Terms of Reference

CONSULTANCY: Feasibility study of Sanitary Landfill for Sargassum Disposal in Quintana Roo, Mexico

1. BACKGROUND

The Mesoamerican Reef (MAR), stretching over 1,000 km along the Caribbean coasts of Mexico, Belize, Guatemala, and Honduras, is the largest barrier reef in the Western Hemisphere. It supports ecosystems and economies valued at approximately USD $4.5 billion annually through tourism, fisheries, and coastal protection (WRI, 2016). However, declining reef health threatens these benefits and could result in economic losses reaching billions of dollars by 2030 (Burke et al., 2011). The Mesoamerican Reef Fund promotes reef conservation through funding mechanisms and strategic partnerships. One such initiative is MAR+Invest, launched in 2022 by the Global Fund for Coral Reefs. MAR+Invest focuses on financing reef-positive ventures, including sustainable tourism, waste management, and other nature-based solutions (UNEP, 2022). More information is available at mar-invest.org.

Sargassum, a brown macroalgae that forms part of the "Great Atlantic Sargassum Belt," has increasingly inundated Caribbean shores, especially along the coastline of Quintana Roo. As it decomposes, sargassum releases nutrients and toxins that damage coral reefs, seagrasses, and mangroves. It also emits hydrogen sulfide (H_2S) and ammonia, contributing to unpleasant odors and potential health issues. In 2024, Quintana Roo collected approximately 37,000 tonnes of sargassum, an increase of 60% compared to 2023 (Mexico News Daily, n.d.-a). When improperly disposed of in unlined sites, sargassum can leach heavy metals such as arsenic and cadmium, threatening both groundwater and nearby marine ecosystems (Western, n.d.; Florida Department of Health, 2023). Anaerobic decomposition further exacerbates the issue by producing methane and H_2S, posing serious environmental and public health risks (United States EPA, n.d.; Vázquez-Delfín et al., 2024).

Carbonwave, a company that transforms sargassum into agricultural and cosmetic products, plays a key role in valorizing this biomass. However, current collection volumes exceed processing capacity, leaving residual waste that requires safe disposal. To address this, MAR+Invest and Carbonwave are proposing a feasibility study for the development of a sanitary landfill designed specifically for sargassum. This facility would comply with Mexican environmental standards (e.g., NOM-083-SEMARNAT-2003) and include safeguards such as impermeable liners, leachate collection systems, and gas control infrastructure to mitigate environmental impacts

2. OBJECTIVES OF THE CONSULTANCY

The overall objective of this consultancy is to assess the feasibility of adapting and operating a sanitary landfill dedicated to Sargassum disposal in Quintana Roo, Mexico, to safely manage the region's sargassum influx in an environmentally sound manner. This entails a comprehensive evaluation of technical, environmental, and regulatory aspects to ensure that any proposed landfill solution:

1. Meets environmental protection standards: effectively containing or treating leachate and gas emissions to prevent pollution of soil, groundwater, and air (thereby mitigating impacts on the MAR coastal ecosystem and nearby communities).

2. Complies with Mexican laws and guidelines: adhering to all relevant federal and state regulations for waste disposal (including Official Mexican Standards (NOMs) and Quintana Roo's specific permitting

requirements for waste management and coastal protection).

3. It is technically and economically feasible: identifying suitable site options and necessary infrastructure (liners, leachate collection systems, monitoring systems, etc.), evaluating operational requirements, and estimating costs for implementation and maintenance.

4. Needs to be demonstrated through an experiment to to measure leachate generation and composition, gas emissions (e.g. methane, H_2S), and other "fermentation" by-products, to inform the full-scale design of a landfill solution and assess potential impacts.

By achieving these objectives, the consultancy will provide MAR Fund, Carbonwave, and local authorities with a clear roadmap for establishing a sanitary sargassum landfill that protects the environment while handling the growing volumes of beached seaweed. The findings will guide decision-making on whether and how to proceed to full-scale project development, including any further investment, engineering design, or Environmental and Social Impact Assessments (ESIA) that may be required.

