: none"> MSWR has the mandate to formulate and initiate sustainable waste management policies. 	<ul style="list-style-type: none"> Current Waste Sanitation is not been well implemented by the Municipal assemblies.

8.2.6 Public Investment Division (PID)

8.2.6.1 Overview

The Public Investment Division operates under the Ministry of Finance and has a PPP Unit to oversee PPP Programmes in Ghana. The PID is to serve as the PPP Advisory Unit to support and build the capacity of the relevant Ministries, Departments and MMDCEs in the development and management of prospective PPP transactions.

This PPP Unit has the technical and financial expertise on PPP project development and is rolling out training packages to help equip the major players in policy and project implementation circles.

PPP status

PPP Law is currently at the cabinet level. An inter-ministerial committee has the task to look at the framework of enacting a PPP act to get legislative approval into law. The process will also include stakeholder consultation. The Law will facilitate all plans and modules of PPP to be instituted.

Current capacity to implement and manage PPP

The PPP Unit has the mandate to support contracting authorities to identify, scope, implement and manage PPP projects. Capacity Building Plans include joint reviews with contracting authorities and appraisals as well as political input for PPP projects.

In addition, the development of nodal units in the Municipal District Assemblies (MDAs) with the skill set and knowledge on PPP is one goal the PPP Unit is looking at implementing. This will aim at building capacity across the board by instituting a PPP unit for all relevant line entities to instil the ethos of PPP project development and management.

Currently, some contracting authorities such as the MSWR (Teshie Desalination Project) have garnered some knowledge and experience from PPP projects.

Training

Currently, key players in project development and management from the Ministries, contracting authorities, PPA and MDAs are undergoing training on appraisal of PPP project proposals. This should build capacity and equip these stakeholders with the technical and financial expertise of PPP projects and contract administration.

A private consultant has also been hired to draft a standard request for proposal RFP and other contract Standards for PPP to be studied and incorporated for PPP project implementation and evaluation.

Long-term goal is to institute the PPP project study in the tertiary education curricula.

Building capacity for PPP/PBC

The PPP Unit can help build capacity if they are furnished with the information and all relevant project data, which includes:

- Project Inception Reports;
- Feasibility Study report;
- Project Concept Note.

Another way to build capacity is to hire a private consultant with the expertise to undertake a transaction advisory job, together with identified project implementation and management team members from the various authorities and entities. This will aid them grasp the input of developing and managing the PPP/PBC structure and framework. The results of the capacity assessment and gap analysis is presented in Table 8-8.

Table 8-8: Capacity assessment and gap analysis PID and PPA.

TASK	CURRENT CAPACITY AS ASSESSED	GAPS IDENTIFIED
PROJECT IDENTIFICATION	<ul style="list-style-type: none"> • PID (PPP Unit) serves as the advisory unit to support and develop capacity for PPP Programmes. 	<ul style="list-style-type: none"> • The PPP Unit is still awaiting the PPP Law to back it operation.
PROJECT SCOPING	<ul style="list-style-type: none"> • PID (PPP Unit) assist PPP programme’s Contracting Authority in putting together is the regulatory body that puts together the scoping for projects. • PID (PPP Unit) is in the process of standardising Request for Proposal documents to be incorporated in PPP project implementation and evaluation 	<ul style="list-style-type: none"> • There are no PPP Units or departments in the various instritutions that man PPP projects and programmes
SELECTION CRITERIA AND AWARD	<ul style="list-style-type: none"> • PPA is the regulatory body which monitors the effective implementation of projects per the Public Procurement Laws • The PPA is developing a framework and modules to regulate PPP Procurement fully. 	<ul style="list-style-type: none"> • The PPA is yet to develop a full operating module for PPP

8.2.7 Public Procurement Authority (PPA)

8.2.7.1 Overview

The PPA is the regulatory body responsible for the effective implementation of the Public Procurement Law. PPA also make proposals for the formation of policies on procurement. The PPA has vetted and is aware of the current (2019) dredging contract with Dredge Masters Limited.

PPP Option.

According to the PPA, Public-Private Partnership is legally feasible. The PPA is developing its modules to accommodate the PPP fully since a number of PPP projects is currently ongoing in the country.

PPP/PBC

The type of agreement and contract should be well drafted on both the technical and financial side. This would require some legal formulation to help it work well.

Bundling of contracts (secondary drains, primary drains and waste management) should be done strategically to avert confusion on roles and responsibilities, since it will result in the involvement of many players.

Project selection criteria and award

The various Ministries and Metropolitan, Municipal and District Chief Executives (MMDCEs) have their autonomous procurement units whose operations and processes are guided by the PPA Laws in Ghana. Currently, the PPA is undertaking a training and workshop programme with the various MMDCEs, stakeholders and entities on their contract administration and management modules.

Capacity to manage PPP/PBC

The PPA is always open to new modules since procurement modules are evolving. Currently the PPA adopts the FIDIC contract management system however they are always open to build capacity on PPP/PBC since it is new in the system.

World Bank projects do not go through the PPA but for sustainability post the World Bank funding. It would mean the PPA must be in a position to handle contracts of that complexity.

Challenges and risk

Main risk associated with the PPP/PBC will be political. Changes in the political regimes may influence the implementation and management of the contract. World Bank funded projects may not be stopped or halted since the funding is not internal but there may be transitional delays, which may break down the contract management framework instituted.

8.2.7.2 Capacity assessment and gap analysis (PID)

The results of the capacity assessment and gap analysis is presented in Table 8-9.

Table 8-9: Capacity assessment and gap analysis PID and PPA.

TASK	CURRENT CAPACITY AS ASSESSED	GAPS IDENTIFIED
PROJECT IDENTIFICATION	<ul style="list-style-type: none"> • PID (PPP Unit) serves as the advisory unit to support and develop capacity for PPP Programmes. 	<ul style="list-style-type: none"> • The PPP Unit is still awaiting the PPP Law to back it operation.
PROJECT SCOPING	<ul style="list-style-type: none"> • PID (PPP Unit) assist PPP programme’s Contracting Authority in putting together is the regulatory body that puts together the scoping for projects. • PID (PPP Unit) is in the process of standardising Request for Proposal documents to be incorporated in PPP project implementation and evaluation 	<ul style="list-style-type: none"> • There are no PPP Units or departments in the various instritutions that man PPP projects and programmes
SELECTION CRITERIA AND AWARD	<ul style="list-style-type: none"> • PPA is the regulatory body which monitors the effective implementation of projects per the Public Procurement Laws • The PPA is developing a framework and modules to regulate PPP Procurement fully. 	<ul style="list-style-type: none"> • The PPA is yet to develop a full operating module for PPP

8.3 Assessment of needs and proposed training plan

As part of the study, a training needs assessment will be conducted to ascertain the required skills and expertise required for the planning, implementation and management of PPP/PBC projects. This will focus on:

- Project planning;
- Project implementation;
- Sediment sampling analysis.

Key objectives in conducting the assessment is to make the necessary findings for the preparation of a strategic training plan to tackle areas in need and build capacity for a sustainable PPP/PBC project management framework

8.3.1 Methodology of training needs assessment

The determination of training needs requires careful and further research with all the stakeholders, contracting authorities and entities for improving work competency, together with the development of specific related skills and capacity.

In order to arrive at the training needs assessment, it is imperative to assess the current capacity in terms of jurisdictions, mandate and responsibilities given to all the relevant stakeholders and players in drainage and maintenance.

From assessing and analysing the current capacity in the various quarters in respect of jurisdictions, mandate and responsibilities, certain gap areas have been identified and targeted for capacity building for PPP/PBC contract management and project implementation.

For identifying the required skills and expertise amongst the various agencies, department and units, the following factors need to be considered:

- Mandate;
- Policy framework;
- Main roles and responsibilities;
- Geographic area of work;
- Existing gaps in executing mandate;
- Skills and expertise existing;
- Skills and knowledge needed;
- Projection into future demands;
- Challenges.

8.3.2 Assessment of training needs

The assessment of the training needs are presented in Table 8-10, and follow the different steps of the project (preparation implementation and -if applicable follow-up). Based on these items each step gets a score in accordance with its gaps. The scores given represent following scale:

- 1 = no capacity, or substantial improvement required;
- 2 = basic capacity, some improvement required;

- 3 = some capacity, moderate improvement required;
- 4 = adequate capacity, minimal improvement required;
- 5 = good practices established, little or no improvement required.

Table 8-10: Assessment of training needs.

