UNITED NATIONS

EP

Distr. LIMITED

UNEP(DEPI)/CAR WG.44/INF.17 Rev.1
20 May 2025

Original: ENGLISH

Seventh Meeting of the Scientific and Technical Advisory Committee (STAC) to the Protocol Concerning Pollution from Land-Based Sources and Activities in the Wider Caribbean.

Virtual, 22 – 25 July 2025

REGIONAL CRITERIA AND STANDARDS FOR N AND P LOADS IN DOMESTIC AND INDUSTRIAL WASTEWATER DISCHARGES

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FINAL INTEGRATED REPORT

ACTIVITY 2

REGIONAL CRITERIA AND STANDARDS FOR N AND P LOADS IN DOMESTIC AND INDUSTRIAL WASTEWATER DISCHARGES

SMALL-SCALE FUNDING AGREEMENT

Prepared by: Institute of Marine Affairs &

Centro de Investigación y Manejo Ambiental del Transporte

SUBMITTED BY THE INSTITUTE OF MARINE AFFAIRS

APRIL 2025

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EXECUTIVE SUMMARY

Under the LBS Protocol, Annex III provides the existing discharge limits for domestic wastewater into coastal and marine water bodies. However, these limits do not yet include any parameters for nitrogen (N) and phosphorus (P) compounds. Excess N and P from domestic wastewater, untreated sewage, agricultural runoff and industrial effluents are known to be the potential root cause of eutrophication, harmful algal blooms and other unnatural events that result in deleterious effects on aquatic ecosystems.

The Regional Activity Centres (RACs), IMA and CIMAB, collaborated to review and analyse the existing standards, water quality criteria or permissible limits regarding N and P compounds in the region towards the establishment of standards or criteria for these compounds in domestic and industrial discharges. The IMA (English Speaking) and CIMAB (Spanish Speaking) evaluated the corresponding legislation and effluent regulations of twenty countries across the Caribbean, Central and Latin America. The countries were assessed via a questionnaire and desk study.

Many differences across the region were observed from the analysis of wastewater legislation and regulations. Central to this is the manner in which water quality is addressed which is at times based on how standards, criteria or discharge limits are applied in a particular country. Though similar, these terms can have very distinct meanings and are critical to how N and P compounds are regulated. In addition, existing legislative framework does not automatically translate into regulations as a few countries are prohibit discharge into water bodies but are without established limits. However, many countries have limits or criteria for N and P but there is minimal uniformity across the region in what particular compounds (and its respective forms) are included.

Examples from other countries were also reviewed to provide insight from different regions. Australia and the European Union offered useful information on domestic wastewater discharge and utilising N and P limits for the protection of coastal water bodies. This highlighted the importance of not only the establishment of N and P limits but its application in a way that can assist environmental management agencies to prevent potential harmful events.

After review, specific N and P compounds were proposed with corresponding discharge limits for domestic wastewater into Class I and Class II waters. Recommendations also made on the establishment of limits for industrial effluent and the potential use of pollutant loads in the longer term. The proposed limits must be considered as an initial step to the establishment of limits for nitrogen and phosphorus that will augment the LBS Protocol to prevent marine pollution in the wider Caribbean region.

1. INTRODUCTION

The objective of this study is to support the establishment of regional criteria for Nitrogen (N) and Phosphorus (P) compounds contained in wastewater discharges and other effluents from both domestic and industrial sources. N and P compounds are prevalent in sources of nutrient pollution. Achieving uniformity through the development of regional standards for N and P could contribute towards strengthening a foundation for protection of the marine environment in the Caribbean.

The importance of this study and its outcomes is through the support it would lend to the Regional Nutrient Reduction Strategy and Action Plan (RNRSAP). The development of the RNRSAP was initiated by the Cartagena Convention, with one of the goals being establishment of a collaborative framework for the progressive reduction of impacts from excess nutrient loads on priority coastal and marine ecosystems in the Wider Caribbean Region (WCR). An evaluation of existing regional nutrient (N and P) standards, discharge limits and water quality criteria provides significant information towards this effort.

Figure 1 - Map of the Wider Caribbean Region

There was a total of twenty (20) countries assessed regionally, ten (10) English and ten (10) Spanish speaking countries. These countries are Antigua and Barbuda, The Bahamas, Barbados, Belize, Grenada, Guyana, Jamaica, Saint Lucia, Trinidad and Tobago and United

States of America, Colombia, Costa Rica, Cuba, Guatemala, Honduras, Mexico, Nicaragua, Dominican Republic, Panama and Venezuela.

1.1 METHODOLOGY

Questionnaire

A questionnaire was designed by the LBS Regional Activity Centres (RACs), the Institute of Marine Affairs in Trinidad and Tobago (RAC IMA) and the Centre of Engineering and Environmental Management of Coasts and Bays in Cuba (RAC CIMAB) and circulated to the LBS focal points of all the aforementioned countries. The aim was to collect information on the existing regional N and P criteria/limits/standards and respective compounds proposed by each country. A total of 7 countries (Barbados, Belize, Guyana, Honduras, Jamaica, Trinidad and Tobago and the United States of America) responded to the questionnaire. These responses were reviewed and incorporated into the respective sub-regional report.

Desktop Review

A thorough desktop study was completed to gather any existing information on each country for N and P limits, especially in cases where there was no response to the circulated questionnaire. In this case, main data sources were legal instruments from each country related to the subject (standards, resolutions, laws, decrees) obtained online. To further augment the proposal of limits, a review of existing standards and criteria in countries of other regions was also conducted.

Outcome

The results obtained in each sub-regional study were collated, organized and then integrated for presentation under a single regional report. This work intends to provide additional clarity to the existing N and P limits of countries within the WCR and assist in the proposal of guidelines for N and P criteria and standards for potential inclusion into the LBS Protocol.

The importance of this study is the ability to provide a regional baseline for effluent limits according to N and P compounds. Ultimately, the national authorities responsible for environmental management, particularly monitoring, will be better able to protect sensitive coastal ecosystems from anthropogenic activities. By guarding against the drivers of nutrient pollution, contracting parties continue to effectively implement the LBS Protocol.

This activity was financially supported through a Small Scale Funding Agreement with the United Nations Environment Programme (UNEP) and the Swedish International Development Agency (SIDA).

2. GENERAL STANDARDS AND CRITERIA OF ENVIRONMENTAL QUALITY

Standards, criteria and regulations are generally interconnected. Regulations referring to the water quality and discharges into water bodies are obligatory, formulated by government agencies or environmental authorities. Their approach is based on safety, that is, the established requirements are centred on prioritising both human and the ecosystem health.

The water quality regulations for discharges are generally arranged into effluent limitations, that directly limit the wastewater discharge to receiving water bodies, determining maximum permissible limits for certain pollutants in the form of concentration or load. Effluent limitations establish limits or quality measures that aim to ensure that after the effluent enters the receiving environment waters, the ambient water quality standards established for that receiving water body are not exceeded. Lastly, combined standards consolidate and impose different effluent limits per class or use of the receiving water body.

Unlike regulations, Environmental Quality Standards (EQS) are defined ambient concentrations of parameters existing in the air, water or soil, that are sufficiently low so as to not represent a significant risk to human health or the environment. The application of an EQS is directly to the receiving bodies, namely air, water and soil. These quality standards are not legal requirements, but rather, are used to establish environmental policies. In addition, they are applied in a manner that aims to establish an acceptable quality level for the emissions rendered by the population.

Maximum Permissible Limits (MPL) are measures of the concentration or load of parameters that characterise an effluent or pollutant that, when exceeded, causes or has the potential to cause ambient concentrations of pollutants in the receiving waters to increase, to levels that may lead to harmful effects to human health or the environment. The application of an MPL is at the point of discharge into a receiving water body. Unlike the Environmental Quality Standards, the MPLs establish a limit applicable to emissions, effluents or discharges into the environment, based on a particular human activity. In this way, the MPLs can be enforceable and their compliance can be made mandatory by effluent regulations.

When applied to a water body with a designated use or purpose, standards for ambient pollution concentrations or MPLs for discharge concentrations, they form water quality criteria. Comparing measured pollutant concentrations in the ambient water and discharges to the chosen parameter levels required in the water quality criteria can be used to indicate whether a particular water body is presently in a state that is appropriate for its designated use. Once the established criteria are met, it serves to protect the quality of that water body and prevents it from being degraded to a quality level that is harmful to human health and/or marine ecosystems.

In essence, the function of having criteria is to enable the agency responsible for environmental water quality to determine compliancy with respect to the established regulations. In addition, criteria can be used to evaluate a water body to ascertain the current

parameter levels in comparison to the natural state and what may be a suitable designated use for that particular site.

It is important to note that even though the terms above have been generally defined, they have been observed to be used interchangeably at times in legislation by different countries. As such, it is important to keep this in mind as efforts were made reflect directly was has been reviewed in this study while trying to minimise any conflation of these terms.

3. REGULATORY FRAMEWORKS FOR THE DISCHARGE OF WASTEWATER

3.1 Criteria and Standards for the Discharge of Domestic and Industrial Wastewater in English Speaking Countries

3.1.1 ANTIGUA and BARBUDA

The Water Quality and Criteria Guidelines (Schedule VII, Section 64 (2)) of the Environment Protection and Management Act, 2019 (EPMA) holds the national Water Quality Policy which established guidelines for the quality management of water resources in Antigua and Barbuda, with the overarching goal of protecting human health, aquatic life and aesthetic qualities. The Policy treats with the maintenance of existing water quality of its classified waters, point and non-point sources of pollution and discharge of wastewater into water bodies.

"(7) to the extent practicable, all new point sources of pollution shall not discharge into near-shore or fresh surface waters;

(8) all sewage and waste shall receive the degree of treatment necessary to protect the beneficial uses of waters of Antigua and Barbuda before discharge;

(11) all waste water from industrial or commercial facilities that are located close to a public sewerage system should be disposed into that system, subject to such quality and flow conditions as the owner of the sewerage system may apply;

(12) there shall be no direct or indirect discharge of sewage or other waste into any planned or intended ground or surface source of public drinking water;

(18) a point source or a non-point source of a water pollutant should not, in isolation or combination with any other source(s) of that pollutant, cause a condition to exceed the water quality standards mentioned in this Schedule;

(19) in order to meet the water quality guidelines and standards in receiving waters mentioned in this Schedule, the concentration of a substance in a point source discharge shall not exceed that water quality guideline or standard…"

Furthermore, the Water Use and Classification Criteria within Schedule VII outlines the classification of waters and also provides the respective Water Quality Standards required to maintain the given classifications for ground waters, fresh waters and coastal waters. These standards include water quality criteria for each sub-category of water classification and the respective uses to which they apply. The coastal waters are classified as Class AA, Class A, Class B, i.e. most (AA) to least stringent (B) respectively. As per the classification, Class AA does not permit point source discharge of any kind. Class A will only act as a receiving body for any effluent if the highest degree of treatment or control is performed, making it compatible with standards for that classification. Class B water bodies act as receiving bodies for sewage and industrial effluent where the highest degree of treatment is performed for

that classification. The water quality standards to protect human health, aquatic life and aesthetic qualities in coastal waters with respect to nitrogen and phosphorous compounds are as shown in Table 1. It is important to note that the forms of the nitrogen compounds [1](nitrate and nitrite) were not specified in the guidelines and are not conclusive based on this information.

Table 1 - Antigua and Barbuda Standards for N & P Compounds in Receiving Coastal Waters

	Parameter (mg/L)			
Application	**Nitrate**	**Nitrite**	**Total Nitrogen (N)**	**Total Phosphorus (P)**
[2]Protection of coastal waters (Class A, Class B) Aquatic Life and Human Health	50	3		
EQS for Coastal Waters			0.4 (Class AA, A) 0.8 (Class B)	0.025 (Class AA, A) 0.5 (Class B)

The table above shows the levels of nitrogen compounds for the protection of aquatic life in coastal waters and human consumption of fish and other aquatic organisms with respect to receiving water bodies. These are determined as an average value over four (4) consecutive days and should not be exceeded. The total nitrogen and total phosphorus values are the concentrations that should only be altered by natural causes. These can be considered EQS as they are only dependent upon the natural state of the waters.

[1] The names and/or expressions (chemical formula) of the nutrients are included exactly as they appear in the Standard or Regulations specified

[2] Average of samples taken over four (4) consecutive days

3.1.2 BAHAMAS

The Environmental Planning and Protection Act 2019 (EPPA) provides general rules towards pollution control. The release of any water pollutant into the environment is prohibited which is exemplified in the EPPA under Section 25 (a) "No person shall release or cause to be released any air pollutant or water pollutant into the environment which is in violation of any applicable standards, conditions or permit requirements under this Act…". With respect to effluent discharge into water sources, the Act defines pollution of a water resource, water way or water body and any action that causes water to become non-compliant with any water resource management standards.

