Notes for Information Paper on Possible Nutrients Guidelines/Standards for Domestic Wastewater Discharges

Pre LBS STAC Meeting

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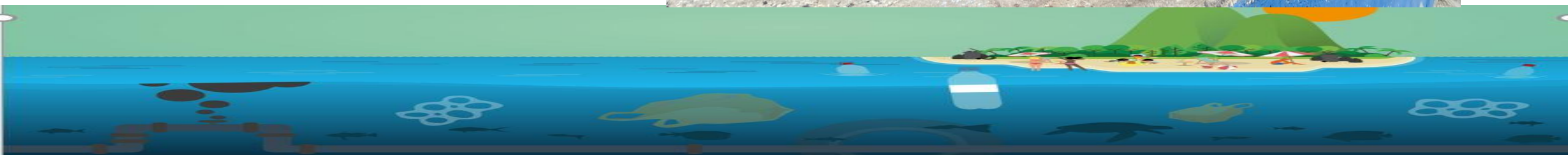


Objectives and Expected Output of the Consultancy

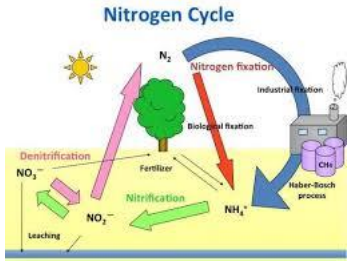
- The objective is:
  - **To improve the management of nutrients in domestic wastewater discharged into coastal waters of the WCR.**
- The expected primary output of this study is recommended revisions to the LBS Protocol as pertain to achieving the above objective.

Proposed Main Section Headings for Information Paper

1. Introduction
2. Existing Relevant Global & Regional Frameworks and Initiatives
3. Principles and Approaches to Setting Wastewater Effluent Standards
4. Selective Review of Existing Standards for Nutrients in Wastewater Discharges in WCR and Beyond
5. Barbados Case Study
6. Conclusions and Recommendations
7. References
8. Annexes

The Nutrients Problem

- Globally, the natural nitrogen and phosphorus cycles have been significantly altered post the Industrial Revolution:
  - Haber Bosch Process – agricultural fertilisers
  - Fossil fuel combustion – nitrogen oxides/nitric acid release
  - Isotopic ratios of nitrogen being altered in biota
  - 90% increase in bioavailable N
  - Known sources of mined phosphate rock are being rapidly depleted
  - Demand for phosphorus fertiliser likely to double by 2050
  - 3 million tonnes of phosphorus discharged in human urine and faeces. (Chemistry World, 2011)
  - Almost 40% of the fertiliser applied in WCR countries is wasted. (RNRRSAP, 2021)



The Problem with Nutrients in the WCR

Persistent hypoxic zone in the northern area of the Gulf of Mexico - also linked to legacy nitrogen.

Poor coastal water quality adjacent to river basins (e.g. Magdalena River Basin of Colombia and the Mississippi-Atchafalaya River Basin of the USA).

Increasing algal cover of coral reefs – sensistive marine receptor.

New sargassum dynamic equilibrium being established.

WCR population expected to increase to 800 M in 2050. (as compared to 160 M in 1978) (UN, 1978)