3. CONTRACT RESPONSIBILITIES

To accomplish the above objectives, the consultant or consulting team will carry out the following scope of work:

A) **Preliminary Research and Site Selection:** Conduct a review of current sargassum disposal practices and alternatives in the region (e.g., landfilling, composting, agricultural uses), and identify potential site(s) in Quintana Roo for a dedicated landfill. This should include evaluating existing facilities operated by municipalities or private operators that could be upgraded, as well as assessing new site options. A clear baseline must be established across environmental, operational, and social parameters, following the reference criteria outlined in the *SEMA normative appendix on sargassum disposal residues*. Environmental indicators should include leachate quality (pH, COD, BOD, nutrients, heavy metals), water quality (groundwater and surface), air emissions (H_2S, NH_3, VOCs), greenhouse gases (CH_4, CO_2), soil conditions, and biodiversity impacts — particularly those that can be linked to coral reef health and resilience. Operational indicators should cover disposal volumes, collection frequency and logistics, landfill capacity, handling practices, infrastructure conditions, and costs per ton. Social and economic aspects should consider employment generated, community concerns, proximity to sensitive areas (tourism, agriculture, settlements), public perception, and current diversion to alternative uses. This baseline will serve as the benchmark to measure improvements and validate pilot outcomes. The consultant should also perform initial environmental and social screening of candidate sites, considering location relative to coastlines and aquifers, land tenure, accessibility, and existing conditions. In parallel, the consultant must review the legal framework and permitting requirements with Mexican authorities for establishing or modifying a landfill, engaging with the Quintana Roo Secretaría de Ecología y Medio Ambiente (SEMA) and SEMARNAT to clarify requirements and explore potential collaborations. The expected output is a short-list of feasible sites and a recommendation of the most suitable option for the pilot and potential full-scale development.

B) **Sargassum Waste Management Infrastructure Analysis**: Assess the existing waste collection and transportation infrastructure for sargassum in Quintana Roo. This involves understanding how sargassum is currently collected (e.g. by Navy boats, municipal crews, contractors) and transported to disposal sites and evaluating whether the current logistics can support the operation of a dedicated landfill. The consultant should evaluate the capacity and conditions of any current landfill or dumpsite being used for sargassum (e.g. capacity remaining, presence or absence of liners/leachate systems, operational practices). They should determine what modifications or upgrades would be needed to convert an existing site into a sanitary sargassum landfill – or, if a new site is proposed, what infrastructure (roads, utilities, equipment) must be put in place. In addition, the analysis should include an estimate of **running costs**, covering staff, maintenance, permits, and other operational expenses, to ensure long-term financial viability of the proposed solution.

C) **Regulatory Compliance and Permitting:** Identify and study all relevant environmental regulations, norms, and technical guidelines applicable to sargassum disposal in Mexico (with a focus on Quintana Roo). This includes federal standards like NOM-083-SEMARNAT-2003 (which sets specifications for site selection, design, operation, and closure of municipal solid waste disposal sites) and any other NOMs or guidelines related to handling organic wastes, coastal zone management, or marine debris. The consultant should also review Quintana Roo's state laws and regulations (and municipal bylaws, if any) that pertain to waste management or coastal environmental protection. Special attention should be paid to requirements for leachate management, gas management, and protection of groundwater in karst terrain, given the sensitivity of the Yucatán aquifer. The consultant will engage with regulatory authorities (such as SEMA, SEMARNAT's local delegation, and CONANP if near protected areas) to ensure the proposed pilot and eventual project can meet all legal requirements. This task should result in a clear checklist of compliance criteria and permits needed for a sargassum landfill, and strategies to fulfill them. The consultant is expected to work closely with the authorities throughout the project to address any regulatory concerns proactively and incorporate any specific recommendations (e.g. design criteria or monitoring obligations).

D) **Experimental Pilot Landfill Design and Implementation:** Based on the findings of Tasks A–C, design a pilot sanitary landfill cell for sargassum disposal (approximately 250-500 square meters in area) and oversee its implementation. The design should ensure simulation of key aspects of a full-scale sanitary landfill operation, albeit at a smaller scale, in order to test effectiveness and gather data.
Design considerations include:

- An appropriate liner system (such as an HDPE geomembrane or clay liner) to prevent leachate seepage.
- A leachate collection system (e.g. french drains or a sump to collect leachate for treatment or analysis).
- Provisions for gas venting or capture (installing vent pipes or small flare, if needed, to safely release or burn off gases).
- Operational protocols for layering and covering the sargassum (e.g. using soil or other material as daily cover to reduce odor and pest issues).