The legislation subsequently prohibits the discharge of a pollutant into a water system in Part VIII section 56 (1) "No Person shall discharge or emit any pollutant into a water resource other than in accordance with the provisions of this Act…" However, pollutant discharge maybe allowed through the granting of a pollution control permit, which must be in accordance with prescribed requirements. The holders of any such permit issued under the Act must be recorded into the Environmental Registry that would also maintain pollutant records.

Further to this, there are not yet established regulations that explicitly define the criteria and standards containing maximum permissible limits of designated pollutants, including nutrients such as Nitrogen and Phosphorus compounds. The EPPA established the Department of Environmental Planning and Protection and also directly outlined the development of these standards as a function of the Department of Environmental Planning and Protection section 6 (d) "develop objectives and quality standards with respect to environmental protection including bodies of water, air and soil".

Importantly, the minister with responsibility for the environment of Bahamas can enact regulations that would provide for the establishment environmental standards as per section 65 (a) "the prevention and control of pollution or contamination of the air, water and land" and (b) "specify standards in excess of which pollutants discharged into the environment shall not be discharged or emitted"

3.1.3 BARBADOS

The Health Service Regulations also pertain to the prohibition of discharging waste into any coastal waters. Sections 11-12 of the statute mandates against effluent discharge from any public or private sewerage system to flow into the sea or any other place other than a particular site, where such a site is approved by the Minister or government official. Lastly, the Coastal Zone Management Act 1998, mandates the development of a coastal zone management plan, wherein standards should be established as part of the coastal resource management and conservation efforts. Section 4 (1)(c) provides that the plan shall comprise of "standards for water quality in coastal and marine areas to effect the maintenance, rehabilitations and enhancement of coastal and marine habitats." It is important that the Marine Pollution Control (Discharge) Regulations are developed with a holistic approach so as to be applicable to other fragments of related legislation.

The Marine Pollution Control Act 1998 (MPCA) prohibits the release or cause to release any pollutant into the environment that is in violation of any standards, conditions or requirements applicable and specified under the statute as per Section 3(1). Furthermore, Section 4(3-4) of the MPCA provides for the implementation of a programme to prevent, reduce and control pollutants into the environment. The Director of the statutory body with responsibility for the environment can prescribe by governmental order, a list of pollutants with their prohibited concentration levels.

In addition, Section 13(1) provides that the minister with responsibility for the environment may make regulations that establish standards or requirements to effect provisions within the Act. However, while the aforementioned has not yet been instituted, the Marine Pollution Control (Discharge) Regulations are currently being drafted for review and subsequent approval by the Minister. These regulations are expected to include provisions that treat with wastewater discharge i.e. maximum permissible limits for identified pollutants such as nutrient compounds.

However, the Environment Protection Department (EPD) is responsible for environmental monitoring and pollution in Barbados. Through the EPD, discharge or "end of pipe" standards were established under the Table of Prohibited Concentrations 2023, as a guidance mechanism towards compliance for effluent sources. Standards for domestic waste were made in accordance with water classification [3](Class 1 and Class 2) specific to the territorial waters of Barbados. Table 2 shows the nutrients included as well as the ambient standards established.

Table 2 - Barbados Discharge Limits into Coastal and Marine Waters

Application	**Parameter (mg/L)**	
	Total Nitrogen	**Total Phosphorus**
End of Pipe Standards for Domestic Waste	5 (Class 1) 45 (Class 2)	1 (Class 1) 10 (Class 2)

[3] Class 1 - Surface and subsurface waters extending from the farthest distance inland to the 100 metres isobath or 200 metres seaward of the outer edge of the bank reef whichever is farthest.
Class 2 - Marine waters extending the outer most boundary for class 1 waters but within the territorial waters of Barbados.

3.1.4 BELIZE

The Environment Protection Act (2011), established general provisions for prevention and control of pollution, through the Department of Environment, by prohibiting the discharge of effluents, including both domestic and industrial sources. This is exemplified in Section 8. Prohibition of Discharge of Pollutants (1) "*No person, installation, factory or plant shall, unless specifically permitted by the Department, emit or discharge any pollutant into the atmosphere in contravention of the permitted levels …"*

In addition, a more specific reference to coastal and marine resources is included in Section 11 (1) "*No person shall emit, import, discharge, deposit, dispose of or dump any waste that might directly or indirectly pollute water resources or damage or destroy marine life."*

The Environment Protection (Effluent Limitations) Regulations, 2009 supplement the Environmental Protection Act 2011 which is the substantive law that aims to protect Belize's natural and environmental resources, prevent and control pollution, inter alia. These Regulations were originally established in 2003 and amended in 2009 which included a revised definition of industrial effluent. The statute also adopted the definition of domestic effluent as per the LBS Protocol and the corresponding discharge limits. Importantly, the Regulations specifically apply to discharges of effluent into any inland waters or the marine environment (Section 3). They also consist of Schedules which outline parameter limits for Specific Industries (Schedule I) and Other Industries and Commercial Activities (Schedule II). The third Schedule refers to Discharges from domestic wastewater treatment systems (sewage and wastewater) into both Class I and Class II waters.

The framework aims to maintain the water quality of classified waters through Section 5A "*Every person who discharges domestic effluent that adversely affects Class I or Class II waters, shall ensure that such Class I or Class II waters are treated by an existing domestic wastewater system whose effluent achieves the effluent limitations set out in Schedule III"*

The responsibility for the adequate treatment of effluent is further designated to such persons in Section 6 (1) "*Every industry which discharges effluent shall ensure that such effluent can be assimilated by the receiving water into which the effluent is discharged."*

Under the Regulations, while discharge is allowed from different industries, it is mandatory that the discharge itself must be within the given type. Substances outside of this are prohibited under Section 10 – "*No person shall discharge or cause or permit the discharge of any of the following substances into any inland waters or into the marine environment: (a) any inflammable liquid; (b) any tar or other related liquids*"

Lastly, while the discharge arising from domestic waste via waste disposal systems is permissible, industrial or commercial sources of effluent requires a licence to permit such activity. Section 14-1 "*no person shall: (a) discharge on or cause or permit the entry into waters, on the ground or into the ground, of any effluent or any poisonous, noxious or polluting matter*;" the modifications of any related infrastructure would also necessitate similar documentation beforehand *(b) construct, reconstruct or alter any works for the discharge of any effluent or any poisonous, noxious or polluting matter, except under and in*

accordance with a licence for the purpose granted by the Department under these Regulations.

Since the adopted LBS Protocol discharge limits of Schedule III do not include nutrients, i.e. for domestic wastewater, the existing [4]limits for nitrogen and phosphorus compounds would pertain to industrial effluents as guided by the Regulations as seen in Table 3 below.

Table 3 - Belize Standards for N & P Compounds in Discharges to Coastal Waters

Regulation	Application	Nitrate (mg/L)	Phosphate (mg/L)	Ammonia (mg/L)
Effluent Limitation Regulations, 2009 First Schedule	Food Processing, Garment, Poultry, Brewery Sugar Processing, etc	10	5	
	Fish Processing	10	30	
	Dairy Industry	30	5	
	Rum Refinery, Shrimp Processing, Soft Drink Bottling	10	1	
Second Schedule	For Other Industries or Commercial Activities	3 (as NO)	5 (as PO)	1 (as NH_4)

3.1.5 GRENADA

The Integrated Coastal Zone Management Act 2019 mandates the conservation and enhancement of Grenada's coastal resources. Under the Act, a Coastal Zone Management Plan must be developed and within same provisions are made to include standards for the water quality in the coastal areas. Section 4(1)(c) "standards for water quality in the coastal zone to effect the maintenance, rehabilitation and enhancement of coastal and marine habitats."

The National Water and Sewerage Authority Regulations 1993, prohibit the discharge of effluents into water bodies such as a water course, pond, lake or other body of surface water. Section 7(a) of the regulations proscribe the "discharge sewage or industrial waste to any natural outlet, the ocean or land". Further to this, the Public Health Regulations 2006, established as subsidiary legislation under the Public Health Act, prohibit the disposal of excreta into any watercourse, drain or stream. However, there are no national standards that accompany these regulations to service as water quality guidelines.

It may be noteworthy to mention the Water Quality Act 2005, that administers all matters related to waters that are intended for human consumption. The statute refers to waters that may be in a "natural state or after treatment" and specifically makes reference to the use of such waters pertaining to food production. While this statute is not directly related with domestic or industrial effluent discharge, it was found to be the only current legislation that consists of permissible limits for nutrient compounds during this study.

[4] Refer to fn 1

3.1.6 GUYANA

The Environmental Protection Act 1996, provides for the general management, conservation, protection and improvement of the environment, together with the prevention and control of pollution inter alia. Implementation of the Act is overseen by the Environmental Protection Agency Guyana (EPA Guyana), a statutory body established under the Act. Importantly, the Act prohibits any activity that is likely to cause pollution to the environment and more specifically the discharge of any contaminant into the environment in excess of any levels that may be stipulated by Regulations or the Environmental Protection Agency.

Subsequently, the Environmental Protection (Water Quality) Regulations 2000 was instituted to deal specifically with effluent discharge into the nation's waters. Section 4 mandates that any person operating a facility engaging in an activity that would result in effluent discharge is required to apply to EPA Guyana for an environmental authorisation permit. Subsequently, a discharge activity without such authorisation is explicitly restricted Section 5. (1) "*No person who engages in any of the activities mentioned in regulation 4 shall discharge or cause or permit the discharge of any effluent in or on any inland or coastal waters or on any land unless that person holds an environmental authorisation."*

Section 9 (1) provides for the development of parameter limits for wastewater discharge whereby "The Agency may at any time after the commencement of these Regulations, establish the parameter limits of effluent which may be discharged into any inland or coastal waters or land of Guyana…"

It is important to note that the First Schedule of the Regulations outlines the conditions to which the effluent discharge restrictions are not applicable. It identifies domestic households except where households contain industrial or commercial activity, housing/commercial developments under 30 units and processing, manufacturing and service industries which produce less than the required threshold volume of effluent per day. Furthermore, the Second Schedule contains the list of substances for which limits need to be specified i.e. there are no permissible limits for the parameters/pollutants identified. Both nitrogen and phosphorus containing compounds (Ammoniacal nitrogen, Nitrate nitrogen, Phosphate as P) are included on the Second Schedule. As the environmental statutory body, the EPA Guyana should establish parameter limits for all effluent discharge parameters to further develop its national standards.

3.1.7 JAMAICA

The National Resources Conservation Authority (NCRA) Act 1991 serves as the main environmental legislative framework and outlines the steps for environment protection and management of Jamaica. The legislation mainly references discharge licences for sewage (domestic) and trade (industrial) effluents, as opposed to the explicit prohibition of discharging wastewater into ground or coastal waters.

This is exemplified under the Licences for the discharge of effluents, Section 12 (a) "*no person shall discharge on or cause or permit the entry into waters, on the ground or into the ground, of any sewage or trade effluent or any poisonous, noxious or polluting matter* (b) "*construct,*

reconstruct or alter any works for the discharge of any sewage or trade effluent … except under licence granted by the Authority under the Act"

The Natural Resources Conservation (Wastewater and Sludge) Regulations 2013, adopted the classification of waters under the LBS Protocol and are crafted to protect and manage effluent discharge into coastal waters by explicitly requiring possession of a license, in keeping with the overarching legislative framework. These licenses are issued via an application process with the NCRA.

As per Section 5-(2a), any person that wishes to operate a treatment plant for trade or sewage effluent would require such a licence. However, the discharge of domestic wastewater does not require a licence providing there is adequate treatment which is achieved via soak away pits, absorption or a disposal waste system.

Section 7-1 *A person whose business, industry, manufacturing or trade operations, involve the discharge of trade effluent or sewage effluent or both, as the case may be, from a treatment plant into the environment shall apply to the Authority for a* licence *to discharge such effluent into the environment*

Further to this, the Regulations (Section 7-(5)) require points of discharge to be designated and clearly identified as a means of warning the Public.

The Third Schedule of the Wastewater and Sludge Regulations establish the Sewage Effluent Standards which serve as national criteria for sewage effluent and trade effluents, as per Section 18 (1) "the standards set out in the Third Schedule shall apply to an owner or operator of a treatment plant that discharges sewage effluent, trade effluent or sludge…". The maximum permissible limits for the discharge of nitrogen and phosphorous compounds into the environment included in these standards are shown below in Table 4.