STAKEHOLDER	SCOPE OF ASSESSMENT	DETAILS OF EXPECTED DELIVERABLE	COMMENTS	SCORING (1 – 5)
MWH (Contracting Authority)	PROJECT PREPARATION AND TENDERING	<ul style="list-style-type: none"> Project Identification Project Scoping Tendering and Selection Criteria 	<ul style="list-style-type: none"> The Ministry has the capacity to initiate and prepare projects Coordination with other like HSD is lacking 	2
	PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> Contract Management Framework Monitoring and Performance Indicators Evaluation and Payment 	<ul style="list-style-type: none"> The Ministry will have to collaborate more with HSD in the contract management framework and structure Poor collaboration will leave a huge gap during PPP/PBC 	3
AMA (Municipal District Assembly)	PROJECT PREPARATION AND TENDERING	<ul style="list-style-type: none"> Project Identification Project Scoping Tendering and Selection Criteria 	<ul style="list-style-type: none"> The Drainage Maintenance Unit must well equipped and funded. They manage secondary and tertiary that feed into the main Resource the Waste Management Departments with more Engineers because Waste Management is more Engineering than Administration 	2
	PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> Contract Management Framework Monitoring and Performance Indicators Evaluation and Payment 	<ul style="list-style-type: none"> The Drainage Maintenance Unit must well equipped and funded. They manage secondary and tertiary that feed into the main 	1
HSD (Project Implementers and Contract Managers)	PROJECT PREPARATION AND TENDERING	<ul style="list-style-type: none"> Project Identification Project Scoping Tendering and Selection Criteria 	<ul style="list-style-type: none"> Legislature to upgrade HSD into an Authority will give the powers to operate properly per in its mandate 	2
	PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> Contract Management Framework Monitoring and Performance Indicators Evaluation and Payment 	<ul style="list-style-type: none"> More Expertise and skills to be developed particularly for monitoring and evaluation for PPP/PBC 	2

STAKEHOLDER	SCOPE OF ASSESSMENT	DETAILS OF EXPECTED DELIVERABLE	COMMENTS	SCORING (1 – 5)
MSWR (Contracting Authority)	PROJECT PREPARATION AND TENDERING	<ul style="list-style-type: none"> Project Identification Project Scoping Tendering and Selection Criteria 	<ul style="list-style-type: none"> The Ministry should develop a module to attract the Private sector on PPP projects to collect, transport and recycle solid waste 	3
	PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> Contract Management Framework Monitoring and Performance Indicators Evaluation and Payment 	<ul style="list-style-type: none"> The Ministry should coordinate well with the MDAs on the effective and efficient implementation of Sanitation Policy Volumes of debris dumped in drains affect dredging methodology 	2
	SEDIMENTS HANDLING	<ul style="list-style-type: none"> Sediment Dumpsite 	<ul style="list-style-type: none"> The Ministry must ensure that dredged materials are hauled to an EPA approved dumpsite for final dumping Ministry must coordinate with EPA in the testing and research in exploring the potential of sediment re-use 	1
EPA (Environmental Impact Assessment)	PROJECT PREPARATION AND TENDERING	<ul style="list-style-type: none"> Project Identification Project Scoping Tendering and Selection Criteria 	<ul style="list-style-type: none"> The EPA must move to demand Scoping and EIA reports for all Drainage Dredging works before issuing permits 	3
	PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> Contract Management Framework Monitoring and Performance Indicators Evaluation and Payment 	<ul style="list-style-type: none"> The EPA must continually monitor to ensure that dredging are not flouting or deviating from accepted environmental standards 	1
	SEDIMENTS SAMPLING AND TESTING	<ul style="list-style-type: none"> Sediment Sampling and Testing Sampling Analysis Sediment Dumpsite 	<ul style="list-style-type: none"> The EPA should conduct sampling and testing of sediments periodically and advice on handling and dumping Approve of permanent dumping site and Landfill Explore re-use potential of sediments 	3

STAKEHOLDER	SCOPE OF ASSESSMENT	DETAILS OF EXPECTED DELIVERABLE	COMMENTS	SCORING (1 – 5)
PPA (Procurement Authority)	PROJECT PREPARATION AND TENDERING	<ul style="list-style-type: none"> • Project Identification • Project Scoping • Tendering and Selection Criteria 	<ul style="list-style-type: none"> • The PPA to incorporate PPP Procurement requirement into module for implementation 	4
	PPP PROCUREMENT	<ul style="list-style-type: none"> • Contract Management Framework • Monitoring and Performance Indicators • Evaluation and Payment 	<ul style="list-style-type: none"> • The PPA include PPP module and contract management into training schemes for various stakeholders 	4
PID(PPP Unit)	PROJECT PREPARATION AND TENDERING	<ul style="list-style-type: none"> • Project Identification • Project Scoping • Tendering and Selection Criteria 	<ul style="list-style-type: none"> • PPP Law to be facilitated to enable PPP Laws to enact into projects 	1
	PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> • Contract Management Framework • Monitoring and Performance Indicators • Evaluation and Payment 	<ul style="list-style-type: none"> • The training and formation of PPP nodal unit in the various agencies and entities to be facilitated 	1

8.4 Training plan

The objective of the training for capacity building and development is to either enhance the functional knowledge, improve job related skills or change the attitude and approach to work/mandate. Any one or a combination of the following different modes of training can achieve the required objective:

- classroom training;
- on the job training;
- workshops/seminars;
- study visits;
- educational programmes.

Normally, the mode of training can be a combination of all or most of the above training modes however, the following is recommended;

- Nominating the key officials, staff and agents from the various departments and units in the listed stakeholder target groups to undergo the training programme.
- The modules to be conducted by reputed institutions or resource persons with excellent knowledge and expertise in the area of PPP/PBC
- Sponsoring a few selected officials and key staff, depending on their area of work and training needs, for study visits to other countries where good PPP/PBC ethos and practices have been established. This method will speed up the knowledge gain due to immediate implementation of the knowledge.
- Sponsoring a few selected officials and key staff, depending upon their training needs, for educational programmes in the area of PPP/PBC in foreign institutes of repute. Furthermore, it will help the participants to get a view on the international standards.

It is expected that the trained officials and staff will in return train their support staff to enhance functional and operational knowledge in the area of PPP/PBC project planning, implementation and management.

8.4.1 Phasing of training

A training schedule over an 18-month period is proposed in two phases, based on priority as described:

- **Phase I** - Training of the individual stakeholders which cannot wait and should be completed in the next 12 months.
- **Phase II** - Training that will involve stakeholder engagement, collaboration and coordination, to be completed in the following 6 months after Phase I.

A training module via the training needs assessment and gap analysis will be developed in the next deliverable (D3 Draft Feasibility Study report) where the Capacity Building for PPP/PBC will be further outlined. The final month of the training will be for evaluation, assessment of the training and verification. There will be different monitoring indicators for training interventions as the target groups in have distinctive objectives.

8.4.2 Training plan - Phase II

HOLD – deliverable D3 due 16th December 2019

Table 8-11: Training plan Phase I.

CAPACITY AREA – PPP/PBC	TARGET STAKEHOLDER/AGENCY	DESCRIPTION OF TRAINING PACKAGES	TRAINING MODULES	LEARNING OUTCOMES AND DELIVERABLES	DURATION
PROJECT PLANNING AND PREPARATION	<ul style="list-style-type: none"> Ministry of Works and Housing, MWH Hydrological Services Department, HSD Accra Metropolitan Assembly, AMA Ministry of Sanitation and Water Resources Public Procurement Authority, PPA 				1 st - 4 th Month
PROJECT IMPLEMENTATION	<ul style="list-style-type: none"> Ministry of Works and Housing, MWH Hydrological Services Department, HSD Accra Metropolitan Assembly, AMA Ministry of Sanitation and Water Resources Public Procurement Authority, PPA 				4 th - 10 th Month
SEDIMENT HANDLING, SAMPLING AND ANALYSIS	<ul style="list-style-type: none"> Accra Metropolitan Assembly, AMA Environmental Protection Agency, EPA Ministry of Sanitation and Water Resources 				8 th - 12 th Month

8.4.3 Training plan - Phase II

HOLD – deliverable due 16th December 2019

Table 8-12: Training plan Phase II

TARGET STAKEHOLDER/AGENCY	DESCRIPTION OF TRAINING PACKAGES	TRAINING MODULES	LEARNING OUTCOMES AND DELIVERABLES	DURATION
PROJECT PLANNING AND PREPARATION <ul style="list-style-type: none"> • MWH & HSD • HSD & AMA • MWH, HSD, PPA • MWH, MSWR & PPA • MWH & MSWR • MWH, MSWR, HSD & AMA • AMA & PPA 				1 st – 2 nd Month
PROJECT IMPLEMENTATION <ul style="list-style-type: none"> • MWH & HSD • HSD & AMA • MWH, HSD, PPA • MWH, MSWR & PPA • MWH & MSWR • MWH, MSWR, HSD & AMA 				3 rd – 4 th Month

TARGET STAKEHOLDER/AGENCY	DESCRIPTION OF TRAINING PACKAGES	TRAINING MODULES	LEARNING OUTCOMES AND DELIVERABLES	DURATION
<ul style="list-style-type: none"> AMA & PPA 				
SEDIMENT HANDLING, SAMPLING AND ANALYSIS <ul style="list-style-type: none"> EPA & AMA EPA & MSWR EPA, MSWR & AMA 				5 th Month

8.4.4 Monitoring indicators and verification of capacity outputs

HOLD – deliverable due 16th December 2019

TARGET STAKEHOLDERS/AGENCY	MONITORING INDICATORS	MEANS OF VERIFICATION
MINISTRY OF WORKS & HOUSING		
HYDROLOGICAL SERVICES DEPARTMENT		
Ministry of Sanitation & Water Resources		
ACCRA METROPOLITAN ASSEMBLY		
ENVIRONMENTAL PROTECTION AGENCY		
PUBLIC PROCUREMENT AUTHORITY		

9 Task 9: Preparation of PBC tender and bidding documents

HOLD – deliverable due 16th December 2019 and will be in a separate document following the World Bank procurement layout.

