Feasibility Nanni Weir and Maratakka Spillway

Nickerie, Suriname

INTERMEDIATE REPORT

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Date: May 28th, 2018
Version: 2

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1 Introduction

1.1 General

The Government of Suriname has requested the Bank's technical support in the preparation of an investment loan to finance a Sustainable Agricultural Productivity Program (SU-L1052). The goal of SU-L1052 is to increase agricultural productivity in Surinam through investments in infrastructure and management of irrigation and drainage (I&D) systems; and by improving the quality of available agriculture statistics. The expected results of the I&D component of the Program are: (i) increased agricultural productivity in I&D areas; (ii) improved water management within I&D areas; (iii) operating WB effectively contributing to the operation and management (O&M) of I&D infrastructure.

The objective of the Irrigation and Drainage component is to improve the functioning and management of I&D systems in Suriname, particularly in Nickerie District, by addressing current failings in infrastructure and transferring key management and maintenance responsibilities to Water Boards (WB). The program will finance: (i) rehabilitation/modernization of primary and secondary I&D infrastructure selected to benefit small- and medium-size farmers; (ii) support for developing and strengthening WB capacity to take over the O&M of I&D systems; (iii) capacity building of government bodies in charge of water resource administration for irrigation; and (iv) design and implementation of one-time incentives mechanisms limited in time and scope and aimed at improving efficiency in farmers' water use and increasing their willingness to cover O&M costs. This component will include measures to improve the water resource sustainable management for its different uses, particularly by taking into account climate change impacts (i.e., in regard to water supply and demand) and considering adaptation measures.

During the first stage of the project preparation activities, the Irrigation and Drainage consultancy and the Government indicated during the IDB mission that took place in November 2017 that, to improve the efficiency of the Nickerie I&D system and to reduce the likelihood of flooding in irrigated areas two structures needed to be built: Nanni Weir and the Maratakka Spillway. These structures need to be analyzed as part of project preparation.

1.2 This study

The concerned study is to review existing information and prepare preliminary designs and cost estimates of the two structures as well as the additional works required in the restructuring of the inlets to the main irrigation canals (Van Wouw, Stondansi, HA and Lateral canal).

This study is part of a series of consultancies that will take place simultaneously as part of the SU-L1052 Program preparation plan agreed between the government and the IDB, which includes: economic analysis, institutional capacity analysis, environmental and social analysis and a study on the hydrology of the Nickerie water resource base.

This document presents the Intermediate Report, for the consultancy assignment to address the activities and planning for the feasibility assessment of the Nanni Weir and Maratakka Spillway.

1.3 Objective and approach of this Study

The specific objective of this consultancy is to carry out a:(i) feasibility study of the Nanni Weir and related structures, including preliminary or basic design and estimates of the investment costs required; and (ii) feasibility study of the Maratakka spillway and link canal to the Maratakka River, including preliminary or basic design and estimates of the investment costs required.

The following approach is used to achieve this objective:

- Conduct site visits and review existing data/reports on the structures
- Consult with relevant stakeholders, including the OWMCP, LVV, OWT&C and others
- Conduct field surveys and inspections
- Review and propose solutions and alternative options
- Discuss and agree on selected infrastructure works
- Prepare preliminary designs and cost estimates
- Assess technical and financial feasibility
- Propose implementation schemes and procurement procedures

It is noted that the Inter-Ministerial Irrigation and Drainage Coordination Working Group (IMIDCWG) consists of members of amongst others LVV, OWT&C and OWMCP. They are regularly consulted during the course of this assignment.

Furthermore, discussions are held with the IDB team and other consultants participating in this project. This ensures that relevant available information and data is shared and cross-checked.

2 Background

Appendix I presents an overview map of existing infrastructure and (inlet and outlet) structures. Appendix II presents proposed improvement and new infrastructure in the EU OWMCP Masterplan (2010).

The Nanni Weir

The Multipurpose Corantijn Project initiated in 1981 was never completed due to shortage of funds. The construction of the Nanni Weir and related structures was the major and essential hydraulic structure never completed, resulting in considerable losses of expensive pumped water.

The absence of a weir at the outflow of the Corantijn canal causes the water from the Corantijn canal to spill directly into the Nanni swamp. As a result the water level in the whole Nanni swamp needs to be raised before irrigation water can flow into the irrigation canals. Substantial losses in evaporation occur in the large Nanni swamp estimated at 30% and the whole irrigation supply becomes very inefficient and difficult to manage, in particular when irrigation supply is interrupted.

The construction of the Nanni weir at the outlet of the Corantijn canal requires a regulating structure in the weir that will allow the inflow of irrigation water from the Nanni swamp into the irrigation system as well the outflow of excess water of the Nanni swamp into the Nanni creek through the existing Nanni spillway.

Additional structures need to be considered and include the reconstruction of the Nanni Inlet structure into the Van Wouw and the Stondansi canals, the extension of the Stondansi canal, reconstruction of two intakes from the Stondansi canal into the HA and Lateral canals and strengthening of the swamp retention embankment and deepening of the Suriname canal.

The master plan of the EU-financed study on the Irrigation supply of the Nickerie system identified the Nanni weir and related structures (estimated at 10 million USD in 2009) as the first priority for an improved and efficient irrigation supply with a direct impact on the areas to be irrigated and a reduction of pumping costs.

The Maratakka Spillway

The Maratakka Spillway and related link canal to the Maratakka River was one of two major and essential water control structures that were never completed. Implementation of the Spillway will connect the Suriname canal and allow the evacuation of floodwaters from the Nanni swamp and alleviate importantly the present flood hazards and increase fresh water supply to the Nickerie River.

The main outflow of floodwaters from the Nanni swamp is presently through the Nanni spillway into the Nanni Creek on the west side of the swamp close to the outflow of the Corantijn canal. The outflow on the eastern side of the swamp retention dike was to be realized through the Maratakka spillway that was however never constructed. Excessive rainfall in the Nanni catchment area causes frequently serious flooding, as the capacity of the Nanni spillway is insufficient for the evacuation of floodwaters.

Construction of the Maratakka spillway and related connection canal from the Suriname canal into the Maratakka River would importantly reduce flooding problems and loss of production due to inundations in several polders, while the inflow of fresh water from the Maratakka into the Nickerie River would make additional water available for irrigation and push back saltwater intrusion. Cost estimates of the Maratakka spillway from the EU Masterplan did amount in 2009 to USD 750,000.

3 Review studies and available information

3.1 General

Key reports relevant to this study are:

- Irrigation Master Plan OWMCP (EU funded, 2010).
- Designs of the "DOL" structures (original and "reduced" version) (Sunecon/ILACO, 1989)

Abovementioned and other available literature were reviewed to understand the overall set up of the proposed MCP works and the hydraulic/water management aspects of the concerned Nanni Weir and Maratakka Spillway.

The following sources / stakeholders have been contacted to obtain available data:

- Ministry of Agriculture, Animal Husbandry and Fisheries (LVV) (head office and District Nickerie office)
- Ministry of Public Works, Transportation and Communication (OWT&C) (Drainage department as well as District Nickerie office)
- (Overlaying) Water board MCP (OWMCP)
- District agencies (District Commissioner, and others)
- Anton de Kom University (Adek)
- Contractors, consultants and others who have worked in the MCP area.

The discussions have provided valuable data to understand the recent changes and current status of the structures in the Project area.

The table below presents an overview of key meetings and activities until date.

Date	Meeting with/ activity	Subject/ Topic
March 4th 2018	Mr. G. Van Der Kooye (Min. LVV Nickerie)	Overall project, key issues and objectives
March 9th 2018	Mr. August Lila (Director OWMCP)	Overall project, key issues and objectives, available data, status of infrastructure
March 9th 2018	Mr. Sanjay Triloki (OWT&C department Nickerie)	Site visit Van Wouw Intake area and IKUGH area, status of infrastructure
March 14th 2018	Mr. Martin Smith (consultant)	Discussion about the overall objectives and set up, involvement on different parts of project
March 30th 2018	Field Survey	Nanni Spillway, Van Wouw Intake area and IKUGH area, status of structures, measurements
April 9th – 13th	IDB Analysis Mission	IDB Mission team, Ministry LVV, IMIDCWG , Dr Sieuw Naipal,
April 19-20th	Field Survey	Maratakka Spillway area, measurements

3.2 Initial Site Visit and discussions

A meeting was held with Mr. Van der Kooye (LVV Nickerie) on 4th March 2018. He explained the reasons behind the several proposed Nanni Weir and Maratakka Spillway including related structures and works. The key points are listed as:

- Nanni Weir is needed to allow more intake of water from the Nanni Swamp and divert this water towards the north/east via the Suriname Canal. This is to feed the northern agricultural areas, including the remote Autonoom area, with sufficient fresh water.
- There is a need for other structures to be taken into account for rehabilitation and construction. This includes Van Wouw Intake, which is in poor condition (see picture) and experience substantial water losses. Furthermore, some other structures need rehabilitation such as Nanni Spillway, IKUGH Intake (see picture) and Swamp Retention dam along the Suriname Canal.

- An alternative may be considered by abandoning the Van Wouw Intake and making a new intake in the Suriname Canal close to the new Nanni Weir.
- The Nanni Weir is needed to reduce losses from Corantijn Canal through flowing back into the Nanni swamp.
- Maratakka Spillway is to have a controlled discharge of water during high water levels in the swamp, as the existing Nanni spillway does not have sufficient capacity. As such, flooding occurs regularly after heavy rainfall periods.
- The Maratakka Spillway is also to discharge about 5 m3/s of fresh water during dry seasons into the Maratakka River. This is to push back and control the salt intrusion in the Nickerie River.

An initial site visit was conducted on 9th March 2018 to the Van Wouw Intake area and IKUGH area. The site visit provided valuable information about the status of the several existing infrastructure and structures. It further provided a good overview of the possible interventions proposed in the 1977 and 2010 studies. The visit to the proposed Maratakka Spillway location could not be undertaken during this visit due to unavailability of airboats. The Suriname Canal, between IKUGH and Maratakka, is not accessible by normal boat due to floating grass/weed.

Van Wouw intake and Nanni spillway

IKUGH and HA intake

A meeting was held with Mr. August Lila, Director of OWMCP on 9th March at his office. He confirmed more or less the same as Mr. Van der Kooye. In addition, it was discussed that the need for alternatives to supply more water is direly needed for the northern/Autonoom Area. The operation of the Wakay pumps is affected due to insufficient available fuel. The use of larger storage volumes of fresh water from the Nanni Swamp should be considered as much as possible.

Mr. Lila also indicated that there were alternatives designed for the Nanni Weir in the so called "DOL Werken (klein)" from 1989. These were the simplified works for Distribution, intake and retention as compared to the original DOL works.
Furthermore, discussions in the past were also to increase the pump capacity at Wakay from 30 to 50 m3/s.

It was discussed with Mr Lila to provide the following data (if possible within 2 weeks): Historical (long range) water levels (swamp, rivers, canals), rain fall data, flow discharge measurements, levels of dams and canals (measured in the recent past) and copies / scans of relevant reports.
OWMCP is in charge and maintains the Corantijn Canal, Wakay pumps and inlet/outlet structures along the Corantijn Canal. They furthermore conduct water level measurements and other management tasks as provided in the state decree for OWMCP. All levels (divers) are regularly checked to see if the NSP levels are correct.

Mr. Sanjay Triloki, from OWT&C drainage department in Nickerie, joined the site visit and provided valuable information about the operation of the several structures. OWT&C is in charge of operating and maintaining all main inlets and outlets, such as Van Wouw, Nanni and IKUGH. The swamp retention dam was rehabilitated in 2016/2017 and is now in most sections at sufficient height. Only smaller parts, e.g. along Corantijn Canal, may not be at sufficient height (info from Mr. Lila).
Mr. Tiloki emphasized to look at structures that would be able to work under different water level conditions. The current inlet and outlet main structures are more than 40 years old and need some proper rehabilitation.
His view is that it may be cheaper to construct an inlet near halfway Suriname Canal (after the Lateral Canal) than to reinforce the Swamp Retention Dam over a length of over 30 km. He noted that the Suriname Canal is linked with Nanni Swamp through several channels/drains. This was confirmed during the site visit (see picture).

Also the Nanni Swamp has always water, but due to low water levels during dry seasons, intake for irrigation can not be done under gravity. Farmers in the north of the swamp often use their own pumps to take water from the Suriname Canal for irrigation.

Mr. Triloki mentioned that it takes lots of efforts to keep the lengthy canals clean. The Suriname Canal between IKUGH and Maratakka is only partially clean.
He also indicated that regular maintenance in the far past was conducted by a pontoon with an excavator or draglines on it. This pontoon was operated continuously for all canals, including Nanni Creek up to the Nanni lake/reservoir further south. This way sufficient water was released through the Nanni Creek, even in dry periods. At the moment, the Nanni Creek is not maintained due to lack of accessibility and high costs for special swamp excavator equipment. The creek has a reduced discharge capacity.

