Business Case - Promoting treated wastewater as a resource

Jamaica

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BOD	Biochemical Oxygen Demand
CAPEX	Capital Expenditure
COD	Chemical Oxygen Demand
CReW	Caribbean Regional Fund for Wastewater Management
DN	Diameter Nominal
GEF	Global Environment Facility
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
MAR	Managed Aquifer Recharge
NEPA	National Environmental and Planning Agency
NRC	Natural Resources Conservation
NRCA	Natural Resources Conservation Authority
NRW	Non-revenue water
NWC	National Water Commission
OPEX	Operational Expenditure
OUR	Office of Utilities Regulation
SCADA	Supervisory Control and Data Acquisition
TSS	Total Suspended Solids
UN	United Nations
UV-Vis	Ultraviolet/Visible
WRA	Water Resources Authority
WWTP	Wastewater Treatment Plant

1. Introduction

The availability of water in sufficient quantity and quality "is at the core of sustainable development and is critical for socio-economic development, healthy ecosystems and for human survival itself" (UN, 2022a). However, in Jamaica, water resources have been and will be affected by climate change. Factors such as increase in temperature, decrease in daily rainfall, increase in intensity of extreme events and sea level rise will have a cumulative negative effect on quantity and quality of available surface and groundwater resources (CSGM, 2020).

This business case on the reuse of treated wastewater aims to support concrete measures to improve the amount of reused water and guide the development of a policy for the reuse of treated effluents. The most promising installation for short-term pilot implementation was chosen out of 14 plants analyzed. In a mission in Jamaica, the WWTP Innswood was chosen with the possibility of Aquifer recharge.

Importance of a business rationale

While wastewater reuse is perceived as a "green" issue and therefore generally perceived as positive, the situation changes in the specific case when wastewater reuse is offered. The possible acquirer, as well as the supplier, will not accept a cost higher than their current cost unless required by law or if there is a need for a "green seal" for their business. Therefore, it is important to determine the additional costs clearly and it is necessary to propose ways to balance the additional costs to at least zero.

2. Description of the business case

The Innswood garden treatment plant (Figure 1) connected to the existing Aquifer Recharge was chosen as the most promising installation for a pilot implementation. For detailed description see the report on C3 – Pilotplant.

Figure 1 - Innswood garden Oxidation ditch

Source: ***adapted from*** *Google Earth*

2.1. Reuse potential

The Innswood plant is close to the Aquifer recharge facility (MAR). Therefore, it is a very interesting possibility to use the existing MAR (Figure 2) for the treated wastewater. In this case, the effluent could be piped to the point where the Water Resources Authority (WRA) is extracting water from the Canal and at that point it could be mixed with water from the Canal going to the Aquifer Recharge facility, which was built in 2016.

Figure 2 - Innswood - Aquifer Recharge facility

Source: ***adapted from*** *Google Earth*

Figure 3 - Aquifer recharge Innswood – inlet to the plant with water from the canal

Source: @CREW+/Platzer

The plant is a sequence of four settling ponds (Figure 4) followed by 6 reed beds (Figure 5), joining the water and discharging into the Aquifer at several points - Injection wells and caves (Figure 6).

Figure 4 - Aquifer recharge Innswood – Visit to the Plant and settling ponds

Source: @CREW+/Platzer

Figure 5 - Aquifer recharge Innswood – reed beds

Source: @CREW+/Platzer

Figure 6 - Aquifer recharge Innswood – discharge to a cave

Source: @CREW+/Platzer

The main purpose of the recharge is to protect the aquifer against saline intrusion. The WRA indicated that they would be very interested in getting more water for recharge and would not have issues with treated wastewater. This aspect is important to be followed up with the National Environmental and Planning Agency (NEPA). Regarding the minimum standards required for recharge, there has not been a clear indication by NEPA. Therefore, this is an aspect to be developed in the policy setting, however it is also necessary to already have a clear vision to be able to move forward with the possible project.

As the Recharge is working all year, the plant could have a 100% reuse in all situations.