The consultant will develop an experimental pilot plan detailing how much sargassum can be disposed of, over what time period, and how the cell will be managed and monitored. Safety measures should be included to protect workers and nearby communities during experiments (given the H_2S gas and odor potential). Once the design is finalized (in consultation with MAR Fund/Carbonwave and regulators), the consultant will assist in constructing or preparing the pilot cell at the selected site to be fully tested. This may involve coordinating with local waste management authorities or contractors to install the liner and other systems, as well as establishing environmental monitoring systems (as detailed in Annex A below) to collect data on leachate and gas. The output of this task is the design and setup of a functioning pilot disposal site for sargassum, built to the specified sanitary standards, ready to receive a test quantity of sargassum for monitoring.

E) **Pilot Monitoring and Data Collection:** Operate the disposal cell over a defined period (e.g. several weeks or months) to monitor leachate generation, gas emissions, and other relevant parameters as the sargassum decomposes. The consultant will develop a monitoring protocol (see Annex A for guidance on parameters and frequency) and be responsible for carrying out or supervising the data collection. This includes sampling leachate regularly to analyze its volume and composition (such as pH, salinity, biochemical oxygen demand, nutrient content, heavy metals concentration, etc.) and measuring gas emissions from the pilot cell (e.g. using portable gas detectors or fixed sensors to track H_2S levels in and around the pile, methane concentration, carbon dioxide, and ammonia). The consultant should also document any observed operational issues (e.g. excessive odor, rapid filling of leachate collection, etc.) and how they are addressed. All data should be recorded systematically, and samples sent to accredited laboratories for analysis where appropriate (e.g. heavy metal tests). If possible, the consultant may install observation wells or checks around the pilot area to ensure no leachate is escaping (though the cell pilot is expected to be fully lined, this is an extra precaution). Throughout this phase, the consultant will gather not only quantitative data but also qualitative observations (e.g. efficacy of the liner, any wildlife attraction, etc.). The aim is to generate empirical evidence of how a sargassum landfill performs and what environmental controls are necessary, which will feed into design and operational recommendations for scaling up.

F) **Data Analysis and Feasibility Reporting**: Analyze the data and findings from the pilot and all prior tasks to draw conclusions on the technical feasibility, environmental sustainability, and regulatory acceptability of a sanitary sargassum landfill. The consultant will compare the pilot results against regulatory standards and baseline environmental quality to evaluate whether the approach sufficiently mitigates risks (for example, checking if leachate quality after treatment could meet discharge criteria, or if gas emissions were within safe limits). The consultant should identify any design improvements or operational practices needed for a full-scale implementation based on pilot learnings. Additionally, this task includes an economic and operational feasibility analysis: an estimate of capital and operating costs for the recommended solution (both at pilot scale and projected for a larger scale handling the expected sargassum volumes), an assessment of the operational requirements (equipment, personnel, maintenance), and consideration of how the facility would integrate into existing waste management workflows in Quintana Roo. Potential financing or business models (e.g. public operation vs. private concession, cost recovery through tipping fees or carbon credits for methane capture) can be discussed if

relevant. Finally, the consultant will compile all findings, conclusions, and recommendations into a comprehensive feasibility report. This report should clearly state whether a sanitary landfill for sargassum is viable and beneficial and outline the next steps for implementation (e.g. if moving forward: requirements for detailed engineering design, Environmental and Social Impact Assessment (ESIA) and Environmental and Social Management Plan (ESMP) in compliance with MAR Fund's standards, stakeholder consultations, etc.). The report should be evidence-based and include an executive summary for decision-makers.