A meeting was held on 14th March 2018 with Mr. Martin Smith, another consultant in this project. The site visit data and initial findings until date were exchanged with him. Furthermore, the overall objectives and base set up of this project were discussed. It was understood that Mr. Smith would focus on the Water Board rehabilitation works and other related activities to improve the efficiency of water use and management.

4 Assessment of Existing structures

The following existing structures or areas have been visited for inspection and assessment of current condition.

1) Nanni Spillway
2) Van Wouw Intake structure
3) HA Intake Structure
4) IKUGH Inlet structure
5) Swamp Retention dam (Stondansi canal, Lateral canal)
6) Surinam Canal
7) Corantijn Canal/dam (only section near Nanni Weir location)
8) Maratakka Spillway area (end of Surinam Canal/link to Maratakka River)

Field topographic surveys and measurements have been conducted as and where possible.

4.1 Existing structures near Nanni Weir and IKUGH

The existing structures: Nanni Spillway, Van Wouw Intake, HA Inlet and IKUGH inlet have been inspected and their conditions have been checked. This general assessment was to understand if the existing structures would fit within the main infrastructure system for water supply and if rehabilitation would suffice to be included in the main system or new structures would be needed. The results are presented in a separate report in Appendix III.

Note: the further detailed investigation and related rehabilitation works and costs are conducted through a separate consultancy activity of the IDB and are not part of the scope of this Report.

Also, the report includes some cross sections of the Swamp Retention dam (between Stondansi and Surinam Canal) and Surinam Canal with levels. It appears that the Swamp Retention dam has an average crest level of about NSP +4.0 m. This implies that the further increase to the required NSP +4.45 m would only need a clay backfill of average 55-60 cm (considering some settlements) and hence would probably not involve a major risk of instability (sliding of slopes) of the dam. Also the dam has already been constructed for over 30 years, so the sub-soil is most probably stabilized over time.

The Swamp Retention dam along Lateral Canal could not be measured due to inaccessibility (canal was overgrown). However, from field check near IKUGH it was observed that the crest level of this dam is more or less at similar elevation as the dam along Stondansi Canal.

The embankment dam between the Surinam Canal and Nanni Swamp is at approx. NSP +2.20 m in the section along the Stondansi Canal. It is assumed that the level of the swamp embankment in the section along the Lateral Canal is more or less the same. This embankment would be prone to instability if the dam needs to be raised with 1 to 2 meters.

4.2 Corantijn Canal swamp retention dam

The Corantijn Canal, including side embankments, has been rehabilitated about 10 years ago. The crest level of the swamp retention dam is reportedly at sufficient elevation. Some spots show settlements and may require some maintenance. OWMCP carries out regular inspections and repairs when possible.

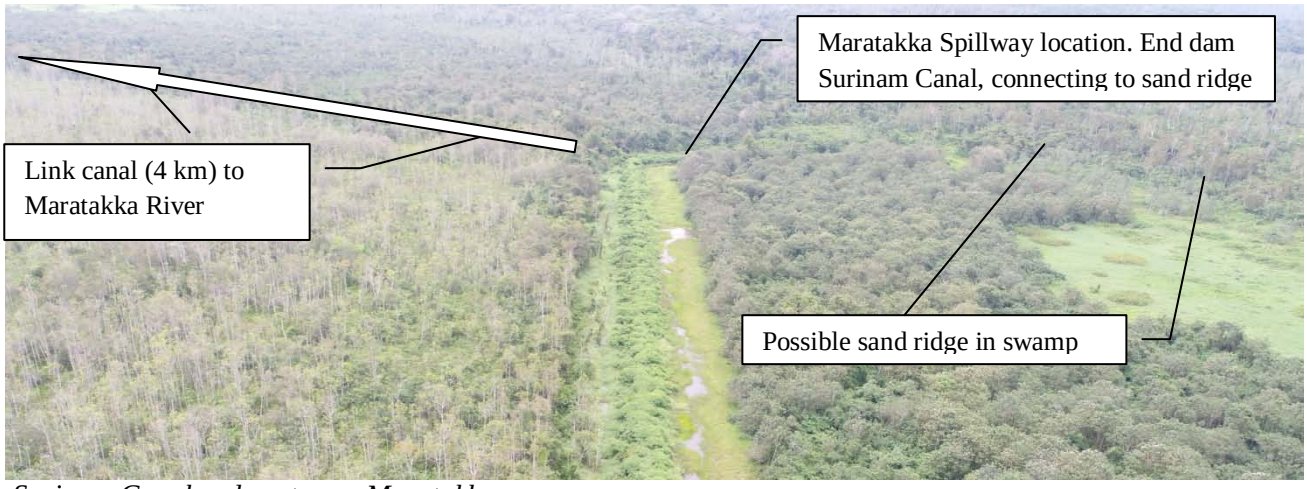
The Corantijn Canal flows uncontrolled into the swamp area and Surinam Canal near the Nanni Spillway. This open section is about 350 m long. The swamp retention dam needs to be continued along this section with a crest level at NSP +4.45 m, in order to have a controlled conveyance of water from the Corantijn Canal to the agricultural areas. The existing open water area near Nanni Spillway and the future Nanni Weir can be further excavated to create a pond area from where water can be distributed to different directions.

The dam can be constructed on the existing embankment with the Nanni Swamp using clay from the canal and pond.

4.3 Area near Maratakka Spillway

The proposed Maratakka Spillway location was difficult to access. It is located at the end of Surinam Canal and the beginning of the linkage to the Maratakka River and the access from the Surinam Canal was practically impossible due to the heavy overgrown canal. The linkage canal was partially (1.5 km) accessible by boat. Further travel had to be by walking on the old northern dam along this canal.
There are no known benchmark levels nearby, so the water level at IKUGH (30 km distance) was used to estimate the approximate levels in NSP (National chart datum) in the Surinam Canal at Maratakka. The elevation levels at this location may therefore have a +/- 15 to 20% deviation.

The cross section measurements are shown in Appendix IV.



Surinam Canal end part near Maratakka

Link canal to Maratakka River (overgrown)

View from end dam Surinam Canal

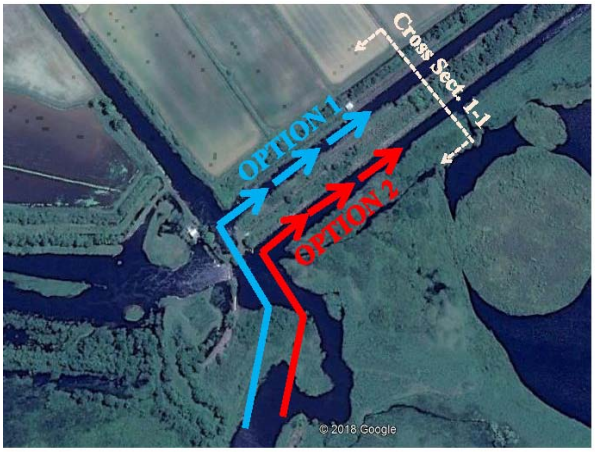
The crest level of the Swamp Retention dam (north) along Surinam Canal and at the end is about NSP +4.0 m. This means that the spillway structure will require some excavation of the end dam to lower the level.
It is expected that a sand ridge (also referred to as Cupido ridge) goes further to the south and parallel to the Surinam Canal. The top of this sand ridge is unknown, but from previous estimates (Environmental studies 2007 and hydrological studies 1977) it is assumed that the top varies between NSP +3 and +4 m. It is likely that the end dam at Surinam Canal is connected to the sand ridge, and thus blocking or reducing free flows from the swamp to the link canal (towards Maratakka River).

5 Alternatives for water distribution from Corantijn Canal

This section contains an assessment of two alternatives to distribute the water from Corantijn Canal to the agricultural areas. During dry seasons water levels in the Nanni Swamp gets below the required level of NSP + 2.50 m to distribute water under gravity into the agricultural areas. At this level, the pumps at Wakay start operating and fill up the Corantijn Canal (source: OWMCP).

There are two options to distribute the Corantijn Canal water to the agricultural areas in Eastern and Western polders (up to Lateral Canal 1). See Appendix V.

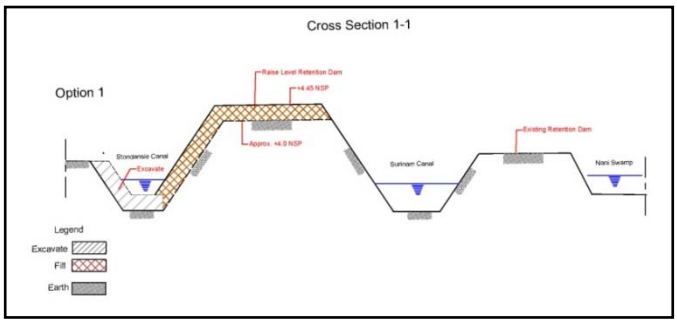
1) Option 1: the water is distributed through the Stondansi Canal (about 3.75 km) and via a new connection (850 m) to the Lateral Canal 1 (about 7 km).
2) Option 2: the water is distributed through the Surinam Canal (total 11.5 km)

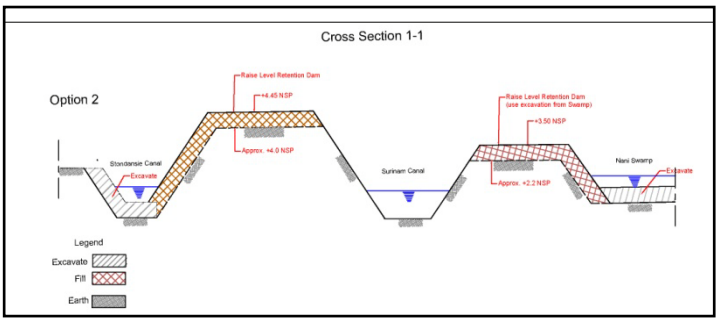


In both options it is assumed that the distribution of water will primarily focus on supply to the Eastern and Western Polders. The Autonomous Area will only receive water from Corantijn Canal if there is sufficient available. That means that a hydraulic structure (end control gate) is required in both options.

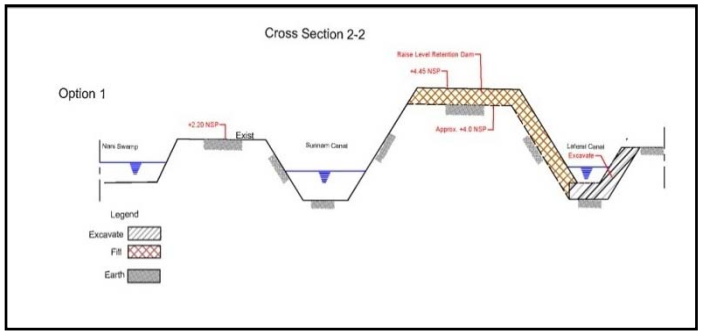
Both options also require that the new Swamp Retention dam (approx. 350 m) between the existing dam of Corantijn Canal and the existing Swamp Retention dam at Stondansi / Surinam Canal.

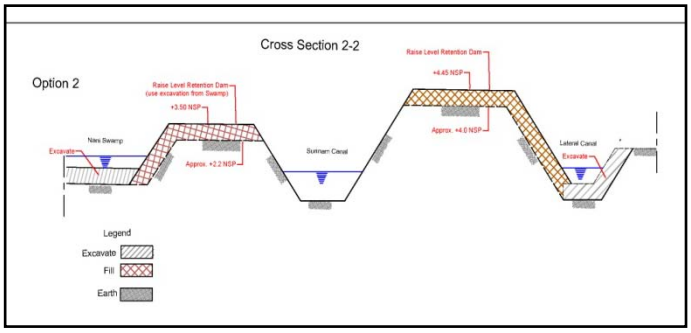
The Swamp Retention dam between Stondansi and Surinam Canal is about 4.5 km long and the Swamp Retention dam between Lateral and Surinam Canal has a length of about 7 km.





Cross section 1-1 (Stondansi and Surinam Canal) for Option 1 and Option 2.





Cross section 2-2 (Lateral and Surinam Canal) for Option 1 and Option 2.

The table below contains an overview of the assessment of both options.