2.1.1. Required standards

According to NEPA, the required standard for recharge would be defined as the same as the discharge to surface water. At a later moment, it may be that for phosphorous the standard is eliminated or set higher, as phosphorus is not critical in a groundwater recharge. As there is currently no legislation in this regard, the strictest standard is used. This means that the values in the last column of Table 1 must be met.

Table 1 - Sewage effluent standards

Parameter	Effluent Limit			
	WWTP (1997 or older)	WWTP (1998 to date)	Effluent used for irrigation	NRCA standards for direct discharges
BOD_5	20 mg/L	20 mg/L	15 mg/L	20mg/L
TSS	30 mg/L	30 mg/L	15 mg/L*	20mg/L
Total Nitrogen	30 mg/L	10 mg/L	-	10mg/L
Phosphates	10 mg/L	4 mg/L	-	4mg/L
COD	100 mg/L	100 mg/L	<100 mg/L	100mg/L
pH	6-9 pH units	6-9 pH units	-	6-9 pH
Faecal Coliforms	1000 MPN/100 ml	1000 MPN/100 ml	12 MPN/100 ml	200MPN/100mL
Residual Chlorine	> 1.5 mg/L	> 1.5 mg/L	< 0.5 mg/L	> 1.5 mg/L
Floatables	-	not visible	-	not visible
Oil and grease	-	-	10 mg/L	

* The Total Suspended Solids (TSS) standard was altered to 15 mg/l. The NRC regulation indicates 1.5 but that being an error accordingly to NEPA.

Source: Natural Resources Conservation (Wastewater and Sludge) Regulations 2013

2.1.2. Necessary infrastructure

As the infrastructure exists completely on the receiving side, there will be no costs on the reuse side.

2.2. Wastewater treatment plant

2.2.1. Description of the WWTP

Innswood is a very robust plant. The plant is equipped with a double oxidation ditch (Figure 7) and two secondary clarifiers. Currently the plant is upgraded to its full capacity of 23 l/s. Pretreatment is done with a horizontal drum screen.

Figure 7 - Innswood – oxidation ditch with sludge return

Source: @CREW+/Platzer

The potential of the plant is good. At the moment of the visit, the plant had an extremely high sludge level and only one secondary clarifier was operating, therefore the clarifier was overloaded (Figure 9), resulting in sludge loss to the Chlorination basin discharge (Figure 8).

Figure 8 - Innswood – chlorination basin discharge

Source: @CREW+/Platzer

Figure 9 - Innswood – overloaded secondary clarifier

Source: @CREW+/Platzer

A sludge volume test with 15 min duration was performed. There was no settling within this time. Neither in the Imhoff cone nor in the cylinder (500 ml) was any settling detected. This indicates that the plant is retaining too much sludge in the treatment cycle

The operator was aware of how the sludge volume test works and explained that he usually keeps the sludge volume around 500 mL/L (done in an Imhoff cone). However, he also indicated that he is manually returning the sludge with about 5 hours of pumping per day, which is not the best practice for sludge return.

The facility is currently upgrading the drying beds, as there are not enough possibilities for sludge drying, leading to the mentioned problem of high sludge volume.

Putting sludge management in order, the plant should have a very effective nitrogen removal. No phosphorous removal by precipitation is installed.

The chlorination is very inefficient. There is a clear problem in the operation with chlorine Gas from a safety and a quality control standpoint. The consultant strongly recommends a safety training and provision of minimal chlorine gas safety equipment.

2.2.2. Verification of the upgrading project

Developer documents regarding the upgrading of the plant were provided by the National Water Commission (NWC) to the consultant. In general, it should be noted that the documents are organized with a significant lack of transparency, not in accordance with the standard way in which engineering documents are provided.

Often the information is somewhere in the document, but it is not clear where the numbers are derived from, and therefore it is difficult to cross-check the numbers without extensive own calculations.

In the report regarding C3, the consultant recommended actions to the NWC to ensure the effluent standard. This report assumes that standards will be met with the upgrading of the plant.

2.2.3. Wastewater volumes

The design flow rate of the plant is 23 L/s. The current flow rate is about 7 L/s[1], which is equivalent to 209,875 m^3 per year.

2.2.4. Current standards

The plant must meet nutrient standards after completion of the renovation (Table 1, last column).