DELIVERABLES

The consultancy will produce several key deliverables to document the work and results:

a. A **technical feasibility study report** detailing all analyses, findings, and recommendations from the tasks above. This report should include an executive summary, methodology, results (with supporting data, graphs, and maps as needed), conclusions, and recommendations. It should be provided in English.
b. A **PowerPoint presentation** (in English and Spanish) summarizing the objectives, approach, key findings, and recommendations. This presentation will be used to communicate results to stakeholders (e.g. MAR+Invest partners, local authorities, donors) in a concise format.
c. An **Excel data workbook** containing all raw and processed data collected during the study and pilot implementation. This should include, at minimum, the environmental monitoring data from the pilot (leachate analysis results, gas readings over time, etc.), as well as any relevant site evaluation data, cost calculations, or regulatory checklists compiled during the consultancy. The data should be well-organized and labeled, enabling independent review or future reference.
d. A short **video (approximately 5 minutes) and pictures** capturing the pilot trial and results. The video should visually document the pilot landfill setup and operation, including footage or images of the site, the process of laying liners and collecting sargassum, interviews or commentary explaining the project's purpose, and highlights of the outcomes. The video is meant for communication purposes to showcase what was done and the benefits of proper sargassum management. It should be of good quality suitable for presentation to stakeholders or on websites.

All deliverables should be prepared to high professional standards. All data collected (monitoring results, analysis outputs, photographs, etc.) must be handed over to MAR Fund and Carbonwave along with the final report. Photographic images should be provided in high resolution. If the consultant captures any photos or videos that include identifiable people, the consultant must obtain written consent (release forms) from those individuals for use of their image in project communications.

Throughout the assignment, the consultant is expected to adhere to MAR Fund's Environmental and Social Management System (ESMS) guidelines. MAR Fund's ESMS provides standards for ensuring that projects are implemented in an environmentally responsible and socially inclusive manner. The consultant should familiarize themselves with these safeguards and apply them, for example, by incorporating health and safety measures for workers, engaging local stakeholders (such as nearby communities or land owners) as needed during site

selection and pilot implementation, and avoiding or mitigating any negative impacts of the pilot. The final report should include a brief section on how ESMS considerations were addressed in the consultancy.

4. OVERSIGHT

The consultant will work under the direct oversight of the **MAR+Invest Coordinator at MAR Fund**, who will serve as the focal point for this consultancy. The MAR+Invest Coordinator will be responsible for overall supervision, facilitating access to information, and coordinating the review and approval of deliverables. The coordinator will also liaise with MAR Fund's donor (GFCR/Pegasus Capital) as needed for any technical reviews.

In addition, the consultant will work in close coordination with the **Research & Development (R&D) team of Carbonwave**. Carbonwave's R&D staff will provide technical input regarding sargassum characteristics, operational practicalities of collection/upcycling, and desired outcomes. They will collaborate with the consultant especially on pilot design details and will review technical deliverables to ensure they meet the innovative goals of the project. The R&D team may also assist in providing access to Carbonwave's facilities or data if needed (for example, if the pilot is conducted near an area where Carbonwave operates, or if previous sargassum analysis data is available). Regular update meetings (e.g. biweekly or monthly) will be held with MAR Fund and Carbonwave representatives to monitor progress. The consultant is expected to maintain open communication lines, promptly raise any issues or needs (such as delays, additional resources, or changes in scope), and incorporate feedback from the oversight team.

Final approval: of all products and reports will be agreed with MAR Fund. The MAR+Invest Coordinator, in consultation with Carbonwave and relevant experts, will review each delivery for quality and completeness. Only upon written approval by MAR Fund will a deliverable be considered accepted. The consultant should factor in time for revisions based on feedback in the work plan.

5. DURATION OF THE CONTRACT

This consultancy is expected to last a maximum of **12 months** from the date of contract signature. Work is anticipated to commence in September 2025 (exact start date to be determined upon contracting). The timeline below is an approximation and will be refined in the consultant's work plan:

> **Months 1-3:** Preliminary research, site visits, stakeholder consultations, and site selection (Tasks A & B). Initial regulatory review and permitting discussions (Task C). Submission of a brief inception report and work plan after the first month; draft site selection and regulatory findings report by end of Month 3.
> **Months 4-5:** Detailed pilot design and preparation (Task D). This includes engineering design of the pilot cell, procurement/installation of materials, and setup of monitoring systems. Permitting processes should be initiated in this period if required for the pilot.
> **Months 6-8:** Pilot implementation and active monitoring phase (Task E & F). Sargassum will be placed and observed, data collection ongoing. This period may vary depending on sargassum availability, so the schedule should be adjusted to ensure the pilot captures a realistic scenario of disposal.