Overview of details and assessment of Option 1 and 2

Works/items	**Option 1**	**Option 2**
Closing dam between Corantijn Canal dam and Stondansi Swamp Retention dam	Closing dam with crest level at NSP +4.45 m, approx. 350 m long.	Required, same as Option 1.
Increase of Swamp Retention dam crest level. Total length about 11.6 km (Stondansi 4.6 km and Lateral 7 km).	Increase from NSP +4.0 m to NSP 4.45 m. About 60 cm (incl settlement) increase over about 8 m wide crest.	Required, same as Option 1
Widen/re-profiling Stondansi Canal to allow more flow, less hydraulic losses	Widen and re-profiling of Stondansi canal (about 2-3 m wider, with stable slopes both sides)	Not applicable for Option 2.
Increase swamp/Surinam canal embankment crest level and re-profiling Surinam Canal. Total length about 11.5 km.	Not applicable for Option 1.	Raise crest level from NSP +2.20 m to about NSP +3.50 m to avoid Corantijn Canal water going into swamp. Close all open connections between swamp and Surinam Canal in this section. About 1.5 m (incl settlement) higher over 5-6 m wide crest with shallow slopes (for stable dam). Re-profiling of Surinam Canal to convey water with less hydraulic losses. **Note:** raising the embankment further could impose higher risks of instable side slopes and slides. This would increase costs and time to allow for gradual settlement and water pressure dissipation in the underground.
New Nanni Weir	Needed at junction of Nanni Creek/ new swamp retention dam	Required, same as Option1. (Note: swamp water will be conveyed to HA/IKUGH via new Nanni Weir and Surinam Canal)
End control structure at end of Eastern Polders (start of Autonomous area)	New outlet/end control structure at end of Lateral Canal 1. Discharge into Surinam Canal	Same as Option 1. New outlet/end control structure at end of Surinam Canal. Discharge into Surinam Canal
New Canal	New Canal connection (850 m) between Stondansi and Lateral Canal 1. Including end check hydraulic structure at end of Stondansi Canal to control water levels.	Not applicable for Option 2
Rehabilitate existing hydraulic structures	Rehabilitate Nanni Spillway, Van Wouw and IKUGH. Construct **new HA Intake** together with end check structure Stondansi	Rehabilitate Nanni Spillway, Van Wouw and IKUGH, same as Option 1. **Rehabilitate HA Intake** structure.

The cost comparison for both options is shown in the table below. Some works are the same for both options and have not been included for the comparison. Only the differences are shown.

Cost comparison Option 1 and 2 (excluding structures applicable for both)

Works/Item	**Cost Option 1**	**Cost Option 2**
Increase swamp embankment (along Surinam Canal) crest level.	Not Needed.	Approx. 15 m3/m, total 11.5 km is approx. 172,500 m3 excavation and backfilling and profiling of Surinam Canal. USD 1.3 M.
Widening/re-profiling Stondansi Canal	Approx. 18 m3/m excavation and backfilling, 3.75 km long. Combine with increase of dam (see next) USD 500,000	Not needed.
Increase of Swamp Retention dam crest level (along Stondansi Canal) (raise dam along Lateral canal is same for both options)	Approx. 7 m3/m, **total 3.75 km** excavation, back filling and profiling. USD 200,000	Approx. 7 m3/m, total **4.5 km** excavation, back filling and profiling. USD 240,000
Excavate new canal to connect Stondansi with Lateral Canal and construct Swamp Retention dam alongside	Approx. 60 m3/m, total 850 m long is 51,000 m3 excavation, backfilling and profiling. This is also part of Swamp Retention dam crest level increase. USD 380,000	Not needed.
HA Intake structure	New HA Intake, combined with new end check control structure Stondansi Canal. USD 800,000	Rehabilitate HA Intake structure. USD 50,000
End control structure	End control structure at end of Lateral 1 Canal to discharge to Surinam Canal USD 300,000	End control structure at end of Surinam Canal (parallel at Lateral 1 Canal) to discharge to Surinam Canal. Capacity is bit larger then for Option 1 to allow discharges both from Corantijn Canal as well as from Swamp. USD 500,000
Total extra costs per option	**USD 2.13 M**	**USD 2.09 M**

The costs for extra works in Option 1 are slightly higher than in Option 2. Given the level of costs assessment, this difference is considered negligible.

However, Option 2 carries more risks than Option 1. In particular, the risks lie with the instable soil that is expected in the swamp area. The embankment between Surinam Canal and the Nanni Swamp will require a balanced work method to increase the crest level in small steps. Also, special swamp equipment will need to be used, as access over land is very limited. With the longer expected execution of works and input of special equipment, extra costs are likely to be faced.

Another advantage of Option 1 is that all water flows (pumped and gravity) will be conveyed and controlled through one main supply canal. This may have benefits when measuring and control devices will be linked together for improved and efficient operation.

It is recommended to continue with Option 1 for further implementation. This option is also the same as recommended in previous studies.

6 Rationale for Nanni Weir and Maratakka Spillway

Improved main infrastructure for Irrigation: the Nanni Weir

The Multipurpose Corantijn Project (MCP) initiated in 1981 was never completed due to shortage of funds. The construction of the Nanni Weir and related structures was the major and essential hydraulic structure never completed.

The proposed Nanni Weir structure consists of several works combined:

1) Construction of the Nanni Sluice/weir structure: this is a sluice concrete structure with 2 gates, adjacent steel sheet piles as retaining structures, inlet weed control mechanism and mechanical hinges to lift the doors.
2) Embankment Swamp retention dam between Corantijn Canal and Stondansi Canal. This is to close the gap between Corantijn Canal and Nanni Swamp, and at the same time create a basin to distribute the water from Nanni swamp properly.
3) Connect Stondansi Canal to Lateral Canal (Eastern area) and construction of an end/control structure.

The Nanni Weir including closing dam and structure is primarily meant to ensure sufficient water supply to the polders during dry seasons, when the water level in the Nanni Swamp gets lower than NSP +2.5 m and gravity supply is not possible anymore.

In addition to these works, other related works are required: increase crest level (to NSP +4.45 m) of the Swamp Retention dam along Stondansi and Lateral Canal, rehabilitation of the Nanni Spill Way, rehabilitation of Nanni Creek, rehabilitation of the Van Wouw Intake, construction of a new Intake at HA and rehabilitation of IKUGH inlet.

It is noted that more structures have been proposed in the original MCP, but these aimed at full water supply for a larger projected irrigation area. These other structures will be needed when those areas are to be developed for rice cultivation in the future.

The key advantages for the Nanni Weir structure are:

1) The pumped water from Wakay through Corantijn Canal will be conveyed directly to the Western and Eastern Polders. Having such a closed circuit of transport of pumped irrigation water is much better to control and to avoid waste of water resources. The flows and water levels can be controlled for all agricultural areas linked to the main system, i.e. MCP, Western Polder, Easter Polder and Autonomous Area.
2) Currently, the pumped water is dispersed into the Nanni Swamp through the open connection at the proposed Nanni Weir. This means that the pumped water first fills up the swamp area along the Surinam Canal, and only is usable when the level reaches to a sufficient level (NSP +2.50 m) for gravity supply into the irrigation canals of the Western and Easter Polder areas and Autonomous area. The small scale farmers do not have own pumping systems, and need to wait some time before they are supplied with water. During this delayed availability of water, they are faced with the risks of loss of crops and income: too long time waiting or weed on field, getting less water due to forced abstraction by large farmers (e.g. Autonomous area) and less yield/ha.
3) The pumped water from Corantijn River (Wakay) is expensive as compared to the water in the Nanni Swamp. It requires fuel and expensive annual maintenance of pumps. Furthermore, at the current stage pumping has to be continued until sufficient water level is reached in Nanni to ensure gravity flow. That means often more pumping then strictly is needed for the irrigation capacity. Surplus of pumped water not used for irrigation is then discharged through the Nanni Spillway to the Corantijn River. This means relative expensive water (per m3 or per ha) is wasted.
4) It is expected that less pumped water will be needed to supply the area with the required amount under the current demand. The areas with less than 2 crops per years may be able to increase their crops and yields as well.

5) A controlled distribution of water will also enable the OWMCP to release water as needed in each section/area. They intend to introduce a "water calendar" to distribute water as scheduled. This will minimize the pumping requirements due to much lesser losses.
6) The controlled discharge or release of water per section will also make it easier to introduce properly measured water fees for each area separately. At this moment, it is understood that payment of fees for O&M of the main structure is not introduced due to lack of trust by the farmers that they get what they pay for.

The Maratakka Spillway

The Maratakka Spillway and related link canal to the Maratakka River was one of two major and essential water control structures that were never completed. Currently, the emergency spills are only located in the western part of the Nanni Swamp, with Nanni Spillway (about 25 m3/s) as the main release structure. The capacity of the Nanni Spillway is often reduced to about 11 m3/s due to small discharge capacity of the Nanni Creek, encroachment on the creek banks with low dam level and high tide in Corantijn River. Two small (inlet) structures are located in the southern parts of the Corantijn Canal and can function also as spill.

The Maratakka Spillway is located in the north-eastern part of the Swamp at the end of the Suriname canal and will allow the accelerated evacuation of floodwaters (during rainy seasons) from the northern part of the Nanni swamp.
The proposed structure is a concrete broad crested weir at fixed top level (NSP +3.65 m), with an estimated capacity of at least 15 m3/s. At this stage, it is recommended to only construct the emergency spillway. In the future, the spillway structure may be extended with a sluice to release a minimum of 5 m3/s during dry weather conditions.

The key advantages for the Maratakka Spillway structure are:
1) The Maratakka Spillway alleviates greatly the present potential flood hazards during rainy seasons. Any flooding of the agricultural areas will directly result in loss of crops and income.
2) The risks are reduced not due to extra spill capacity but also by locating the spillway at the opposite site of the Nanni spillway. Both structures can work independently, just in case of non-functioning of either structure.
3) The costs for the Maratakka Spillway are much less then to improve the Nanni Creek to its full capacity (if deemed feasible under the current conditions). The measures for Nanni Creek upgrading may be costly or not be feasible to the full extend, e.g. due to land ownership issues and regular siltation of the creek bottom and outflow area at the river.
4) The Maratakka Spillway will increase fresh water supply to the Nickerie River through the Maratakka River, and contribute to pushing back the salt water intrusion. This will enable more production due to increased irrigation at the right bank of the Nickerie River. It is noted that the pumping station at Wageningen is currently under rehabilitation. This will allow pumping more fresh water during high tide (when salt water intrusion is expected to reach furthest in the river). However, further studies for the salt water intrusion assessment, including hydrologic modeling, is required to justify large investments in just adding extra fresh water flows into the Nickerie River.
5) The extra spill way, together with the new Nanni Weir and dam, will enable OWMCP to keep the water levels in the northern part of the swamp more controlled and evenly distributed over the east-west section. This is expected to be better for the flora and fauna.

7 Preliminary designs and cost estimates

This section contains the schematic designs and cost estimates for the Nanni Weir and related structures, as well as the Maratakka Spillway. It is noted that the designs are at schematic/ preliminary level, which entails certain margins for unknown conditions such as geotechnical properties of the soil and topographic levels. Further assessments are being conducted to fine tune the designs and costs where possible.
It is noted that detailed designs and engineers cost estimate are to be carried out during the implementation of the Program.

The following key data for designs have been abstracted from the previous studies and reports. No major changes are foreseen at this stage, as most of the starting points used in the earlier designs are still applicable. Some of the capacities are higher than actually required at this stage of development in the polders. However, the structures are for a design life of at least 30-35 years and may need the capacity in the near future.
It is noted that certain water use efficiency is envisaged at the individual farmers. This can be by grading the terrains, using different crop techniques using less water and re-using water where possible.

Water supply:

Wakay pump:	30 m3/s.
Capacity Nanni Weir:	17 m3/s, between NSP +2.5 and NSP +3.30 m. Concrete wall and crest level at sides at NSP +4.45 m.
Stondansi Canal:	31 m3/s (increase capacity, reduce hydraulic losses)
Van Wouw Intake:	maintain capacity; Crest of concrete walls and side dams to be increased to NSP +4.45 m. Optional: demolish existing intake and build new inlet (12.5 m3/s) further upstream in Van Wouw Canal. This option is
IKUGH Intake:	maintain capacity. Crest of concrete walls and side dams to be increased to NSP +4.45 m.
HA Inlet:	new inlet with 2.5 m3/s capacity.

Spillways and flood control:

Swamp Retention dam:	raise to NSP +4.45 m (along Stondansi and Lateral 1 Canal)
Nanni Spillway:	maintain at 20-25 m3/s. Increase crest level at sides to NSP +4.45 m.
Maratakka Spillway:	15 m3/s. Crest level at NSP +3.65 m. Crest level at side dams to NSP +4.45 m.

Schematic designs for the key structures have been presented in the EU OWMCP Masterplan. See Appendix VI for overview of the schematic designs.

In principle these designs can be maintained. For these structures some recommend improvements have been included in this report. Reference is made to the Appendix III.

Cost estimates:

Cost estimates for the works have been prepared using Bills of Quantities and unit rates of existing similar infrastructure works or prices from other sources (like contractors, suppliers, etc). An attempt has been made to determine costs within a margin of 10-15%.
It is noted that the cost estimates depends on assumptions of soil/geotechnical conditions, availability of source of material and accessibility for equipment. Furthermore, it is assumed that works will be combined as much as practically possible in one contract, so that contractor's overhead and other costs can be minimized.

