



# Herring River Carbon Project Feasibility Study

**Final Report**

Prepared For

**Restore America's Estuaries**



Author / S. Settelmyer, E. Swails, J.Eaton

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# Executive Summary

The Herring River Restoration (HRR) project involves replacing and installing up to three new tidal gates in the Herring River floodplain that would restore tidal flows to more than 1,000 acres of former salt marsh. In addition to restoring native vegetation and habitat for fish and wildlife, the project would generate greenhouse gas (GHG) benefits by reducing methane emissions and increasing sequestration of carbon dioxide in restored marsh soils. This report, prepared in connection with the Bringing Wetlands to Market (BWM) project, evaluates the feasibility of developing a carbon offset project to monetize the GHG benefits of the HRR project, and considers the market, technical, financial, legal, and organizational aspects of carbon project development.

## *Market Analysis*

At the current time, the HRR project would be able to sell carbon offsets into the voluntary market. While no compliance markets currently accept carbon offsets from tidal restoration projects, the development of such projects in the voluntary market will provide needed evidence that the GHG benefits from these types of projects can be reliably quantified and included in regulatory programs in the future. Buyers in the voluntary markets consist mainly of U.S. and European multinational companies in consumer facing industries such as financial services and technology. Demand in the voluntary market has been steady over the past few years, averaging about 75 million tons per year based on the most recent market survey. Due to an increased supply of offsets, prices in the voluntary market have fallen over the past few years and averaged \$3.00/ton as of the last market survey. However, prices of offsets from individual projects varied widely based mainly on the environmental and community co-benefits that they generate. Average prices for land-based carbon offsets trade at a premium to other sectors ranging from \$4.20/ton to \$9.50/ton in the most recent market survey. Based on the climate change adaptation co-benefits, and the interest in blue carbon amongst buyers, we believe that offsets from the HRR project should trade at the high end of land-based offsets.

## *Technical Analysis*

The HRR project meets the applicability and additionality requirements of the VCS Methodology for Tidal Wetland and Seagrass Restoration (VM0033) and therefore this methodology can be utilized to account for the GHG benefits of the project. The key gases and pools to measure include soil methane, soil carbon dioxide, and biomass carbon stocks. Soil related emissions or sequestration (referred to as fluxes) can be quantified for each vegetation type using a combination default values, published values, modeled values, or field collected values. Biomass stocks will need to be quantified using field collected data.

For this feasibility analysis, we estimated soil and biomass GHG emissions for each current and projected land cover class using field data where available and literature estimates where field data was not available. Due to the uncertainty in some estimates, we developed three emission reduction scenarios with varying soil GHG and project area assumptions to illustrate the range of net emission reductions that could be generated by the HRR project (Low, Mid, and High scenarios). We also assumed a staggered implementation schedule for the HRR project over ten years.

**Table E1. GHG Emission Reduction Estimates over 40 years (metric tons CO<sub>2</sub>e)**

<b>Results</b>	<b>Low</b>	<b>Mid</b>	<b>High</b>
Baseline soil emissions (a)	-14,157	62,582	188,346
With project soil emissions (b)	-30,117	-38,274	-148,165
Emissions reductions from the soil pool (c = a-b)	15,960	100,856	336,510
Emissions from the biomass pool (d)	16,280	16,280	14,519
Emission reductions from soil and biomass pool (e = c-d)	-320	84,576	321,991
Non-permanence buffer (f)	0	0	-10,383
<b>Carbon offsets (e+f)</b>	<b>0</b>	<b>84,576</b>	<b>311,608</b>

Our Mid scenario estimate of carbon offsets generated by the HRR project over the initial 40-year crediting period is approximately 85,000 metric tons CO<sub>2</sub>e. Due mostly to uncertainty in the amount of methane emissions in the low salinity areas (<18 ppt) of the HRR project, the range of outcomes under Low to High scenarios is approximately between 0,000 and 300,000 metric tons CO<sub>2</sub>e over this same time period. Due to the impact of biomass emissions, the project would generate cumulative positive emission reductions starting in years 36, 11, and 3 in the Low, Mid, and High scenarios respectively. Supplemental analysis of Phase 1 areas (owned by the National Park Service) is included in the appendix of our report.

#### *Financial Analysis*

We assessed the financial feasibility of the HRR project by estimating the net cash flows over the first 40 years of the project as well as the payback period to cover carbon project costs. Our assessment is based on three scenarios of offsets that would be generated, carbon offset prices, as well as carbon project costs.

We assessed cash flows at offset prices from \$5.00-\$15.00/ton in our three scenarios, with \$5.00/ton representing a mid-point for land based carbon transactions in the voluntary market, \$10.00/ton representing the high end of prices observed for voluntary offsets from land-based projects, and \$15.00/ton approximating today's

compliance market prices and acknowledging the possibility of expanded compliance markets over the 40 year time horizon of our analysis. We assumed carbon project costs were the same across all three scenarios, consisting of \$150,000 in upfront costs for project design and third-party validation, and \$75,000/year every five years for monitoring and third-party verification of emission reductions (noting that carbon monitoring is not just a cost, but also provides a benefit to the project).

As illustrated below, based on our assumptions, cash flows over 40 years are above break-even in the Mid Scenario and significantly positive in the High Scenario. Net cash flows in the Low Scenario are negative over 40 years resulting from low projections of carbon offsets.

**Table E2. Financial flows and metrics over 40 years**

	Low	Mid	High
Revenues	\$0	\$845,755	\$4,674,125
Expenses	-\$750,000	-\$750,000	-\$750,000
Net Cash Flows	-\$750,000	\$95,755	\$3,924,125
Payback (years)	N/A	35	10

We also performed sensitivity analysis in each scenario to varying carbon prices up to \$40.00/ton, which is the central estimate for the social cost of carbon as well as the carbon price that many economists consider necessary to sufficiently reduce GHG emissions and avoid the worst impacts of climate change. We found net cash flows are negative at all carbon price assumptions for the Low Scenario. In the Mid Scenario, net cash flows are positive at prices of \$10.00/ton and higher, and net cash flows are significantly positive in the High Scenario at all carbon prices from \$5.00/ton and higher.

**Table E3. Sensitivity of Net Cash Flows to Carbon Prices**

Carbon Price	Low	Mid	High
\$5.00/ton	-\$750,000	-\$327,122	\$808,042
\$10.00/ton	-\$750,000	\$95,755	\$2,366,083
\$15.00/ton	-\$750,000	\$518,633	\$3,924,125
\$20.00/ton	-\$750,000	\$941,510	\$5,482,167
\$40.00/ton	-\$750,000	\$2,633,021	\$11,714,334

### *Legal Analysis*

Carbon offsets that could be generated by the HRR project would accrue to the landowners of the HRR project area. In the case of the HRR project, the primary landowner of the project area is the National Park Service. However, there are a number of private organizations and individuals that also own land that would be part of the project area.

Therefore, to claim emission reductions for the entire HRR project area, it will be necessary to secure agreements with all landowners that transfer carbon rights on their lands. In this way, a single project can be developed that covers the entire project area. If it is difficult to secure the participation of affected landowners at the start of the project, the HRR project could be structured as a grouped project to allow the addition of land and landowners to the project subsequent to project validation.

It will also be important to further assess the authority of the NPS to sell or transfer carbon offsets from the project to a buyer or funding partner. Precedent carbon offset transactions, within the Department of Interior (DoI) at the U.S. Fish and Wildlife Service (USFWS), were structured as donations subject to conditions (i.e., carbon rights transfer) that furthered the interest of the USFWS.