Table 4 - Jamaica Standards for N & P Compounds in Discharges to Coastal Waters

Application	Nitrate (mg/L)	Phosphate (mg/L)	Ammonia/Ammonium (mg/L)	Total Nitrogen (mg/L)
Sewage Effluent Standards for Existing Plants	30 (as-NO_3-N)	10 (as PO_4^{3-})		
Sewage Effluent Standards for Plants other than Existing Plants		4 (as PO_4-P)		10
Trade Effluent Standards	10 (as NO_3)	5 (as PO_4)	1.0 (measured as NH_4)	

3.1.8 SAINT LUCIA

The Water and Sewerage Act 2008 makes provision for the management of water resources and the regulation of water supply and sewerage services, inter alia. Pursuant to the Act, the Water Resources Management Agency (WRMA) was established to manage water resources. The Act makes two key designations, a water control area and waste control area. A water control area is defined as an area where the regulation of water use/class of use should be regulated in the public interest based on availability, demand and ecological factors, etc. A waste control area is a defined location where waste can be discharged in order to maintain

water quality or protect water resources from pollution. This area maybe land, sewer/drain, bore or any water not limited to surface, groundwater or coastal. The discharge of any waste is prohibited, Section 25 (1) "*A person shall not use water in a water control area or discharge waste or a class of waste in a waste control area, except in accordance with a permit for the purpose granted to that person …*" and is regulated by the requirement of a permit issued by the WRMA.

The Public Health (Water Quality Control) Regulations aim to maintain water quality by prohibiting any act that would diminish same as stated in Section 3 (1) "*No person shall commit or cause to be committed any act which may impair the quality of water in any river, stream, spring, well, pond reservoir or any other place."* The Regulations also specifically restrict sewage and broadly encompass industrial discharges in Section 3 (3) "*No person shall discharge or cause to be discharge into any river, stream, watercourse or sea any sewage, industrial or trade waste or any other matter likely to be injurious to health…*".

While the aforementioned legislative instruments instituted rules against effluent discharge into waterbodies, defined permissible limits of pollutants were not included. However, the Saint Lucia Bureau of Standards (SLBS) developed the Guidelines for Recreational Water Quality (SLNS 83: 2016) which serve as the national standards for maximum permissible limits of effluent discharge into surface and coastal waters of the island. It is noteworthy that these standards are applied to waters classified under the LBS Protocol, Class I and Recreational waters, but are not intended to allow the degradation of water quality where a body of water is unclassified. The discharge limits of nutrient compounds in the Guidelines are shown in Table 5.

Table 5 - St. Lucia Standards for N & P Compounds in Discharges to Class I Waters and in Recreational Waters

Application	**Nitrate (mg/L)**	**Phosphate (mg/L)**	**Total Nitrogen (mg/L)**	**Total Phosphorus (mg/L)**
[5]Effluent limits for discharges into Class I Waters			5	1
EQS for Recreational Waters	0.0098 (as NO_3-N)	0.00248 (as PO_4-P)	0.1	0.015

3.1.9 TRINIDAD and TOBAGO

Under the Environmental Management Act 2000, water quality is managed by the Environmental Management Authority (EMA), a statutory body founded under the Act. The law prohibits the release of water pollutants, i.e. the discharge of untreated water that may contain any contaminant above specified levels. Here water is defined to be all inclusive and refers to any surface water, sea, groundwater, wetlands or marine areas within the environment.

[5] Based on a monthly average

The Water Pollution Rules (WPR) 2019, specifically serve to maintain the quality of the national water resources by regulation of effluent discharge. Although the legislation does not include explicit definitions for domestic or industrial effluent, those under the LBS Protocol can be assumed to be adopted. The WPR outlines all substances or parameters and given levels that would determine them as pollutants in Schedule I (Register of Water Pollutants). It also established Schedule II (Permissible Levels) or "End of Pipe" standards, which identify threshold levels of all parameters for any substance that maybe discharged via a discrete source into inland, coastal nearshore, marine offshore and environmentally sensitive areas.

The WPR prohibits water pollution in Section 5 (1) which states, "A person shall not release a water pollutant into any water approved by a competent governmental entity for human consumption without treatment or where treatment has been limited solely to disinfection"

The WPR furthers the above prohibition of water pollutants initially set out in the Act by mandating the requirement of persons who discharge pollutants into waters to be licensed via permit application. Section 7(1) "Where a person is releasing a parameter or substance listed in Schedule I into a receiving environment, he shall apply for a permit to the Authority."

8. (1) "*Where any person releases a water pollutant into a receiving environment outside the permissible level, that is likely to cause harm to human health or to the environment, the Authority may at any time notify that person to apply for a permit.*"

Conditions of the permit allow for adequate records and management of discharge by the Authority

15. (1) *The Authority shall establish in each permit— (a) the water pollutants authorised to be released; (b) the quantity, conditions and concentrations the permittee may release; (c) the exact location where the sampling of the release shall be performed; and (d) reporting requirements*.

In the WPR, bodies of water are considered wastewater recipients. As mentioned, Schedule II outlines the maximum permissible limits for effluent discharges. The nitrogen and phosphorous parameters within are shown (Table 6) below.

Table 6 - T&T Standards for N & P Compounds in Discharges

Receiving Environment	**Ammoniacal Nitrogen as NH_3-N (mg/L)**	**Total Phosphorus as P (mg/L)**
Inland Surface Water	10	5
Coastal nearshore	10	5
Marine Offshore	10	5
Environmentally Sensitive Waters	0.1	0.1

Lastly, Schedule III of the WPR establishes the Ambient Water Quality Standards for both freshwater and marine environments and outlines parameter values that could be assumed to represent waters in their "natural state". The marine standards (Table 7) for nutrients

[6](Nitrate, Ammonia and Total Phosphate) are intended to protect waters for aquatic life and aquatic ecosystems, and recreational use.

Table 7 - T&T Ambient Marine Water Quality Standards for N & P

Ambient Water Quality Standards - Marine	Nitrate (mg/L)	Total Phosphate (mg/L)	Ammonia (mg/L)
Protection of Aquatic Life & Aquatic Ecosystems	≤10	≤0.1	≤0.5
Recreation	≤10	≤0.5	≤0.5

3.1.10 UNITED STATES OF AMERICA

Under the Clean Water Act, there are multiple statutes contributing to the legal framework prohibiting effluent discharge into the different water classes that exist across the United States of America. Section 1311, Effluent Limitations, declares that any discharge of pollutants must be in compliance with the law. Any party that is responsible for doing so must ensure the necessary treatment is performed (unless it is a publicly owned treatment facility) to be within compliance.

Additionally, the Limitations are applied to all point sources of discharge. As per section 1312 (a), where water quality is related, "*whenever discharges of pollutants from a point source or group of point sources would interfere with the attainment or maintenance of that water quality in a specific portion of the navigable waters which shall assure protection of public health, public water supplies, agricultural and industrial uses, and the protection and propagation of a balanced population of shellfish, fish and wildlife, and allow recreational activities in and on the water, effluent limitations (including alternative effluent control strategies) for such point source or sources shall be established which can reasonably be expected to contribute to the attainment or maintenance of such water quality*."

Though the overarching legislation requires a permit, a discharging entity must have Certification (Section 1341) from the State that the effluent originates or will originate from, as part of the compliance procedure before a permit is duly granted by the EPA.

Under Section 1342, the National Pollutant Discharge Elimination System (NPDES) was created to effectively manage point source effluent discharge into USA waters. With oversight from the EPA, different States can authorize permits which allow a facility to discharge a specified amount of a pollutant into a receiving water under certain conditions. The NPDES permit system is based on the Effluent Limitations and are developed using the required water quality standards in tandem with available technologies for pollutant control with respect to industrial entities as per industrial category.

With respect to national standards, for simplicity, the state of Florida is used in this study as an example for the United States of America as a contracting party, due its proximity to the other English speaking countries included. National standards for all water bodies within the

[6] Refer to fn. 1

US are established by the Water Quality Standards (WQS) Regulations (40 CFR Part 131). Each body of water would hold a designated use or class via water classification system of the CWA. Subsequently, the Regulations then specify limits for parameters in each water body Class. As such, within the Florida Surface Water Quality Standards (62-302.530), the criteria for Nitrogen and Phosphorous are identified in Table 8.

Table 8 - Florida (USA) Criteria Levels for N & P in Surface Waters

Florida Surface Water Quality Standards	**Nitrate (mg/L)**	**Elemental Phosphorous (mg/L)**	**Total Ammonia Nitrogen (mg/L)**
Class I - Potable Water	10		30 Day Average
Class II - Shellfish Propagation & Harvesting	10	0.0001	30 Day Average
Class III - Predominantly Marine		0.0001	30 Day Average

It is important to note, that in addition to the parameters above, the Total Nitrogen and Total Phosphorous parameters are collectively referred to as “Nutrients”. However, this parameter is assessed through a numeric interpretation which means its value is derived via a calculation and the resulting data is assessed with other specific parameters over a fixed time period (annually) to define a threshold value. This data via numeric interpretation is established in a manner that is site specific (i.e., where it pertains to a particular water body). As a result, nutrients are assessed as a pollutant load capacity over time and not as a permissible limit.

3.2 Criteria and Standards for the Discharge of Domestic and Industrial Wastewater in the Spanish Speaking Countries

3.2.1 COLOMBIA

From the Stockholm Conference, Colombia developed and established its own environmental legislation creating Law 23: 1973, which decrees power to the government for the creation of the National Code of Renewable Natural Resources (Decree Law 2811: 1974) with the main objective of managing these resources. Later, in 1993, the Colombian Congress created the Ministry of Environment and Sustainable Development (Minambiente) through Law 99: 1993, constituting the governing body for the management of the environment and renewable resources. In this way, the National Environmental System (SINA) was created to deal with environmental issues.

Decree Law 2811: 1974 determines the natural resources to protect in Colombia. This decree formulates procedures that regulate the use of water, which is one of the most important resources for the country. In chapter II articles 134 to 138, reference is made to the preservation and control of water pollution and renewable resources.

Decree 1541: 1978, in articles 220 to 231, provides the concessions for the National Institute of Renewable Natural Resources and Environment (INDERENA) relating to the use of the aqueduct service and other benefits for this purpose. It regulates the discharge of wastewater for domestic and municipal, agricultural, irrigation, drainage and industrial use to guarantee the conservation of the receiving bodies. Subsequently, article 231 is revoked by article 79 of Decree 3930: 2010, which stipulates that, if the discharges to a receiving water body is to a stream or reservoir, in addition to the pertinent studies established, the following is included: discharge census, classification of the receiving stream, effectiveness of treatment systems, among others. For its part, Decree 3930: 2010 establishes the provisions related to the uses, discharges and management of water resources, soil and sewers. It also establishes the quality criteria needed to determine the use of the resource.

The effort to protect the Colombian environment continued with the approval of different decrees that establish the regulation of the retributive rates for the direct and indirect use of water as a recipient of specific discharges. The National Decree 2667: 2012 guides the remuneration rates payment based on the pollutant load input to the water resource. This decree stipulates pollutant load aims that can be for the sewerage service providers: global, individual, group and pollutant load.

Decree 1076: 2015 issued by the Ministry of Environment, is the current regulation in Colombia to control the discharge of wastewater into surface waters. To prepare this decree, other existing regulations were compiled, such as Decree 1594: 1984 of the Ministry of Agriculture and Public Health, Decree 3930: 2010, Decree 4728: 2010 (partially modifies Decree 3930: 2010), Resolution 631: 2015 issued by the Minambiente and Decree 1640: 2012 that establishes the monitoring and follow-up of the water resource.

For its part, Decree 50: 2018 partially modifies Decree 1076: 2015 and is a Single Regulatory Decree of the Environment and Sustainable Development Sector. This defines the physical, chemical and biological characteristics that must be assessed for the approval or denial of domestic wastewater discharge to the soil and surface waters.

The following resolutions establish the parameters and maximum permissible limit values in specific discharges to different water bodies:

- Resolution 0631: 2015 directed to surface water bodies and public sewage systems does not apply to specific discharges to seawater or soil, and does not establish maximum permissible limit values for nutrients.
- Resolution 0883: 2018 for discharge into bodies of marine water that is part of the strategies for the prevention and control of coastal and marine water pollution by point sources and complements the regulations established by Decree 1076: 2015 for the protection of water resources.
- Resolution 501: 2022 modifies some articles of Resolution 0883: 2018.

Table 9 - Maximum Permissible Limits for nutrients discharged into seawater in Colombia

Standards or Regulations for the discharge of wastewater into coastal areas and/or inland bodies of water.	**Nutrients included[7]**	**Limits or maximum permissible values for nutrients (mg/L)**	**Comments**
Resolution 0883:2018. "By which the parameters and maximum permissible limit values are established in specific discharges to marine water bodies." • Article 8 Article 15	• Orthophosphate (P-PO_4^{3-})[8] • Total phosphorus (P) • Nitrate (N-NO_3^-)[9] • Nitrite (N-NO_2^-) • Ammoniac nitrogen (N-NH_3)[10] • Total nitrogen (N)	P-PO_4^{3-} = 0.3 P= 0.4 N-NO_3^- = 0.1 N-NO_2^- = 0.02 N-NH_3 = 0.3 N = 1.0	For discharges of domestic wastewater, sewage systems and industrial, commercial and service activities.