The total estimated costs for the new main infrastructure works are about USD 5.1 Million, excluding turn over taxes.

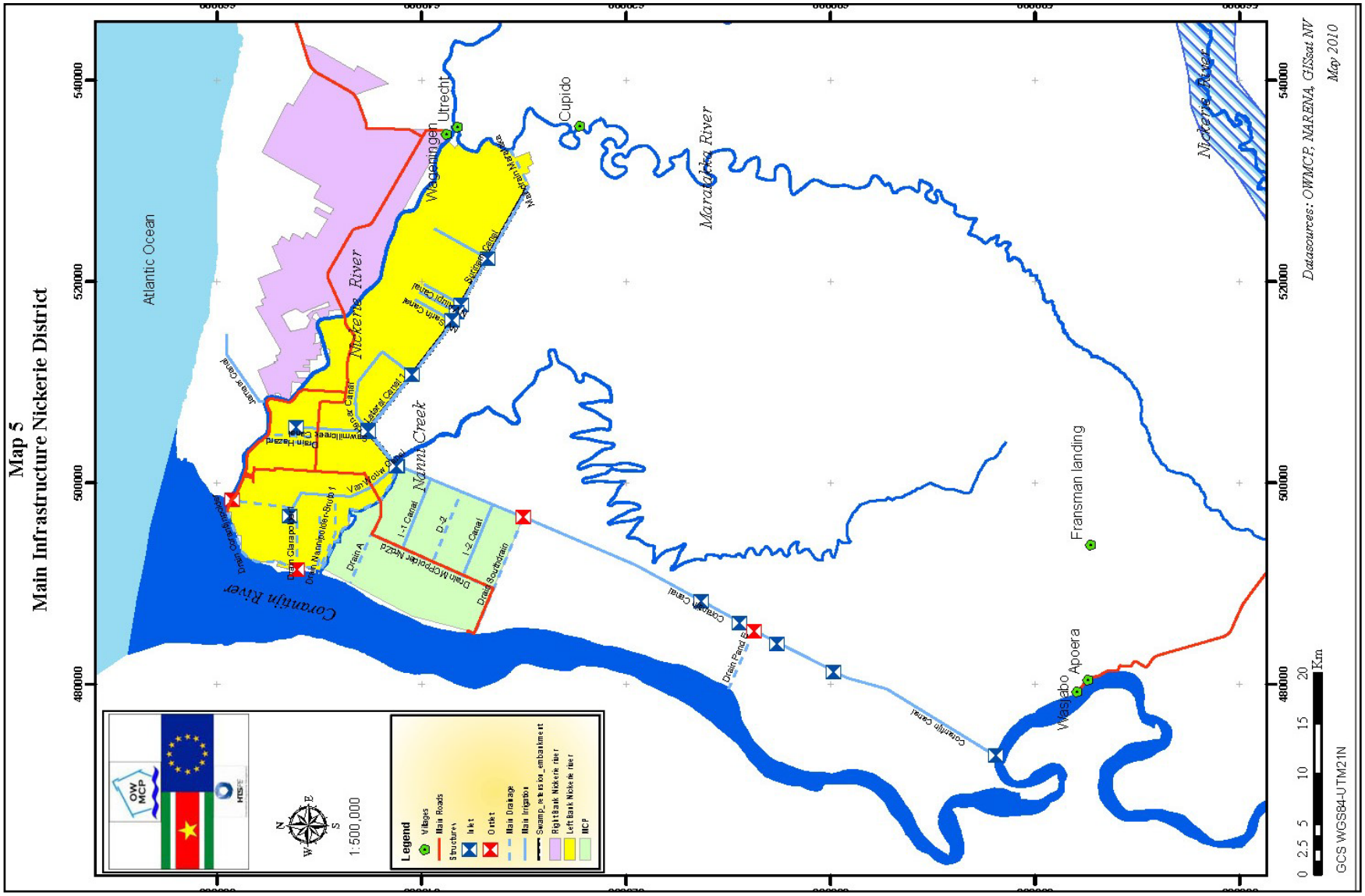
	New Main Infrastructure Works OWMCP	***Option 1: Use Stondansi Canal to convey to IKUGH***	
			Cost USD
No	***Component***	***Description***	**25-May-18**
1	Nanni Weir	New intake structure from Nanni Swamp, including closing dam (ca. 350 m)	2,000,000.00
2	Stondansi Canal/Swamp Retention dam	Widening Stondansi Canal and raising retention dam level to +4.45 m, 3,75 km	703,125.00
3	HA Intake	New intake (1 x 5 m wide), combine with regulator, demolish existing, close dam	250,000.00
4	Regulator/end check Structure Stondansi	Regulator structure (2x 5 m) at end Stondansi to connect with canal to Lateral 1	550,000.00
5	Diversion canal Stondansi to Lateral Canal 1	New canal (850 m) with Swamp Embankment dam	382,500.00
6	Lateral Canal 1/ Swamp Retention dam	Profiling canal and raising dam level (to +4.45 m) 7 km long	630,000.00
7	End check/regulator outlet	Regulator structure at end Lateral Canal 1 (2x 2.5 m) to discharge in Sur Canal	350,000.00
8	Maratakka Spillway- only Part 1: Weir	Spillway weir end Surinam Canal/Nanni swamp north to Maratakka	225,000.00
	Note: Only new main infrastructure.	**Total Works Main Infra for Option 1**	**5,090,625.00**
	Cost of rehabilitation of exisiting main structures	**(Excluding 10-15% surveys, design, tender, supervision)**	
	are not included		

In addition to the costs of the Works, 10-15% has to be added for Project/Contract Management, detailed topographic surveys, soil investigations, detailed designs and Construction supervision.

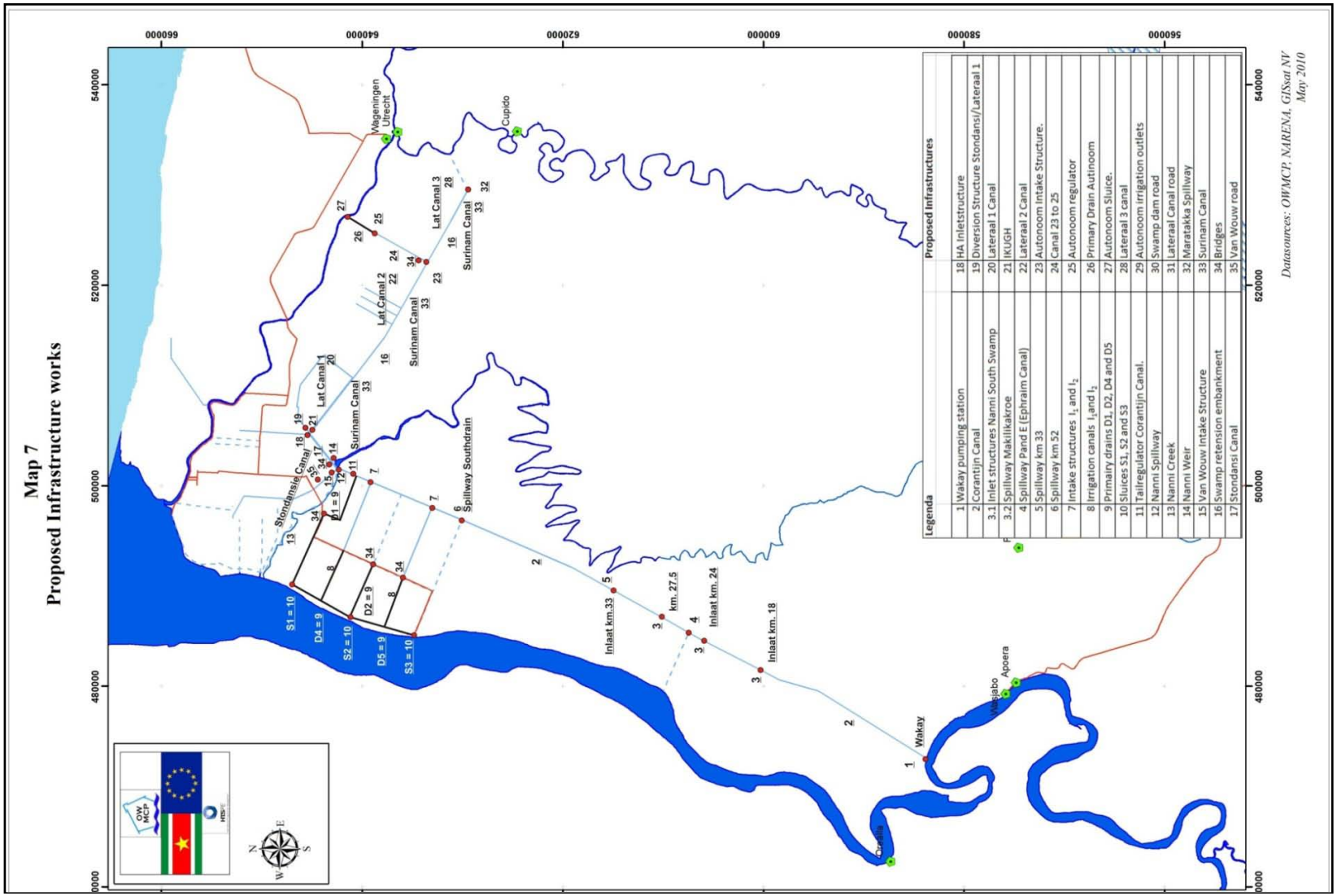
It is noted that rehabilitation of important existing main structures, Nanni Spillway, Nanni Creek, Van Wouw Intake and IKUGH Intake, are direly needed for an improved overall main water supply infrastructure. The costs for rehabilitation of these structures are not part of this document, and are assumed to be covered by other means.

Appendices:

Appendix I: Overview map (Source: EU Masterplan 2010)



Appendix II: Proposed Infrastructure (Source: EU Masterplan 2010)



Appendix III: Assessment of existing structures: Nanni weir, Van Wouw Inlet, HA Intake and IKUGH inlet and survey results

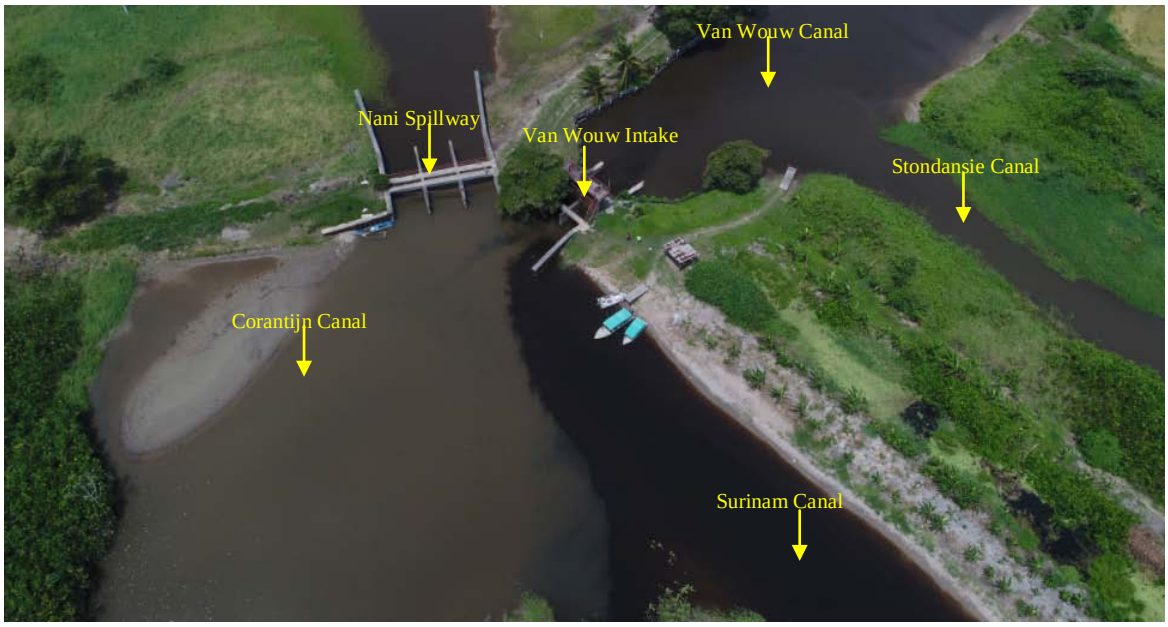
MEMO

Project : Feasibility Nanni Weir and Maratakka Spillway
Subject : Assessment Existing Hydraulic Works Nickerie OWMCP
Date : April 2018

Contents

1. General/ Project area

The project area consists of four hydraulic structures, namely the Van Wouw Intake, Nani Spillway, IKUGH (Integraal Kunstwerk Groot Henar) and HA Inlet Structure. Field survey occurred in March and April 2018. The structures have been assessed if they could be rehabilitated and used again as main structure. In addition some surveys and cross-sections have been carried out to assess the main dam and canal levels.