### *Organizational Analysis*

Finally, we assessed the roles and responsibilities of key participants if a carbon project is developed, and have identified potential organizations to fill each role. Restore America's Estuaries could be a logical choice to serve as the project proponent, in particular, to lead the technical development and sale of offsets from the carbon project. The National Park Service (NPS) and a number of private individuals and organizations would be the landowners and carbon offset owners. The Town of Wellfleet (who will own bridge and tide gate) and Friends of Herring River (who will manage the level of tidal flows - at Mill Creek and Chequessett Road-- and who could manage landowner relations for the carbon project) would be considered implementation partners. Technical partners would include research partners (organizations supporting BWM), consultants, and third-party validation and verification bodies (auditors). If the project moves forward, agreements between participants that spell out roles and responsibilities will need to be drafted.

*Next Steps*

We recommend the following next steps before moving forward with a decision to pursue carbon project development, understanding that some of these steps may operate in parallel.

**Table E4. Next Steps**

Next Steps
1. Request review and advice from Department of Interior counsel regarding transfer of carbon rights on NPS lands.
2. Collect additional CH <sub>4</sub> data from low salinity systems (<18 ppt) in all strata that cover the HRR project area to narrow the range of potential offsets, and to serve as basis for quantifying CH <sub>4</sub> emissions for the project.
3. Finalize technical approach, including publishing of soil C and CH <sub>4</sub> papers, and additional sea level rise modeling for baseline and with project scenarios.
4. Identify potential grant funding sources to cover costs with initial project development and first monitoring event.
5. If deemed feasible, draft agreements amongst all partners and proceed with project development (after restoration funding is secured).

# 1.0

## Introduction

### 1.1 Background

The Herring River floodplain in Wellfleet and Truro, Massachusetts is composed of approximately 1,100 acres of former salt marsh, intertidal flats, and open-water habitats. In the early 1900s, a dike was constructed at the mouth of the Herring River at Chequessett Neck to help control salt marsh mosquitos. The dike (rebuilt in the 1970s), along with smaller dikes upstream, allows only minimal tidal exchange leading to significant degradation of the flood plain.

Degradation impacts are many. Soils have subsided by up to 3 feet in many places as sediments have been blocked and drainage has led to aeration and oxidation. Salt marsh vegetation has been replaced by freshwater and upland vegetation and trees. Fisheries have declined as the acidity of the water has increased and dissolved oxygen levels have decreased due to reduced tidal flushing.

In 2005, the town of Wellfleet (who owns the Chequessett Road dike) and the National Park Service (NPS) (Cape Cod National Seashore owns about 80% of the floodplain) agreed to work together to restore the river floodplain. A series of studies were evaluated as part of the Herring River Final Environmental Impact Statement/Report to assess the environmental impact of three restoration alternatives.

The preferred restoration alternative calls for replacing the dike at Chequessett Road with a new tidal gate that would have wider openings and allow more tidal flows to reach upstream. It also calls for new tidal gates at Mill Creek and Pole Dike Creek Road. The gates would be adjusted gradually over time based on monitoring and using adaptive management, with tidal range increasing from about 2 feet currently to 5.9 feet at mean high water spring tides when fully implemented. In addition to installing new tidal gates, restoration plans include implementing flood mitigation measures at a golf course (Chequessett Yacht and Country Club) to elevate lower lying areas which could be periodically flooded post restoration, along with additional flood mitigation at other private properties and roads.

## 1.2 Objectives

This report documents the results of a feasibility study to determine if the planned restoration (herein referred to as the Herring River Restoration project or HRR project) could be implemented as a blue carbon offset project and generate net carbon revenues. The feasibility study evaluates the market, technical, financial, legal, and organizational aspects of developing a carbon project around the HRR project.

This carbon project feasibility study is part of the second phase of the Bringing Wetlands to Market (BWM) project. The BWM project is a multi-year research project led by the Waquoit Bay National Estuarine Research Reserve (WBNERR) and funded by the NOAA National Estuarine Research Reserve Science Collaborative. The project goals are to provide the science and tools necessary to quantify and value the climate benefits of coastal wetlands.

The outputs from phase one of the project (BWM 1.0) included an approved carbon accounting methodology for tidal wetland restoration, a user-friendly model to estimate the GHG fluxes from tidal wetland restoration, and an economic and policy analysis of carbon storage in tidal wetlands.

The outputs from phase two of the project (BWM 2.0) include this carbon project feasibility study, additional research data to expand the GHG model to a range of ecological conditions in New England, and educational activities to stakeholders to increase the understanding of blue carbon and the tools that have been developed as part of the BWM project.

# 2.0

## Market Analysis

### 2.1 Overview

Carbon offsets may be transacted on voluntary or compliance carbon markets. In voluntary carbon markets, buyers are typically motivated by corporate social responsibility – they are concerned about climate change and have set a target to reduce their emissions, outside of or ahead of regulation. In compliance carbon markets, buyers are motivated to purchase offsets when they offer a more cost-effective way to meet their requirements to cut emissions under the law – for instance, if the price of offsets falls below the cost of allowances or the carbon tax<sup>1</sup>.

As discussed below, at the current time, the Herring River Restoration project could only sell offsets into the voluntary markets, as compliance markets do not currently accept offsets from tidal wetland restoration projects. However, we examine both the voluntary and compliance markets to help frame the short-term opportunities as well as the long-term opportunities to sell carbon offsets from the HRR project.

### 2.2 Voluntary markets

Voluntary carbon offsets are issued to eligible projects by voluntary standards such as the Verified Carbon Standard (VCS), American Carbon Registry (ACR), and the Climate Action Reserve (CAR). Tidal wetlands restoration projects, such as the HRR project, are currently only eligible under the VCS which is the dominant voluntary standard in the carbon market, representing about 50% of all newly issued credits<sup>2</sup>.

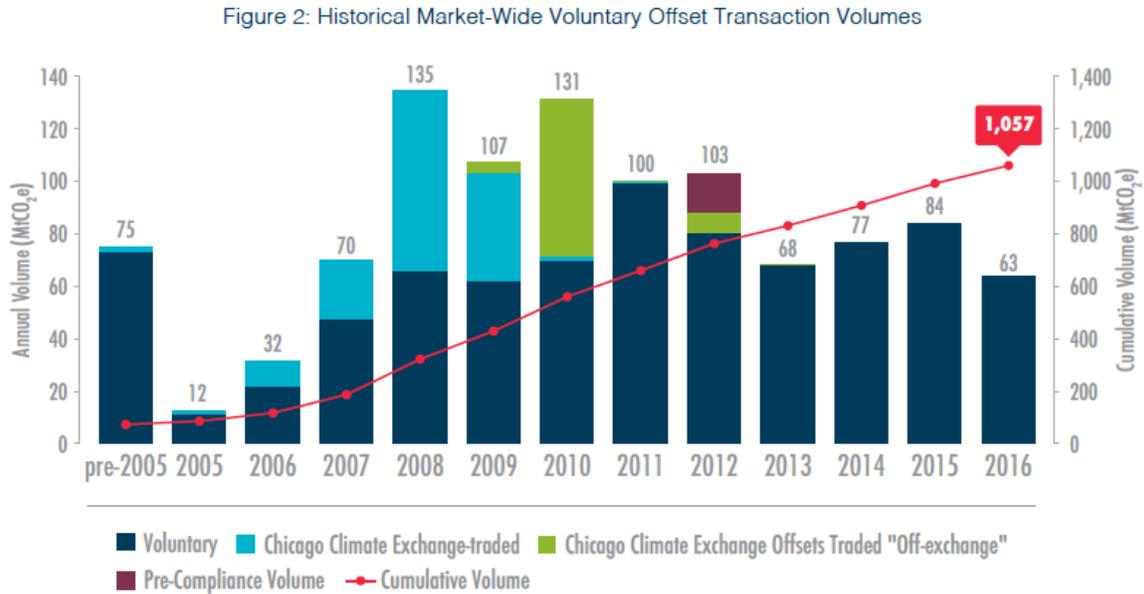
The voluntary market has been transacting certified carbon offsets for about 10 years. In that time, about 1 billion tons have been sold at a value of \$4.8 billion (see Figures 2.1 and 2.2 below).