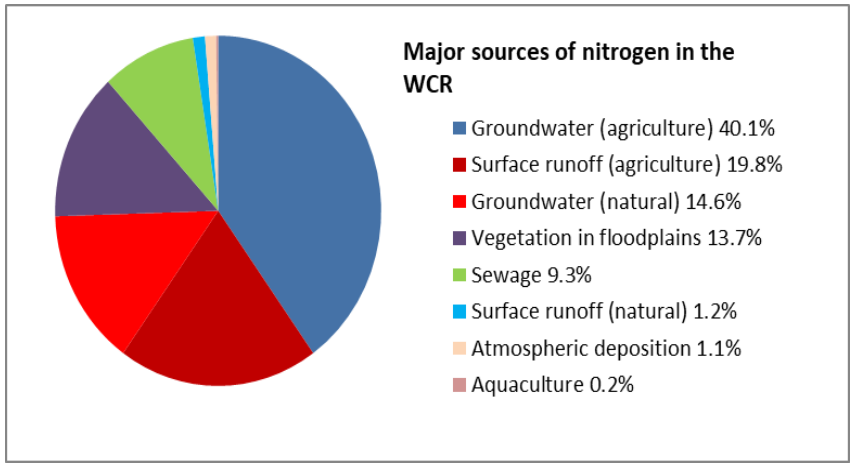
WCR Stats

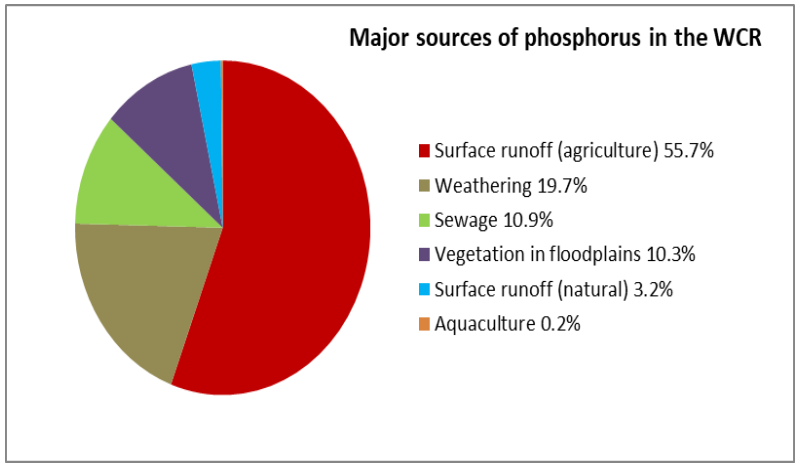
An aggregate watershed-scale population of 352,449,000.

Released untreated sewage in the order of about 1.5 X 10^{10} m^3 into WCR. (Total volume of WCR = 9.3 X 10^{15} m^3)

Nutrient load from sewage - 869,000 tonnes of N & 152,000 tonnes of P for model year 2010 (RNRS Database, Linke et al. 2019)

Major Sources of N & P (UNEP CEP 2019)