[7] The names and expressions (chemical formula) of the different nutrients are presented in the same way as are included in the standards and regulations specified in the previous column

[8] The chemical expression utilized in this standard for the orthophosphate is mainly used to refer to the phosphorus included in the ion

[9] The chemical expressions in this standard for nitrate and nitrite are generally in both cases referring to nitrogen contained in the respective ions

[10] In this case, the resolution specifies that the ammoniacal nitrogen refer to nitrogen in the form of soluble ammonia (N-NH_3).

3.2.2 COSTA RICA

In 1973 the General Health Law (Law 5395: 1973) was approved, and in 1995 the Organic Law of the Environment (Law 7554: 1995) which constitutes the main environmental regulatory instruments of the country was incorporated.

Further to this, the Biodiversity Law (Law 7788: 2010) aims to conserve biodiversity and the sustainable use of resources, as well as fairly distribute the benefits and costs derived. While the Law for the Integral Waste Management (Law 8839: 2010) regulates comprehensive waste management and the efficient use of resources, through the planning and execution of regulatory, operational, financial, administrative, educational, environmental, monitoring and assessment. The National Wastewater Sanitation Policy of October 2016 contains the proposals for public policy guidelines on the issue of wastewater sanitation based on the participation process of different sectors of the public and private sphere.

Regarding the Costa Rican regulations that control liquid waste discharge, there are several laws, decrees and resolutions. Decree 34431-MINAE-S: 2008, has the purpose of regulating the canon (Economic Instrument for Environmental Regulation) for the use of water resources to discharge polluting substances, which will hereinafter be called Environmental Canon for Discharges. This decree based on the "the polluter pays" principle, regulates the payment for discharge polluting substances into surface water bodies. The Ministry of Environment and Energy of Costa Rica (MINAE) is the institution in charge of managing the resources designated for environment protection and energy use.

Costa Rica also has Executive Decree 36304-S-MINAE: 2010, which is a Partial Reform of the Regulations for Discharge and Reuse of Wastewater and General Regulations for the Granting of Operating Permits from the Ministry of Health. This decree formulates modifications, additions and repeals Executive Decree 33601-MINAE-S: 2007 "Regulations for Discharge and Reuse of Wastewater"; but it does not modify the general and complementary physical-chemical parameters that appear in this former decree.

Executive Decree 33601-MINAE-S: 2007 does not specify the receiving body type; it states that it is any spring, recharge areas, river, stream, permanent stream or not, lake, lagoon, marsh, natural or artificial reservoir, artificial channel, estuary, mangrove, swamp, fresh, brackish or salt waters; where wastewater is discharged.

Wastewater is classified as ordinary type (domestic wastewater) and special type (non-ordinary wastewater type). The decree establishes maximum permissible limits (Table 10) of compounds such as Total Nitrogen and Phosphates for special type wastewater discharges to a receiving body and into the sewer system. In the case of domestic wastewater, it does not include limits for nutrients discharge. As a result, the summary of the MPL of nitrogen and phosphorus for Costa Rica regarding the discharge of wastewater of domestic origin in coastal areas is not included.

Table 10 - Maximum permissible limits for nutrients discharged at seawater in Costa Rica

Standards or Regulations for the discharge of wastewater into coastal areas and/or inland bodies of water.	Nutrients included[11]	Limits or maximum permissible values for nutrients (mg/L)	Comments
Executive Decree 33601-MINAE-S: 2007	• Phosphate (PO_4^{3-}) • Total nitrogen (N)	PO_4^{3-} = 25 TN = 50	For discharges of special type (non-ordinary wastewater type). Mandatory for wastewater from livestock, poultry farming, fish farming, and the textile and leather industry

3.2.3 CUBA

In the case of the Republic of Cuba, Law 150: 2022 (GOC-2022-625-058) "Law of the System of Natural Resources and the Environment" was recently approved, which establishes the principles and basic standards that regulate the State actions, citizens and society in general to ensure the implementation and operation of the system of natural resources and the environment.

Attention to environmental issues at different levels is performed by national and local mechanisms. Among them, we can point out environmental strategies, science, technological innovation and management programs and specialized national commissions. The National Environmental Strategy includes Sectorial and Territorial Environmental Strategies, both have a specific Action Plan aimed at achieving concrete objectives through comprehensive environmental management in solving the identified problems.

The protection of coastal ecosystems in Cuba is performed through the Integrated Management of Coastal Zones (MIZC), which is governed by Decree-Law No. 212 "Management of the Coastal Zone" (Decree-Law 212: 2000). This legal provision is geared towards three dimensions: delimitation, protection and sustainable use of the coastal zone.

In Cuba, there are two standards to regulate wastewater discharges, the Cuban Standard 27:2012 "Discharge of wastewater into land, water and sewerage - Specifications" (ONN, 2012) and the Cuban Standard 521:2007 "Discharge of wastewater to the coastal zone and marine waters Specifications" (ONN, 2007). Both regulations, taking into account the characteristics of the ecosystems and the proposed socio-economic use, do not differentiate the wastewater origin and are applied to all discharges from social and economic activities, such as domestic, municipal, industrial, agricultural and any other discharge type.

[11] The names and expressions (chemical formula) of the different nutrients are presented in the same way as are included in the standards and regulations specified in the previous column

Regional Criteria and Standards for N and P Loads in Domestic and Industrial Wastewater Discharges

NC 27:2012 establishes the average maximum permissible limits of a group of quality indicators for discharges into sewers and land waters (rivers, reservoirs and hydrogeological zones) including nutrients (Total Phosphorus, TP and Total Kjeldahl Nitrogen, TKN) only for this last type of receiving body.

For its part, NC 521:2007 establishes the maximum permissible limits of a group of parameters, including nutrients, but in this case total phosphorus (TP) and total nitrogen (TN, Kjeldahl + Nitrate) according to the classification established by the NC itself. Standards of coastal marine bodies (Table 11). This standard, like NC 27:2012, establishes the MPL in the form of concentration, however it also includes limits in the form of pollutant load (including for TP and TKN) to classify a polluting source as such.

Table 11 - Maximum Permissible Limits of nutrients for wastewater discharged into the coastal-marine zone of Cuba

Standards or regulations for the discharge of wastewater into coastal areas and/or inland water bodies	**Nutrients included**	**Limits or maximum permissible values for nutrients (mg/L)**	**Comments**
Cuban Standard 521:2007 "Discharge of wastewater into the coastal and marine zone. Specifications"	• Total Nitrogen (Kjeldahl + Nitrate) (TN) • Total Phosphorus (TP)	TN= 10; TP= 5	The limits are established according to the marine receiving body classification and the use in six (6) classes: Class A: Marine areas of ecological conservation zones, or protected areas
		Discharge is NOT allowed	Class B: Marine areas dedicated to bathing (direct contact) and in the existence of coral reefs.
		TN= 20; TP= 7	Class C: Marine areas where fishing takes place.
		TN= 40; TP= 10	Class D: Marine areas whose waters are for industrial use such as power generation.
		TN= 20; TP= 5	Class E: Marine areas in bays where maritime-port activity takes place.
		TN= 40; TP= 10	Class F: Marine areas for navigation and other uses.

3.2.4 DOMINICAN REPUBLIC

Law 64: 2000 "On the Environment and Natural Resources" is the overarching legal instrument that regulates the sustainable use of natural resources in the country and protects the biodiversity of sensitive environments in the Dominican Republic.

Under the responsibility of the Ministry of the Environment and Natural Resources, the establishment of various regulations has taken place, including mechanisms and procedures for the application of this Law. In addition, there is a group of sectorial laws, standards for water quality, air, soil, energy, tourism, among others. Currently there are two bills: a Sectorial Law on Coastal and Marine Resources and another titled the Water Law, which in one way or other will serve as instruments for the conservation and sustainable use of water resources and particularly coastal marine resources.

In the Dominican Republic, the standard that establishes the characteristics of liquid waste or wastewater discharges to surface water bodies, sanitary sewers, and coastal waters is the NACDAS: 2012 "Environmental Standard on control of discharges to surface waters, sanitary sewers, and coastal waters". This standard defines the maximum permissible values of a group of environmental quality indicators, including nutrients, for municipal (domestic) wastewater discharges in coastal waters without distinction of the uses or classification of the receiving body (Table 9). The MPL for the discharge of municipal wastewater for towns of over 10,000 inhabitants are displayed. In towns of less than 10,000 inhabitants, limits for nutrients are not established.

For wastewater of industrial origin, the standard sets maximum permissible limits according to the type of industry, equally without distinction of the classification of coastal zones. However, it clarifies that for wastewater discharges of any origin that require exhaustive studies of their discharges in coastal waters, the maximum permissible limits must be met, which are defined according to the types or classification of coastal waters in the NA-CACS: 2012. “Environmental Standard for the quality of surface and coastal waters”.

Table 12 Maximum Permissible Limits of nutrients for municipal and industrial wastewater discharged into coastal waters of the Dominican Republic

Standards or regulations for the discharge of wastewater to coastal areas and/or inland water bodies.	**Nutrients included**	**Limits or maximum permissible values for nutrients (mg/L)**	**Comments**
NA-CDAS-2012 "Environmental Standard on control of discharges to surface waters, sanitary sewers and coastal waters" (2012)	• Ammonium nitrogen ($N\text{-}NH_4$) • Ammonium nitrogen ($N\text{-}NH_4$) plus nitrates (NO_3) • Phosphorus orthophosphate ($P\text{-}PO_4$)	$N\text{-}NH_4$ =30 $N\text{-}NH_4 + NO_3 = 50$ $P\text{-}PO_4 = 8$	For municipal wastewater discharges into coastal waters from populations larger than 10,000 inhabitants. For populations of less than 10,000 inhabitants, nutrient limits are not established.

3.2.5 GUATEMALA

The legal framework for environmental protection in Guatemala is the "Law for the Protection and Improvement of the Environment" (Decree Law 68: 1986), which aims to ensure the maintenance of the ecological balance and the environment protection to improve the life quality of the country's inhabitants. From Decree Law 68:1986, various environmental standards and regulations have emerged, however, there are still gaps, competence duplication, thematic and geographical dispersal between the governing institutions entities of the environmental elements and natural resources (IARNA-URL, 2012). Environmental policies, standards and laws, also have scarce resources for their application, that is, “without teeth”, or policies “with blunt teeth and not at all strong” (Environmental Agreement in Guatemala 2016-2020, 2016).

Guatemala has the "Policy for the Integrated Management of Coastal-Marine Zones" approved through Government Agreement 328: 2009. This policy constitutes a first step to support the socioeconomic progress of coastal populations, as well as sustainable development and conservation of coastal-marine resources, guiding the creation of instruments and tools that guarantee the maintenance and good use of these resources in the long term.

In the Guatemala Caribbean zone, there is no departmental legislation or local ordinances specifically aimed at Integrated Coastal Management (ICM), beyond those aimed at beach maintenance, solid waste management and urban water (Caviedes, Arenas and Barragan, 2021).

Guatemala has two Government Agreements where the following criteria and requirements for the discharge and reuse of wastewater must be satisfied:

- Government Agreement 236: 2006. "Regulation of Discharges and reuse of wastewater and sludge disposal." Rectified in 2019 by Government Agreement 254 in which its Article 24 was amended, because of successive modifications and extensions of the established terms, proving new compliance dates as appropriate for the years 2024, 2028 and 2032.
- Government Agreement 12: 2011. "Regulation of discharges for receiving bodies of the Atitlan Lake basin." This Agreement considers this regulation, that aims to set the parameters and maximum permissible limits, for wastewater discharge to receiving bodies of the Atitlan Lake basin, either directly or indirectly, in order to rescue, protect and prevent pollution of the water system.

Government Agreement 236:2006 defines ordinary wastewater as that produced by domestic activities conducted through the sewer system and defines special wastewater as those of industrial, agricultural or hospital origin (in general all those that do not classify as ordinary). It also classifies as “receiving bodies” the natural reservoirs, lakes, lagoons, rivers, streams, springs, wetlands, estuaries, mangroves, swamps, coastal waters and groundwater. However, neither in Agreement 236:2006 nor in the updated Government Agreement 254:2019, are the maximum permissible limits (concentrations) associated with the receiving body usage or the

wastewater type but rather they are linked with the submission terms (maximum dates for compliance with these limits).