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11 Appendices

Annex A

Task 1 annexes

A.1 Leaflets Cutter Suction Dredgers (CSD's)

IHC BEAVER® 65 DDSP CUTTER SUCTION DREDGER



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PU 25AB-6

The IHC Beaver® 65 DDSP is reliable, fuel-efficient, has low maintenance costs and high-productivity levels at all dredging depths. This robust dredger is equipped with state-of-the-art technology. The key features include:

- low cost per cubic metre
- a diesel directly driven submerged pump (DDSP) that makes it possible to dredge at high-mixture densities
- the Curve® impeller that combines high efficiency with excellent suction performance and low-energy consumption
- first class ergonomics and diagnostics
- wear-resistant parts for the dredge pump
- class certification (BV Coastal area)
- integrated spud carriage installation.

RELIABLE AND EFFICIENT

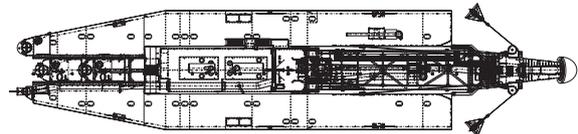
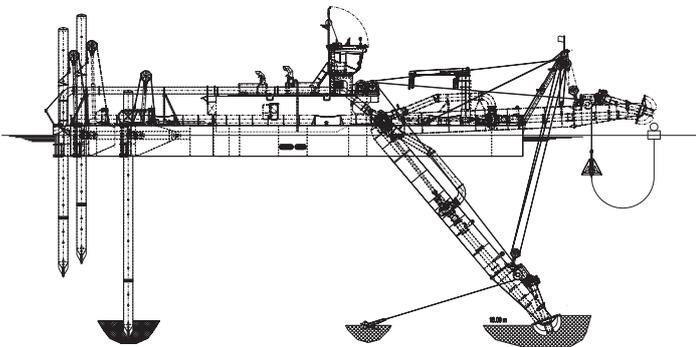
The IHC Beaver® is well known for its robust construction, reliable operation and excellent performance. To date, Royal IHC has supplied more than 800 of these standard cutter suction dredgers worldwide.

TRANSPORTABLE AND DELIVERABLE FROM STOCK

IHC Beaver® dredgers can be dismantled for transport via road, rail or sea. A wide range of optional equipment is available, as well as complementary auxiliary equipment, such as work boats and discharge pipelines. These vessels are mostly delivered from stock.

SERVICE AND SUPPORT

IHC can provide a complete package of spare parts, maintenance support, equipment training programmes, dredging advisory services and dredge operators for hands-on instruction and commissioning.



MAIN PARAMETERS

Dredging depth	18.0m (larger depth optional)
Discharge diameter	650mm (larger diameters optional)
Total power	2,819kW



**THE TECHNOLOGY
INNOVATOR.**

ROYALIHC.COM

DIMENSIONS

Length overall (ladder raised), approx.	58.0m
Length over pontoons	43.50m
Breadth	12.44m
Depth	2.97m
Side pontoons	43.50 x 4.67 x 2.97m
Mean draught with full bunkers	1.95m
Maximum standard dredging depth	18.0m
Suction pipe diameter	650mm
Discharge pipe diameter	650mm
Total installed power	2,819kW

SWING WIDTH WITH 35° SWING EACH SIDE

At maximum dredging depth	48.5m
At minimum dredging depth	59.5m

DREDGE PUMP

Type	IHC HR/MD 121-26-60, with Curve® impeller inside
Engine type	Caterpillar 3516C SCAC
Continuous engine power	1,825kW @ 1,600rpm
Specific fuel consumption	206.9g/kWhr

AUXILIARY POWER (CUTTER, WINCHES AND SPUDS)

Engine type	C32 DITTA Acert
Prime power	994kW
Specific fuel consumption	207.2g/kWhr

ELECTRICAL INSTALLATION

Voltage	24V DC
Battery capacity	800Ah
Voltage (50Hz)	230/400V AC
Power (50Hz)	26kW

CUTTER

Type	IHC 20-CB-ACR-2220-550
Power at shaft	700kW in order to absorb load peaks
Diameter	2,220mm
Maximum speed, approx.	30rpm

LADDER AND SWING WINCHES

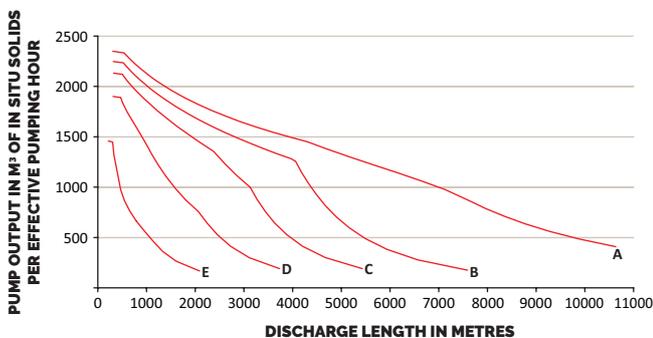
Line pull, first layer	240kN
Maximum line speed	23m/min
Wire diameter	36mm
Drum diameter	762mm
Swing wires length	150m
Anchor weight	1,500kg

SPUDS

Length	23.4m
Diameter	900mm
Weight	15,500kg

PUMP OUTPUT

Discharge pipe diameter = 650mm
Dredging depth = 18.0m
Maximum volumetric concentration of in situ solids of 30%
Final elevation at end of discharge pipe = 4.0m



SPUD HOISTING CYLINDERS

Force	798kN
Spud stroke (each time), approx.	3.75m

SPUD CARRIAGE TRAVELLING CYLINDER

Stroke of cylinder	4.50m
--------------------	-------

DECK CRANE

Lifting power	40kN
Outreach	5.10m

CLASSIFICATION

Bureau Veritas Class I, ✕ HULL • MACH Dredger - no propulsion
Coastal area

OTHER FEATURES

- standard design, allowing for short delivery times and competitive pricing
- spare parts available from stock
- durable heavy-duty marine engines compliant with IMO Tier II
- efficient fuel consumption
- fresh-water engine cooling system
- dredge pump driven through pivoting gearbox
- cutter drive accepts temporary overload, resulting in high maximum cutter power
- reliable hydraulic system
- completely assembled and fully tested afloat before delivery
- dismountable and transportable by road, rail or sea
- ready for operation on arrival at site
- one-man operation
- on-board toilet and wash basin
- special tools are supplied for connecting and disconnecting pontoons and the cutter ladder, and for maintenance of the dredge pump and diesel engine
- wide range of services and auxiliary equipment available (including work boats, boosters and pipelines).

OPTIONAL EXTRA'S

- anchor booms
- IHC Spud Guard®
- swivel bend
- discharge valve and vacuum-relief valve
- Lancelot® cutterhead (special multi-blade)
- production measurement, automation and positioning system
- Operator Assist System for online monitoring
- increased discharge pipeline diameter
- increased dredging depth
- life-cycle support packages (including training, technical support etc.)
- accommodation
- optional packages: comfort (including air conditioning); HSE (health, safety and environment); nautical; and inventory plus.

Output calculated for:

SOIL TYPE	DECISIVE GRAIN SIZE	SITU DENSITY
A Fine sand	100µm	1,900kg/m ³
B Medium sand	235µm	1,950kg/m ³
C Coarse sand	440µm	2,000kg/m ³
D Coarse sand and gravel	1.3mm	2,100kg/m ³
E Gravel	7mm	2,200kg/m ³

NOTE

Calculated output curves indicate pumping capacity, based on the maximum available power on the pump shaft. When used for estimation actual outputs, the nature of the material to be dredged and local job conditions must be considered. Please consult IHC for dredging conditions outside these curves.



**THE TECHNOLOGY
INNOVATOR.**

Royal IHC

info@royalihc.com
www.royalihc.com

EQUIPMENT SHEET

BEAVER ST LAWRENCE
CUTTER SUCTION DREDGER



CONSTRUCTION/CLASSIFICATION

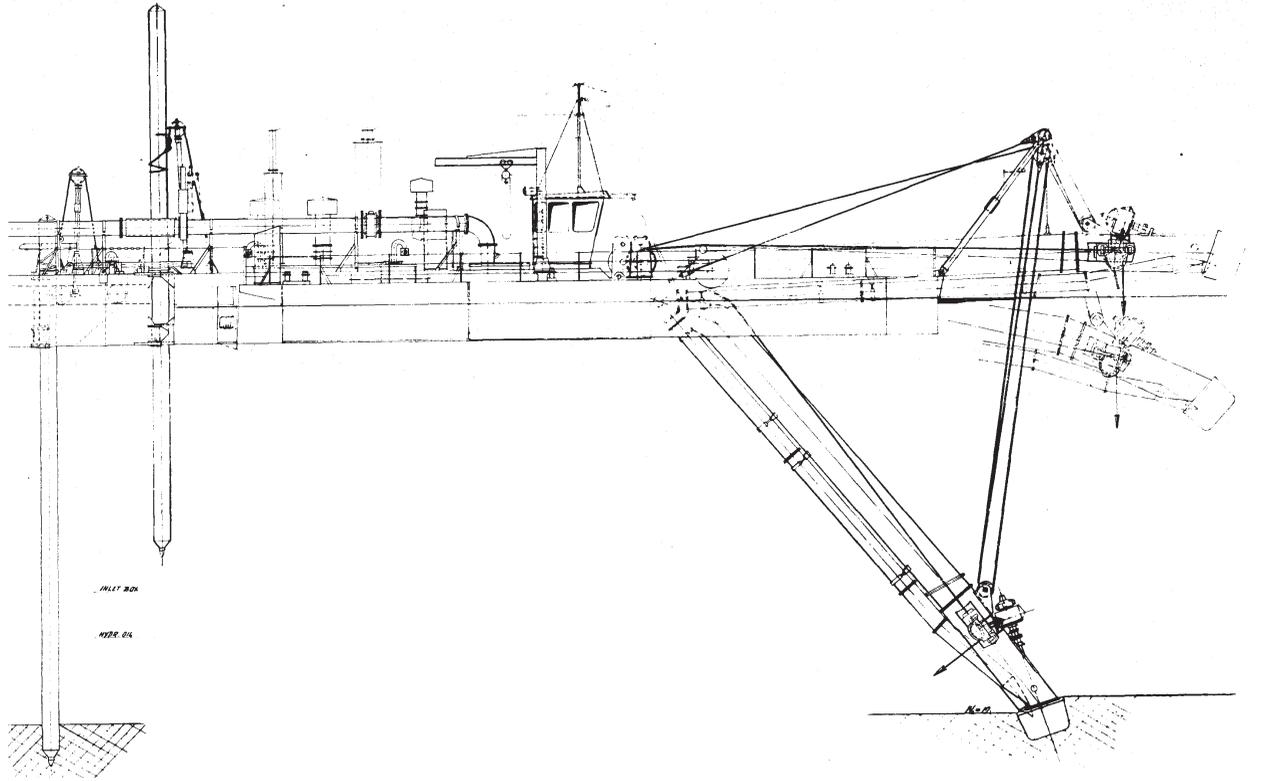
Built by	IHC, Sliedrecht
Year of construction	1983
Classification	B.V. I 3/3D Coastal Service