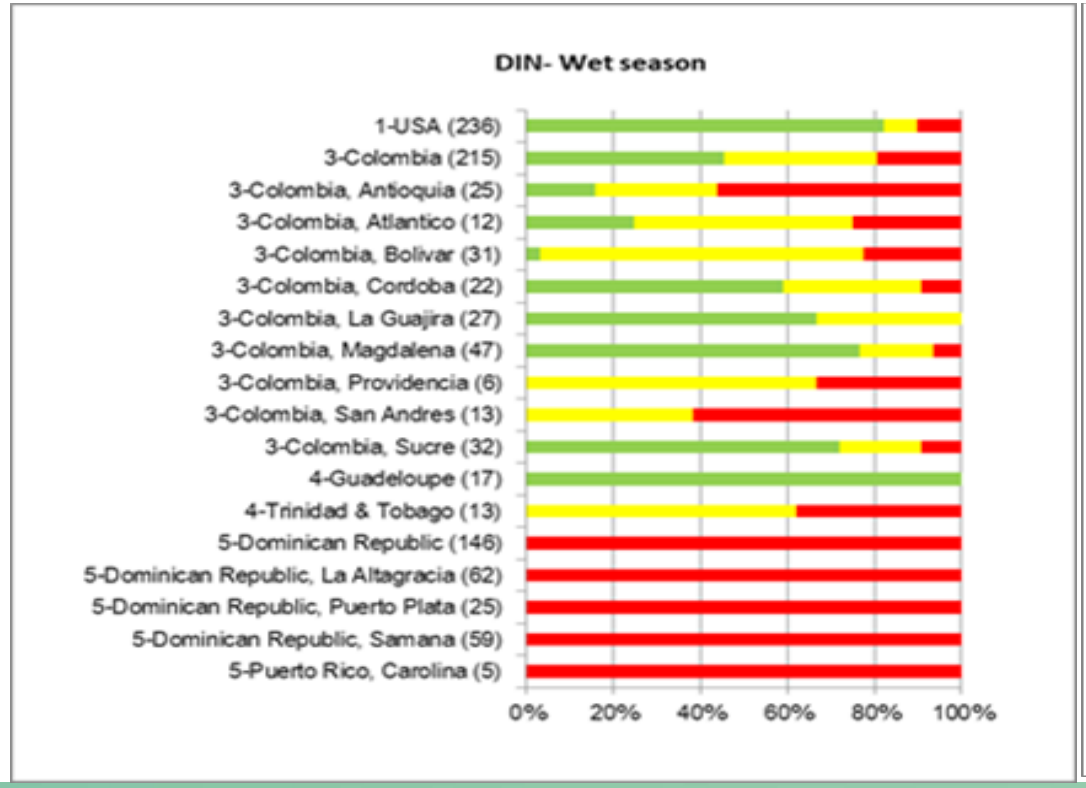


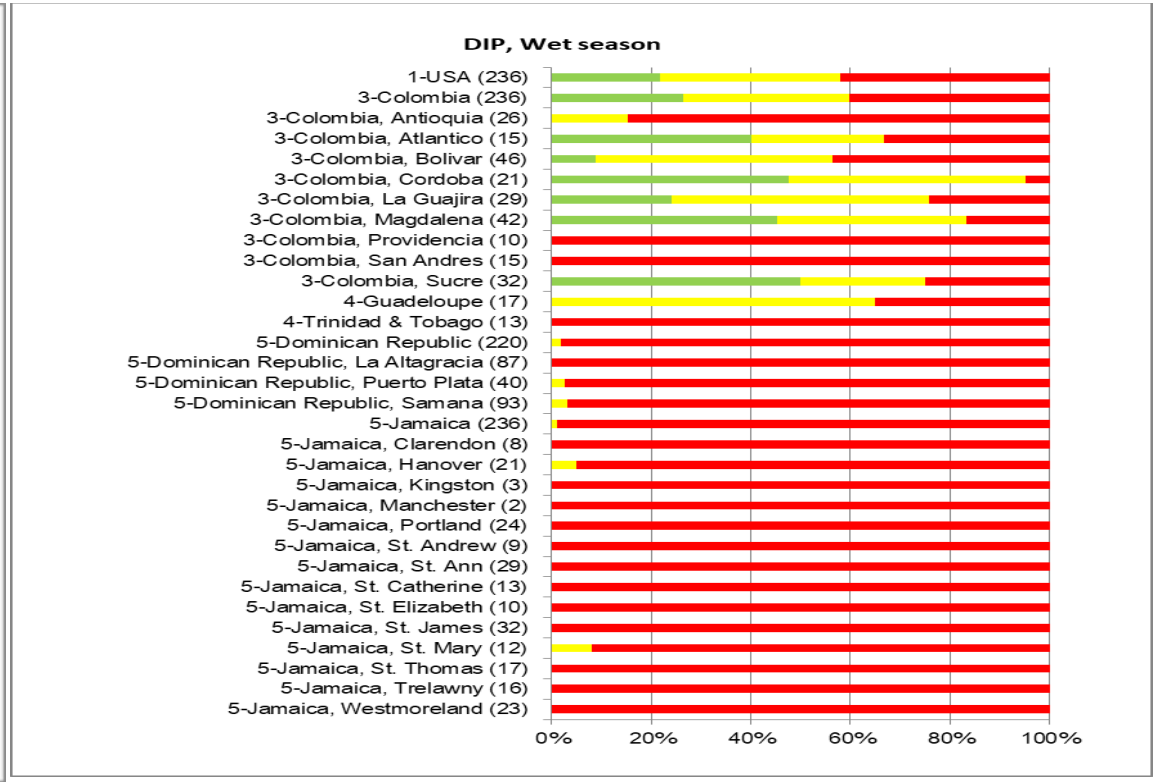
- Noted apparent higher contribution of sewage (24%) in WCR Sub-region V.

AMCECC - Barbados

- Analysis of isotopic N ratios to determine source of nitrates entering west coast – 50% human and animal waste / 50% fertiliser.
- Study also determined pathways for nitrates into Caribbean Sea – 86% via groundwater/14% via surface.
- Comment: Agriculture is at least as big a culprit as sewage. N.B. EU Nitrogen Directive.