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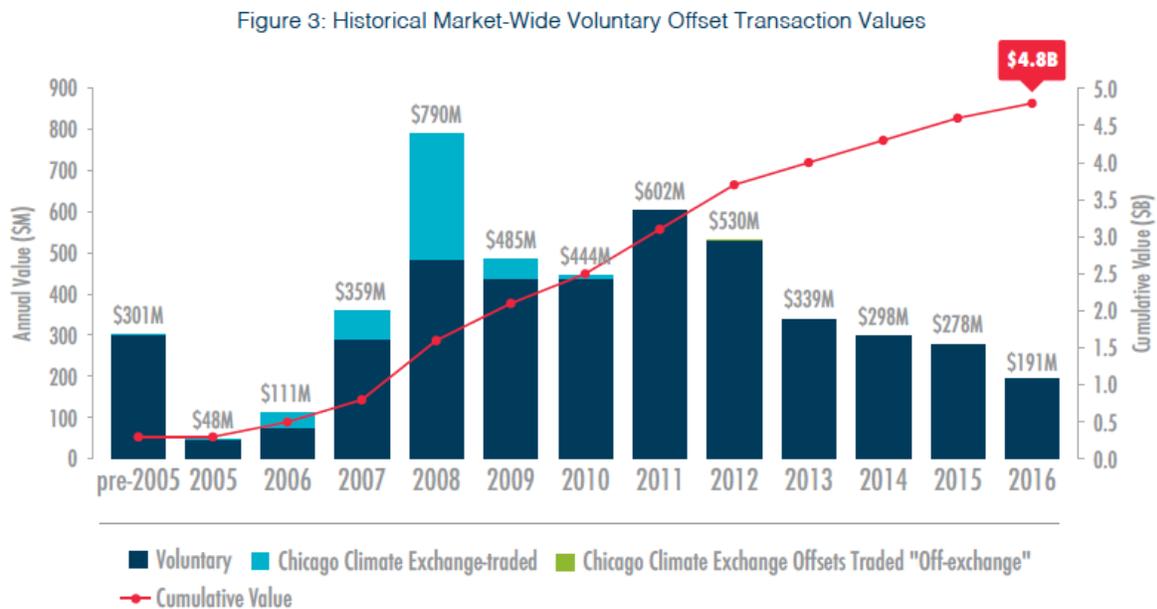
<sup>1</sup> Goldstein, Allie. *The Bottom Line: Taking Stock of the Role of Offsets in Corporate Carbon Strategies*. Washington, DC: Forest Trends, 2015.

<sup>2</sup> Hamrick, Kelly. *Unlocking Potential: State of the Voluntary Carbon Markets 2017*. Washington, DC: Forest Trends, 2017

**Figure 2.1. Historical Market-Wide Voluntary Offset Transaction Volumes<sup>2</sup>**



**Figure 2.2. Historical Market-Wide Voluntary Offset Transaction Values<sup>2</sup>**



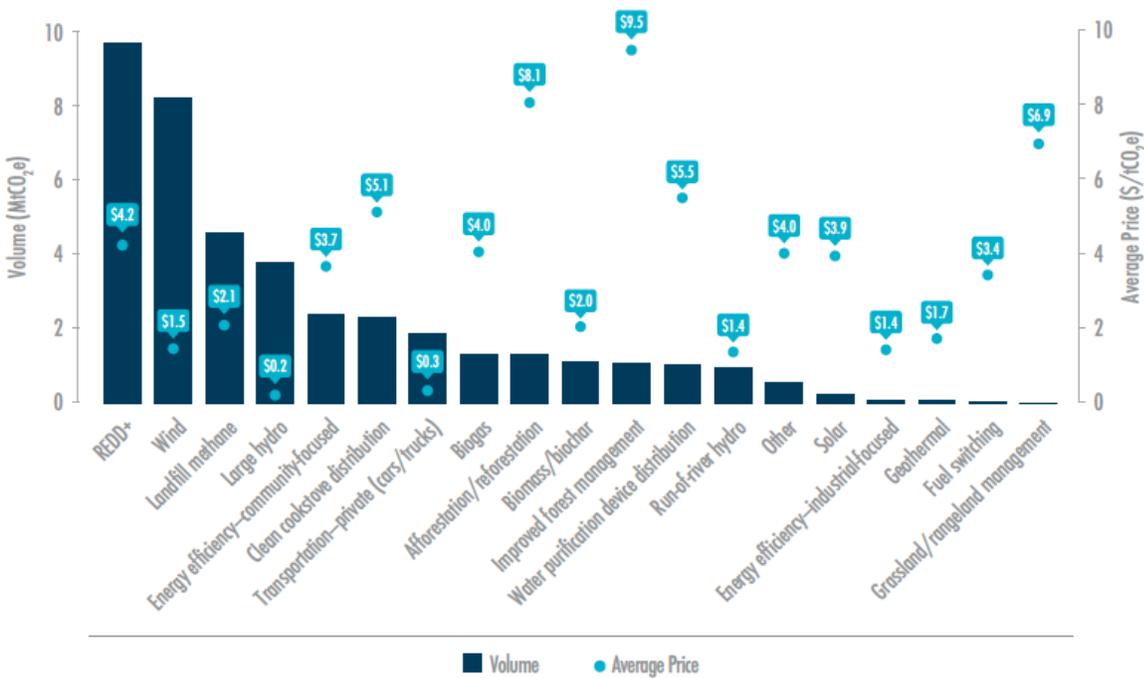
As illustrated in Figure 2.2, the volume of offsets sold in the voluntary market has fluctuated over time, with recent volumes between 2014 and 2016 averaging about 75 million tons. Over the past few years, because the supply of offsets has increased

faster than demand, average prices have dropped to \$3.00/ton in 2016 (compared to \$5.00/ton in 2013).

Forestry and other land use offsets continues to be one of the most popular project types in the voluntary carbon market, accounting for more than 25% of all voluntary transactions in 2016. While the average voluntary carbon price in 2016 across all project types was \$3.00/ton, the average prices for forest and land use projects ranged from \$4.20/ton (avoided deforestation) up to \$9.50/ton (improved forest management) (see Figure 2.3).<sup>2</sup>

**Figure 2.3. Average offset prices in 2016 by project type<sup>2</sup>**

Figure 6: Transacted Volume, Average Price, and Price Range by Project Type, 2016



The buyers of voluntary credits are companies located mainly in North America and Europe. Most buyers come from consumer-facing industries, with companies in the energy, financial services, consumer goods, and transportation industries topping the list. Beyond purchasing offsets to meet emission reduction targets, buyers are interested in supporting projects with strong co-benefits (i.e., benefits in addition to greenhouse gas mitigation) and projects that are located in the same region(s) that their businesses operate.

Tidal wetland restoration projects, like the HRR project, should be well positioned to sell offsets to voluntary buyers as they can be expected to generate a number of co-benefits, including increased resilience to sea level rise and storm surges and improved water quality for shellfish and finfish. We expect U.S.-based buyers to

have the strongest interest since the co-benefits will be most appreciated by stakeholders in the United States. For reference, we have compiled a partial list of U.S. based voluntary offset buyers (Table 2.1 below) that could be contacted about offsets from the HRR project should the carbon project development go ahead.