Months 9-10: Data analysis as the pilot concludes, and formulation of draft feasibility study report (Task F). Additional consultations with authorities on preliminary findings (especially if any regulatory or design adjustments are indicated by pilot results).

Months 11-12: Finalization of deliverables, incorporate feedback from MAR Fund/Carbonwave on the draft report, finalize the report, presentation, and video. Conclude any pending activities and formally close the pilot site (ensure proper decommissioning or interim measures for the pilot cell until full project execution).

The above timeline is an estimation, and the consultant may propose a slightly different schedule of tasks based on their methodology. The key is to align the schedule with sargassum seasonal patterns and allow sufficient time for thorough analysis. Any extension beyond 12 months would require justification and approval by MAR Fund. Conversely, a significantly shorter duration (e.g. under 6 months) is not envisioned given the need to implement and monitor the pilot over time.

6. PAYMENTS

Payments for this consultancy will be disbursed according to a deliverable-based schedule, tied to the satisfactory completion of agreed products and milestones. The payment tranches and amounts will be finalized during contract negotiations based on the consultant's financial proposal.

It is emphasized that all payments will be contingent on **MAR Fund's approval** of the corresponding deliverables. The consultant is expected to produce high-quality output; if deliverable is deemed unsatisfactory or incomplete, MAR Fund may request revisions before payment. The consultant's financial proposal should consider all the costs of the consultancy (professional fees, travel, equipment, permits, etc.), as no additional reimbursements will be made outside the agreed contract sum. All payments will be made in USD or MXN (to be specified) and are inclusive of any taxes or obligations that the consultant must fulfill.

7. PLACE OF WORK

The consultant is not required to be based in Quintana Roo but must be available to travel there as needed. While some tasks (e.g., data analysis, report writing) can be completed from their primary location, field presence is essential for key activities such as site reconnaissance, stakeholder meetings, pilot supervision, and monitoring. Travel frequency will depend on the work plan, with extended stays likely during pilot setup. The consultant must manage their own travel logistics within Mexico, particularly to coastal areas like Cancún, Tulum, or Cozumel. Support from MAR Fund and Carbonwave will be provided for coordination, but the consultant should be prepared to work independently under tropical outdoor conditions with strict safety protocols and appropriate insurances.

8. QUALIFICATIONS AND ATTRIBUTES OF THE CONSULTANTS

The assignment may be undertaken by an individual consultant or a team/firm. In either case, the collective qualifications should cover expertise in environmental sciences, specifically solid waste management and compliance. The required profile is:

- **Solid Waste Management Expert / Environmental Scientist (Lead Consultant or Team Lead):** Minimum of 5 years of experience related to solid waste management, with a strong understanding of landfill systems including liners, leachate control, and gas management—particularly in the context of organic or biodegradable waste. Familiarity with waste challenges in coastal or environmentally sensitive areas is desirable. Experience with innovative or nature-based waste solutions will be considered an asset.
- **Environmental Scientist/Analyst:** Experience in environmental impact assessment, water quality or soil contamination analysis, and handling of environmental monitoring data. Should be capable of designing sampling plans and interpreting results for pollutants (e.g. familiarity with leachate chemistry, gas emission metrics).
- **Knowledge of Mexican Environmental Regulations:** At least one team member should be well- versed in Mexican environmental laws and permitting, particularly waste management regulations (such as NOM-083) and any Quintana Roo state regulations. Prior experience dealing with SEMARNAT/SEMA or navigating environmental permits in Mexico is highly desirable.
- **Language and Communication:** The consultant (or team) must be capable of producing high- quality technical documents in English, with clarity and rigorous analysis. Additionally, the ability to communicate in Spanish is required for field work and coordination in Quintana Roo (meetings with local stakeholders, reading regulations, etc.). All key team members should ideally be bilingual (English/Spanish) or have translation support.
- **Project Management and Innovation:** Demonstrated ability to manage a complex field project, coordinate with multiple stakeholders, and deliver output on time. The consultant should exhibit strategic and innovative thinking – for instance, ability to adapt methods if field conditions change, propose creative solutions for unforeseen challenges during the pilot, and integrate multidisciplinary perspectives (engineering, environmental, social).