2. Van Wouw Intake Structure

2.1 Structure assessment

The Van Wouw Intake Structure consists of two gates of steel with a lifting tower and two hinged trash racks. The inflow side is at the Corantijn Canal whereas the outflow side of this structure is at the Van Wouw Canal.

Steel sheet piles

Several steel sheet piles at both the inflow and outflow side of the Van Wouw Intake Structure are heavily corroded.

Proposed works:
- Replace only steel sheet piles that are corroded, and give the piles the necessary coating
- Replace all steel sheet piles, and give the piles the necessary coating

Concrete

At several locations both on the inflow and outflow side of the structure, steel reinforcement is shown due to concrete decay.

Proposed works:
- Replace pile cap at the inflow side

Wooden sheet piles

At the outflow side of the structure wooden sheet piles are anchored to land. Several of these piles are rotten and broken. There is also heavy erosion seen. Geo-textile is placed between wooden piles and land to prevent further erosion.
Proposed works:
- Replace wooden piles with new one

Trash racks

There are two trash racks. At some sections the racks are also corroded. The racks are hinged, but there is no control system.

Proposed works:
- Replace current trash racks with new ones of aluminum
- New control system for trash racks
- Equipment to clean racks

Steel gates

There are two sliding gates that show corrosion at several locations. Both of the gates are being operated manually with a hoisting system. Each gate has two pulley systems, yet only one gate has a hoisting system that is connected.

Proposed works:
- Replace current steel gates with new ones made of lighter material (e.g. aluminum)
- Give the gates the necessary coating
- Replacing current rebates (grooves) with new ones including Teflon

Hoisting mechanism

There are currently 4 systems with a maximum of 5 ton. Only 1 mechanism is connected to a gate, two of the mechanisms are not connected and 1 hoisting system has no mechanism.

Proposed works:
- Replace the complete hoisting system with new system
- Give the gates the necessary coating

The structure should be adapted to the reservoir level of NSP 4.45

The structure should be passable for floating maintenance equipment and boats.

3. Nanni Spillway

The main function of this structure is the need to regulate the water level in the Nani-reservoir.

3.1 Structure assessment

Inflow/outflow side

At both outflow and inflow side of the spillway steel sheet piles show heavily corrosion.

Proposed works:
- Replace current steel piles with new ones (Incl. necessary coating)
- Instead of replacing the steel sheet piles, fill the area with rip rap

Sliding gates

The Nani Spillway consists of three wooden gates. These gates are manually opened without any hoisting mechanism. Steel profiles are used to keep the gates open. The gates are in rabbets made of steel.

Proposed works:
- Replace current sliding gates with aluminum doors
- Control mechanism with complete new pulley system

Erosion

At some locations there is also erosion seen.

Proposed works:
- Fill erosion areas with ripe clay

Concrete structure

This structure has minimal concrete decay.

Proposed works:
- Applying concrete spray techniques to rectify concrete elements

The spillway has to be adapted to embankment levels of NSP 4.45 and width of 4 m to allow equipment to drive up to the structure by the Corantijn Canal embankments.

Currently there are no trash racks, these should be implemented.

4. IKUGH

IKUGH structure has three inflow and outflow sections, each with a gate of steel.

4.1. Structure assessment

Steel gates

This hydraulic structure consists of three gates of steel. At several locations the gates show corrosion. The gates are in chamfers, also made of steel. Some gates are not in chamfers anymore. The gates are manually operated with wooden planks.

Proposed works:
- New aluminum gates
- New rabbets with Teflon

Trashracks

The structure used to have three trash racks at the inflow side. Currently these racks are unconfined.

Inflow/Outflow side

The steel sheet piles and its anchoring show corrosion. At several locations at both inflow and outflow side concrete decay is shown. There is also erosion seen at the inflow side near the steel sheet piles.

Hoisting mechanism

As mentioned above the gates are manually operated. There are no lifting mechanisms presents.

The structure has to be adapted to embankment levels of NSP 4.45

5. HA Inlet Structure

This hydraulic structure consists of one gate of steel and one outflow section with a valve culvert.

5.1. Assessment structure

Gate inflow

This hydraulic structure consists of one gate of steel at the inflow side. At several locations it is corroded. The gate is placed into rabbets, that also show corrosion. The gate has a whirl control system.

Proposed works:
- Replace current steel gate with a new one made of a lighter material (e.g. aluminum)
- Rabbets need to be renewed, with new profiles and rubber
- Trash racks need to be placed

Hoisting mechanism

This structure has a whirl mechanism and is manually operated.

Proposed works:
- The whirl system needs to be inspected and renewed

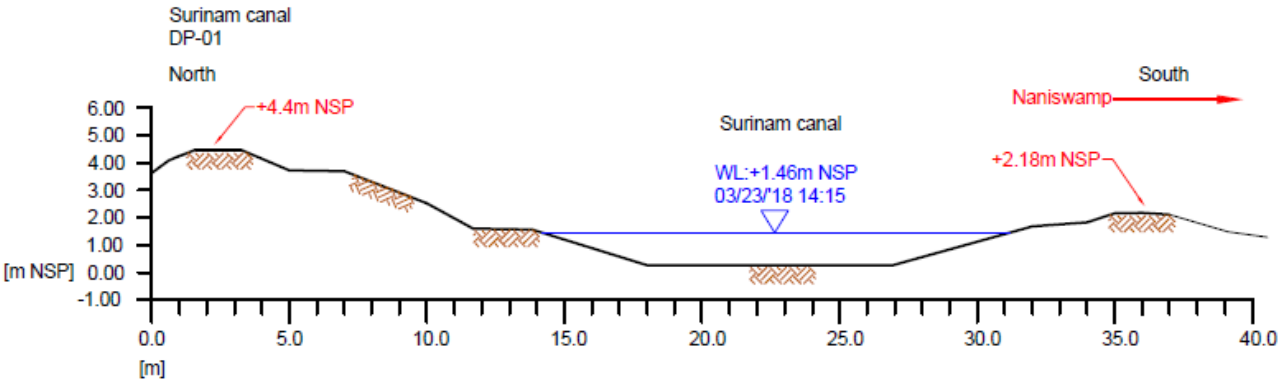
Concrete culvert

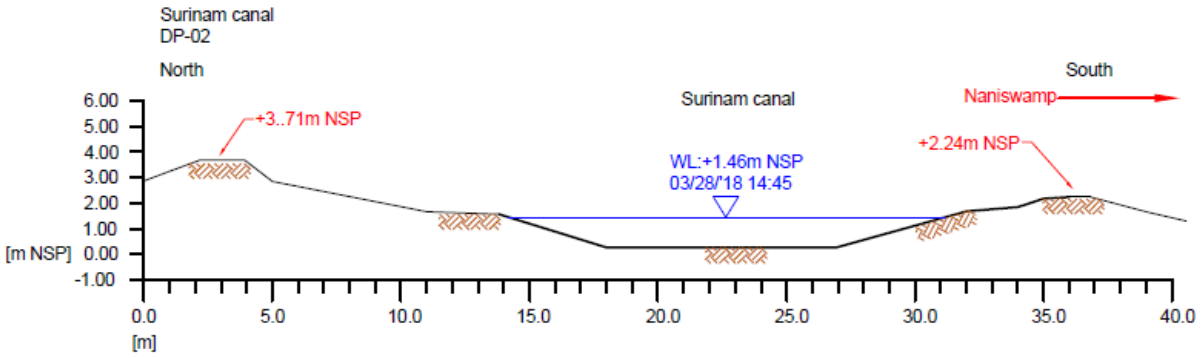
The concrete culvert shows some concrete decay

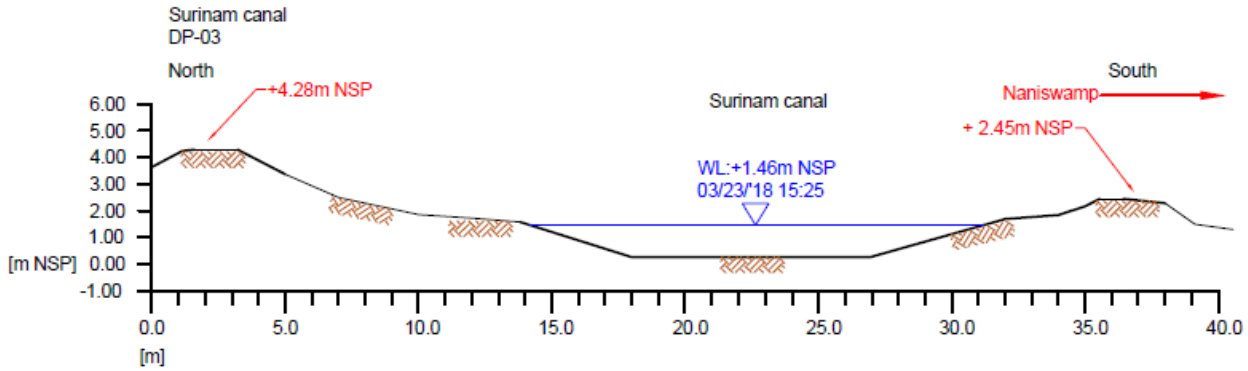
Proposed works:
- By using concrete spray techniques, the concrete decay can be repaired

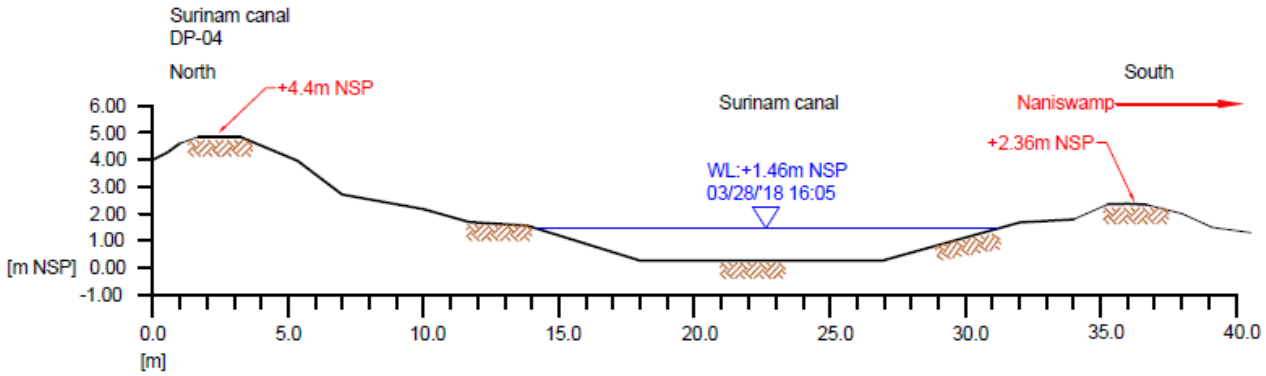
7. Cross section profiles Surinam Canal

GPS	Location
DP-01	Cross Section 1 Surinam Canal
DP-02	Cross Section 2 Surinam Canal
DP-03	Cross Section 3 Surinam Canal
DP-04	Cross Section 4 Surinam Canal



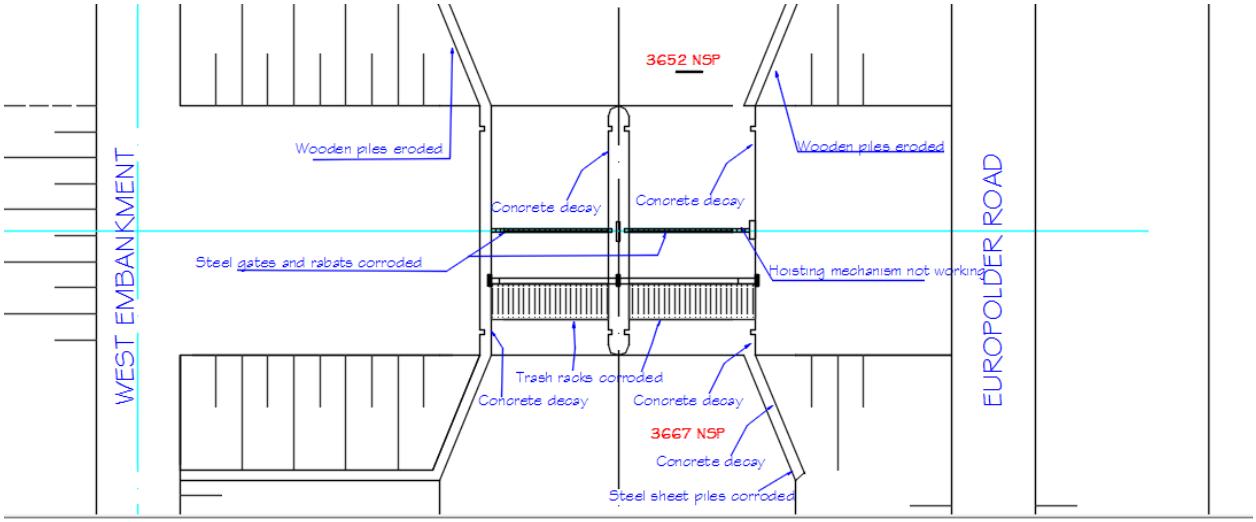

Surinam canal
DP-02
North
South
Naniswamp
Surinam canal
+3..71m NSP
+2.24m NSP
WL:+1.46m NSP
03/28/'18 14:45
6.00
5.00
4.00
3.00
2.00
1.00
[m NSP] 0.00
-1.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
[m]