Lake Atitlan is especially emblematic and important in the country. In recent years, significant eutrophication problems have been observed due to the increasing pressure in its basin. Due to the importance that Lake Atitlan has for Guatemala, a specific rule to regulate wastewater discharges was established. In this case, the limitation pertains to direct discharges to the lake and to the basin, which is much more rigorous than those in the general standard, with especially strict limits on nutrients. For these reasons, although it is not the object of this study, the allowable concentration levels for nutrients expressed as TN (Total Nitrogen) and TP (Total Phosphorus) appears as reported in Government Agreement 12: 2011. Therefore, regarding these two indicators, for entities emitting wastewater discharges directly into this receiving body, the concentrations of TN must not exceed 25 mg/L and for TP should not exceed 15 mg/L.

For indirect discharges into Lake Atitlan, the following limits were established in the Government Agreement 12: 2011: Rivers, streams, ravines and ditches - TN 25mg/L, TP 15mg/L. Subsoil - TN 25mg/L, TP 15mg/L. Sewerage - TN 35mg/L, TP 20mg/L.

Table 13 shows the maximum concentrations of nitrogen and phosphorus, according to Decree 254: 2019, which must not exceed the wastewater treated by the enterprises in charge for such purposes or by the municipalities, to enter into the receiving bodies, delimited for the years 2024, 2028 and 2032.

Table 13 - Maximum Permissible Limits for nutrients discharged into receiving bodies in Guatemala

Standards or Regulations for the discharge of wastewater into coastal areas and/or inland bodies of water.	**Nutrients included**	**Limits or maximum permissible values for nutrients (mg/L)**	**Comments**
Government Agreement 254:2019 Reform to Government Agreement 236:2006: "Regulation of discharges and reuse of wastewater and sludge disposal".	• Total Nitrogen (TN) • Total Phosphorous (TP)	TN = 150 TP = 40	The regulation establishes the year 2024 as the date of accomplishment. By year 2023, all the municipalities (*including domestic wastewater*) must comply with having complete treatment systems in operation, at least for the two (2) main discharges that are reported in the inventory without treatment.
		TN = 70 TP = 20	The regulation establishes the year 2028 as the date of achievement. In year 2027, all the municipalities must comply with having treatment systems in operation fir sixty percent (60%) of the total discharges described in the inventory.
		TN = 20 TP = 10	The regulation establishes the year 2032 as the date of accomplishment. In year 2031, all the municipalities must comply with having treatment systems in operation for forty percent (40%) of the

			total discharges described in the inventory.

3.2.6 HONDURAS

The General Environmental Law of Honduras (Decree 104: 1993) establishes the appropriate budgets for environmental management that allows the development of a national awareness and the participation of all Honduran citizens. This decree will monitor the progress of the general and special laws regarding basic sanitation and air, water and soil pollution, in order to guarantee an appropriate environment for the population.

In Honduras, Agreement 058: 1996 "Technical standards for wastewater discharges to receiving bodies and sanitary sewers" is the only regulation that controls wastewater discharges to receiving bodies. This Agreement has simple technical guidelines that only provide general discharge restrictions into the receiving environment, without making distinctions of singular situations. It does not specify the type of receiving body, nor the wastewater class. It determines the quality parameters and the maximum allowable value of each one, that should include the wastewater discharges to a receiving body directly or indirectly; establishing parameter groups according to their characteristics. The groups are arranged from A to G; Group D includes the MPL for the nutrients Kjeldahl Total Nitrogen (TKN), Ammoniacal Nitrogen (N-NH_3) and Total Phosphorus (TP) (Table 14).

Table 14 - Maximum Permissible Limits for nutrients discharged from wastewater in Honduras.

Standards or Regulations for the discharge of wastewater into coastal areas and/or inland bodies of water	**Nutrients included[12]**	**Limits or maximum permissible values for nutrients (mg/L)**	**Comments**
Agreement 058: 1997 "Technical Standards for wastewater discharges to receiving bodies and sanitary sewers".	• Total Kjeldahl Nitrogen (TKN) • Ammoniacal Nitrogen (N-NH_3)[13] • Total Phosphorus (TP)	TKN= 30.0 N-NH_3 = 20.0 TP= 5.0	For discharge into receiving bodies (it does not specify the type of receiving body or the origin of the wastewater, therefore it is assumed that it applies to all wastewater and for discharge in coastal areas).

In 2009, the General Water Law (Decree 181: 2009) was approved, in which it is stated that direct or indirect wastewater discharges can be carried out in a receiving water body, providing that the discharges do not contain insecticides, fertilizers and any other toxic or

[12] The names and expressions (chemical formula) of the different nutrients appears in the same way, as are included in the standard or regulations specified in the previous column.

[13] This agreement does specify the chemical formulation of the referred element. Ammonia nitrogen correspond to nitrogen in the form of soluble ammonia (N-NH_3).

polluting product or substance. The requirements of this law are of public order and obligatory observance.

The Secretary of Natural Resources and Environment in the Official Gazette published the Agreement 003: 2020 in May 2021, which approves the National Regulation for the Discharge and Reuse of Wastewater, controlling the wastewater and sludge discharge from treatment systems. The prevention, control and reduction of pollution generated by wastewater discharges to receiving bodies is the main objective of this agreement, to ensure human health and environmental protection. It does not establish nutrients MPL; it only presents the removal efficiencies of Phosphorous (P), Organic Nitrogen (N_{org}) and Ammoniacal Nitrogen (N_{amon}) from some primary and secondary wastewater treatment facilities.

3.2.7 MEXICO

Mexico, through the General Law of Ecological Balance and Environmental Protection (LGEEPA) of 1998, established the basis for the sustainable use, water management and of other natural resources. This Law stipulates that federal government is responsible for establishing federal environmental regulations for the main projects. State and local governments have responsibilities in regulating and supervising water pollution in protected areas created by the federal government and in the ordinary application of regulations and standards regarding water pollution by municipal sewage systems.

On the other hand, in the National Water Law (DOF 06-01: 2020), a permit from the National Water Commission (CNA) is required to discharge wastewater of any type in all water bodies, including marine waters, in coordination with the Secretary of the Navy, when the discharges are done from mobile sources or platforms at sea. The CNA sets the maximum concentrations of quality indicators by determining the assimilation capacity of water bodies or pollutants dilution, emission standards, as well as quality aims and the achievement provisions. Generally, in Mexico the regulatory requirements of the National Water Law in terms of management and control of water quality are also applied to marine waters, which are defined as such by article 3 of the Federal Law of the Sea (DOF 08 -01:1986).

For its part, the Ministry of the Environment and Natural Resources (SEMARNAT) in January 1997 published the Official Mexican Standard NOM-001-SEMARNAT: 1996, which established the maximum permissible limits of pollutants in wastewater discharges into national waters and assets, in order to protect the water quality and enable its uses. In this document, a wastewater receiving bodies' classification appears, including coastal waters and defines three classes: fishing operations, navigation and other uses, recreation and estuaries.

The Official Mexican Standard, NOM-001-SEMARNAT: 2021 published by SEMARNAT in March 2022 revoked the aforementioned standard in order to protect, conserve, and improve the quality of national waters and assets. However, this legal instrument entered into force on April 3, 2023, according to the provisions of the transitory articles and published in the Federation Official Gazette.

The NOM-001-SEMARNAT: 1996 standard does not differ from the permissible limits according to the wastewater type; in fact, usually it is classified as "*water of varied*

composition of discharges from commercial, agricultural, livestock, domestic as well as the mixture of them". In the updated standard (NOM-001-SEMARNAT: 2021), the limits are also not differentiated according to the wastewater type.

Among the modifications made to this latest regulation are the classification of the receiving bodies of wastewater discharges (in the previous one, "coastal waters" were defined as the receiving body with 3 subdivisions according to the use and now it appears as "Mexican marine zone" without distinctions of use) and the permissible pollutants limits among them, the nutrients quality indicators under study (Table 15).

Table 155 - Maximum Permissible Limits of nutrients for wastewater discharges in Mexico

Standards or Regulations for the discharge of wastewater into coastal areas and/or inland bodies of water	**Nutrients included**	**Limits or maximum permissible values for nutrients (mg/L)**	**Comments**
Official Mexican STANDARD NOM-001-SEMARNAT: 2021, which establishes the permissible limits of pollutants in wastewater discharges in receiving bodies. It entered into force progressively from April 3, 2023.	• Total Nitrogen (TN)	TN = 25 (M. A.) 30 (D. A.) 35 (I. V.)	For discharges in Mexican marine areas. M.A: Monthly average. D.A: Daily Average. I.V: Instantaneous Value
	• Total Phosphorus (TP)	TP = 15 (M. A.) 18 (D. A.) 21 (I. V.)	

3.2.8 NICARAGUA

In Nicaragua, the General Water Law (Law 620: 2007) governs the national legal framework of all the country's water resources: surface, underground, wastewater, marine, with the purpose to establish the institutional legal framework for the administration, conservation, development, use and sustainable exploitation of the water resources.

In turn, in 2009 the Law for the Development of Coastal Zones (Law 690: 2009) was approved and aims to outline the legal management for its administration, protection, conservation, use regulation and sustainable exploitation and guarantee to the population access to coastal zones of the Pacific Ocean and the Caribbean Sea.

For the protection of the natural resources in Nicaragua, the General Law on the Environment and Natural Resources (Law 217:2014) was approved and constitutes a responsibility to the State and all citizens. This law formulates the rules for the conservation, protection, improvement and restoration of the environment in the country and has management as the basic principle.

The country has a legal instrument for the water bodies classification (Obligatory Technical Standard, NTON 05007-98: 2000), which establishes the required parameters to determine the quality levels of water bodies (lakes, lagoons, artificial lakes, springs, rivers, groundwater, estuaries and seas), according to the intended uses. Six categories are recognised in this standard to classify the receiving bodies.

According to the classification, Category 3 specifically refers to marine waters or coastal environments aimed at the breeding and exploitation of shellfish for human consumption. However, it is acknowledged that categories 4, 5 and 6, according to the proposed uses, can also be associated with coastal marine waters to some extent or another.

In 2017, a regulation was formulated which establishes the determinations for wastewater discharge in Nicaragua (Decree 21: 2017). This document outlines the discharge provisions of wastewater from domestic, industrial, commercial, agro-industrial and service activities to receiving bodies and sanitary sewerage, through the establishment of limits or maximum permissible ranges of discharges for different quality indicators expressed in concentration terms.

The regulation defines the receiving body as "*current or natural deposit of water in reservoirs, channels, marine areas or public domain assets, where wastewater is discharged, as well as the land where said wastewater is infiltrated or injected* ". Although it does not establish the limits or ranges of discharge according to the receiving body, but according to the origin or source of the wastewater, it does provide in Article 5 that discharges may not introduce effluents into the receiving body that modify and alter the characteristics of water quality for the different uses to which they are intended.

Based on the above, it is inferred that the discharge limits or ranges defined in the Regulation (Decree 21: 2017) must be precise enough so as not to modify the required quality levels of water bodies according to their use (NTON 05007 -98: 2000), but the relationship between both legal instruments is not clearly defined.

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Although it is not the subject of this study, it is also important to mention that in its chapter VI, Decree 21:2017 includes the provisions on discharges from industry to receiving bodies, establishing more than 30 different types of industrial activities with their respective limitations. To this, we must also add the distinction made for agro-industrial activities. Table 6 shows the values of the MPL for nutrient discharges according to Decree 21 of 2017 (chapter VII).

Table 16 Maximum Permissible Limits of nutrients for wastewater discharged into receiving bodies (including marine waters) for Nicaragua.

Standards or Regulations for the discharge of wastewater into coastal areas and/or inland water bodies	Nutrients included	Limits or maximum permissible values for nutrients (mg/L)	Comments
Decree 21:2017. "Regulation that establishes the provisions for the discharge of wastewater."	• Total Phosphorus (TP). • Total Nitrogen (TN). • Total Kjeldahl Nitrogen (TKN) • Ammoniacal Nitrogen (N-NH_3)[14]	TN= 45 TP= 15	For discharges from sanitary sewer treatment systems.
		TN= 30 TP= 10	For discharges from domestic wastewater treatment systems.

[14] This agreement does specify the chemical formulation of the referred element. Ammonia nitrogen corresponds to nitrogen in the form of soluble ammonia (N-NH_3).

3.2.9 PANAMA

Panama approved the General Environmental Law (Law 41: 1998), which establishes the basic principles and standards for the protection, conservation and recovery of the environment, promoting the sustainable use of natural resources. It also regulates environmental management and establishes the integration with social and economic objectives, in order to achieve sustainable human development in the country. This forms a main framework on data and involvement in environmental issues and creates responsibility for environmental damage.