Consultants/teams with prior experience in the Caribbean region or similar sargassum management projects will have an advantage. A background in coastal environmental projects, marine debris, or related fields (like composting, biogas from waste, etc.) can also be beneficial. The CVs of key personnel should reflect relevant project experience, and if a firm, a portfolio of similar projects (e.g. feasibility studies for waste facilities, environmental pilot projects, etc.) should be provided.

9. APPLICATION PROCEDURE

Interested consultants or consulting firms should submit a proposal for this assignment. The proposal must include the following elements:

- **Technical Proposal:** This should describe in detail the proposed approach and methodology for the consultancy. It should include a work plan with a timeline and milestones, a description of how each task will be carried out, and any specific techniques or tools to be used (for example, modeling of leachate, use of drone surveys for site selection, etc., if applicable. The technical proposal should also outline the consultant's team composition and the responsibilities of each member, as well as a timetable of activities. A draft outline of the final report and list of expected contents can be included to demonstrate understanding of the ToR. Important: The proposal should address all the components listed in these

Terms of Reference and ensure that the pilot implementation and monitoring aspects are well-covered (including how the consultant will ensure reliable data collection). If the ToR includes an Annex A (e.g. monitoring parameters), the proposal should confirm inclusion of those items or justify any deviation.

- **Financial Proposal:** A detailed budget in USD (or MXN, with conversion to USD) for the consultancy, broken down by deliverable or task. The budget should clearly distinguish professional fees for personnel (with daily or monthly rates and expected days of effort) and any reimbursable expenses (travel costs, equipment purchases or rentals, laboratory analysis fees, etc.). The financial proposal must cover all costs of the consultancy; no additional funds will be provided beyond the contracted amount. The total cost should be summarized, and a suggested payment schedule linked to deliverables should be included.

- **Portfolio and Experience:** For firms, include a brief company profile and relevant project experience. For individual consultants, include a listing of similar consultancies or projects completed. In all cases, provide examples of at least one similar project carried out, including the client, date, project title, and a brief description of the work (especially those related to waste management, environmental feasibility studies, or pilot project implementation). If available, attach or provide links to any reports or outputs from those projects that demonstrate the quality of work.

- **Curricula Vitae (CVs):** Include CVs of all key team members (lead consultant, and any specialists such as co-consultants or field experts). The CVs should highlight education, relevant experience, technical expertise, and language skills. Ideally, each CV should be no more than 3 pages.

- **References:** Provide at least three (3) professional references who can attest to the consultant's qualifications and past performance. Include the reference's name, organization, position, relationship to the consultant (e.g. project director for X project), email and phone contact information. MAR Fund reserves the right to contact these references as part of the evaluation process.

All proposal documents should be submitted in **electronic format** (PDF preferred for the technical and financial proposals). The technical and financial proposals may be submitted as one combined document or as two separate files.

CONSIDERATIONS:

Prospective proponents are responsible for all costs associated with the preparation and submission of their proposals. MAR Fund will not be liable for any costs incurred by applicants in preparing proposals or attending interviews/presentations, regardless of the outcome of the selection process. No advance payments or compensation will be provided for proposal preparation.

The submission of a proposal shall be construed as an acceptance of the terms and conditions of this ToR. Proponents acknowledge that the issuance of this ToR does not constitute a commitment by MAR Fund to award a contract. MAR Fund reserves the right to cancel the procurement at any stage, or to award only portions of

the work, without assigning any reasons. Preparation of the proposal is entirely at the risk and expense of the proponent.

The selection will follow MAR Fund's internal evaluation guidelines and procurement policies. MAR Fund is not obliged to select the lowest-cost proposal. The evaluation will consider both technical merit and cost-effectiveness, as well as the demonstrated capacity of the consultant. The decision of the selection committee will be final, and no appeals will be made.