**Table 2.1. US-Based Companies in Top 100 Voluntary Offset Buyers<sup>1</sup>**

Company	Industry	Location
Biogen	Biotech	Massachusetts
Entergy	Energy	Louisiana
Capital One Financial	Financial Services	Georgia
Delta Airlines	Transportation	Georgia
Exelon	Energy	Illinois
FedEx	Transportation	Tennessee
General Motors	Transportation	Michigan
Goldman Sachs	Financial Services	New York
Hilton Worldwide	Tourism	Virginia
Google	Technology	California
Interface	Consumer goods	Georgia
Intuit	Technology	California
JP Morgan Chase	Financial Services	New York
Microsoft	Technology	Washington
Office Depot	Consumer goods	Florida
PG&E	Energy	California
Reynolds American	Consumer goods	North Carolina
SC Johnson	Consumer goods	Wisconsin
State Street	Financial Services	Massachusetts
UPS	Transportation	Georgia
Walt Disney	Tourism/Communications	California

### **Future developments -- CORSIA**

The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) is the most significant future development for the voluntary carbon offset market. International aviation is excluded from the UN's Paris Agreement on climate change, and instead, the airline sector working through UN's International Civil Aviation Organization (ICAO), has committed to carbon neutral growth in international aviation beginning in 2021. These commitments are the first sectoral GHG commitment in the world and will be implemented through CORSIA. Under CORSIA, airlines will be able to achieve GHG targets by improving aircraft fuel efficiency, transitioning to cleaner fuels (e.g. biofuels), and purchasing carbon offsets. Considering recent and expected rapid growth in international air travel, and the current scarcity of biofuels and efficiency opportunities for aviation, it is expected that airlines will rely heavily on offsets to meet their targets.

It is forecast that CORSIA could provide 1.6-3.7 billion tons of demand for offsets between 2021 and 2035<sup>3</sup>. ICAO has indicated that it will allow offsets issued by voluntary carbon standards that meet broad criteria, however, the rules regarding eligible offset project types, standards, and vintages (year in which emission reductions occur) have been delayed and recently delegated to a newly formed Technical Committee within ICAO. While many observers expect that land based credits issued by most voluntary carbon standards will be eligible with CORSIA, the process to date has been slow and opaque.

The ultimate demand for offsets from CORSIA and its impact on offset prices will depend on the implementation of CORSIA as previously announced by each country, as well as on the final rules that are adopted around eligible offsets.

## 2.3 Compliance markets

At the moment, there are no compliance markets that accept offsets from tidal wetland restoration projects. However, we have reviewed the only two compliance cap-and-trade programs in the United States, the California GHG program and the Regional Greenhouse Gas Initiative, which could be relevant to the HRR project if future changes are made to offset rules in these programs. We have also reviewed a new compliance program under consideration in the northeast that could provide additional demand.

### *California GHG Program*

The California cap-and-trade program started in 2013 and is one of several policies implemented in California aimed at reducing GHG emissions. The first phase of the program covers the period 2013-2020 with the goal to reduce California's emissions to 1990 levels by 2020. The program initially covered large emitters (>25,000 tons CO<sub>2</sub>/year) in the electricity generation sector and was expanded in 2015 to also cover transportation, residential, and commercial fuels.

Under the cap-and-trade program, regulated entities are required to purchase and retire allowances or offsets equal to their GHG emissions during the relevant compliance period. The program regulator, the California Air Resources Board (ARB), has approved six offset protocols to date covering forests, urban forests, livestock methane, ozone depleting substances (ODS), rice cultivation and coal mine methane projects. From 2013-2020, regulated companies can use offsets to meet up to 8.0% of their compliance requirement.

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<sup>3</sup> CORSIA: Quantification of the Offset Demand, Sean Healy, Berlin, June 2017

Since the offset program started, ARB has issued more than 150 million tons of offsets with forest offsets accounting for more than 75% of all issuances, or 120 million tons as of March 15, 2019.

In 2017, the California legislature extended the cap and trade program from 2021 to 2030 and made several changes to the offset rules. The offset limit will drop to 4.0% from 2021-2025 and then increase to 6.0% from 2025-2030. Additional limitations will be imposed so that not more than 50% of offsets used from 2021-2030 can be sourced from projects that do not have a direct environmental benefit (DEB) in California (still being interpreted, projects located in the state of California will meet this requirement).

Prices for offsets in California are closely linked to allowance prices which represent the alternative compliance instrument for regulated companies. Allowances prices in California have traded at or near the price floor established by the program for its allowance auctions. The auction floor price was initially set in 2012 at \$10.00/ton with annual increases at 5%+CPI; for 2019, the auction floor price has been set at \$15.62/ton.

Since the start of the program, offset prices have traded at a discount to allowance prices, in part to provide a price incentive for compliance buyers to purchase offsets. California compliance offsets have recently traded around \$12-13/ton.

Forest projects located in the lower 48 states and southeast coastal Alaska are generally eligible to participate in the ARB compliance offset program. The only exclusions are projects located on federally owned land (as in case of the HRR project) or projects on land where a federal entity holds an easement. When ARB issued the compliance forest offset protocol, ARB stated that it excluded projects on these lands due to their additional complexity and that further study would be needed (in particular, about enforceability of ARB's rights on federal entities).<sup>4</sup>

At this moment, ARB currently does not issue carbon offsets to other land use projects such as tidal wetland restoration. However, new offset methodologies can be developed and submitted to ARB for consideration by standards bodies such as the VCS, ACR, or CAR. In fact, two new offset methodologies have been approved (coal mine and rice methane) since the ARB offset program was first established.

While it is hard to know whether ARB would approve a tidal wetlands restoration methodology in the future (or whether it would also contain a federal lands exclusion), it is certain that pilot blue carbon projects like the HRR project would

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<sup>4</sup> <http://www.arb.ca.gov/regact/2010/capandtrade10/cappt5.pdf>, page 15

help inform ARB's decision by demonstrating how these types of projects could accurately quantify GHG emission reductions.

*Regional Greenhouse Gas Initiative (RGGI)*

RGGI is a cap and trade program that operates in nine northeastern states, including Massachusetts, Connecticut, Maine, Maryland, New Hampshire, New York, Rhode Island, and Vermont. It started in 2009 and covers only electric utilities. New Jersey has recently announced that it will be rejoining RGGI in 2021.

Due to an initial oversupply of allowances, prices for RGGI allowances fell to the floor price which had been set at around \$2.00/ton. In 2012 and in 2017, regulators lowered the emissions cap (and hence supply of allowances). Despite the lower cap, prices in RGGI have remained low (\$5.35/ton in December 2018 auction).

RGGI allows regulated companies to use offsets from projects that reduce GHG emissions (including forests, landfill methane, and livestock methane) to meet 3.3% of their compliance obligation, provided that the projects are located in a RGGI state or in another state that has an MOU in place with that RGGI state. Due to the low prices for RGGI allowances, only one offset project has been registered to date (related to landfill methane reduction).

While it's premature to predict offset project development in RGGI, we believe that adding tidal wetland restoration projects as an eligible offset project type over the longer term could be supported by many of the RGGI states that rely on tidal wetlands for their own coastal protection such as Massachusetts. Of course, as mentioned above, pilot projects like the HRR project could serve as valuable demonstration that the climate benefits of tidal wetland restoration can be reliably quantified.