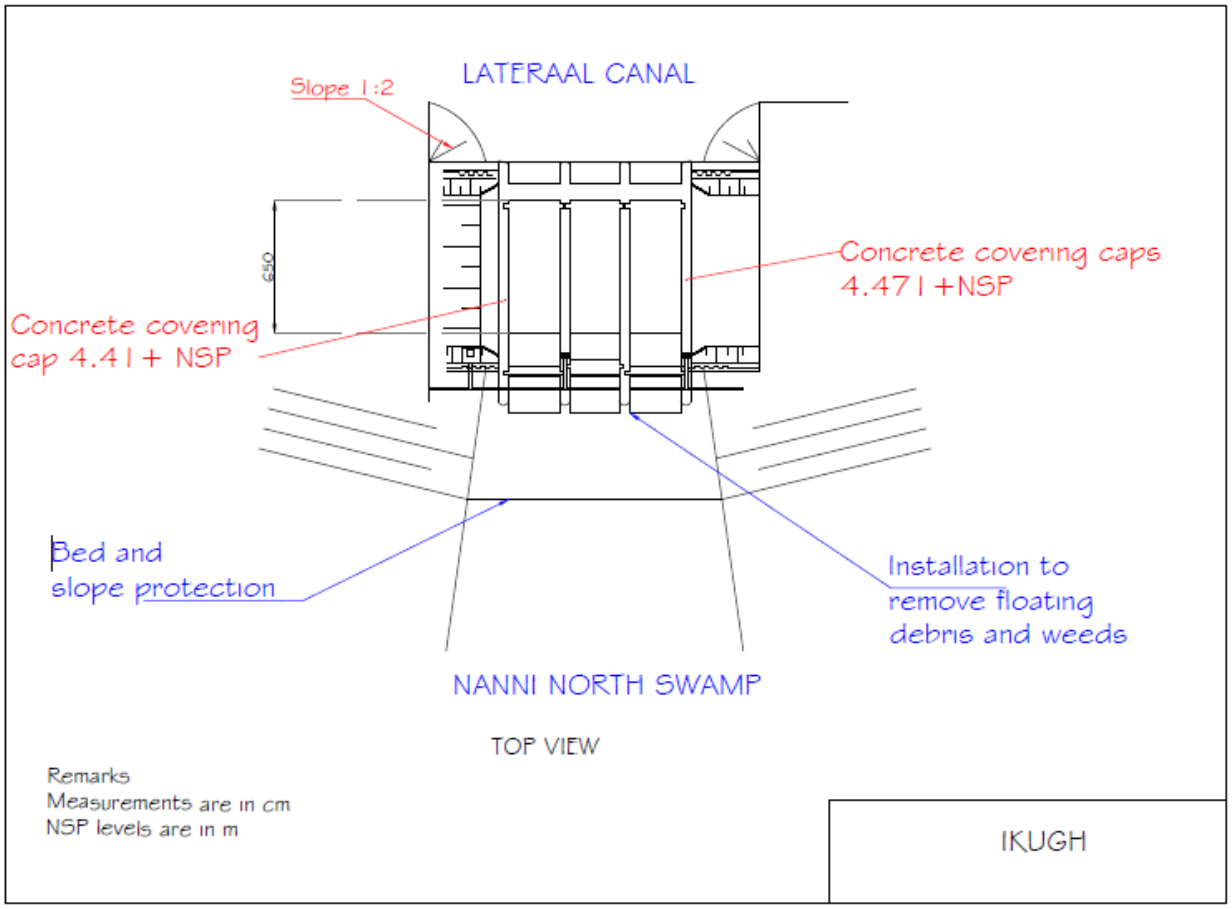

Surinam canal
DP-03
North
South
Naniswamp
Surinam canal
+4.28m NSP
+ 2.45m NSP
WL:+1.46m NSP
03/23/'18 15:25
6.00
5.00
4.00
3.00
2.00
1.00
[m NSP] 0.00
-1.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
[m]

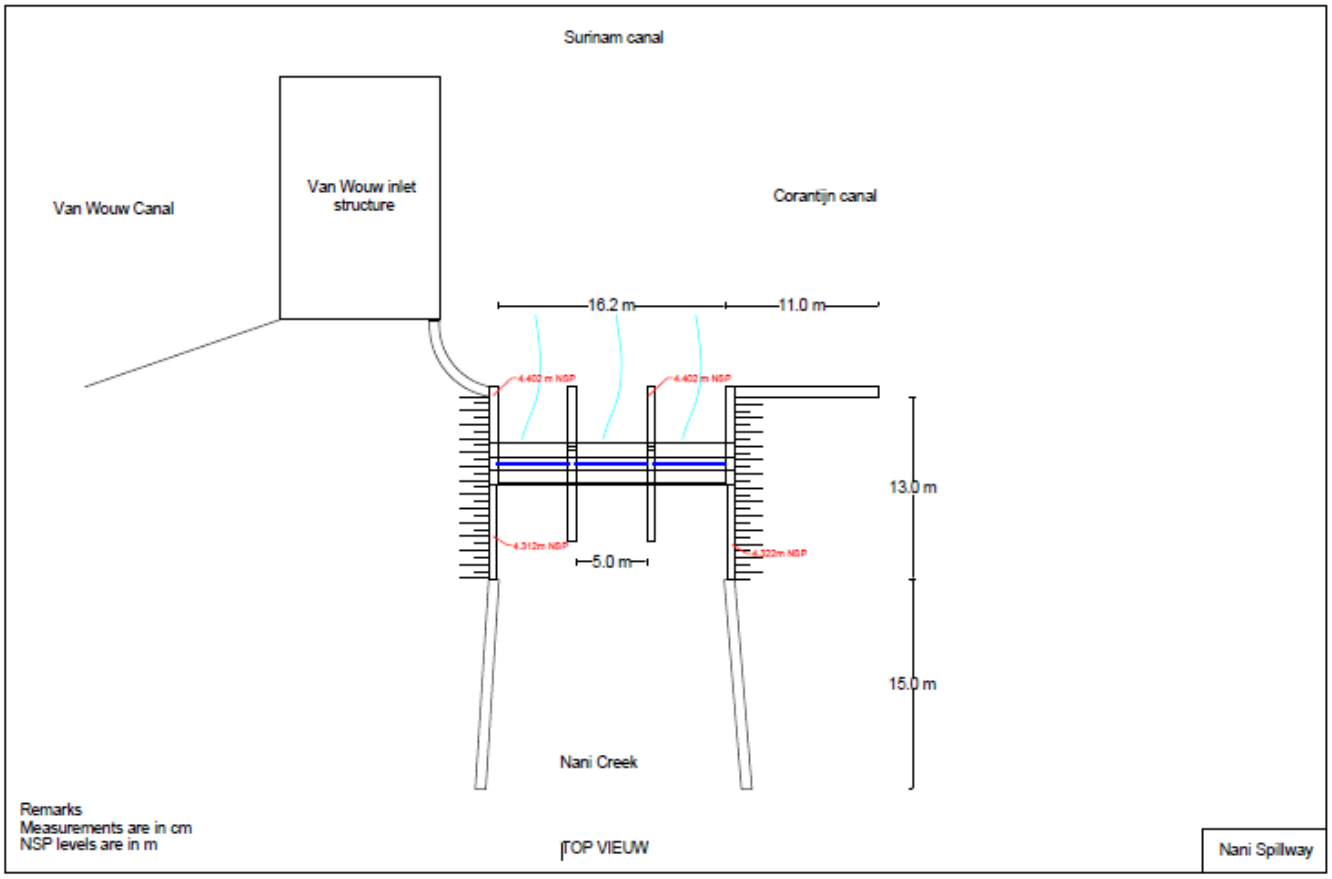

Surinam canal
DP-04
North
South
Naniswamp
Surinam canal
+4.4m NSP
+2.36m NSP
WL:+1.46m NSP
03/28/'18 16:05
6.00
5.00
4.00
3.00
2.00
1.00
[m NSP] 0.00
-1.00
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
[m]