Only the top-ranked candidate(s) – e.g., those who are shortlisted after an initial evaluation, will be contacted for further discussion or interviews. MAR Fund or Carbonwave will notify the selected consultant in writing. If you do not hear back, please assume that your proposal was not selected. Feedback to unsuccessful bidders may be provided upon request, at MAR Fund's discretion.

The consultant (if selected) must be willing to enter into a consultancy agreement with MAR Fund under the terms set out in this ToR. Any exceptions or reservations should be clearly stated in the proposal. MAR Fund's standard contract includes provisions on confidentiality, intellectual property (with MAR Fund retaining rights to all deliverables), and compliance with policies (including ESMS and code of ethics). The consultant will be expected to sign and adhere to these conditions. In addition, MAR Fund conducts a due diligence process for all contract signatories and will request the submission of appropriate documentation.

10. DEADLINE AND CONTACT

Interested consultants should submit their proposals (technical + financial) **no later than October 20, 2025** at 23:59 hr (GMT-5, Cancun local time). Late submissions will not be considered.

Proposals and any inquiries regarding this ToR should be sent via email to the following contacts:

- **Amy Jones, MAR+Invest Coordinator – MAR Fund** (Email: *ajones@marfund.org*)
- **Sebastián Aguilar, R&D Scientist – Carbonwave** (Email: *saguilar@carbonwave.com*)

Please include both contacts in all correspondence. The email should have the subject line: "**Proposal for Sargassum Landfill Feasibility** – [Your Name/Company]". If files are large, you may send a download link. You should receive an acknowledgment of receipt within 2 business days; if not, please follow up to ensure your submission is received.

Timeline Summary: The deadline for questions or clarification requests is one week before the proposal submission deadline. Answers to all queries will be compiled and shared (via email) to all who posed questions or expressed interest, to ensure fairness.

We thank all applicants for their interest in this important initiative. Through this consultancy, MAR Fund, MAR+Invest, and Carbonwave aim to develop a sustainable solution to the sargassum influx that will safeguard the precious Mesoamerican Reef and the well-being of Quintana Roo's coastal communities. We look forward to your proposals and to partnering on this innovative pilot project.

Annex A: Pilot Landfill Environmental Monitoring Plan

To ensure the pilot disposal cell yields actionable data, the consultant will implement a monitoring plan with the following components:

Leachate Analysis

Objective: Determine the quantity and quality of leachate generated by the decomposing sargassum in the pilot cell, to assess contamination risks and inform leachate management design for a full-scale landfill.
Parameters to Measure:

- **Volume of leachate** collected (e.g. liters per day or after each rain event) to estimate leachate generation rates.
- **Basic water quality:** pH, Electrical Conductivity (salinity/TDS), and Temperature. These indicate general leachate characteristics (acidity and salinity are expected to be high due to seawater content in sargassum).
- **Organic load:** Biochemical Oxygen Demand (BOD_5) and Chemical Oxygen Demand (COD) to measure the concentration of biodegradable and total organic matter in the leachate. High BOD/ COD would reflect strong oxygen demand if released, affecting water bodies.
- **Nutrients:** Ammoniacal Nitrogen (NH_3-N), Nitrate (NO_3^-), Total Kjeldahl Nitrogen (TKN), and Phosphate (PO_4^{3-}). These nutrients can cause eutrophication in water bodies if leachate is untreated.
- **Heavy Metals:** At minimum, **Arsenic (As)** and **Cadmium (Cd)** (given known high levels in sargassum), as well as other relevant metals like Lead (Pb), Mercury (Hg), or others if suspected. These toxins are critical to monitor for groundwater protection.
- **Sulphates and Chloride:** As indicators of salt content and potential contributors to H_2S production (sulfates) and salinity (chlorides). High sulphate in leachate can lead to generation of H_2S in anaerobic conditions Fecal Coliforms / Pathogens: (Optional, if budget allows) to check if decomposing biomass harbors any pathogenic bacteria that could be of concern if leachate reaches water sources or if workers are exposed.

Frequency: Leachate sampling should be done at least monthly during the pilot, and ideally more frequently in the initial weeks when decomposition is most active (e.g. biweekly). After major rainfall events, an extra sample should be taken to see the dilution or increase in leachate volume/ composition.