*Future compliance markets*

New compliance market opportunities may also emerge in the future that could provide additional demand for offsets from tidal wetland projects like the HRR project. One new program in the early stages of consideration is the Transportation and Climate Initiative, or TCI, which is a new collaboration between 12 northeast and mid-Atlantic states (including Massachusetts) and the District of Columbia to cap and reduce transportation sector emissions. Details of the program, including the emissions cap, entities covered by the program, and the use of offsets have not yet been determined. TCI has an ambitious goal to complete design by December 2019 after which each jurisdiction will need to decide whether to adopt and implement the program.

# 3.0

## Technical Analysis

### 3.1 Methodology applicability

In late 2015, the VCS approved the first globally applicable methodology for tidal wetland restoration - VCS Methodology for Tidal Wetland and Seagrass Restoration (VM0033) - that was developed as part of phase one of the BWM project. We have reviewed the applicability conditions of the VCS Methodology for Tidal Wetland and Seagrass Restoration (VM0033), herein after referred to as the “methodology”. These conditions would need to be met in order to use the methodology to account for the GHG benefits of the HRR project.

The detailed results of our assessment are contained in Appendix 1. Key conclusions are:

- The HRR project activities of removing barriers and restoring tidal flows to tidally restricted wetlands are eligible activities under the methodology (applicability conditions #1 and 2).
- The HRR project meets the condition that no productive activities are occurring in the project area that could be displaced from restoration and result in off-site emissions (applicability condition #3).
- Harvesting of live tree biomass and prescribed burning (potential HRR project activities) are permitted under the methodology (applicability conditions #4 and 5).
- The hydrological connectivity of the HRR project to other areas must not result in increased offsite GHG emissions (applicability condition #12). Therefore, it will be important to delineate the HRR project area to include all areas to which it is hydrologically connected and where increased GHG emissions could be expected, so that a full accounting of GHG impacts is performed.
- Nitrogen fertilizer cannot be applied in the project area after restoration (applicability condition #14). If the area of the golf course that will be impacted by restoration is elevated, and therefore hydrologically isolated from the project area, then it can be carved out of the project area to meet this condition while still meeting the above applicability condition (#12).

## 3.2 Additionality requirement

In addition to meeting the methodology applicability conditions, a carbon project must also satisfy an additionality requirement to ensure that the project would not have occurred in the absence of carbon market incentives or as part of “business-as-usual” activities.

In the case of the VM0033, all tidal wetland restoration projects located in the United States are deemed to meet the additionality requirement (due to the low penetration or occurrence of these activities) so long as they are not required by any law, statute, or other regulatory framework. Therefore, because it is located in the United States and is not required by any law, statute or regulation, the HRR project would meet the additionality requirement of the methodology.

## 3.3 GHG Accounting Approach

### *Project Area*

Assuming all landowners participate in the carbon project (see section 5 and 6), the project area under the preferred restoration alternative (Alternative D) is approximately 1,006 acres and includes all areas that are hydrologically connected and that would be impacted by the HRR project activities. A preliminary map of the project area is provided in Figure 3.1 below.

**Figure 3.1. HRR Project Area (in red below)** <sup>5</sup>



FIGURE I-1: HERRING RIVER RESTORATION PROJECT AREA

### GHG Pools/Fluxes

The methodology identifies the carbon pools and greenhouse gases (GHGs), that if significant, must be accounted in the baseline and project scenario to determine the net greenhouse gas impacts of tidal wetland restoration projects (see Table 3.1). The options for measuring these pools and gases are outlined in the methodology and summarized in Appendix 2. The baseline scenario represents the most likely land use scenario in the project area during the project crediting period in the absence of the restoration project. The project scenario is the land use scenario in the project area during the crediting period after the restoration project is implemented. See section 3.4 for further discussion of land use classes in the baseline and project scenarios.

**Table 3.1. Carbon Pools and GHGs for Tidal Wetland Restoration Projects**

Pool/Greenhouse Gases	Sub-pools/greenhouse gases
Biomass	Trees/Shrubs + Herbaceous Vegetation
Soil	Soil CO <sub>2</sub> -Deduction for Allochthonous Soil CO <sub>2</sub> +SoilCH <sub>4</sub> +SoilN <sub>2</sub> O
GHG Fossil Fuel Burning*	CO <sub>2</sub>
Non-CO <sub>2</sub> Emissions from Prescribed Burning (vegetation)*	CH <sub>4</sub> +N <sub>2</sub> O

\*Not detailed in this report due to relative insignificance

<sup>5</sup> Final Environmental Impact Study, page 3

## **Biomass**

Under the methodology, the GHG flux from the biomass pool is estimated based on changes in biomass carbon stocks. The carbon stocks in the biomass pool would be estimated at the start of the project using field data for woody biomass (collected by J.Fouse and T.Smith) and default values from the methodology for herbaceous biomass. For the baseline scenario, biomass stocks could be modeled forward based on expected growth rates. For the project scenario, biomass stocks would be re-measured periodically (e.g., every 5 years) using field collected data (e.g., diameter at breast height by species) for woody biomass and using default values for herbaceous vegetation.

Across the entire HRR project area, we have assumed that biomass carbon stock changes in the baseline scenario, representing a mature steady-state system, are negligible, and that biomass carbon stock changes in the project scenario will be negative, or a net emission, as lower biomass salt marsh systems replace higher biomass forest and woodland/shrubland systems.

## **Soil**

GHG flux from the soil pool includes carbon dioxide (CO<sub>2</sub>) emissions (adjusted for carbon sequestered offsite but transported into the project area – so called allochthonous carbon), methane (CH<sub>4</sub>) emissions, and nitrous oxide (N<sub>2</sub>O) emissions.

In the case of the HRR project, soil CO<sub>2</sub> emissions can be estimated based on soil carbon stock changes. For the baseline, soil carbon stock changes can be estimated using field measurements of soil carbon accretion for each vegetation type in the HRR project area previously collected by the BWM Science Team (see Table 3.4). For the project scenario, soil carbon stock changes can also be estimated from similar, periodic field measurements going forward. The BWM team collected two cores for each vegetation type and used lead-210 age dating to measure soil accretion. Additional plots may be necessary to meet precision targets and avoid uncertainty deductions under the methodology. The methodology requires deductions where precision levels exceed 20 percent or 30 percent at the 90 percent or 95 percent confidence intervals respectively.

The methodology also allows for the use of published values for estimating soil CO<sub>2</sub> emissions in the baseline and project scenario. Therefore, ongoing field measurements could be avoided if the existing soil carbon measurements collected by the BWM Science Team were published. A paper including estimates of soil CO<sub>2</sub> emissions for each vegetation strata at HRR would need to be published in a peer-reviewed journal.

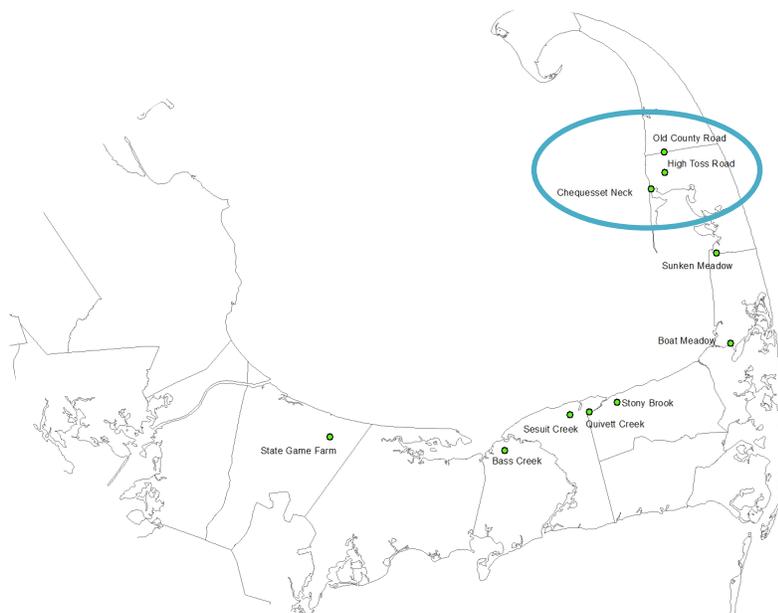
For the HRR project, soil CH<sub>4</sub> emissions for each vegetation type in the baseline and project scenario could be estimated from a variety of sources. For example, for areas

covered by salt marshes with salinity > 18 ppt (a majority of the salt marsh areas in the restored HRR project area), default values from the methodology can be used to estimate soil CH<sub>4</sub> emissions.