Within the Panamanian regulatory framework figures is the standard management related to the sewage or wastewater discharges. The General Directorate of Industrial Standards and Technology (DGNTI) reviewed the Technical Regulation DGNTI-COPANIT 35: 2000 “Water. Discharge of liquid effluents directly to water bodies, surface and groundwater masses”; and after various meetings, adaptations and modifications by members of the public and private sectors, approved the replacement of the name of the Technical Regulation to DGNTI-COPANIT 35:2019 "Environment and health protection. Security. Water quality. Discharge of liquid effluents to water bodies and water masses of continental and marine”, in order to comply with the International Classification of Standards (ICS) and expand the scope of application according to the geographical conditions of the Panamanian territory.

The DGNTI-COPANIT Regulation 35: 2019 establishes the maximum permissible limits that dischargers of liquid effluents from domestic, commercial, industrial and institutional activities must comply with, into bodies and masses of continental and marine waters. It also allows the protection of the health of the population, the environment and the preservation of water, continental and marine resources, whether surface or underground, natural or artificial, from contamination of anthropic origin derived from the aforementioned activities, within the Republic of Panama. This regulation takes into account the MPL of total phosphorus, nitrates, total nitrogen and ammoniacal nitrogen for wastewater discharges in their entirety. Annex A, Table A1, provides a list of parameters controlled by the economic activity, and based on the International Standard Industrial Classification (ISIC), which recognizes 307 different industrial activities.

Table 17 shows the nutrients MPL that are included in the aforementioned Regulation DGNTICOPANIT 35: 2019.

Table 177 - Maximum Permissible Limits for nutrients discharged into continental and marine waters in Panama

Standards or Regulations for the discharge of wastewater into coastal areas and/or inland bodies of water.	**Nutrients included[15]**	**Limits or maximum permissible values for nutrients (mg/L)**	**Comments**
Technical Regulation DGNTI-COPANIT 35:2019. Environment and health protection. Safety. Water quality. Discharge of liquid effluents to bodies and masses of continental and marine waters	• Total phosphorus (P) • Total nitrogen (N) • Ammonia nitrogen ($N\text{-}NH_3$) • Nitrate (NO_3^-)	P = 10.0 N = 15.0 $N\text{-}NH_3$ = 3.0 NO_3 = 10.0	All liquid effluents from domestic, commercial, industrial and institutional activities that discharge to bodies and masses of marine and continental waters or infiltration wells, must comply with the MPL established in this Regulation.

3.2.10 VENEZUELA

The Constitution of the Bolivarian Republic of Venezuela, has established the nature of all waters as public domain assets of the Nation, also instructing that a law must establish the provisions to guarantee the protection, use and recovery, respecting the phases of the hydrological cycle and the land use planning criteria, understood as comprehensive water management. In its strategic action for the uses of water, the Ministry of Popular Power for Water Attention (MINAGUAS) was created through Decree 3466 on June 15, 2018. This Decree appears in the Extraordinary Official Gazette No. 6382.

The creation of this ministerial body led to the creation of a new National Water Authority and with it the exercise of public policies and an institutional framework that responds strategically to the protection, treatment, surveillance and management of water resources (drinking water, sewage, river basins and reservoirs) as a whole, with the unavoidable need to establish a single and uniform legal regime for water usage.

With the establishment of this governing body, the different legal provisions dispersed in laws and decrees are combined, which allows the organic and sovereign control of the different uses of water. The elimination of conflicts and eliminating the sectorial and land fragmentation regarding the comprehensive management of the resource, in such a way as to guarantee the necessary tools to comply with the established principles. The MINAGUAS authorities use various regulations to protect the water resources and among them was Decree 883 formulated in 1995 to classify water according to its uses. This Decree, through public consultation was reviewed and approved that same year, and remains in force.

[15] The names and expressions (chemical formula) of the different nutrients that appears are included in the Technical standard or regulations specified in the previous column.

Decree 883: 2005 aims to establish standards with the objective of conserving and improving the water body quality through the control of liquid effluent discharges. The criteria observed for the classification, quality control and liquid effluent discharges of water bodies appear in this decree. Also, it suggests actions for the correct management of the resource that are aimed mainly at the reduction or prevention of effluents to raise environmental quality. Similarly, the use of cleaner production technologies and the establishment of maximum polluting limits for elements in discharges, as well as applying recycling and reuse practices.

All of the above must have the approval and control of the Ministry of the Environment and Natural Resources (MARN), with the aim of not compromising current and potential uses, and establishing the specific rules to which its management will be subject in each case. This governing body may design master plans for the control and management of specific water quality for each hydrographic basin in the national territory, in order to improve the quality of a certain water body or sections thereof.

Table 188 - Maximum Permissible Limits of nutrients for wastewater discharges in Venezuela

Standards or regulations for the discharge of wastewater to coastal areas and/or inland water bodies.	**Nutrients included**	**Limits or maximum permissible values for nutrients (mg/L)**	**Comments**
Decree 883: 2005 Rules for the Classification and Quality Control of Bodies of Water and Discharges or Liquid Effluents.	• Total Phosphorus (TP) • Total Nitrogen (TN)	TP = 10 TN = 40	Only carry out discharges to the marine-coastal environment in areas where there is rapid mixing of the discharge with the receiving body.

3.3 Analysis of Regulatory Framework of Nutrients for the Discharge of Domestic Wastewater in the WCR

The analysis of countries within the WCR has shown that each of the countries assessed possesses some form of established legislation that prohibits unregulated wastewater discharge into coastal waters. The legal instruments of the Spanish-speaking countries of the WCR, related to wastewater discharges of domestic origin affirms that all have regulations, laws, decrees, among others, to limit the discharge of nutrients (i.e. nitrogen and phosphorous and/or associated compounds) directly or indirectly into land or marine receiving water bodies. However, in only six of the 10 Spanish speaking countries assessed (Colombia, Panama, Mexico, Venezuela, Cuba and the Dominican Republic), do the regulations clarify or specify the application of numerical values (maximum concentrations) to limit the discharge of domestic wastewater in coastal marine waters. In the remaining countries (Honduras, Nicaragua and Guatemala), the limitations on the discharge are addressed equally to all receiving bodies and the marine waters are mentioned among them.

With respect to the English speaking countries analysed, despite each country having existing environmental protection legislation, only six (Antigua & Barbuda, Belize, Jamaica, Saint Lucia, Trinidad & Tobago and USA) have established further regulations inclusive of maximum permissible (concentration) limits or threshold values for wastewater discharge. Further to this, only four of these countries (Antigua and Barbuda, Barbados, Jamaica and Saint Lucia) have established limits specifically for domestic wastewater discharges. Alternatively, the USA utilises its water quality criteria for water bodies, which is comprised of pollutant loads.

An important observation of the review of national standards is the disparity of the nitrogen and phosphorous compounds that are represented as monitoring parameters in the legislation of countries in the WCR. There is very little uniformity observed in the nutrient parameters of those countries with existing limits for N and P compounds. The predominant compounds in all countries were found to be Total Phosphorus and Total Nitrogen (Table 19). While there are just three (3) different species of phosphorus compounds, there are 9 different species of nitrogen compounds being evaluated between all countries in a sporadic selection of these parameters. As a result, there is a marked dispersion in terms of the value range of maximum permissible limits for different nutrient compounds across the region, even for receiving water bodies with similar classification. For instance, regarding discharges for domestic wastewater, the distribution in the range of values in English speaking countries in comparison to Spanish speaking countries is exemplified with total nitrogen, where the given value for Saint Lucia is (5 mg/L) and is (30 mg/L) Nicaragua.

A particularly important aspect is that discharge standards are mainly expressed in terms of pollutant concentration and not pollutant load regionally. Therefore, the flow rate is not measured when assessing the impact of substances or compounds that can cause damage to the receiving water body. If flow rates were to be measured, it would permit determining the load (flow x concentration), which allows one to know the mass of the pollutant per unit of time. By assessing loads, a more holistic understanding of pollutant impacts on the receiving waters is achieved, permitting the comparison of different pollution sources (Tosic et al.,

2018) and enabling target setting for pollutant load reduction over a given period of time (Tosic et al., 2019). An accurate accounting of the load of pollutants entering a water body permits judgement and prediction of the current and future trends of water pollution and potential ecosystem reaction (e.g. algal blooms), thus providing a scientific basis for government decision-making and management, and providing data support for water resource protection and water pollution prevention (Han, 2021). In this case, the potential of pollutant load control is extremely valuable and should be considered as a future benchmark for countries when revising and updating their effluent limits. However, the use of pollutant concentrations for MPL represents significant progress in pollution control and highlights the importance of establishing standards for N and P compounds in domestic and industrial wastewater.

One of the challenges of defining effective maximum discharge limits is the lack of available information on coastal zone mixing processes. To understand whether a discharge limit will effectively protect receiving waters by maintaining water quality within predetermined environmental quality standards, one requires knowledge of the coastal zone's hydrodynamic characteristics which will determine the dispersion and dilution of a given contaminant. For example, Tosic (2019) developed a novel method for setting policy targets for maximum load limits to the coastal zone using a scientific ecosystem-based modelling approach (see also, Tosic et al., 2019). Such methods may allow for the application of precise target setting exercises as the implementation of hydrodynamic models in the region continues to emerge in the future.

Table 19 - Maximum Permissible Limits of Domestic Discharges for Nutrient Parameters in the WCR

Country	Wastewater Source	Receiving body	Parameters (mg/L)											
			P or TP	PO_4^{3-}	$P\text{-}PO_4^{3-}$	N or TN	TKN	NO_3^-	$N\text{-}NO_3^-$	NO_2^-	$N\text{-}NO_2^-$	$N\text{-}NH_3$	$N\text{-}NH_4^+$	$N\text{-}NH_4^+ + NO_3$
Antigua and Barbuda	Sewage	Coastal waters						50		3				
Barbados	Domestic Wastewater	Class 1 - Coastal	1			5								
		Class 2 - Marine	10			45								
Jamaica	Sewage effluents from existing treatment plants	Coastal waters		10					30					
	Sewage effluent from plants other than existing plants				4	10								
Saint Lucia	Domestic Wastewater	Coastal and Recreational Waters	1			5								
Colombia	Domestic wastewater and industrial, commercial and service activities.	Marine waters	0.4		0.3	1			0.1		0.02	0.3		
Cuba	Sewage water (Does not specify the typology).	Marine areas of ecological conservation zones or protected areas. (Class A).	5				10							
		Marine areas where fishing takes place (Class C).	7				20							

		Marine areas whose waters are for industrial use (Class D).	10				40							
		Marine areas in bays where maritime-port activity takes place (Class E).	5				20							
		Marine areas in bays where maritime-port activity takes place (Class F).	10				40							
Dominican Republic	Municipal wastewater for populations over 10,000 inhabitants. For minors not determined.	Coastal waters			8								30	50
Guatemala	Municipal wastewater with complete treatment systems, at least, for the two (2) main discharges that are reported without treatment in the inventory.	Receiving bodies, unspecified.	40			150								
	Municipal wastewater with treatment		20			70								

	systems for 60% of discharge													
	Municipal wastewater with treatment systems for 40% of discharges		10			20								
Honduras	Wastewater (their origin is not specified)	Receiving body	5				30					20		
México	Wastewater (their origin is not specified)	Marine zones	15			25								
Nicaragua	Discharges from sanitary sewer treatment systems	Receiving bodies	15			45								
	Discharges from domestic wastewater treatment systems		10			30								
Panamá	All liquid effluents from domestic, commercial, industrial, and institutional activities.	Continental and marine waters	10			15		10				3		
Venezuela	For all wastewater discharges. (It does not specify its type).	Marine and coastal environment	10			40								

3.4 Analysis of Regulatory Framework of Nutrients for the Discharge of Industrial Wastewater in the WCR

The review of legislation and regulations in this study has revealed a lesser presence of established limits for industrial wastewater. Only three (3) English Speaking countries (Belize, Jamaica, Trinidad and Tobago) and 4 Spanish Speaking countries (Colombia, Costa Rica, Dominican Republic, Nicaragua) have such regulations. Importantly, with respect to nutrients, Jamaica, Dominican Republic and Nicaragua are the only countries, in this study, with distinct limits defined for both domestic and industrial discharges. Belize and Nicaragua have defined N and P limits for various existing industries, however, it is understood that each country will contain different industrial activity. Colombia and Costa Rica have established nutrient limits for fewer industries while the remaining countries have seemingly taken a general approach, whereby the regulations are non-specific and apply to all industrial discharges. In comparison with the domestic wastewater discharge limits (Table 19), it is observed that there are fewer forms of nitrogen and phosphorus compounds for industrial discharges. It may be inferred that the wastewater treatment performed by industries prior to discharge would effectively minimise or remove the presence of some nutrients. The industrial effluent limits for N and P compounds for these countries are included in Table 20 below.