Sample Points: From the pilot cell's leachate collection sump or outlet. If the design includes multiple collection points (e.g., a drain network), samples should be taken where all leachate converges (or from each point if they isolate different sections). If any leachate treatment or storage (e.g. a holding tank) is used in the pilot, samples should be taken of both raw leachate and any effluent after treatment (if applicable). All samples must be collected with proper protocols (clean bottles, preservation like cooling or acidifying for metal samples) and analyzed by a certified laboratory for accuracy.

Gas Emissions Monitoring

Objective: Measure and characterize the gases emitted from the pilot sargassum landfill area to evaluate air quality impacts and the need for gas management systems. This will also inform greenhouse gas considerations for the project. Parameters to Measure:

- **Hydrogen Sulfide (H_2S):** Concentration in air (in parts per million, ppm). H_2S is expected from the breakdown of sulfate in decaying seaweed and is responsible for odor and health concerns.
- **Methane (CH_4):** Percentage concentration (or ppm) of methane in the landfill gas emissions. Methane indicates the anaerobic digestion of organic matter and has implications for greenhouse gas emissions and potential flammability.
- **Carbon Dioxide (CO_2):** Percentage concentration of CO_2 in the emitted gas. CO_2 together with CH_4 helps characterize the bulk of landfill gas (which typically is ~50% CH_4 and 50% CO_2 in mature landfills [2], though the ratio may differ in a purely algal biomass context).
- **Ammonia (NH_3):** Presence of ammonia gas, which can be released from decomposing protein-rich organic matter like algae. Ammonia contributes to odor and can be an irritant.
- **Oxygen (O_2):** (and possibly Nitrogen) in the gas, to understand if the decomposition is mostly aerobic or anaerobic (low O_2 indicates more anaerobic conditions leading to methane).
- **Volatile Organic Compounds (VOCs):** (Optional, if equipment allows) – e.g. measure total VOCs or specific compounds like dimethyl sulfide which might be emitted from seaweed. This is less critical but could be noted qualitatively if odors beyond H_2S/NH_3 are detected.

Frequency: Gas monitoring should ideally be continuous or semi-continuous during the pilot use of portable gas detectors or stationary sensors. At a minimum, the consultant should take gas readings daily for the first 1-2 weeks of the pilot (when freshly buried sargassum is actively decomposing) and then weekly thereafter. If continuous data loggers for CH_4/CO_2 are available, they should be deployed to see diurnal patterns. H_2S can be spot-checked with a handheld meter (and safety H_2S monitor should be always worn by personnel during site work). Any time a strong odor or spike is suspected; additional measurements should be taken. Weather conditions should be noted (as calm days might allow gas build-up, whereas wind disperses it).

Sample Points: Measurements should be taken at the surface of the pilot cell (near any gas vents installed, or by inserting a probe just above the pile under any temporary cover). Also measure at ground level around the perimeter of the pilot cell to check if H_2S is accumulating near the ground (important for worker safety). If possible, also measure just downwind of the pilot site at some distance (e.g. 50 m away) to gauge how far odors might carry. For methane, if a vent or small flare is installed, measure at that point to gauge the methane content of collected gas. All instruments used should be calibrated, and the consultant should record the time, location, and conditions of each measurement. If any gas capture or oxidation system is trialed (e.g. bio-filter), monitor its inlet vs outlet concentrations.

Other Environmental Observations:

In addition to leachate and gas data, the consultant should log observations that might not be captured by instruments, such as: the presence of vectors or scavengers (insects, birds) at the site, any noticeable seepage or

surface runoff during heavy rain (to see if leachate escapes the cell), the efficacy of any cover material in controlling odor, and the general state of the sargassum (e.g. how quickly it decomposes, any spontaneous combustion or unusual behavior). If any nearby water bodies or groundwater wells are adjacent to the pilot site, the consultant should, in coordination with authorities, take at least one water sample from those (upgradient and downgradient, if applicable) to ensure no contaminants appear (this is a precautionary step given the pilot's small scale, but important for community assurance if applicable. These would be tested for basic parameters like nitrates or any indication of leachate influence, just to confirm containment effectiveness.

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