Alternatively, for salt marsh areas across a wider range of salinities, estimates of soil CH<sub>4</sub> emission rates can be estimated using the GHG model that is being developed as part of the BWM project. This model (“BWM GHG model”) estimates CH<sub>4</sub> emissions based on easily observed variables like soil salinity, soil temperature and sunlight. The methodology requires models to be peer-reviewed and published, and to have been validated with “direct measurements from a system with the same or similar water table depth and dynamics, salinity, tidal hydrology, sediment supply and plant community type as the project area”.

The BWM GHG model will be developed with direct measurements of model parameters and GHG emissions collected from both natural and restored salt marshes on Cape Cod (including three sites in the HRR Project Area) as well as in Rhode Island. See Figure 3.2 below. These so-called Tier 1 sites of the BWM project were selected to cover a range of salinity, vegetation, and hydrological gradients of salt marshes that are also found in the HRR project area, and therefore, it is anticipated that the model would meet the methodology requirement above and could be used to estimate the GHG emissions in salt marshes in the project area in both baseline (current) and project (restored) scenarios once peer reviewed and published.

**Figure 3.2. Tier 1 Sites in BWM Project** (sites at HRR Project area in blue circle)



We note that the methodology is silent on how baseline emissions should be projected if a model is used, and how baseline parameter values for the model should be estimated. In the case of the HRR project, we suggest that parameter values that are influenced by the project (soil salinity) are estimated for baseline projections based on historical field data. We further suggest that parameter values that the project does not influence (like soil temperature and sunlight) should be updated each year based on actual observed values. In this way, a dynamic baseline, whereby baseline emissions are updated each year, would be employed and ensure that any emission reductions that are generated are related to project activities.

For non-salt marsh areas not covered by default values or the BWM GHG model (see Table 3.2), soil CH<sub>4</sub> emissions can be estimated based on field measurements or published values. Published values can be used to establish baseline CH<sub>4</sub> emissions and for estimating with project CH<sub>4</sub> emissions in non-salt marsh areas over the length of the project crediting period. Because published values must be suitable to the project area, the CH<sub>4</sub> data collected by the BWM Science Team should be expanded to all non-salt marsh vegetation strata in the HRR project area and collected over a longer time period (existing data for fresh emergent marsh covers only for 5 days over the course of the growing season in 2017). Expanding data collection and publishing a paper with the results would avoid the cost of ongoing CH<sub>4</sub> field measurements during the life of the HRR project.

Finally, soil N<sub>2</sub>O emissions are likely minimal and can either be excluded as insignificant (<5% of estimated net emission reductions) (e.g., justified by regional research by Moseman-Valtierra et al.) or included using default values from the methodology.

### 3.4 GHG Assumptions

For purposes of this feasibility study, we estimated soil and biomass GHG emissions for current (baseline) and projected (project) land cover classes. The current and projected land cover classes were determined based on SLAMM modeling of existing conditions and conditions with restoration of tidal flows to the project area prepared by USGS and provided by the National Park Service (NPS) (Table 3.2). We note that the area included in the SLAMM analysis is slightly less (968 acres) than the total number of acres in the project area per the EIS (1,006 acres). We further note that the HRR project may be implemented in phases, and have therefore provided estimates of project area for the Phase 1 area only (owned by NPS) in Appendix 3.

Baseline conditions represent current land cover in the HRR project area. If the project is developed, further modeling of the baseline over the length of the baseline period incorporating the effects of sea level rise will be required (per the

methodology). The VCS requires tidal restoration projects to update their baseline emission projections every 10 years. Further modeling over 40 years would also improve our estimates of baseline emissions that are provided below. Based on discussions with the BWM Science Team, modeling could incorporate the impact of higher water tables within the HRR project area that are likely to lead to the transition of low-lying wooded and shrub vegetated areas (with high biomass stocks and lower methane emissions) to fresh emergent marsh (with lower biomass stock and higher methane emissions) and likely results in higher baseline emissions than we have estimated here.

Project conditions represent future land cover scenarios 5 years after the HRR project is fully implemented and do not incorporate sea level rise. Project condition #2 assumes intensive management to promote accretion and restore native intertidal habitat and is used in our High scenario to estimate GHG emission reductions. Project condition #1 does not make this assumption and is conservatively used in our Low and Mid scenario estimates. Further modeling of the project scenarios over 100 years that also incorporate sea level rise and the associated impacts on groundwater and vegetation will also need to be completed if the project is developed and would improve our estimates of GHG emissions in the project scenario which are provided below.

**Table 3.2.** Land cover classes and areas projected under baseline and project scenarios from SLAMM modeling (T. Smith, 10 May 2019)

Land cover	Area (hectares)		
	Baseline Condition	Low and Mid Scenarios Project Condition #1	High Scenario Project Condition #2
Upland	10	1	1
Non-tidal Wooded Swamp	116	9	9
Scrub-Shrub Freshwater Wetland	90	18	14
Fresh Emergent Marsh (<5 ppt)	123	10	10
High Salt Marsh	1	0	82
Low Salt Marsh	24	112	216
Tidal Flat	0	156	16
Beach	0	1	1
Open Water	28	85	43
<b>Total</b>	<b>392</b>	<b>392</b>	<b>392</b>

For our analysis, we focused on GHG emissions in non-tidal wooded swamp, scrub-shrub freshwater wetland, fresh emergent marsh, and salt marsh (Table 3.3). We assume that emissions from areas converting to tidal flat and open water in the project are negligible due to high expected salinity and have therefore excluded these areas from the analysis of emissions. Areas converting to other land covers in the project comprise a negligible proportion (<5%) of the project area and are likewise excluded from accounting.

We also divided the freshwater emergent marsh strata into two primary vegetation types - typha and phragmites - based on differences in methane emissions. We estimated the relative areas of these two vegetation types in the baseline and project by applying a ratio of *Phragmites* to *Typha* dominated marsh of 9:43 using data from the *Herring River Restoration Project Final Environmental Impact Statement/Environmental Impact Report* (Final EIS) produced by the Department of Interior, National Park Service, and Herring River Restoration Committee.

**Table 3.3.** Land cover classes and areas in the HRR Project Area

Land cover	Area (hectares)		
	Baseline Condition	Low and Mid Scenarios	High Scenario
		Project Condition #1	Project Condition #2
Non-tidal Wooded Swamp	116	9	9
Scrub-Shrub Freshwater Wetland	90	18	14
Fresh Emergent Marsh-Typha	102	9	9
Fresh Emergent Marsh-Phragmites	21	2	2
Salt Marsh	25	112	298
Areas with insignificant GHG emissions	38	242	60
<b>Total</b>	<b>392</b>	<b>392</b>	<b>392</b>

Relevant assumptions for estimation of GHG emissions from soil and biomass are listed in Table 3.4. These assumptions correspond to Mid scenario assumptions except for those in parentheses which correspond to our Low and High scenario assumptions. The range of scenarios is intended to illustrate the range of outcomes (section 3.5) given the uncertainty in our assumptions. We used low CH<sub>4</sub> and CO<sub>2</sub> assumptions in the Low scenario, and the high ones in the High scenario, on the basis that the HRR project seeks to lower soil CH<sub>4</sub> emissions and increase soil carbon sequestration.