FEATURES

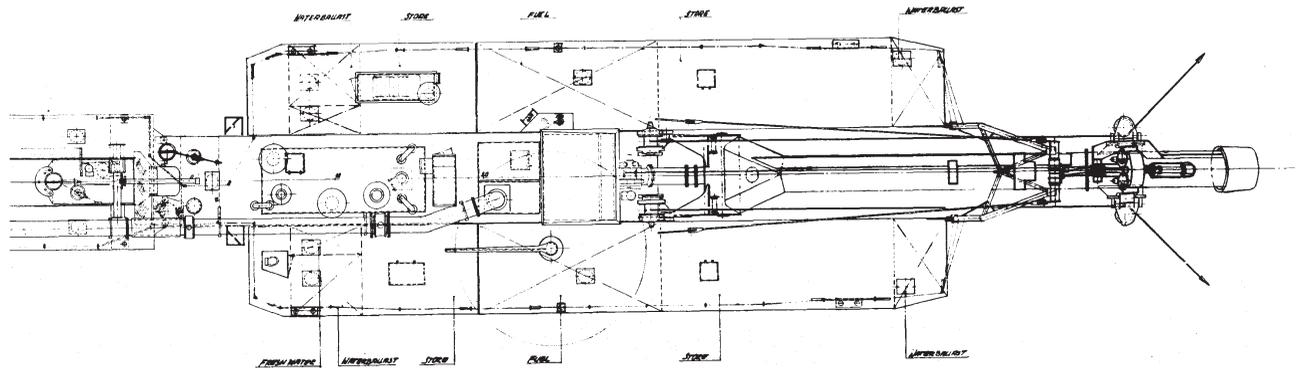
Dismountable
Suitable for shallow water operations.
Designed for fast assembly in remote areas.

MAIN DATA

Gross tonnage	117.0
Length overall	46.30 m
Length hull	34.43 m
Breadth	9.10 m
Moulded depth	2.00 m
Max. draught	1.54 m
Suction pipe diameter	0.55 m
Discharge pipe diameter	0.55 m
Max. dredging depth	14.00 m
Anchoring system	Spud carriage
Total installed power	1,140 kW (1,530 hp)
Cutter output	171 kW (230 hp)
Suction/discharge pump output	839 kW (1,125 hp)

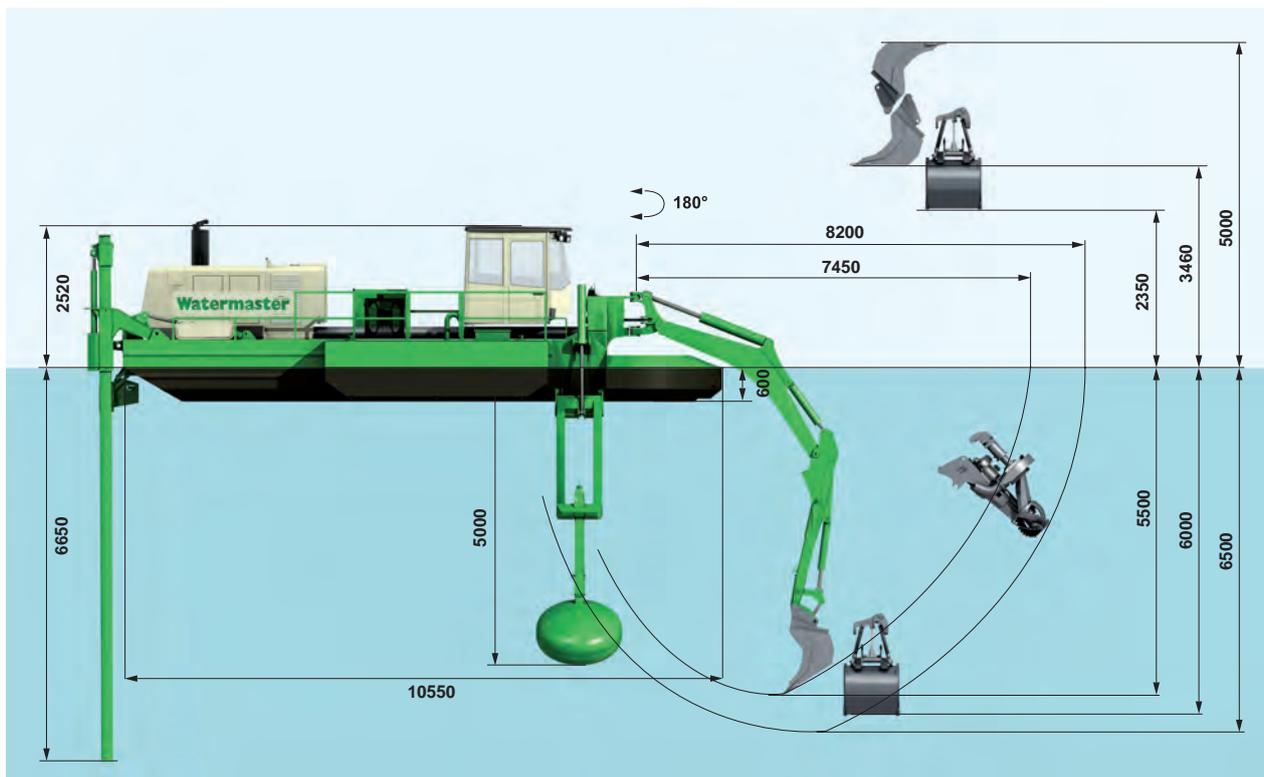


SIDE VIEW



TOP VIEW DECK LEVEL

amphibious multipurpose dredger



Amphibious Multipurpose Watermaster

engine

Caterpillar C7.1, turbo charged, 6-cylinder diesel engine

- air-water radiator cooled
- flywheel power at 2000 rpm

168 kW (Classic IV)
205 kW (Classic V)

- fuel tank capacity
- electric system
- batteries
- electric refueling pump

1200 l
24 V
2 x 170 Ah

hydraulics

one axial piston pump for dredging and propeller - operating pressure

max. 345 bar

one axial piston pump for digging and stabilizers - operating pressure

max. 230 bar

excavator

- swinging angle
- break-out force from bucket cylinder
- digging force from arm cylinder
- lifting capacity at max. reach
- quickly changeable attachments

180°
83 kN
47 kN
24,5 kN

hull

- one piece hull divided into 7 watertight compartments
- corrosion resistant painting outside and inside
- protective skid bars on underside
- mast, signal lights for dredging and navigation

cabin

- modern FOPS certified cabin with excellent visibility
- additional seat for instructor
- 10 work lights

anchoring

- independent anchoring and work movement without assisting vessels, winches or wire-cables
- two front stabilizers, max depth 5,0 m
- two rear tilting stabilizers, max depth 6,7 m

mobility

- self-loading and self-unloading to/from a trailer
- moves independently in and out of water
- self-propelled
- amphibious in all work modes

certified quality

- quality certificate ISO 9001
 - environmental certificate ISO 14001
 - safety certificate ISO 3449
- certificates issued by authorized certification authority

transport dimensions and weight

transport length without boom	11,00 m
transport length with boom	16,00 m
transport width	3,30 m
transport height	3,15 m
transport weight	ca 19,50 t

Technical specifications are subject to change without prior notice.
The pictures in this brochure include optional equipment.
10.2016

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E-mail: watermaster@aquamec.fi





DEEP CUTTER SUCTION DREDGER 500

PICTURE OF SIMILAR VESSEL

GENERAL

Type	DCSD 500
Basic functions	Capital mining and maintenance dredging

DREDGING FEATURES

Max. dredging depth	-25 m
Max. mixture capacity	4,000 m ³ /h

DREDGE INSTALLATION

Dredge pump type	OBP5045
Diam. suction/discharge pipe	550/500 mm
Cutter type	Crown model (with changeable chisels)
Cutter power	110 kW
Spherical passage pump	230 mm
Cutter diameter	1,625 mm

ENGINE INSTALLATION

Dredge pump diesel	Caterpillar 3512C TA
Continuous power A-rating	954 kW @ 1,600 rpm
Hydraulic diesel	Caterpillar approx. 440 kW
Hydraulic installation	Driving cutter, winches and spuds
Electrical installation	24 V DC and 230/400 V AC, 34 kVA

PRINCIPAL DIMENSIONS APPROX.