Regional Nutrient Pollution Reduction Strategy - Figure 1.3 (UNEP CEP, 2021)





Existing Relevant Global & Regional Frameworks and Initiatives

Nutrient management and reuse of domestic wastewater in the WCR are relevant to the following SDGs:

- SDG 2 – Food Security & Sustainable Agriculture
- SDG 3 – Good health & well-being
- SDG 6 – Clean water and sanitation
- SDG 11 – Sustainable cities and communities
- SDG 12 – Responsible consumption and production
- SDG 13 - Climate Action
- SDG 14 – Life below water
- SDG 15 – Life on land
- SDG 17 - Partnerships

Reviews Completed

- Global Programme of Action for the Protection of the Marine Environment from Land Based Activities (GPA)
  - Global Partnership on Nutrients Management (UNEP GPA -GPNM
    - Established under the GPA in 2009
    - Catalyse strategic advocacy
    - Knowledge platform
    - Enhance capacities
    - Mainstream nutients in the Sus. Dev. Agenda

Global Wastewater Initiative – treat wastewater as a resource

- Voluntary network of stakeholders (secretariat provided by the GPA)
- Expected outcomes:
  - Improved synergy among stakeholders including scientists, NGOs, the private sector, governments, and international organizations for more effective wastewater management
  - Healthier ecosystems and improved human well-being
  - Increased opportunities and benefits realized and concerted national and international efforts to embed effective wastewater in national development plans
  - Enhanced knowledge generation, sharing, and utilization for better wastewater management
  - Enhanced recognition of wastewater as a resource and an opportunity by decision-makers and stakeholders
  - Increased utilization of the 3R approach worldwide
  - Enabled complementarities between the GW²I and relevant Conventions and other international instruments, action plans, initiatives, and activities
  - Systematic publication of scoping papers and global assessments on emerging wastewater issues
  - Increased mobilization of resources to address wastewater challenges.

Reviews to be completed

- International Nitrogen Management System
- Regional Seas Strategic Directions (2021 – 2024)
- CLME

LBS Protocol – Article III

- Each Contracting Party shall, in accordance with its laws, the provisions of this Protocol, and international law, take appropriate measures to prevent, reduce and control pollution of the Convention area from land-based sources and activities, using for this purpose the best practicable means at its disposal and in accordance with its capabilities.
- Each Contracting Party shall develop and implement appropriate plans, programmes and measures. In such plans, programmes and measures, each Contracting Party shall adopt effective means of preventing, reducing or controlling pollution of the Convention area from land-based sources and activities on its territory, including the use of most appropriate technology and management approaches such as integrated coastal area management.

LBS Protocol – Question: how often are any of these happening?

- Article V - Contracting Parties shall promote cooperation …..
  - identify and approach potential sources of financing for projects necessary to implement this Protocol.
- Article VI - Each Contracting Party shall formulate and implement monitoring programmes, as appropriate, in accordance with the provisions of this Protocol and relevant national legislation. Such programmes may, inter alia:
  - (a) systematically identify and assess patterns and trends in the environmental quality of the Convention area; and
  - (b) assess the effectiveness of measures taken to implement the Protocol.
- Article XII - The Contracting Parties shall submit reports to the Organisation …..
  - The Scientific, Technical and Advisory Committee shall use the data and information contained in these national reports to prepare regional reports

LBS Protocol – Annexes

- Annex 1
  - Domestic sewage is a priority source category
  - Nitrogen and phosphorus compunds are primary pollutants of concern
- Annex II
  - The Contracting Parties, when developing sub-regional and regional source-specific effluent and emission limitations and management practices pursuant to Article IV of this Protocol, shall evaluate and consider the following factors: …..
    - Total quantity (units discharged, for example, per year or per day) (Load vs. concentration? See Barbados Case Study)
    - Alternative Production, Waste Treatment Technologies or Management Practices
      - (a) Recycling, recovery and reuse opportunities (Water reclamation? Nutrient recovery?)

Annex III – Domestic Wastewater

- Each Contracting Party shall:
- (a) Consistent with the provisions of this Annex, provide for the regulation of domestic wastewater discharging into, or adversely affecting, the Convention area;
- (b) To the extent practicable, locate, design and construct domestic wastewater treatment facilities and outfalls such that any adverse effects on, or discharges into, Class I waters, are minimised;
- (c) Encourage and promote domestic wastewater reuse that minimises or eliminates discharges into, or discharges that adversely affect, the Convention area;
- (d) Promote the use of cleaner technologies to reduce discharges to a minimum, or to avoid adverse effects within the Convention area; and
- Develop plans to implement the obligations in this Annex, including, where appropriate, plans for obtaining financial assistance.
- 2. Each Contracting Party shall be entitled to use whatever technology or approach that it deems appropriate to meet the obligations specified in Part C of this Annex.