**Table 3.4.** Assumptions for estimation from GHG Emissions by land cover class

Parameter	Non-tidal Wooded Swamp	Fresh Emergent Marsh - Typha	Fresh Emergent Marsh - Phragmites	Salt Marsh	Scrub-Shrub Fresh Wetland
Soil C Storage (t C/ha/yr)	0.67 (+/-0.47)	1.69 (+/-0.56)	1.71 (+/-1.19)	2.48/3.30* (+/-1.17)	1.66 (+/-1.106)
Soil CH <sub>4</sub> Emissions (t CH <sub>4</sub> /ha/yr)	0.42 (.02/.80)	0.42 (0.04/0.80)	0.54 (0.33/3.48)	0.0191	0.42 (.00/.80)
Soil N <sub>2</sub> O Emissions (t N <sub>2</sub> O/ha/yr)	0.000864	0.000864	0.000864	0.000487	0.000864
Herbaceous Biomass (t C/ha)		3.00	3.00	3.00	
AG Woody Biomass (t C/ha)	23.14				16.2
BG Woody Biomass (t C/ha)	4.56				3.24

\*Baseline/Project soil carbon burial rates based on discussion with BWM Science Team

Our estimates of GHG flux from the soil pool include carbon dioxide (CO<sub>2</sub>) emissions (adjusted for carbon sequestered offsite but transported into the project area – allochthonous carbon), methane (CH<sub>4</sub>) emissions, and nitrous oxide (N<sub>2</sub>O) emissions.

Soil carbon burial rates were based on mean estimates from data collected from modern wetlands on Cape Cod by USGS (M. Gonnee, 2 April 2019). Burial rates exclude allochthonous carbon. We subtracted one standard deviation to the mean rates to derive our low scenario assumption and added one standard deviation to derive our high scenario assumption. Soil carbon burial rates for salt marshes restored by the HRR project (3.30 tons C/ha/yr) are expected to be higher than rates in existing salt marshes (2.48 tons C/ha/yr) and similar to other restored sites studied that show increased burial in response to initial elevation deficit (M. Gonnee, 12 April 2009).

Soil CH<sub>4</sub> flux rates were derived from literature estimates (Poffenbarger et al, 2011) and direct measurements of methane taken in 2017 from Herring River and Stony Brook sites (J. Tang, 29 March 2019). For the salt marsh strata, we used mean estimates of direct measurements which indicate that methane emissions that are low which is also consistently observed in the literature. For the other strata, we developed low, mid, and high scenario assumptions to reflect the variability of methane emissions in lower salinity systems (<18 ppt) observed in the literature. We used direct measurement data for the low scenario assumptions in the non-tidal wooded swamp, fresh emergent marsh-typha, and scrub/shrub fresh wetland strata

because it more closely aligned with the minimum values observed in the literature. We used literature values for mid (mean fresh estimate) and high (2x mean fresh estimate) scenarios in these same strata. In the case of fresh-emergent marsh *Phragmites* strata, we used direct measurement data for the high scenario because it was more closely aligned with maximum values observed, and literature values for low (lowest estimate for *Phragmites*) and mid (mean estimate for *Phragmites*) scenarios.

Soil N<sub>2</sub>O flux rates were based on default values specified in VM0033 for non-seagrass wetland systems with average salinity low point >18 ppt (0.000487 t N<sub>2</sub>O/ha/yr) and average salinity low point <5 ppt (0.000864 t N<sub>2</sub>O/ha/yr).

To convert CH<sub>4</sub> and N<sub>2</sub>O emissions to CO<sub>2</sub>-equivalent we applied a 100 year Global Warming Potential of 25 for CH<sub>4</sub> and 298 for N<sub>2</sub>O per the IPCC Fourth Assessment (as required by VCS rules).

Biomass carbon stock changes are assumed to be zero in the baseline (steady state, mature forest). Therefore, GHG emissions from biomass for the HRR project are expected from the reduction in biomass stocks occurring in the project scenario in which higher biomass non-tidal wooded swamp and scrub-shrub freshwater wetland is converted back to lower biomass salt marsh. Aboveground (AG) biomass in large shrubs (10.8 ± 2.4 t C/ha) was provided by NPS with small shrub and vine biomass estimated at 50% of large shrubs (T. Smith, 10 April 2019) (total AG of all shrubs and vines estimated at 16.2 t C/ha). We estimated belowground (BG) shrub biomass by applying a belowground: aboveground ratio of 0.2 (Mokany et al. 2006)<sup>6</sup>. Our estimate of woody biomass in non-tidal wooded swamp included large and small shrubs and vines and trees. Aboveground and belowground biomass in trees was estimated applying an allometric equation for mixed hardwood (Jenkins et al. 2003) assuming an average dbh of 24 cm and a density of approximately 62 trees per hectare (T. Smith, 10 April 2019). We assumed biomass in fresh emergent marsh and salt marsh includes herbaceous vegetation equal to the VM0033 default for marshes (3 t C/ha).

Net GHG emission reductions were calculated as the difference in GHG emissions from soils and biomass in the baseline and project scenarios. We assumed that all aboveground and belowground woody biomass is emitted in the project scenario per accounting guidelines in the CDM AR-Tool 14 applied under VM0033. All emissions from changes in biomass in the project scenario were conservatively accounted in the first year of the project.

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<sup>6</sup> Mokany, K., Raison, R.J., Prokushkin, A.S. *Global Change Biology* (2006) 12: 84-96

### 3.5 GHG Estimates

We have developed estimates of the GHG emission reductions (referred to as Emission Reductions from soil and biomass pools in Table 3.5 below) for the HRR project. We developed three emission reduction scenarios with varying soil GHG and project area assumptions as described above to illustrate the range of GHG emission reductions that could be generated by the HRR project (Low, Mid, and High scenarios). We assume staggered implementation, with 10% of the project being implemented each year for 10 years. The time frame for our GHG estimates is forty years, representing a mid-term horizon within the 20-100 year crediting time frame of the VCS (note that crediting periods can be renewed up to a maximum of 100 years). For shorter time horizons, please refer to the chart in Figures 6 below. We have conservatively assumed that biomass stocks are emitted immediately after land use change.

Finally, we have estimated the marketable carbon offsets (verified carbon units) by deducting a 15% contribution to the VCS Non-Permanence Risk Buffer Pool. Like all land use projects, the HRR project would need to make a contribution to the pool at each issuance of credits to protect against potential future “reversals” in carbon stocks (e.g., restoration fails and CO<sub>2</sub> that has been credited is released back into the atmosphere).

The buffer is expressed as a percentage of the net CO<sub>2</sub> benefits (baseline emissions minus project emissions) and is based on an assessment of risk. Net CH<sub>4</sub> and N<sub>2</sub>O benefits are not subject to the buffer as these avoided emissions cannot be reversed. The buffer is established at the time that the project is initially registered and must be updated at each verification event. We have assumed a 15% non-permanence buffer, which is the mid-point of the 10%-20% non-permanence buffer used by most U.S. forest carbon projects.