Length o.a. incl. ladder	46 m
Length over pontoons	28.50 m
Beam	9.00 m
Depth	2.50 m
Draught	1.20 m
Air draught	6.40 m
Total weight	220 ton

TANK CAPACITIES

Fuel oil approx.	20.0 m ³
Hydraulic oil approx.	1.5 m ³

DECK MACHINERY

Ladder hoisting	Hydraulic winch, 270 kN, 0-15 m/min
Side wire winches (2x)	Hydraulic, 120 kN, 0-15 m/min
Spuds (2x)	Ø 610 mm, length 30 m
Spud hosting (2x)	Hydraulic cylinder

INSTRUMENTATION

Dredging depth indicator	
Vacuum and pressure indication of dredge pump	

REMARKABLE FEATURES

- Dismountable design
- Submersible dredge pump for high mixture density
- Diesel direct driven
- Heavy duty robust design
- Simultaneous operation of all functions possible
- Spacious ergonomic designed control cabin
- One operator can control the entire dredger from the control cabin
- Operators cabin with air conditioning and heating
- Most components fit in containers

DEEP CUTTER SUCTION DREDGER 500



DAMEN

DAMEN SHIPYARDS GROUP

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PETRUS PLANCIUS



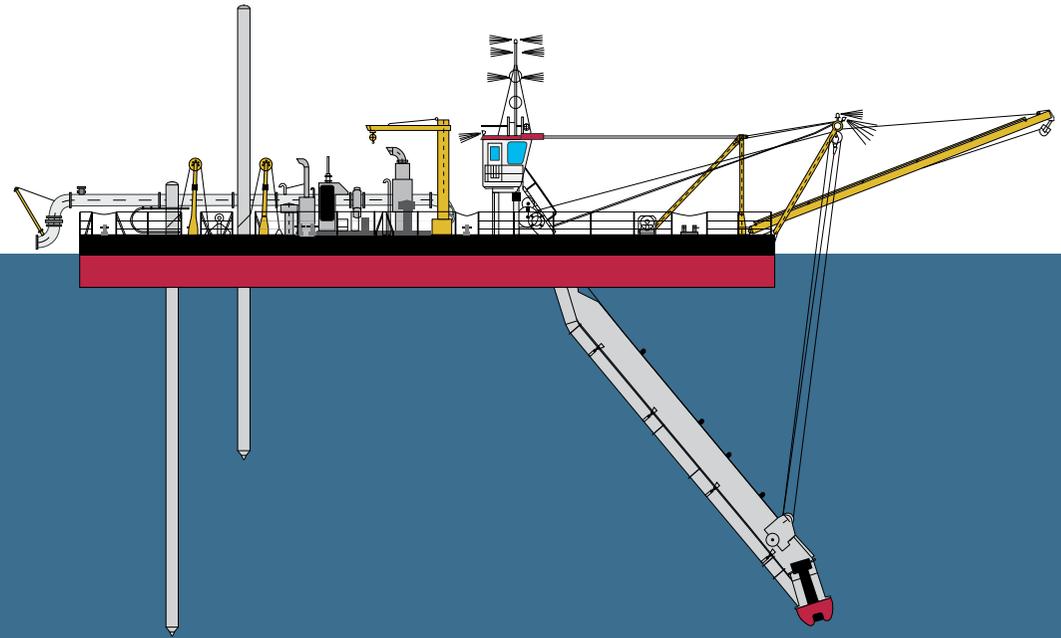
Jan De Nul
GROUP

www.jandenul.com

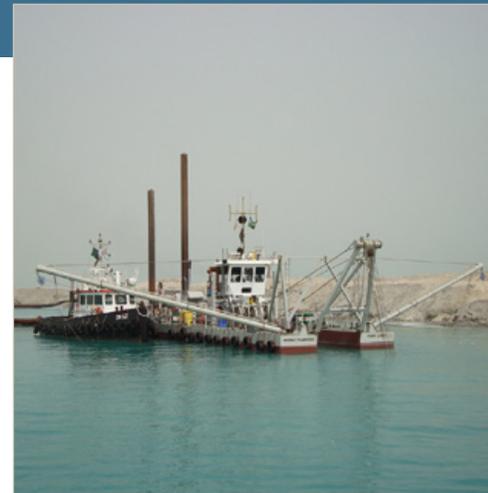
Cutter Suction Dredger

PETRUS PLANCIUS

Length o.a.	44.2 m
Breadth	7.95 m
Draught	1.5 m
Dredging depth	16 m
Suction pipe diameter	550 mm
Discharge pipe diameter	500 mm
Barge loading pipe diameter	-
Submerged pump power	-
Inboard pump power	954 kW
Cutter power	170 kW
Propulsion power	-
Total installed diesel power	1,300 kW
Speed	-
Accommodation	-
Built in	2008



V2013-2



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A.2 Watermaster brochure

Watermaster

Classic IV | Classic V

Amphibious Multipurpose Dredger
For dredging, piling, raking – and more

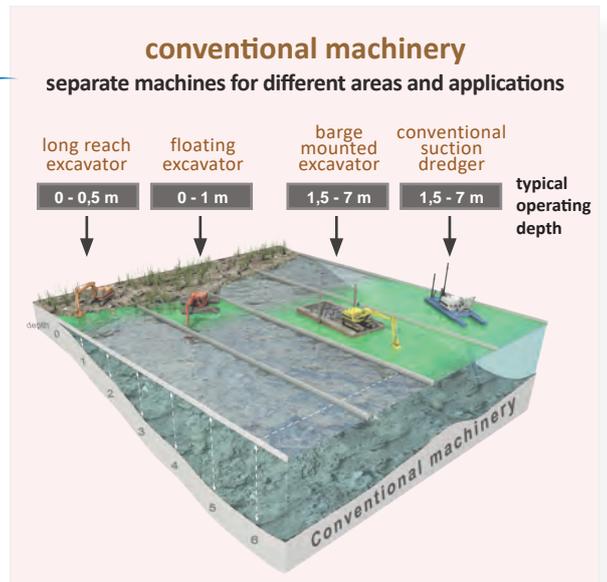
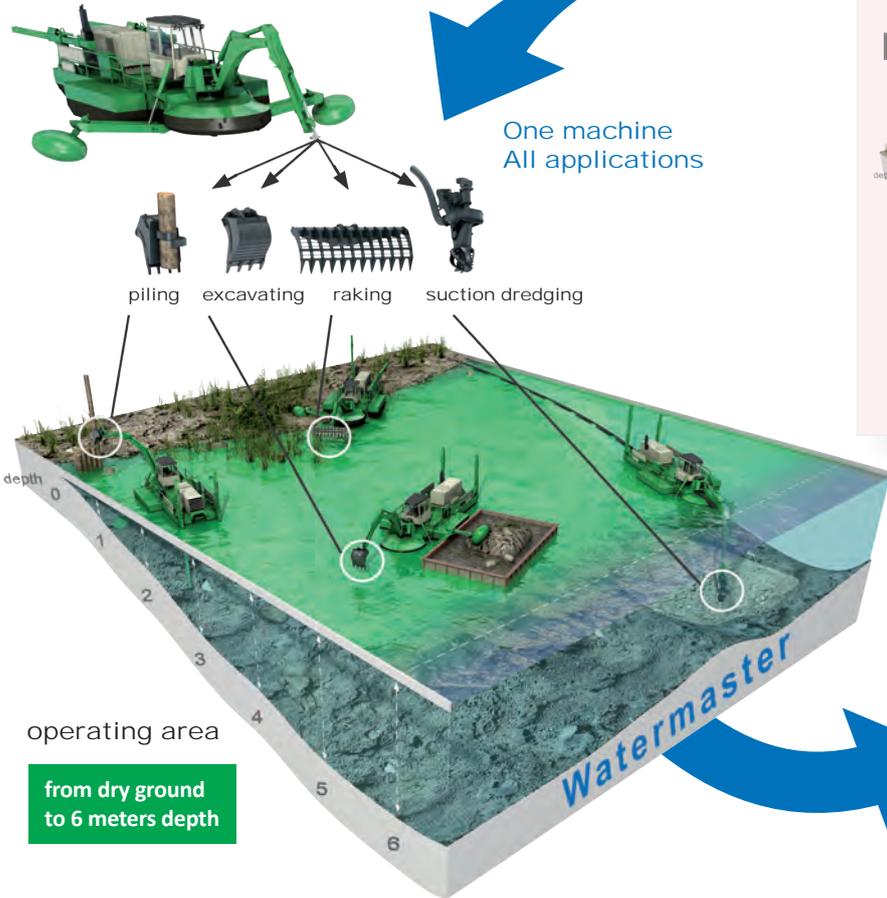
Unique mobility in water and on land.
Operational area from dry ground to 6 meters depth

Made in Finland - Operating worldwide



Watermaster

Amphibious Multipurpose Dredger



Watermaster

- one machine for all applications
- superior mobility and versatility
- replaces several single purpose machines
- reduces investment and operational costs
- proven performance and service



1 transport
on a standard trailer

2 mobilize
without set-up times,
cranes and tugboats

3 work
without winches, wire-cables
and assisting vessels

versatile

mobile

proven

Watermaster

amphibious multipurpose dredger



Watermaster cutter pump

- sludge-pumping capacity up to 600 m³/h with Classic IV and 900 m³/h with Classic V
- Discharge distance up to 1,5 km
- submersible, includes two cutter crowns
- revolutionary integrated cutting knife system (patented)