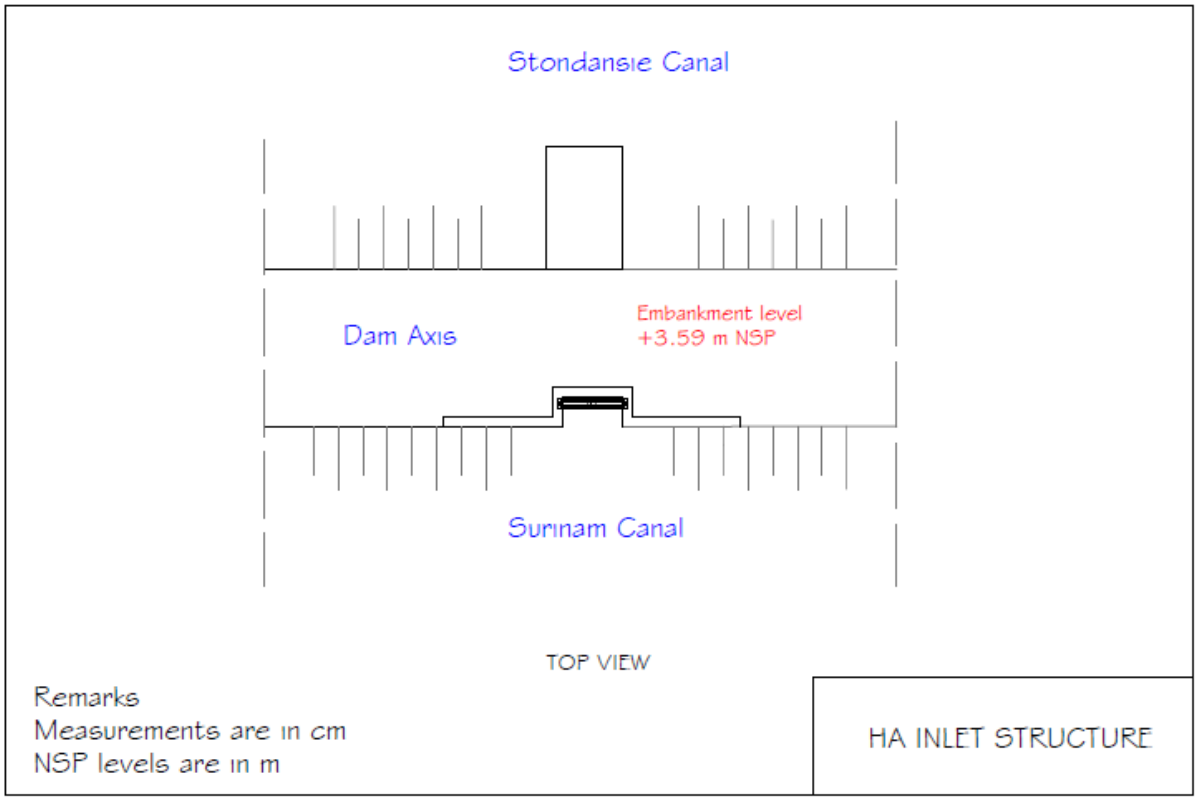
8. Schematic drawings

Van Wouw Inlet Structure

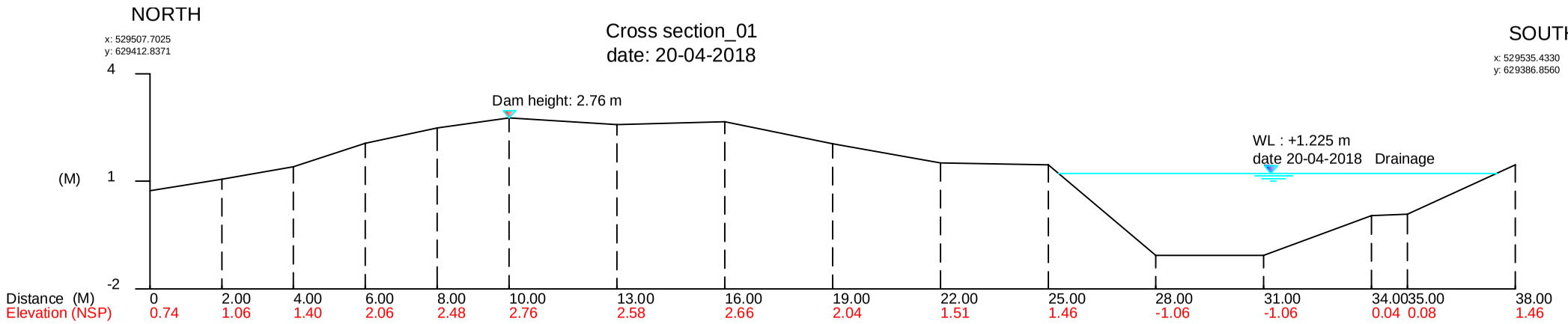


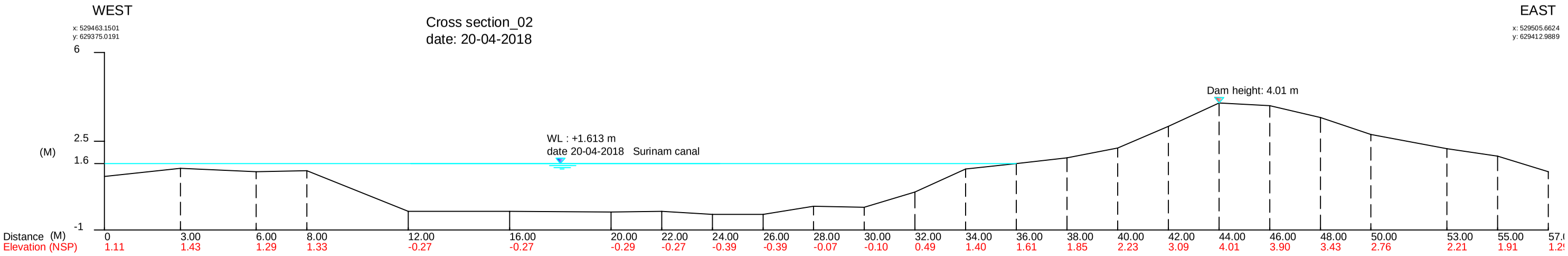



Surinam canal
Van Wouw Canal
Van Wouw inlet structure
Corantijn canal
16.2 m
11.0 m
4.402 m NSP
4.402 m NSP
13.0 m
4.312m NSP
5.0 m
4.322m NSP
15.0 m
Nani Creek
Remarks
Measurements are in cm
NSP levels are in m
TOP VIEUW
Nani Spillway


Stondansie Canal
Dam Axis
Embankment level
+3.59 m NSP
Surinam Canal
TOP VIEW
Remarks
Measurements are in cm
NSP levels are in m
HA INLET STRUCTURE

Appendix IV: Survey results Maratakka Spillway area





* Situation cross section Maratakka and Surinam canal.

Note:
- Waterlevel in Surinam canal estimated from waterlevel measured at IKUGH.