It is important to note, the inclusion of industrial pre-treatment programme within Annex III of the LBS Protocol, which outlines the requirements for potential implementation by contracting parties. This programme particularly deals with the collection of industrial discharge into new or existing domestic wastewater treatment systems and how they are to be protected from possible contamination, damage or any other operational limitations. Consequently, industrial discharge would be collected at treatment facilities that also collect domestic wastewater, the pre-treatment performed prior to discharge should produce effluent that is of similar composition and pollutant levels to domestic wastewater. The establishment of pre-treatment programme is based on the economic capability of the contracting party. Other probable factors related to implementation may include the country's existing sewerage infrastructure, industry location and proximity of receiving water bodies.

Ideally, the establishment of an Industrial Pre-treatment program within contracting parties may potentially be introduced through amendment of the existing regulatory framework. However, it is imperative that the authority/agency with responsibility for environmental protection within each country ensures a holistic approach is taken in development and implementation. In countries where industrial effluent limits are not yet established, the pre-treatment process should result in effluent with pollutant (including nutrient) levels that are compliant with any established discharge limits for domestic wastewater into receiving water bodies or the respective existing water quality criteria. However, multiple industries discharging into the same receiving water body may result in an accumulation of nutrients leading to harmful effects (eutrophication) even though each industry may be in compliance.

Table 20 - Industrial Effluent Limits for Nutrient Parameters in the WCR

Country	Wastewater Source	Receiving body	Parameters (mg/L)									
			P or TP	PO_4^{3-}	$P\text{-}PO_4^{3-}$	N or TN	TKN	NO_3^-	$N\text{-}NO_3^-$	$N\text{-}NO_2^-$	$N\text{-}NH_3$	$N\text{-}NH_4^+$
Belize	Food Processing, Service, Citrus, Garment, Battery Manufacturing, Poultry, Brewery Industry, Sugar Processing	Coastal waters		5				10				
	Fish Processing			30				10				
	Dairy Industry			5				30				
	Rum Refinery, Shrimp Processing, Soft Drink Bottling			1				10				
	For Other Industries or Commercial Activities			3				5				1
Jamaica	Trade effluents	Coastal waters		5				10				1
Trinidad and Tobago	Industries or Commercial Activities	Coastal Nearshore Marine Offshore	5								10	
Colombia	Agriculture and Livestock	Marine waters	2		1.5	10			1	0.5	5	
	Food Industries		2			10						
	Beverage		15			30						

Costa Rica	Livestock, Poultry, Fish farming, Textile and Leather industry	Not specified		25		50						
Dominican Republic	General Industrial wastewater	Coastal waters	2									10
Nicaragua	Animal Slaughterhouses, Cattle farming, Coffee processing	Marine waters				50						
	Dairy industry					45						
	Textile Manufacturing		2								10	
	Thermoelectric Power plants		5									
	Oil refining and petrochemicals										15	
	Iron and steel industry										12	
	Pig and goat farms			20			50					
	Soap and detergent industry		15									

4. REGULATORY FRAMEWORKS FOR NITROGEN AND PHOSPHORUS DISCHARGES IN OTHER REGIONS

4.1 AUSTRALIA

The Australia and New Zealand Guidelines for Fresh and Marine Waters (ANZECC 2000) were established to provide a framework to recognise, protect and manage the uses of the environment's water resources that are important for a healthy ecosystem or for public benefit, welfare, safety or health which require protection from pollution. The ANZECC established guidelines for aquatic ecosystems and recreational water quality of coastal areas.

The ANZECC forms part of the Australian National Water Quality Management Strategy (NWQMS; ANZECC & ARMCANZ 1994) of which the primary objective is based on ecologically sustainable development of water resources. As part of a larger water quality management framework, water quality guidelines are developed via objectives that take into account social, cultural, political and economic concerns where necessary. It is important to note that the guidelines are not considered Standards due to a large range of ecosystem types, environments and food production systems where a critical and discerning approach is taken to apply water quality objectives. As a result, guidelines are numerical and descriptive values that aim towards effective management of environmental water resources. The values are referred to as "trigger values" that incur a predetermined response which maximises ecosystem protection. An example of these is given in Table 21 below which includes the guideline values to protect aquatic ecosystems in Northern Australia. This area referred to as "Tropical" Australia and is particularly characterised by elevated seasonal temperatures, coral reef ecosystems and significant seasonal variability in rainfall. Also in this table, is the recreational water quality guidelines for nutrients that are used in monitoring and management of water bodies to determine suitability for that purpose.

Table 21 - Australia Nutrient Parameter Guidelines for Marine Waters

Environment	**Parameters (mg/L)**					
	Nitrate-N	**Nitrite -N**	**Ammonia-N**	**Total Nitrogen**	**Reactive Phosphorus**	**Total Phosphorus**
Aquatic Ecosystems - Marine						
Inshore			0.001 - 0.01	0.1	0.005	0.015
Offshore			0.001 - 0.006	0.1	0.002 - 0.005	0.01
Recreational Water Quality	10	1	0.01			

It is of particular importance to note that the ANZECC guidelines are developed specifically for a particular ecosystem based on the existing physical and chemical stressors, which are factors that can cause adverse effects in aquatic ecosystems. The issues caused by these stressors are correlated with the potential effects to create a tiered risk-based system. For each issue, guideline values are "packaged" with corresponding ecosystem-specific protocols to minimise harmful environmental effects. Although guidelines for each issue are generally

specified as concentrations, development of load-based guidelines for nutrients, biodegradable organic matter and suspended particulate matter were recommended.

4.2 EUROPEAN UNION

In 1991 the Directive 271:1991 for the EEC (91/271/CEE) was pronounced, which was subsequently modified by Directive 15: 1998 (98/15/CEE) in order to improve the problems of interpretation and adaptation by other member states. This Directive defines the collection, treatment and discharge systems for urban wastewater generated in the countries that make up the Community.

In the specific case of Spain, this Directive has been transposed through Royal Decree-Law 11:1995, which establishes the rules applicable to the treatment of urban wastewater generated in the country, incorporating into the internal law those precepts of the Directive 271:1991. The modifications developed in the Spanish Royal Decree-Law were taken from Royal Decree 509:1996, whose changes are protected by the Royal Decree 2116:1998.

Through Royal Decree 509:1996, discharges from urban wastewater treatment facilities carried out in sensitive areas prone to eutrophication must adhere to discharge requirements for BOD_5, COD, total suspended solids (TSS) and for the nutrients shown in Table 19, adopted from those reported in the Framework Directive 271:1991 of the EEC. The method of establishing limits according to the size of the population is very useful in order to improve control of the impacts, which are proportional to the magnitude of the pollution. Furthermore, investments in wastewater treatment systems for small populations are less common, as is required in a large population.

Table 22 - EU Requirements for discharges from urban wastewater treatment facilities

Parameters (mg/L)[16]	**Concentrations**		**Minimum reduction percentages (%)[17]**
	10 000 to 100 000 h-e[18]	**> 100 000 h-e**	
Total Phosphorus (P)	2	1	80
Total Nitrogen (N)[19]	15	10	70-80

[16] Concentration values constituent mean annuals

[17] The percentages of reduction depend on input flow to the treatment system

[18] h.e. - habitants' equivalents

[19] Total nitrogen includes Kjeldahl nitrogen, nitrate (NO_3^-) and nitrite (NO_2^-).

5. PROPOSALS OF REGIONAL STANDARDS FOR DISCHARGE OF NITROGEN AND PHOSPHORUS FROM DOMESTIC WASTEWATER

In order to put forward any recommendations for regional nitrogen and phosphorus (N and P) discharges, is important to carefully analyse and holistically understand the types of challenges that may be faced in the application process. The standards for discharges observed for the countries in this study, illustrate a very wide range of values for the maximum permissible discharge limits of nutrients. There is further disparity evident in the forms or compounds of N and P.

In the case of phosphorus compounds, total phosphorus (TP) prevails widely in Spanish speaking countries since it is included in the standards of eight (8) of the nine (9) countries evaluated. In the Dominican Republic's standards, only orthophosphate phosphorus ($P\text{-}PO_4^{3-}$) is included, and in the case of Colombia, both compounds are included. Of the English speaking countries, only Barbados and Saint Lucia have included total phosphorus in their national standards. The USA differs as its states develop and submit to the U.S. EPA for approval of Total Maximum Daily Loads (TMDL) – a calculation of the maximum amount of a pollutant allowed to enter a waterbody so that the waterbody will meet and continue to meet water quality standards for that particular pollutant.

With respect to nitrogen compounds, discharge standards are more complex in terms of uniformity. It is observed that the different compounds seem to be evaluated indistinctly. For instance, total nitrogen (TN) is evaluated in six (6) of the Spanish speaking countries, Total Kjeldahl nitrogen (TKN) in three (3), ammoniacal nitrogen (as soluble ammonia, NH_3 or as ammonium ion, NH_4^+) in four (4) countries and nitrate (NO_3^-) and nitrate-nitrogen ($N\text{-}NO_3^-$) in one (1) country each. In English speaking countries, total nitrogen is evaluated in three (3) countries Barbados, Jamaica and Saint Lucia. Monitoring of additional nitrogen compounds is minimal where only Antigua and Barbuda analyses nitrate (NO_3^-) and nitrite (NO_2^-), and only Jamaica analyses nitrate-nitrogen ($N\text{-}NO_3^-$).

Additionally, several discharge standards or regulations mention nitrogen compounds without clearly specifying their chemical forms, and in some cases, the formulations provided are incorrect, leading to potential confusion. For example, ammoniacal nitrogen might be described as the ammonium ion (NH_4^+) or as soluble ammonia (NH_3). Similarly, some standards or discharge criteria refer to nitrite and nitrate as the complete ion (NO_2^- and NO_3^-, respectively), while others report nitrogen content within nitrite or nitrate ($N\text{-}NO_2$ or $N\text{-}NO_3$, respectively). Notably, this ambiguity does not arise with total nitrogen (TN), which is universally understood as the sum of all nitrogen forms (both organic and inorganic), or with total Kjeldahl nitrogen (TKN), which specifically includes organic nitrogen and the ammonium ion (NH_4^+).

N and P compounds have been observed to be co-limiting factors in nutrient enrichment of aquatic ecosystems, leading to harmful effects such as algal blooms (Esler, 2007). After reviewing the existing national standards for wastewater discharge across the region, analysing the predominant forms of nitrogen and phosphorus compounds and considering

the potential inaccuracies regarding the chemical formulations in legal frameworks, particularly with nitrogen compounds, it is proposed that total nitrogen (TN) and total phosphorus (TP) should be included as the nutrient parameters to be evaluated in regional criteria or limits for domestic wastewater discharges in marine and coastal areas. TN and TP concentrations are found to be highly useful yet basic parameters for the assessment of water quality particularly with respect to eutrophication (Yang, 2008). In addition, due to the importance of determining TKN for wastewater treatment systems and recognising the importance of the analytical method for its determination, it is also proposed as an appropriate indicator for inclusion in regional criteria or standard.

Table 23 - Proposed Regional Standards for Nitrogen and Phosphorus in Domestic Wastewater Discharges to Marine Waters

Maximum Permissible Limits	**Parameters (mg/L)**		
Water Classification	**TP**	**TN**	**TKN**
Class I	0.1 - 5	1 - 10	5 - 10
Class II	5 - 10	10 - 50	10 - 40

Though a wide range of maximum permissible limit values in marine and coastal areas is observed regionally regarding the concentrations of nitrogen and phosphorus compounds, in proposing limits for N and P, the following is considered:

- Potential nutrient indicators should initially be considered as a range of values for Class I and Class II waters.
- The ranges are intended to be in alignment with each water classification as per the current designation of the LBS Protocol i.e. stricter limits are proposed for Class I which is in alignment with the protection of sensitive ecosystems and water uses within this classification.
- The main objective of this recommendation is for these values to serve as a guideline for contracting parties in the WCR.
- With reference to the proposed ranges, contracting parties may choose to adopt limits that are within the range or even have stricter limits.

The premise for these proposed limits is to better enable regional environmental authorities in the management and protection of coastal water bodies that currently or potentially could be affected by domestic wastewater pollutants. As per reviewed guidelines such as EPA WQS and ANZECC, the use of a water body should be commensurate with the respective limits. Consequently, conservative values for Class I and its inherent uses are recommended, while lesser values for have been offered for Class II. Ultimately, the limits proposed should be considered attainable but subject to change over a period of time where these thresholds can gradually become more stringent, if necessary and required.