FOPS certified cabin



600 l bucket

- for excavation work



clamshell bucket

- for excavating polluted materials - seals the materials inside the bucket
- ideal for loading into barges
- volume 600 l



rake

- for removal of reeds, roots and other vegetation
- for cleaning the bottom from trash
- 2,75 m wide



piling bucket

- for driving wood piles
- for reinforcing shores
- for marina maintenance



Caterpillar engine

discharging up to 1,5 km away

large work area with flexible excavator arm

quickly changeable attachments

independent anchoring with 4 stabilizers

MINIMIZED REPOSITIONING TIME = MAXIMUM WORK EFFICIENCY

With its flexible excavator arm and four unique stabilizers, the Watermaster covers a large area from each position, and changes its position quickly

keep waterways operational

- deepening and maintaining shallow waterways
- marina and harbor dredging
- beach revitalizing and land reclamation



prevent floods and clean the environment

- flood prevention and control
- removal of invasive vegetation
- cleaning and restoring urban canals



utilize in construction projects

- foundation work by pile driving
- strengthening shorelines by pile driving
- trench digging and laying underwater pipe and cable



Maintain industrial ponds and recover valuable materials

- maintenance of process- and wastewater ponds
- recovering valuable materials from tailings and drainage ponds



proven technology

- continuously developed since 1986
- made in Finland - operating worldwide
- supported by Watermaster service network
- ISO 9001 & ISO 14001 certified serial product



Annex B

Task 5 annexes

B.1 KLERP maps



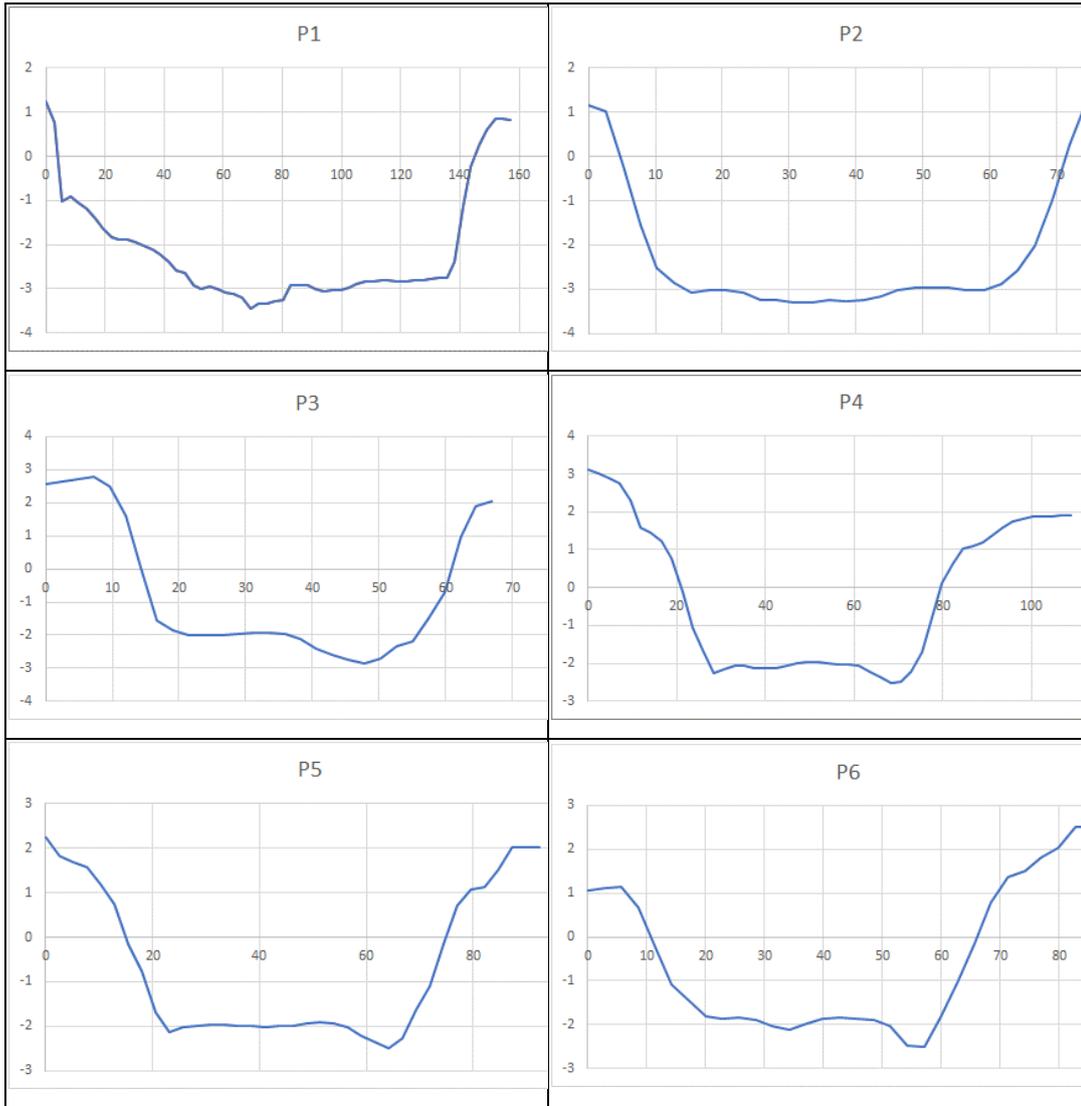
Figure Annex B-1 Before KLERP (satellite image of 10-02-2000 from Google Earth)



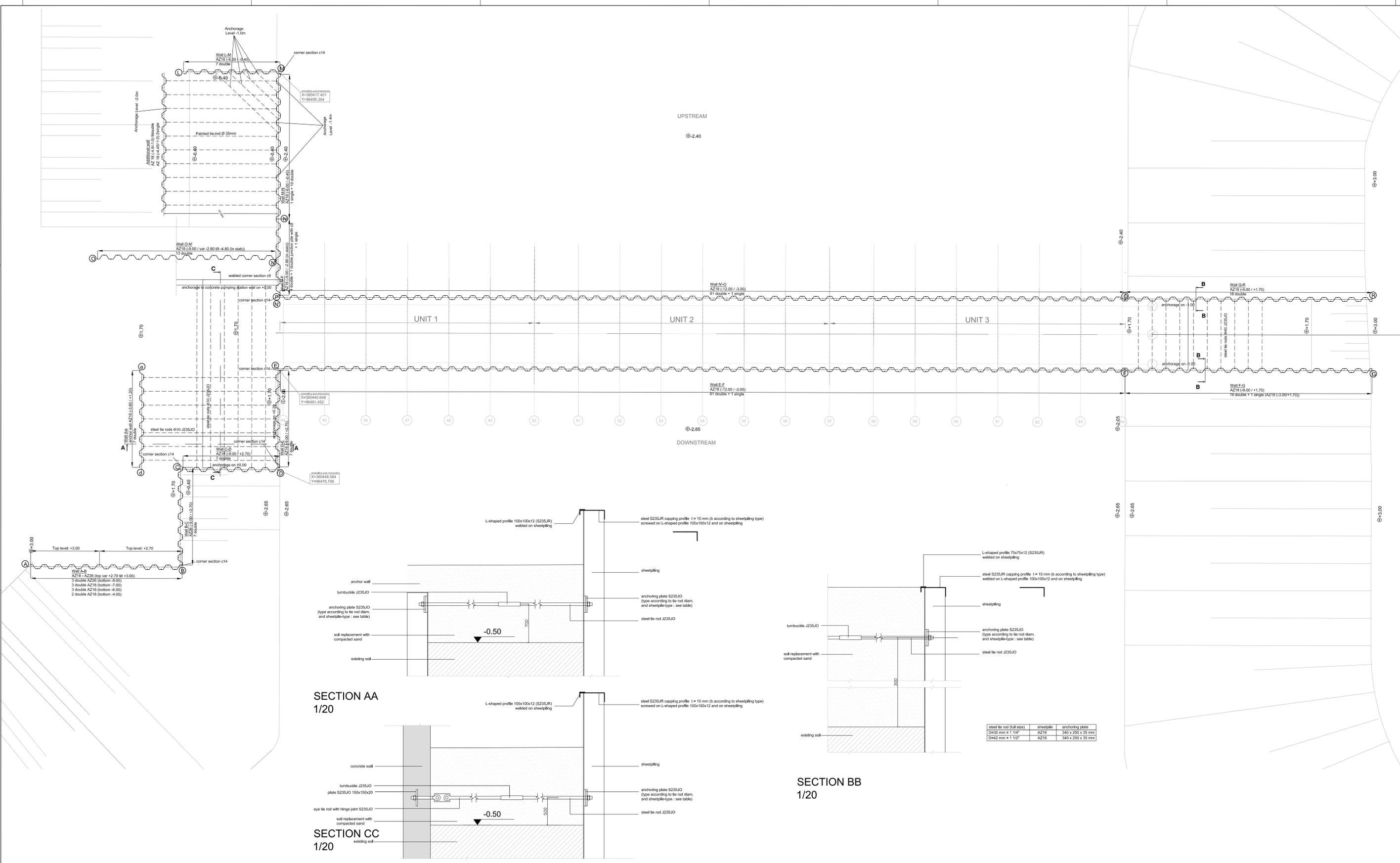
Figure Annex B-2: 2019 situation (satellite image of 08-10-2015 from Google Earth)



Figure Annex B-3: Plan view of the as-built bathymetry of the dredged areas around the interceptor weir. The profiles indicated in red are shown below.