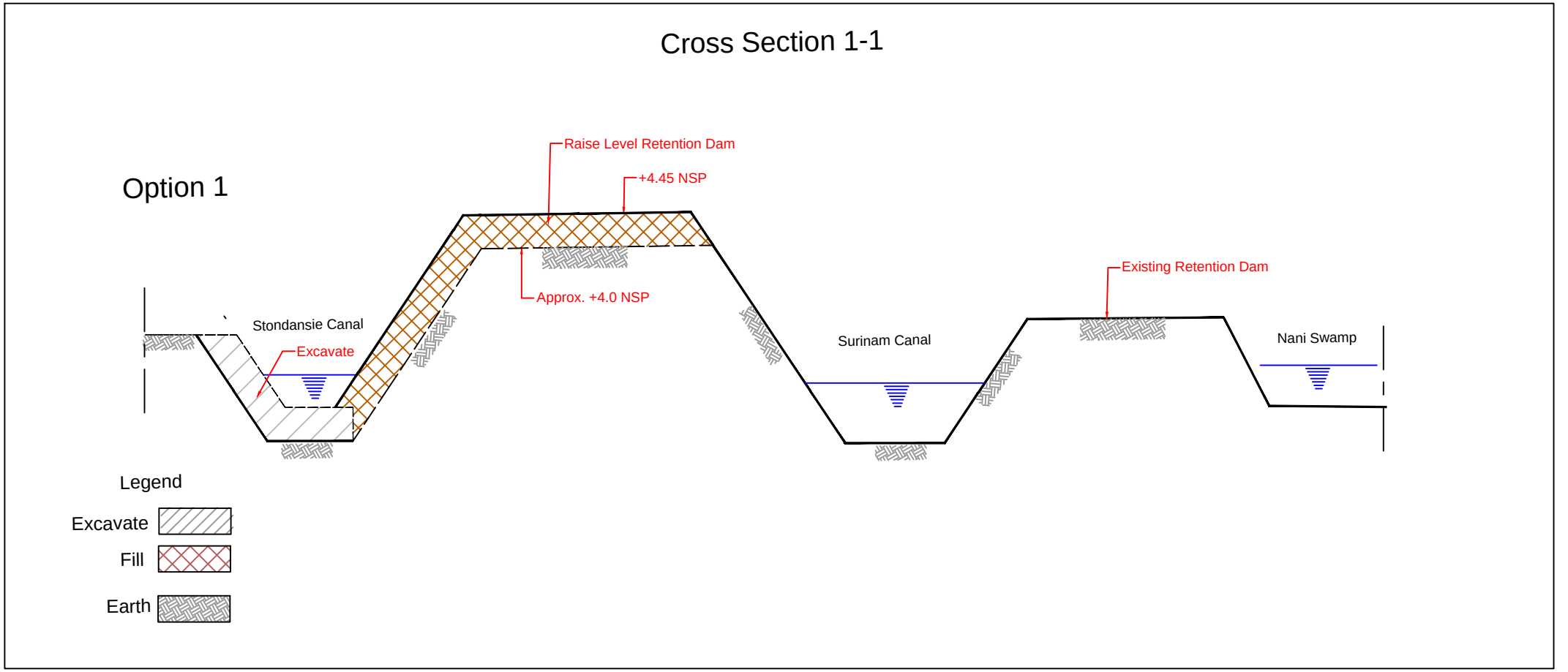
- WL = Waterlevel

Appendix V: Overview Option 1 and 2 for Corantijn Canal supply

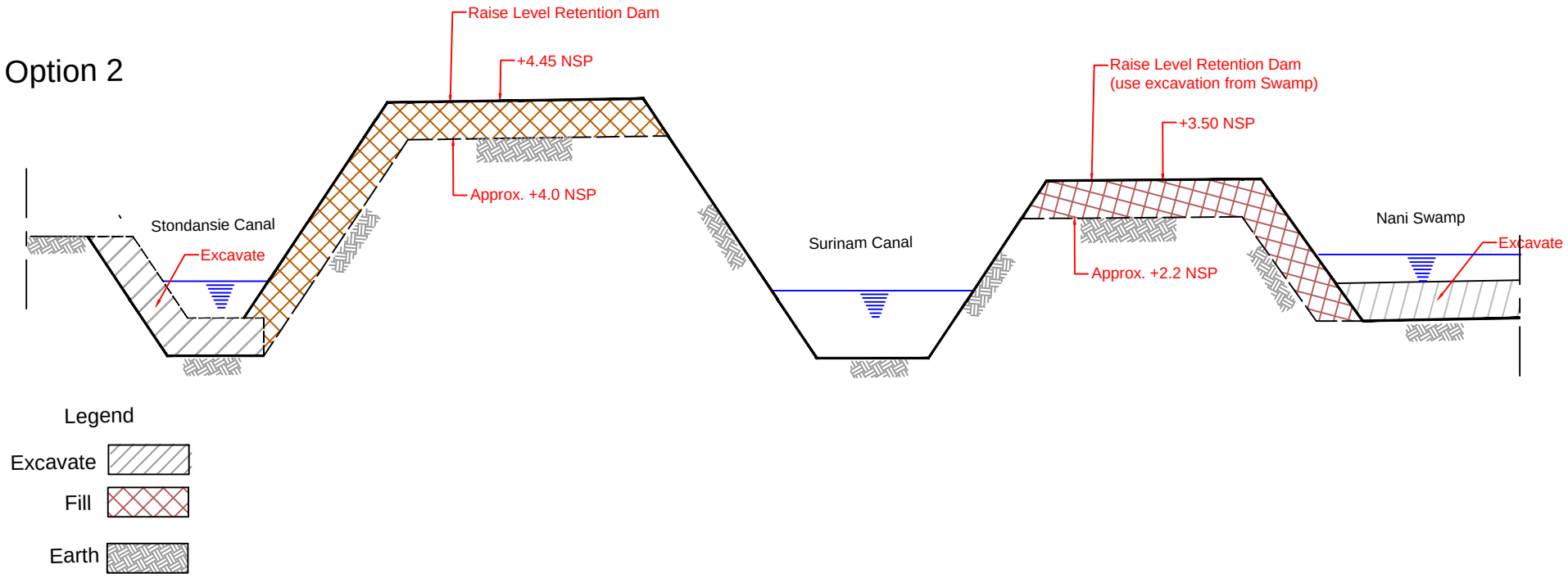

Cross Sect. 1-1
OPTION 1
OPTION 2
© 2018 Google


OPTION 1
OPTION 2
CROSS SECT. 2-2
© 2018 Google
Outlet Structure

Cross Section 1-1

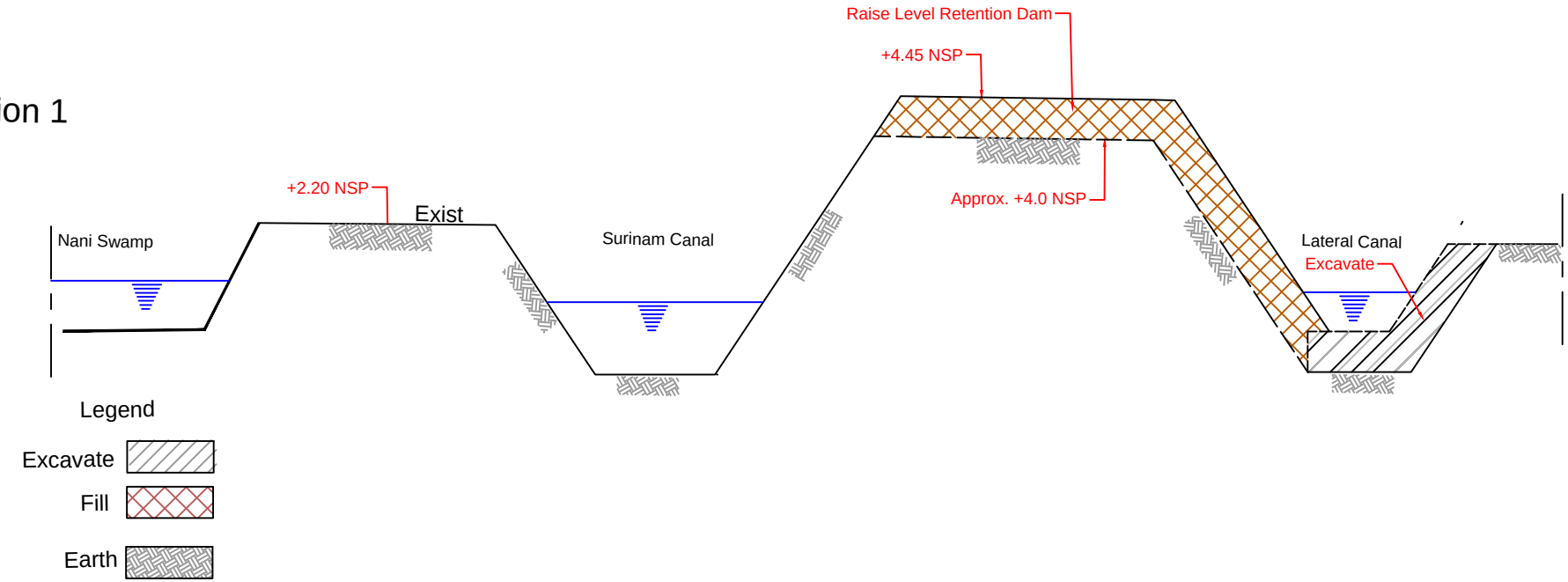


Cross Section 1-1



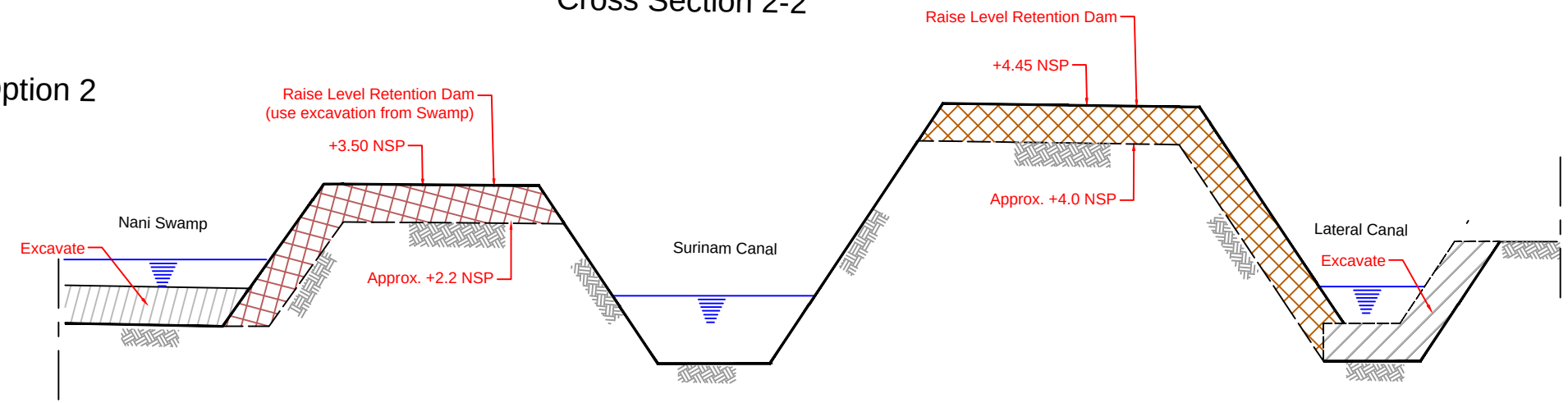
Cross Section 2-2

Option 1



Cross Section 2-2

Option 2



Legend

Excavate

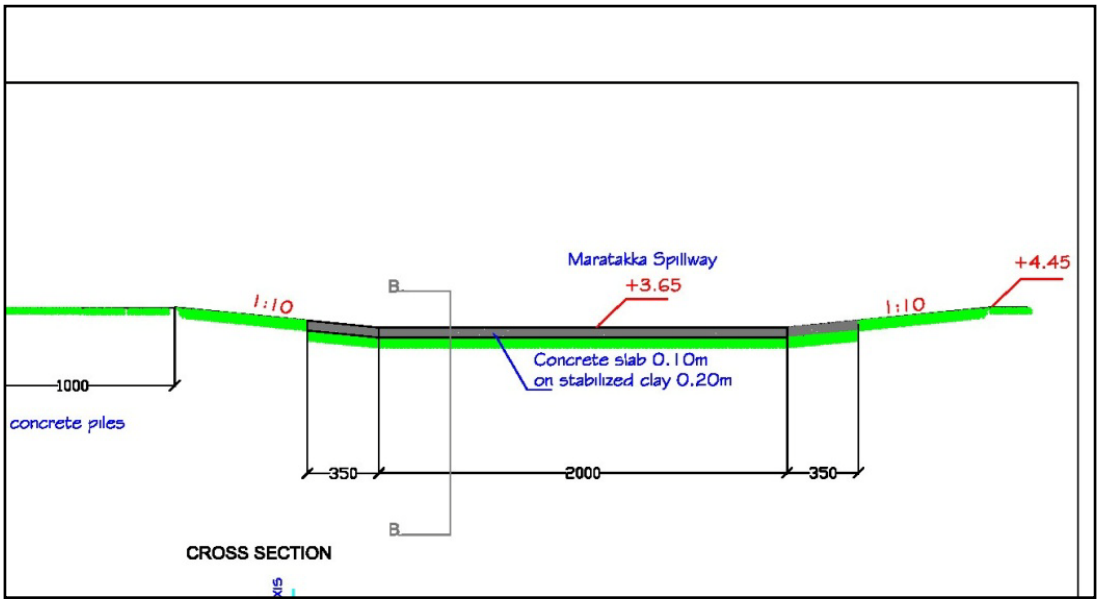
Fill

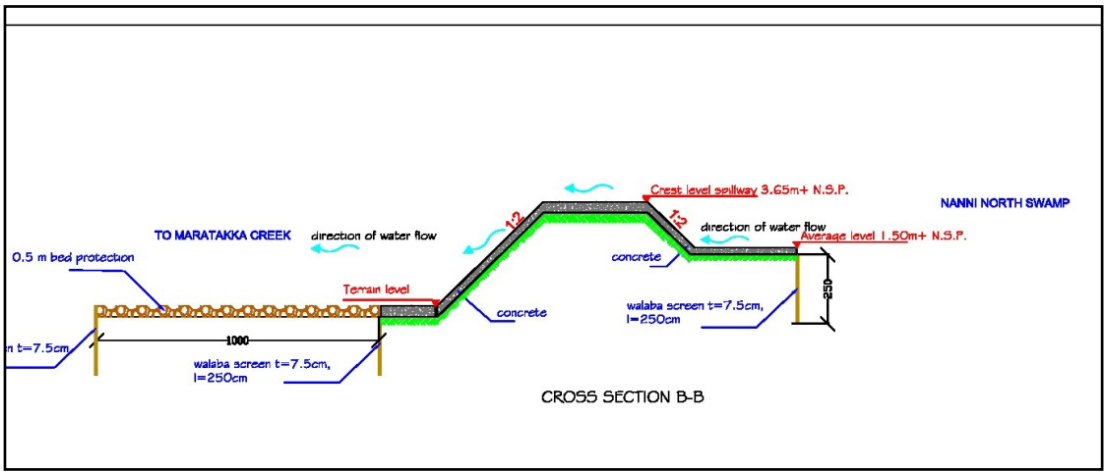
Earth

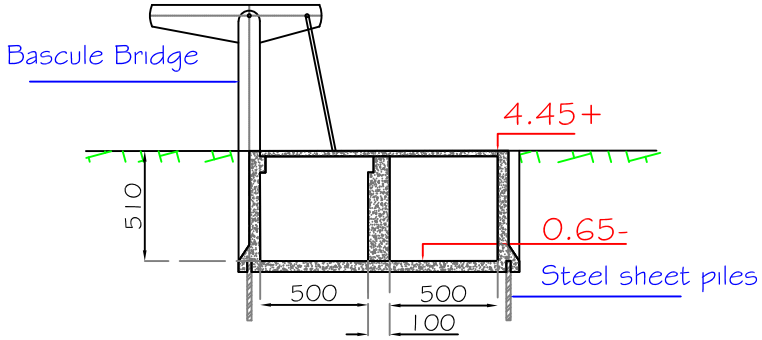
Appendix VI: Schematic Designs Nanni Weir and Maratakka Spillway
(Original source: OWMCP Masterplan, 2010)

Note:
The designs presented in this Appendix are taken from the OWMCP Masterplan. The designs are yet to be checked on some details such as location, position and dimensions.

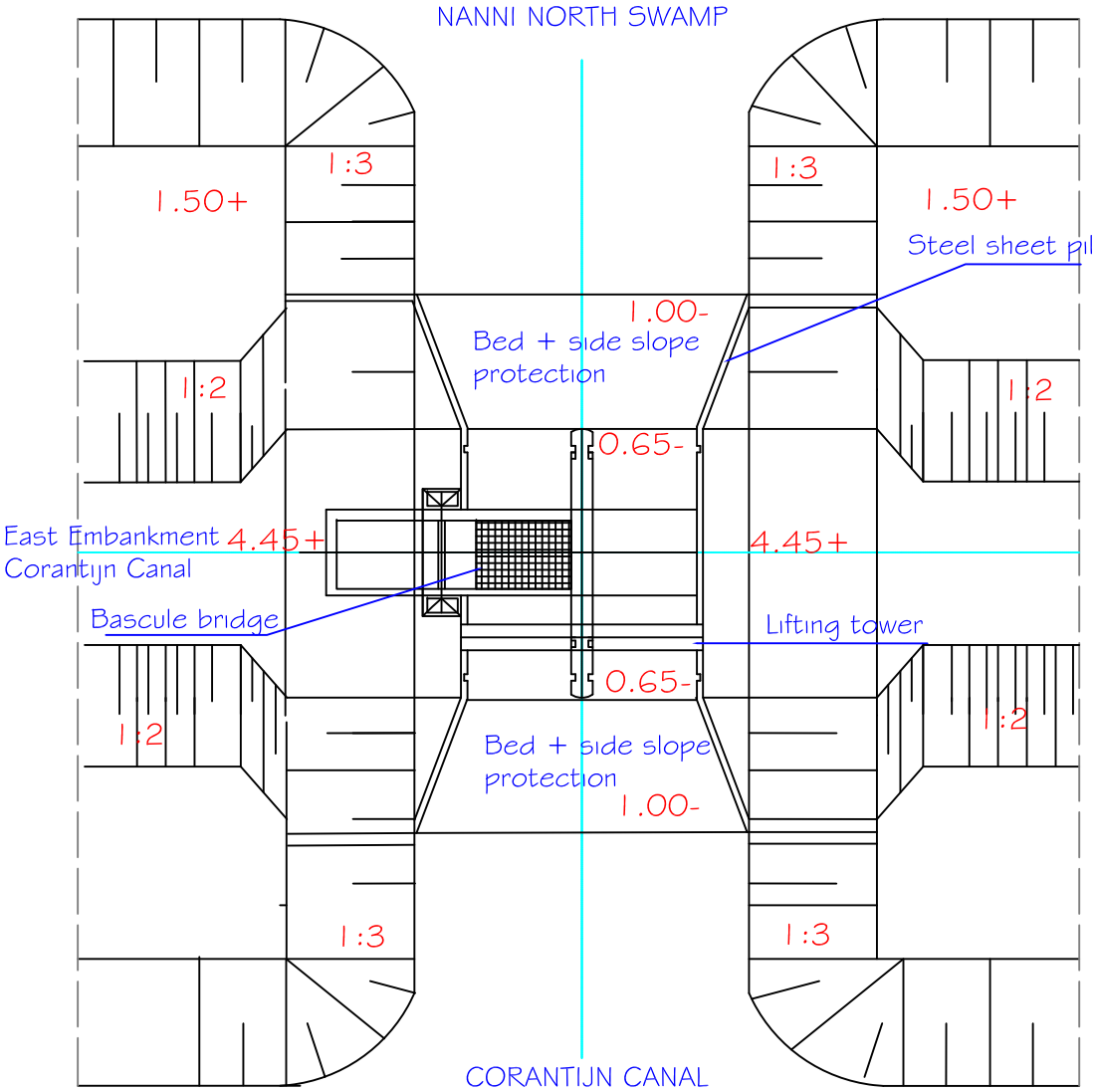
Maratakka Spillway (at end dam of Surinam Canal near link to Maratakka River)



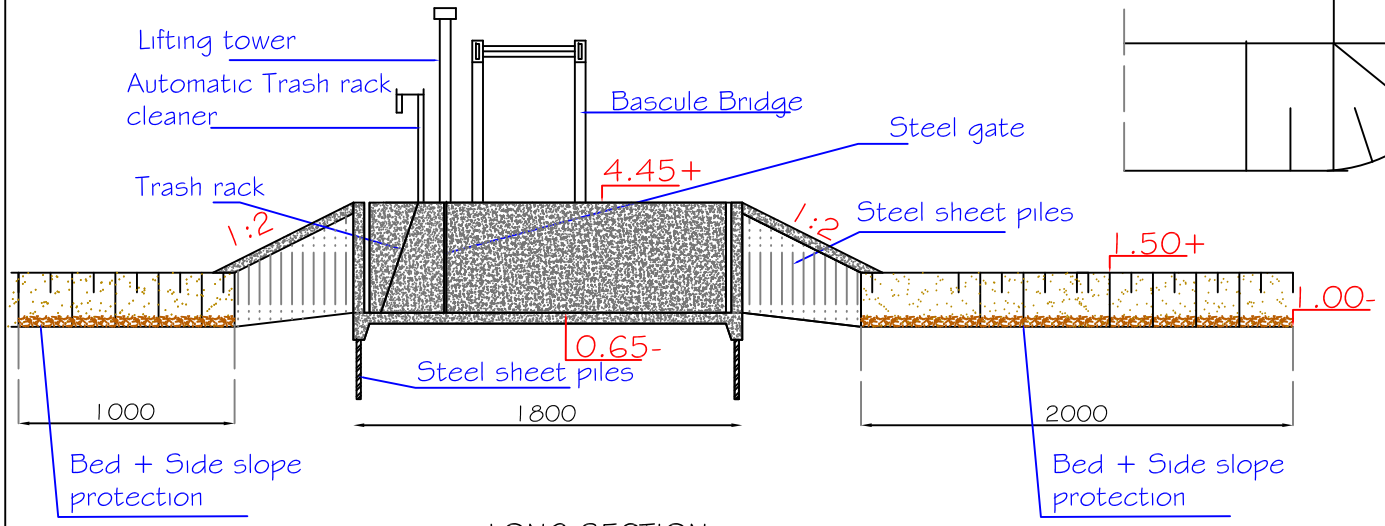




CROSS SECTION



TOP VIEW



LONG SECTION

Remarks
Measurements are in cm
NSP levels are in m

14. NANNI WEIR