Finally, within the majority of countries, the national standards or regulations are observed to utilise a system for maximum permissible discharge limits for N and P compounds in the form of pollutant concentration and not pollutant load. In light of this, it was considered more

prudent to initially recommend discharge limits for these compounds as concentrations. In this way, smoother alignment would be possible and implementation of the recommended limits may be easily facilitated due to the similarities of existing data output. However, the importance and need to include limits as pollutant loads in the future does not go unrecognised.

With respect to developing nutrient standards for industrial effluents, it is also recommended that this would be best done separately. As it stands, the existing discharge limits under the LBS Protocol are definitively for domestic discharges. Therefore, industrial limits for the existing parameters should be developed in concert with N and P. As previously mentioned, the process of pre-treatment is critical for industrial wastewater discharge that may be collected at domestic wastewater treatment systems. In this regard, establishing industrial standards would be dependent on the capability of contracting parties to make this process a requirement.

6. FINAL CONSIDERATIONS

There are existing gaps in the current national standards across the region pertaining to Nitrogen and Phosphorus compounds. Even with inherent challenges, it is implicit that coastal and marine areas categorised as Class I under the Protocol should be protected by the establishment of standards for N and P as these compounds are the cause of nutrient pollution, eutrophication, and deoxygenation, and among the main causes of coral reef degradation, marine biodiversity loss, and marine ecosystem habitat loss. Though some countries have made strides in this regard, there is more to be done in these areas to effectively maintain the marine environment and respective benefits.

Given the importance of nutrients to aquatic ecosystems, the differentiation of standards for domestic wastewater and industrial effluent is required. Countries that are without this distinction should consider revision of existing statutes to better facilitate the management of coastal waters. For those countries that are yet to incorporate such standards or criteria, it is important to make this distinction from the outset and create a sound foundation for nutrient pollution monitoring.

In conclusion, to establish regional limits for nutrient discharges, countries may deliberate the inclusion of the proposed parameters, total phosphorus (TP) and total nitrogen (TN) and/or TKN (total Kjeldahl nitrogen), to be monitored as nutrient pollution indicators. Also, using the range of values recommended, differentiated limits can be proposed for discharges into Class I and Class II waters according to the classification included in Annex III (Domestic wastewater) of the LBS Protocol. Lastly, the proposed nutrient limits are defined in the form of pollutant concentration and not pollutant load, although it is recognised that ultimately the flow factor of pollutants must be included in assessing the impact potential impact.

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ANNEX I

ACTIVITY 2 QUESTIONNAIRE

SECTION C: NATIONAL LEGISLATIVE FRAMEWORK FOR NUTRIENT CRITERIA AND STANDARDS FOR NITROGEN AND PHOSPHORUS LOADS FROM INDUSTRIAL AND DOMESTIC DISCHARGES

1. (a) Does your country have rules/criteria/standards for wastewater discharges into inland water bodies?

Yes ☐ No ☐ In preparation ☐ I don't know ☐

(b) If Yes,

i. Does it include maximum permissible limits and/ or loading for nutrients (in particular for nitrogen and phosphorus)? For example total nitrogen, nitrates, nitrites, ammonia, total phosphorus, reactive phosphates, etc. Please check relevant boxes below.

Yes ☐ No ☐ maximum permisible limits only ☐ loading only ☐

ii. Indicate whether in the discharge rules/ criteria/ standards there is a distinction/differentiation between the maximum permissible limits and or loading for the different indicators according to:

☐ The use or classification of the receiving body
☐ The type of wastewater to be discharged
☐ Other distinctions or classifications. Please specify:

_____

_____

2. (a) Does your country have rules/criteria/standards for wastewater discharges into coastal marine areas?

Yes ☐ No ☐ In preparation ☐ I don't know ☐

(b) If Yes,

i. Does it include maximum permissible limits for nutrients and/ or loading (in particular for nitrogen and phosphorus)? For example, total nitrogen, nitrates, nitrites, ammonia, total phosphorus, reactive phosphates etc. Please check relevant boxes below.

Yes ☐ No ☐ maximum permisible limits only ☐ I don't know ☐

ii. Indicate whether in the discharge standards/criteria there is a distinction/differentiation between the maximum permissible limits and or loading for the different indicators according to:

☐ The use or classification of coastal marine water bodies
☐ The type of wastewater to be discharged
☐ Other distinctions or classifications. Please specify:

_____

_____

(a) Please send a website or bibliographic references where you can find the rules/criteria/standards referred to above (you can also attach it to the survey in digital format).

Document name	**Website or bibliographic reference where the document can be accessed**

3. If the answer is "No" to 1. or 2. above, please specify (you can include more than one option).

☐ Discharge rules/criteria/standards from other countries or region are used
Please state country

_____

☐ Nutrients of high interest are not regulated in the rules/criteria/standards for discharges.

4. Does your country have rules/guidelines/regulations for the use of inorganic fertilizers in agriculture?

Yes ☐ No ☐ In preparation ☐ I don't know ☐

a) If the answer is “Yes” please send the website of the institution responsible in your country for the regulation of the use of inorganic fertilizers in agriculture as well as other bibliographic references of national documents related to the subject (you can also attach it to the survey in digital format)

Name of the institution / document	**Website or bibliographic reference where the institution/document can be accessed**

b) If the answer is “No” please specify (may include more than one option).

☐ Standards/guidelines/regulations are used for the use of inorganic fertilizers from other countries or regions
☐ The use of inorganic fertilizers in the country is not considered significant.
☐ It is not the country's priority to regulate the use of inorganic fertilizers in the country.

ANNEX II

STATISTICAL ANALYSIS

A simple statistical analysis was performed on the data accumulated in this study for the domestic wastewater discharge limits into coastal nearshore and marine areas. The selected data in the Table below is aligned to the proposed nutrients, Total Nitrogen and Total Phosphorus, made above and consists of at least one value for those parameters.

Country	P or TP (mg/L)	N or TN (mg/L)
Barbados (Class 1)	1	5
Barbados (Class 2)	10	45
Jamaica (other plants)	-	10
Saint Lucia	1	5
Colombia	0.4	1
Cuba (Class A)	5	-
Cuba (Class C)	7	-
Guatemala (2024)	40	150
Honduras	5	-
México	15	25
Nicaragua (Sanitary)	15	45
Nicaragua (Domestic)	10	30
Panamá	10	15
Venezuela	10	40

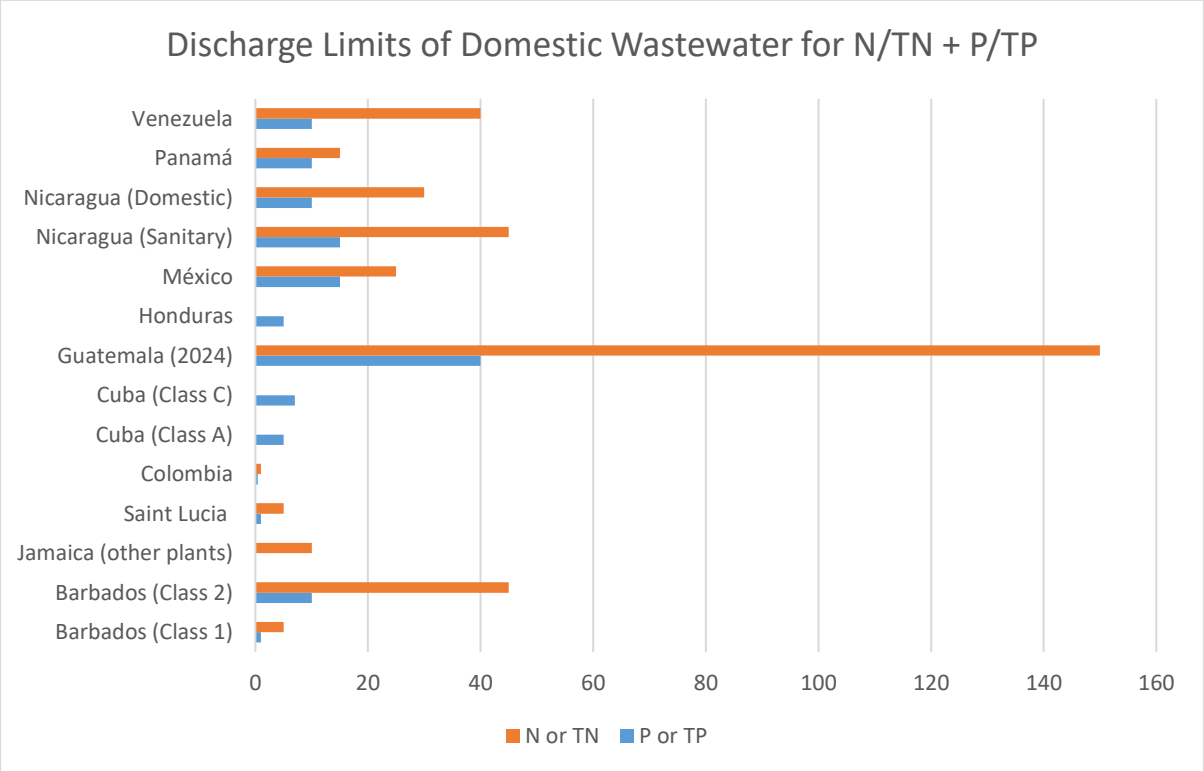

Figure 2 - Bar Graph of Domestic Wastewater Discharge Limits for Proposed Nutrients

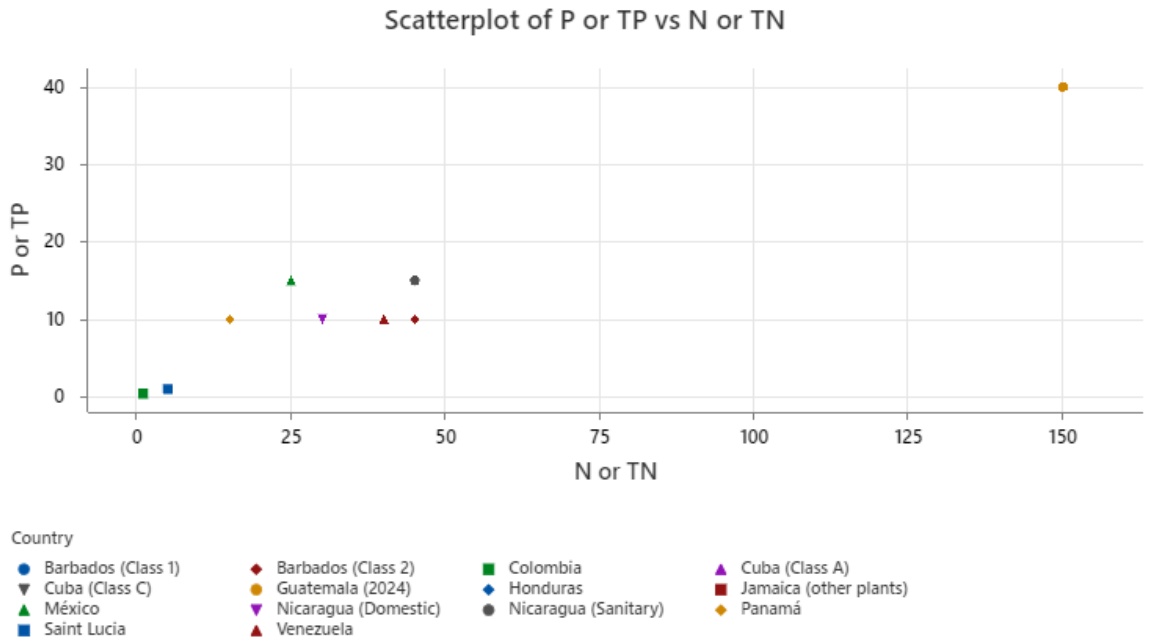

Figure 3 - Scatterplot Graph of Domestic Wastewater Discharge Limits for Proposed Nutrients

Statistics

Variable	Total Count	N	N*	Mean	StDev	Minimum	Median	Maximum
N or TN	14	11	3	33.7	41.9	1.0	25.0	150.0
P or TP	14	13	1	9.95	10.26	0.40	10.00	40.00

From the data above, it is observed that the mean (average) of the TN is 33.7 and TP is 9.95 which reflects that there are generally higher values for nitrogen then phosphorus. The Standard Deviation measures the spread of data in relation to the mean. The values for this statistic show that for TN 41.9 and TP 10.26, there is a greater spread from the mean value among total nitrogen in comparison to Total phosphorus. This is also exemplified by the minimum, median (middle) and maximum values. There is a much larger range of values in TN (1 to 150) than TP (0.4 to 40). In general, across countries with existing domestic wastewater discharge limits for the nutrients parameters proposed for inclusion into Annex III for, Total Phosphorus values are observed to be very similar with a smaller range. However, the values for Total Nitrogen vary more and possess are significantly larger range.