B.2 KLERP as built drawings



NOTE:

- all sheetpiling S240GP, except under interceptor S355GP
- tie rods and anchoring devices : J235JO
- corrosion protection of all sheetpiling above soil level (-2,65) and anchoring elements see technical specifications



GOVERNMENT OF THE REPUBLIC OF GHANA
MINISTRY OF WORKS AND HOUSING

International Marine and Dredging Consultant NV
IMDC

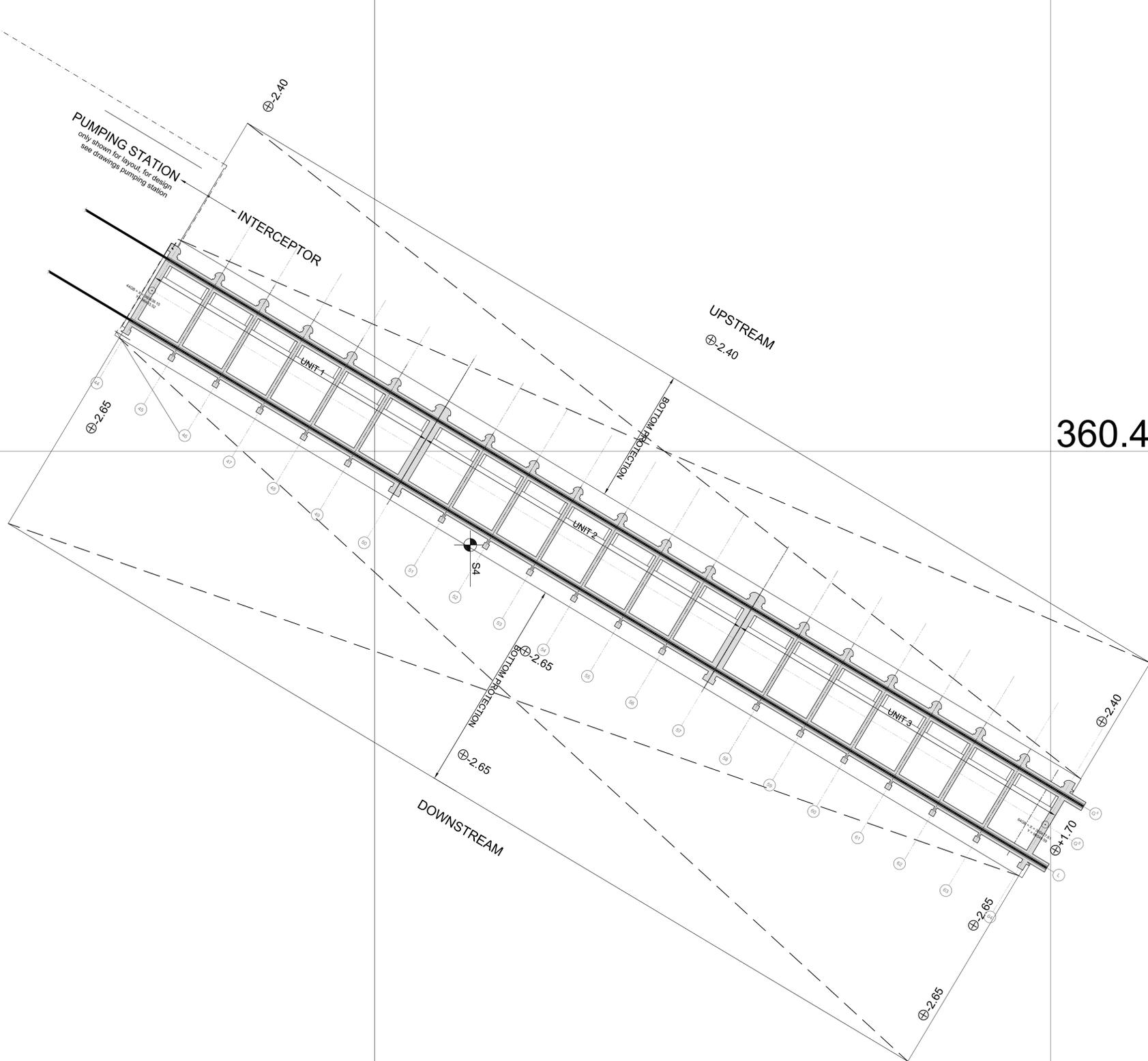
JV DREDGING INTERNATIONAL
GULF DREDGING & GENERAL CONTRACTING CO.

CONSULTANT			CLIENT		
Approved	Date	Name	Approved	Date	Name
Checked			Checked		

**KORLE LAGOON ECOLOGICAL RESTORATION PROJECT
PHASE II - Stage II - Dredging, Earthworks & Marine Works**

REV.	DATE	DESCRIPTION
A	01/09/03	FINAL CONCEPT
B	24/10/03	EXECUTION DRAWING FOR APPROVAL ONLY
C	20/10/03	EXECUTION DRAWING FOR APPROVAL ONLY (2nd ISSUE)
D	24/10/03	For construction
E	18/03/04	For construction (coordinates checked by Technim)
F	15/05/04	For construction (welds on steel pile level +2.70 taken off)
Z	02/07/05	"As Built"

DETAIL DRAWING		DRAWN	
KORLE LAGOON INTERCEPTOR SHEETPILING PLAN			
DATE:	02/07/05	DRAWN BY:	B. Osei
SCALE:	1:100	DATE:	02/07/05
SHEET NO: 1 of 1		PROJECT NO: EST/DET/48324Z.dwg	



360.450

360.500

9

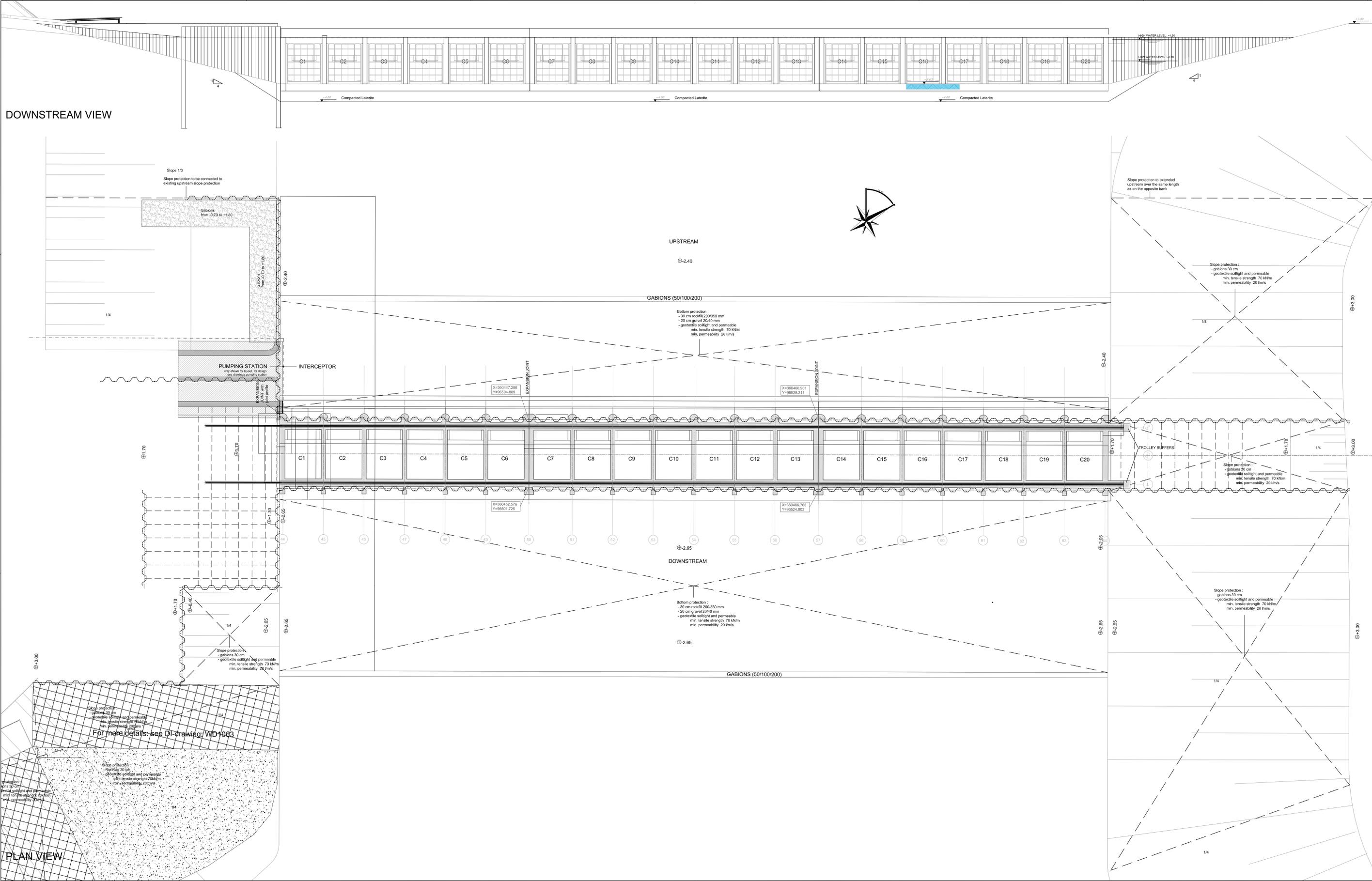
64

44

9

DOWNSTREAM VIEW

PLAN VIEW



GOVERNMENT OF THE REPUBLIC OF GHANA
MINISTRY OF WORKS AND HOUSING

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 Wilhelmsdijk 37-45 (Bus 4)
 1118 CA Schiedam
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JV DREDGING INTERNATIONAL
GULF DREDGING & GENERAL CONTRACTING CO.