2.3. Required additional investment in order to reuse

2.3.1. Required measures to ensure effluent quality

WRA pointed out that its main concern is to maintain the continuous quality of the treatment plant.

To ensure the continuous quality, it is important to have a minimum stock of spare parts. In addition, the operators must be trained to maintain quality and react to quality variations. An on-call maintenance service must be arranged.

In addition to these measures, a recommendation is to install an online UV-Vis spectrometry probe. This probe can identify changes in the regular effluent patterns and in case of stronger deviation automatically shut off the recharge with an automatic valve.

[1] Measurement by NWC in 2021 6,65 l/s

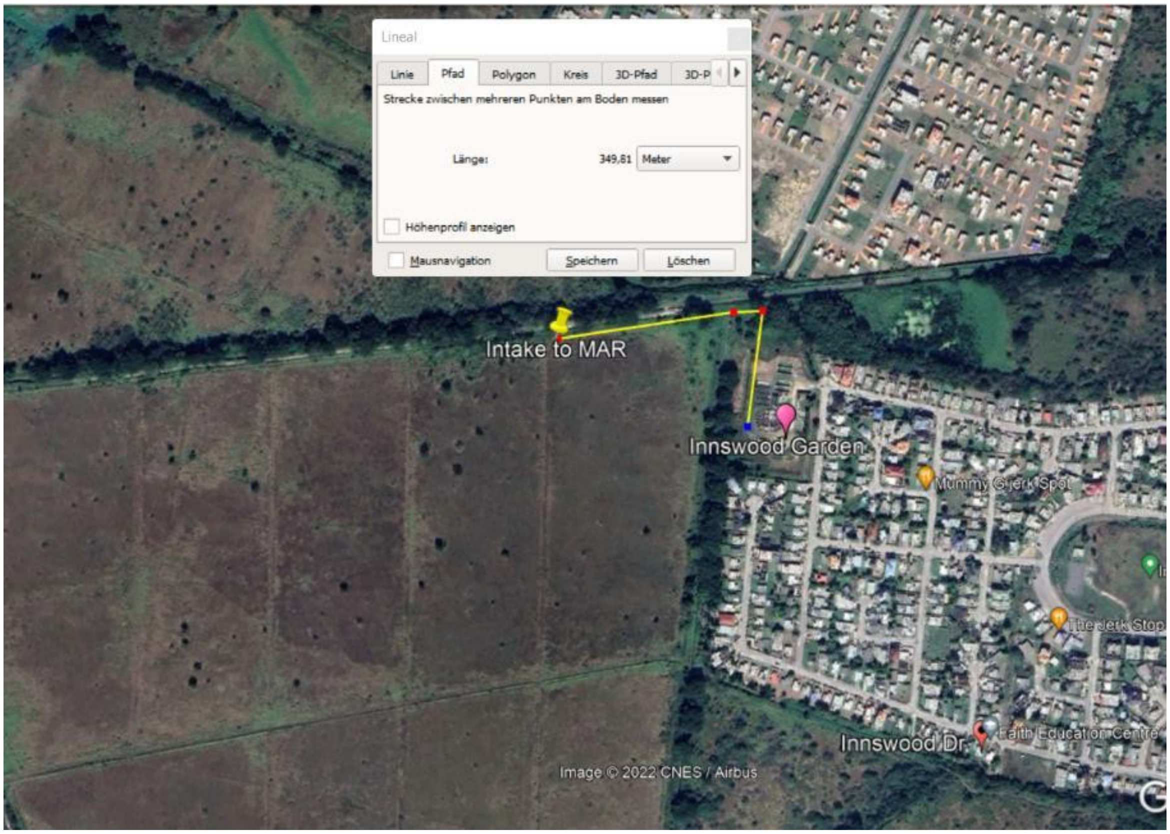
Figure 10 - Example of an UV-Vis Probe

Source: GO Systemelektronik GmbH

2.3.2. Required investments for wastewater conveyance

Figure 11 indicates the piping needed to convey the effluent to the point where the WRA is extracting water from the Canal to the MAR. The approximate length is 350 meters. It seems to be possible to convey the effluent to the Intake by gravity. There is a height difference of about 5 m between the Innswood Garden WWTP and the Aquifer Recharge Facility. The diameter of the pipe must be dimensioned according to the maximum flow of wastewater. An approximate estimate leads to a DN 300 considering peak flow, resulting in a head loss of 0.5 m from the WWTP to the intake.