Effluent Limitations (Monthly Average - # of Samples?)

Parameter	Effluent Limit Class 2 Waters	Effluent Limit Class 1 Waters
Total Suspended Solids	150 mg/l*	30 mg/l*
Biochemical Oxygen Demand (BOD_5)	150 mg/l	30 mg/l
pH	5-10 pH units	5-10 pH units
Fats, Oil and Grease	50 mg/l	15 mg/l
Floatables	not visible	
Faecal Coliform (Parties may meet effluent limitations either for faecal coliform or for E. coli (freshwater) and enterococci (saline water).)	NA	Faecal Coliform: 200 mpn/100 ml; or a. E. coli: 126 organisms/100ml; b. enterococci: 35 organisms/100 ml
Does not include algae from treatment ponds		

Household Systems

- Each Contracting Party shall strive to, as expeditiously, economically and technologically feasible, in areas without sewage collection, ensure that household systems are constructed, operated and maintained to avoid contamination of surface or ground waters that are likely to adversely affect the Convention area. Comment: How? Particularly for those insular countries, where any discharge will eventually reach the coast?

- Household systems include, but are not limited to, septic tanks and drain fields or mounds, holding tanks, latrines and bio-digesting toilets. Comment: In the absence of political will or economic capacity to sewer populations, more focus is needed on smaller on-site treatment technologies that remove/recover nutrients.

All Discharges

- (a) Each Contracting Party shall take into account the impact that total nitrogen and phosphorus and their compounds may have on the degradation of the Convention area and, to the extent practicable, take appropriate measures to control or reduce the amount of total nitrogen and phosphorus that is discharged into, or may adversely affect, the Convention area.
- (b) Each Party shall ensure that residual chlorine from domestic wastewater treatment systems is not discharged in concentrations or amounts that would be toxic to marine organisms that reside in or migrate to the Convention area.

Questions

- Should we change from a qualitative to a quantitative effluent limit for nitrogen and phosphorus?
- If yes, which forms of nitrogen and phosphorus should be regulated in domestic wastewater effluent? Which parameters are better indicators? Ease of measurement?
  - TN or TP
  - TKN
  - Ammonia
  - Nitrates
  - Dissolved Inorganic
  - Orthophosphate
- What about silica?
- What about load vs concentration? (see Barbados case study)

Table 4.3. Summary of the parameters and matrices that are monitored for nutrient pollution by 12 respondent English and French-speaking countries/territories (Values are percentages. NR: r

Which parameters are measured now in the WCR? (Table 4.3 Chapter IV of RNPRSAP)

Parameter	Domestic wastewater			Industrial Wastewater			Surface Water			Groundwater			Coastal/Marine		
	Yes	No	NR	Yes	No	NR	Yes	No	NR	Yes	No	NR	Yes	No	NR
Total nitrogen	33	33	33	42	17	17	42	25	33	58	25	17	67	17	17
Total Phosphorus	42	25	33	42	17	17	42	25	33	58	25	17	58	25	17
Silica	8	58	0[1]	0	78	0[2]	17	42	0[3]	17	58	0[4]	17	50	0[5]
Chlorophyll-a	8	58	0[1]	Not Applicable			33	25	0[3]	0	8	0[4]	33	42	0[5]
Faecal coliform	58	25	17	50	17	8	42	25	33	58	17	25	67	17	17
Enterococci	25	50	25	25	42	8	33	33	33	33	42	25	58	25	17
E. coli	33	42	25	25	42	8	42	25	33	42	33	25	58	33	8

[1]For domestic wastewater, the remaining 33% of respondents were unsure about silica and chlorophyll-a monitoring.
[2]For industrial wastewater, 22% of respondents were unsure about silica monitoring.
[3]For surface water, the remaining 42% of respondents were unsure whether silica and chlorophyll-a were monitored in their country/territory.
[4]For groundwater, 25% of respondents were unsure about silica monitoring, and 92% for chlorophyll-a monitoring.
[5]For coastal/marine waters, 33% of respondents were unsure about silica monitoring, and 25% about chlorophyll-a monitoring.