CONSULTANT			CLIENT		
Date	Name	Signature	Date	Name	Signature

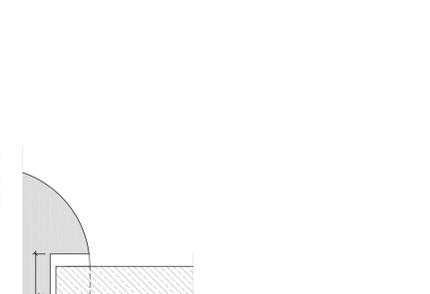
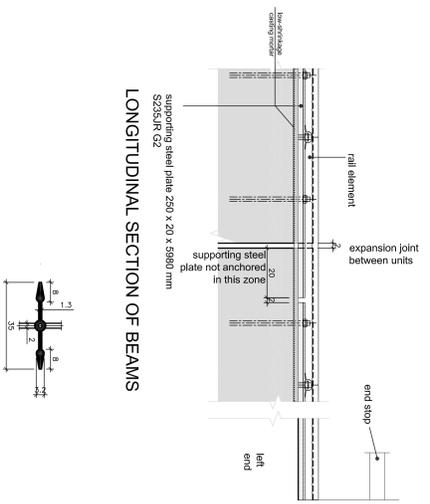
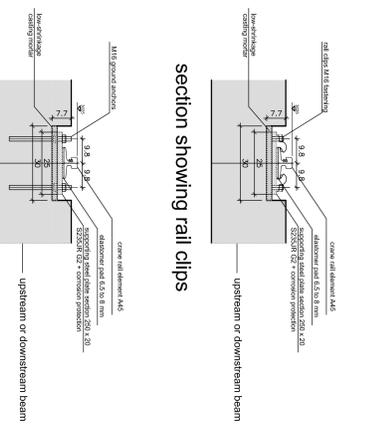
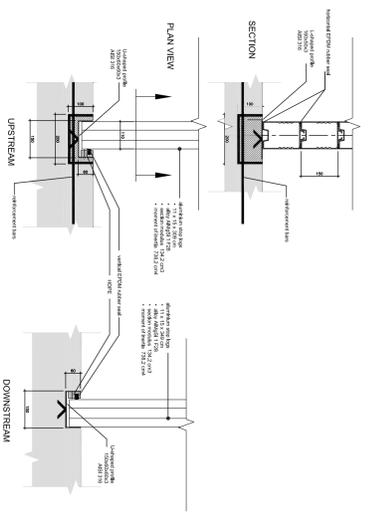
KORLE LAGOON ECOLOGICAL RESTORATION PROJECT
PHASE II - Stage II - Dredging, Earthworks & Marine Works

REV	DATE	DESCRIPTION
A	11/08/03	FINAL CONCEPT
B	14/10/03	EXECUTION DRAWING FOR APPROVAL ONLY
C	24/10/03	For construction
D	10/02/04	For construction (Contractor comments incorporated)
E	12/02/04	For construction (GIS incorporated & coords checked)
Z	02/07/05	"As Built"

LAYOUT
KORLE LAGOON INTERCEPTOR SHORE & BOTTOM PROTECTION

DATE: 02/07/05
 DRAWN BY: B. Ouwens
 SECT: 15000841mm
 SCALE: 1:100
 FILENAME: ESTINLAY4S19Z.dwg

Sheet No: 1 of 1

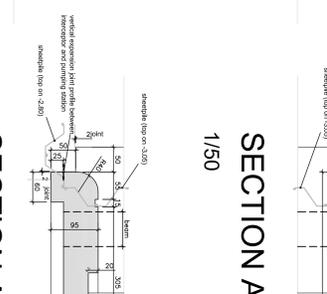
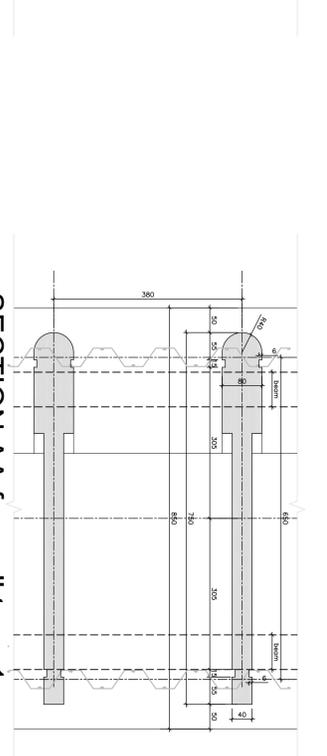
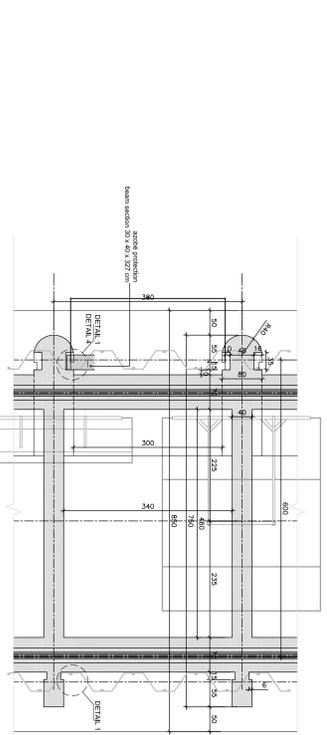


DETAIL 1 : seals for stop logs
Manufactured by Hydromat
1/5

section showing rail clips
upstream or downstream beam

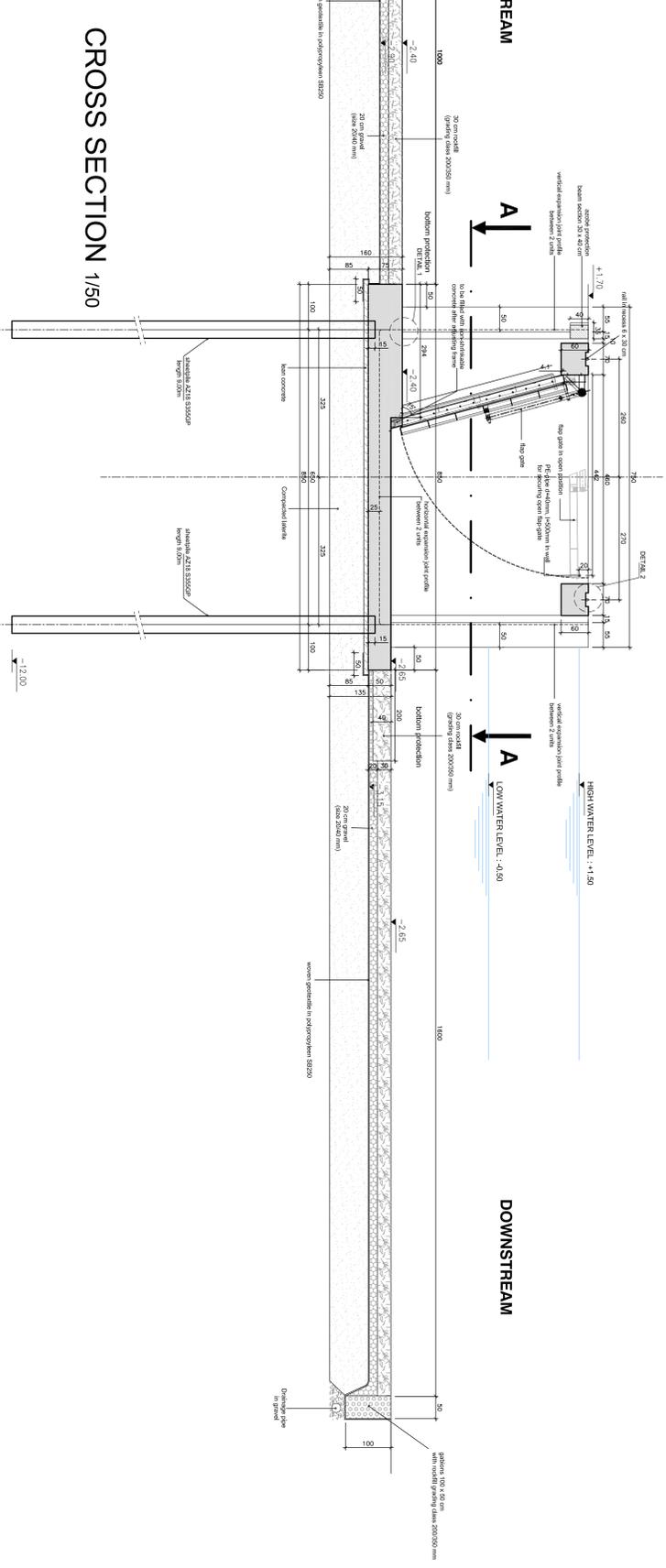
DETAIL 3 : expansion joint profile
Producer: Trelleborg \ Type: Waterstop FM350
1/10

DETAIL 4
1/10



SECTION AA for wall type 1
1/50

SECTION AA
1/50



CROSS SECTION 1/50

SECTION AA
1/50