Figure 11 - Necessary pipeline from Innswood WWTP to the managed aquifer recharge (MAR) intake



Source: Adapted from Google earth

3. Cost-revenue assessment

Based on a period of 10 year, the operational cost per m³ will be calculated. (Capitalization of CAPEX + OPEX) / total amount of water = cost /m³.

3.1. Costs

3.1.1. Investments to ensure effluent quality

In order to ensure the effluent quality at all times, it was planned to install an UV-Vis probe that automatically shuts off the wastewater flow to the MAR. The measurement and the status of the automatic valve should be integrated into a Supervisory Control and Data Acquisition (SCADA) system that is available on handheld devices for transparency between NWC and WRA.

Table 2 - CAPEX for reuse adoption

	CAPEX in USD		
UV-Vis probe	15,000	1	15,000
Integration in SCADA	45,000	1	45,000
Automatic Valve	5,000	1	5,000
Manual valve	1,000	1	1,000
Start - up	3,000	1	3,000
			69,000

Source: @Crew+/Platzer

3.1.2. Investments for wastewater conveyance

For the wastewater conveyance, the consultants recommend a DN 300 pipeline (see report to C3) to avoid pumping. As NWC did not provide costs for the pipeline, the consultants used benchmark project costs in Brazil, which are around USD 190 /m. As the total length is about 350 m, pipeline costs amount to USD 66,500.

3.1.3. Costs for operation and maintenance

For the maintenance of the probe and a closer surveillance of the plant, the consultants recommend planning an additional 50 % time for one plant operator.

NWC provided monthly costs for a plant operator of J$ 237.000[2]. Theoretically, this would be the only additional cost to be considered for the aquifer reuse.

During the field visit, it became clear that the treatment plant suffers from a lack of investment in equipment maintenance. This is a general problem which should be addressed. It is a very common problem in Latin American and Caribbean countries, as wastewater normally competes with water over the same limited resources, although there should be a separation between budgetary positions for maintenance of water or wastewater infrastructure. As water is a product that has a customer, this situation changes when treated effluent is reused. Therefore, the consultant recommends setting aside an annual budget of at least 3%, but ideally 5% of the equipment investment costs for maintenance. As equipment costs for Innswood were not provided, the consultants recommend setting aside at least USD 10,000 per year for this purpose.

As a result, annual costs amount to J$ 2,987,923 (Table 3).

[2] E-Mail from Wendy Harrison 15.09.22

Table 3 - OPEX for reuse adoption

OPEX	USD/un	Quant.	Unit	USD/a	J$/a
50% Plant operator	1,562.16	6	month	9,373	1,416,366
Maintenance of UV-Vis	400	1	Un.	400	60,444
Maintenance general	200,000	5%	Un.	10,000	1,511,112
				19,773	2,987,923

Source: @Crew+/Platzer

3.1.4. Total yearly costs

The investment costs for the case of Innswood amount to USD 135,500. Divided into 10 years, that would be an annual amount of USD 13,550 to be considered[3].

The OPEX for this case comes to USD 19,773.

The total annual costs to be considered are USD 33,023 or J$4,990,146. Based on 14 L/s this represents J$ 11.3/m³. Based on the design flow rate of 23 L/s this represents a cost of J$ 6.88/m³. As Crew+ will finance the CAPEX, in this case only OPEX should be considered. Therefore, the costs come to J$ 6.76 /m³ (14 L/s) or J$ 4.11/m³ (23 L/s).

3.2. Revenue

3.2.1. Reduced discharge fee

Currently, the Aquifer recharge would not result in a reduction of the discharge fee, as Aquifer recharge would be considered as groundwater recharge. But even if a regulation change were to lead to a complete elimination of the discharge fee, in a 7 L/s situation and assuming current nutrient standards were the basis for the discharge fee, the reduction would be only J$ 78,000.00 per year.