Existing Nutrient Discharge Standards for Wastewater in WCR

Nutrient Wastewater Discharge Standards in the WCR (mg/l)												
Parameter	COL	CR	Cuba	DR	GUA	HON	NIC	PAN	T&T	BAR	JAM (existing plants)	JAM (other than existing plants)
N-NO3	0.1										30	
N-NO2	0.02											
N-NH3	0.3						20			10		
Total N	1	50	10		100		30			5		10
P-PO4		25		3							10	4
Total P	0.4		5		75	5	10	5	5	5		
Total Kjeldahl nitrogen (TKN)						30						
N-(NH4+NO3)				18								
N -NH4				10								
Total Organic N								10				
Comments			Class A waters							Proposed. Extra Strength Agreement allowed	Obligatory Nutrients Management Plan	Wastewater and Sludge Regulations 2013

Principles and Approaches to Setting Wastewater Effluent Standards

- Precautionary principle
- Polluter pays
- Technology-based standards. Examples:
  - BAT
  - BCT
  - BATNEEC
  - BPEO
- Note language on technology in LBS Protocol Article III.

Principles and Approaches to Setting Wastewater Effluent Standards Cont.

- Health-based standards – LBS uses microbiological indicators (FC & EC). Questions: Why Most Probable Number and not Plate Counting Method? Is monthly average an arithmetic or geometric mean?
- Ambient-Water Quality Standards - SOCAR (Table 5.4.9) appears to use the following for DIN and DIP:
- Are the proposed water quality criteria adequate?

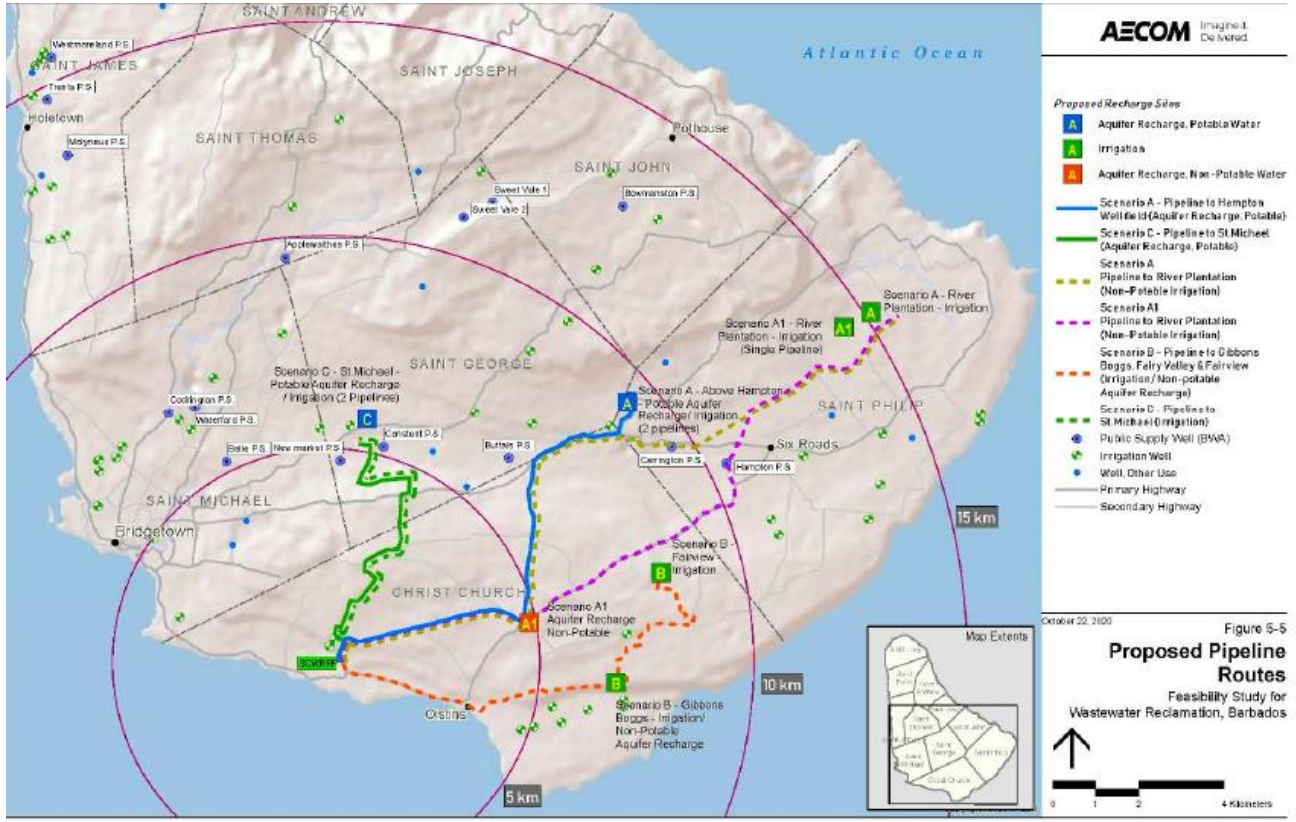
Indicator	Status	Continental $mg.l^{-1}$	Island $mg.l^{-1}$
DIN	Good	< 0.1	<0.05
	Fair	0.1 to 0.5	0.05 to 0.1
	Poor	>0.5	>0.1
DIP	Good	<0.01	<0.005
	Fair	0.01-0.05	0.005-0.01
	Poor	>0.05	>0.01

Total Maximum Daily Loads

- Can we use this approach on a sub-regional/national basis?
- Using the proposed ambient water quality criteria?
- Have we determined NOAECs for very sensitive marine receptors?
- Precautionary principle?

Barbados Case Study – Scenario Planning

- Water scarce
- CC will exacerbate freshwater shortages
- Covid-19 – renewed focus on food security
- Approved water reuse policy
- Water quality – fit for use
- Proposed end uses:
  - Unrestricted agricultural reuse
  - Potable / Non-potable aquifer recharge



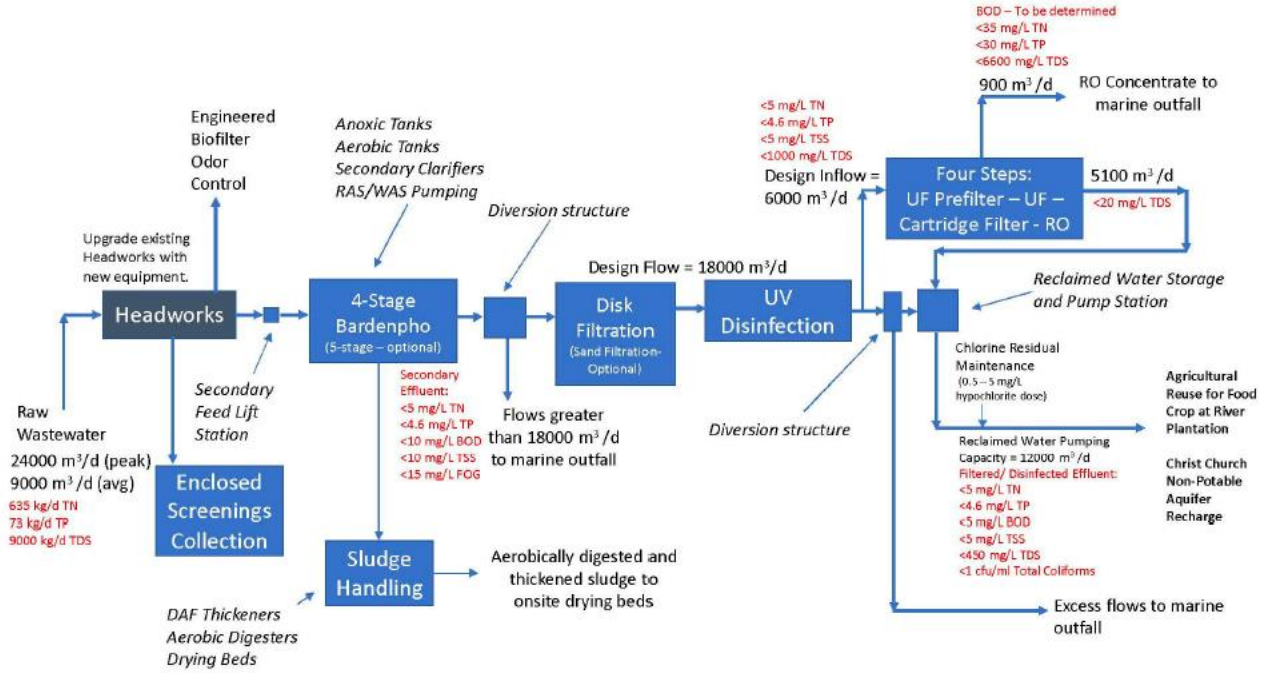
Triple Bottom Line

- Inter-ministerial Techical Working Group
- Social / Environmental / Financial factors considered
- All options deemed to meet regulatory requirements for public health (Fit for Purpose)

Table 7-3:Summary of the Triple Bottom Line Analysis

		Scenario A		Scenario A1		Scenario B		Scenario C	
Potable Aquifer Recharge Location		St. Philip Aquifer		N/A		N/A		St. Michael Aquifer	
Non-Potable Aquifer Recharge Location		Optional		Christ Church Aquifer		Christ Church Aquifer		Optional	
Food Crop Irrigation Location		River Plantation		River Plantation		Gibbons Boggs/Fairy Valley Irrigation		St. George Valley Irrigation	
Social Factors	Potential Health Risks (Regulatory Compliance)	Designed to meet requirements	5	Designed to meet requirements	5	Designed to meet requirements	5	Designed to meet requirements	5
	Food Security (Additional Agricultural Expansion)	Addresses the need for water. Highest potential agricultural acreage	5	Addresses the need for water. Highest potential agricultural acreage	5	Moderate potential agricultural acreage	3	Relatively lower potential agricultural acreage	2
Environmental Factors	Impacts to Marine Environment	Reduces discharge of effluent to marine outfall but generates concentrate	3	Reduces discharge of effluent to marine outfall	4	Reduces discharge of effluent to marine outfall	4	Reduces discharge of effluent to marine outfall but generates concentrate	3