[3] No interest rate was considered in this case

3.2.2. Reduced extraction fee

In order to promote reuse it may be a possibility that a regulation is developed by government, recognizing reuse as a reduction in groundwater use and allowing for a reduction in theextraction fee by volume from WRA (see report to C1).

WRA reported for domestic use/public supply the fee of $0.115 JMD/ 4.54 cubic meters per annum. The consultant therefore calculated a fee of J$ 0.0523/m³,a from the value provided.

The Innswood effluent based on 7 L/s is 220,752 m³ /a, so the total value amounts to J$ 5,591 /a.

3.3. Business result

3.3.1. Cost-revenue over 10 years

Considering the investment costs with an amortization period of 10 years, the costs generated in a regular case would be USD 13,250 to be considered[4].

The OPEX for this case comes to USD 19,773.

The total annual costs to be considered are USD 33,023 or J$4,990,146. Based on 14 L/s this represents J$ 11.3/m³. Based on the design flow rate of 23 L/s this represents a cost of J$ 6.88/m³. As Crew+ will finance the CAPEX, in this case only OPEX should be considered. Therefore, the costs come to J$ 6.76 /m³ (14 L/s) or J$ 4.11/m³ (23 L/s).

In relation to the wastewater tariff of J$ 161.79, this represents 4.1% (14 L/s) or 2.5% (23 L/s) of the tariff.

[4] No interest rate was considered in this case.

3.3.2. Required subsidies to generate positive business case

For the practical case of Innswood, the consultants recommend that the additional cost be covered by the tariff to generate an example, as it is not a relevant additional cost. For the NWC to proceed, it would be necessary to find a solution that would cover the additional costs, as the Office of Utilities Regulation (OUR) already indicated that an increase in the tariff due to reuse would not be possible. In the conversation with OUR, it was mentioned that reuse should be seen as another measure by the NWC to reduce water extraction and withdraw from the same budget that is planned for Non-revenue water (NRW) reduction. The consultants do not agree with this view. While the logic is clear, additional aspects are supporting local agriculture, reducing the threat of saline intrusion, etc. therefore provide benefits that go beyond a direct tariff – customer relationship.

3.4. Other aspects

3.4.1. Operation and maintenance

As mentioned in the Document to C3, it is important to see treated wastewater as a product and therefore it is necessary to improve quality control in order to guarantee a 24/7 operation of the treatment plant complying with the necessary standards. Therefore, the consultants set USD 19,300 /a for this aspect.

3.4.2. Responsibilities

It is important to have an agreement that limits each party´s responsibilities to the limits of their influence.

As recommended by the consultants, this agreement should be a document signed by the NWC, WRA and NEPA.

NWC is responsible for ensuring quality within the standards defined by NEPA up to the point of abstraction for the Aquifer recharge facility (MAR), while WRA is responsible for the discharge into the aquifer. It should be clear that no party is responsible for substances or aspects not mentioned in the current standards.

4. Conclusion and recommendations

4.1. Conclusion

The Aquifer recharge is a very good option for reuse with a very high potential for beneficial use as it is not limited by seasonal aspects, and it is not limited by quantity due to area availability. The example can be an interesting solution for other areas with saline intrusion problems.
It is much more expensive in CAPEX when no infrastructure for the recharge is available. The need for recharge to protect the aquifer resources will define whether other solutions with a higher CAPEX are considered viable or not.

4.2. Recommendations

As part of the preparation for water scarcity due to climate change, it is recommended to carry out a study that analyses the costs and potentials of an aquifer recharge for critical areas. Based on this study, it must be decided who will be responsible for the investment costs necessary for recharge. Possible options are:

- Costs are considered a government task to protect groundwater resources and therefore subsidized by the government.
- Costs are considered a task for those who profit from groundwater extraction and therefore part of the WRA volume-based fee.
- Costs are considered primarily beneficial to users of a defined area and therefore added to the volume-based fee for that area.

- Costs are considered as part of the cost of potable water, as the discharge protects the groundwater water resource that is predominantly for potable use. In this case, a government decision is needed to clarify the situation with the OUR, to make the costs part of the water tariff.

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