	Groundwater Impacts (Quality & Quantity)	Augments GW quantity, potentially enhances GW quality, and potentially reduces GW pumping	4	Augments GW quantity and potentially reduces GW pumping	3	Augments GW quantity and potentially reduces GW pumping	3	Augments GW quantity, potentially enhances GW quality, and potentially reduces GW pumping	4
Financial	Relative Capital Cost	1.38x	3	1.06x	4.5	1x	5	1.23x	3.5
	Relative Operational Cost	1.24x	3	1.03x	4.5	1x	5	1.21x	3.5
Total			23		26		25		21

Barbados Case Study – Upgrade of WWTP Process FLow



Barbados Case Study - Nutrient Loading Vs. Concentration

- Current Baseline daily nutrient loading to outfall:

  Total nitrogen = 9,000 m3/day X 70 mg/l = 635 kg/day
  Total phosphorus = 9,000 m3/day X 8 mg/l = 73 kg/day

  Upgrade Scenario A1 Expected daily nutrient loading to outfall:

  Total nitrogen = 900 m3/day X 35 mg/l = 31.5 kg/day (a 94.6% reduction in daily load)
  Total phosphorus = 900 m3/day X 30 mg/l = 27 kg/day (a 63.6 % reduction in daily load)

- But would likely fail a nutrients concentration standard.

Draft Conclusions & Recommendations (To be completed)

- There should be quantitative limits for nitrogen and phosphorus in domestic wastewater discharges into the Wider Caribbean Sea.
- Effluent limits may have to be set for several forms of N & P.
- Consideration should be given to both concentrations and loads.
- Modern BNR can easily achieve TN < 10 mg/l and consistently achieve < 5 mg/l.
- Phosphorus removal technology is less mature.
- Silica concentrations/loads should be monitored.
- In the absence of large municipal sewerage projects, more emphasis should be placed on nutrients management at source (on-site treatment).
- Precautionary Principle should be used if no adverse effect thresholds have not been established for sensitive marine receptors.

Thank you

Gracias

Merci