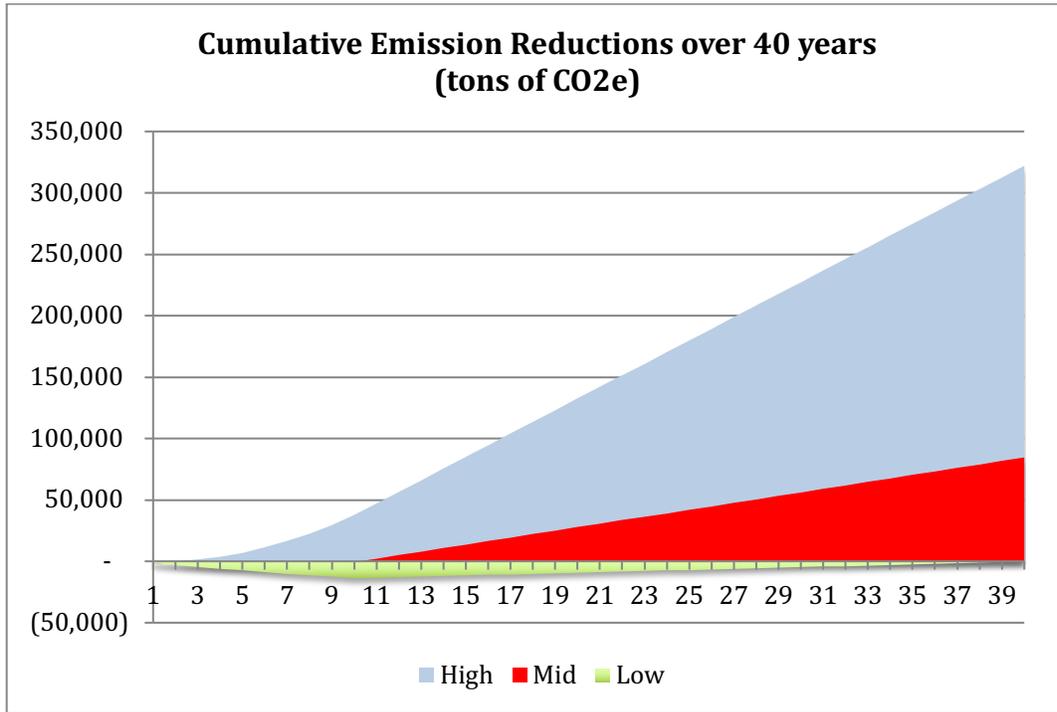
**Table 3.5. GHG Emission Reduction Estimates over 40 years (in metric tons CO<sub>2</sub>e)**

<b>Results</b>	<b>Low</b>	<b>Mid</b>	<b>High</b>
Baseline soil emissions (a)	-14,157	62,582	188,346
With project soil emissions (b)	-30,117	-38,274	-148,165
Emissions reductions from the soil pool (c = a-b)	15,960	100,856	336,510
Emissions from the biomass pool (d)	16,280	16,280	14,519
Emission reductions from soil and biomass pools (e = c-d)	-320	84,576	321,991
Non-permanence buffer (f)	0	0	-10,383
<b>Carbon offsets (e+f)</b>	<b>0</b>	<b>84,576</b>	<b>311,608</b>

Our Mid scenario estimate of carbon offsets generated by the HRR project over the initial 40-year crediting period is approximately 85,000 metric tons CO<sub>2</sub>e. Due mostly to uncertainty in the amount of methane emissions in the low salinity areas (<18 ppt) of the HRR project, the range of outcomes under Low to High scenarios is approximately between 0 and 300,000 metric tons CO<sub>2</sub>e over this same time period. Due to the impact of biomass emissions, the project would generate cumulative positive emission reductions starting in years 36, 11, and 3 in the Low, Mid, and High scenarios respectively (see Figure 3.6).

Because the HRR project may be implemented in phases, we have provided estimates of the GHG results for the Phase 1 area only (owned by NPS) in Appendix 3.

**Figure 3.6. Estimated Cumulative Emission Reductions from HRR Project over 40 years (before non-permanence buffer) (in tons of CO<sub>2</sub>e)**



# 4.0

## Financial feasibility

### 4.1 Approach

We have assessed the financial feasibility of the HRR project by estimating the net cash flows over the first 40 years of the project as well as the payback period to cover carbon project costs. Our assessment is based on three scenarios of estimates of offsets that would be generated (see section 3 above), carbon offset prices, as well as carbon project costs.

While our analysis is simplified (does not consider changes in carbon prices, changes in ongoing monitoring and verification costs, or the time value of money), it provides a first-order estimate of financial impact if the HRR project is developed as a carbon project.

Because the HRR project may be implemented in phases, we have provided estimates of the financial results for the Phase 1 area only (owned by NPS) in Appendix 3.

### 4.2 Assumptions

The key assumptions that we used in our analysis are described below.

**Carbon offsets** are the emission reductions less non-permanence buffer contribution and represent the amount of carbon credits that can be sold. See section 3 above for further discussion.

**Carbon prices** are assumed to be \$5.00/ton, \$10.00, and \$15.00/ton in the Low, Mid, and High scenarios. The carbon price of \$5.00/ton represents a mid-point for land based carbon transactions in the voluntary market (For reference the average voluntary carbon price in 2016 across all project types was \$3.00/ton, the average prices for forest and land use projects ranged from \$4.20/ton (avoided deforestation) up to \$9.50/ton (improved forest management)<sup>7</sup>. The price of \$10.00/ton represents the high end of prices observed for voluntary offsets from land-based projects. The price of \$15.00/ton represents a slight increase from today's compliance offset prices

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<sup>7</sup> Ahead of the Curve, State of the Voluntary Carbon Markets 2015, Ecosystem Marketplace, June 2015

in California and considers the 40-year time horizon of our analysis. Also given the time horizon for our analysis, we present a sensitivity analysis at the end of this section to illustrate the impact of varying carbon prices to net cash flows over 40 years.

**Carbon development and validation costs** are assumed to be \$150,000 and relate to the third-party fees and travel expenses of preparing (\$100,000) and validating (\$50,000) the Project Description to be registered with the VCS. This estimate is based on our experience for similar land use projects. These are one-time expenses that are incurred at the inception of the project.

**Carbon monitoring and verification costs** are assumed to be \$75,000 per monitoring event assuming 5-year monitoring intervals (maximum elapsed time between verifications before VCS buffer credits are put on hold). The estimated costs include the costs to collect soil and biomass carbon data (\$25,000-\$35,000 per event) and preparing and verifying the VCS monitoring report (\$40,000-\$50,000 per event). It does not include costs to collect field data on soil methane (salinity data needed if default values are used; soil temp, PAR, salinity required if BWM GHG model is used; or additional flux data if published values are used).

**Table 4.1. Summary Table of Assumptions**

Assumption	Low	Mid	High
Carbon offsets over 40 years (mtCO <sub>2</sub> )	0	84,576	284,572
Carbon price	\$5.00/ton	\$10.00/ton	\$15.00/ton
Carbon development and validation costs	\$150,000 (one-time)		
Carbon monitoring and verification costs	\$75,000 (every 5 years)		

### 4.3 Results

Based on the above assumptions, we have calculated net cash flows over 40 years and the payback period (see Table 4.2 below). While we did not calculate net present values (NPVs) over this period, we note that the NPVs will be equal to the net cash flows so long as the growth rate of cash flows (and in turn carbon prices) is equal to the discount rate (e.g. cash flows that grow at 5% and then discounted at 5% have the same absolute and net present value). As illustrated below, based on our assumptions, cash flows over 40 years are positive in the Mid and High scenario only.

**Table 4.2. Financial flows and metrics over 40 years**

	Low	Mid	High
Revenues	\$0	\$845,755	\$4,674,125
Expenses	-\$750,000	-\$750,000	-\$750,000
Net Cash Flows	-\$737,917	\$95,755	\$3,924,125
Payback (years)	N/A	35	10

## 4.4 Sensitivity analysis

Given the uncertainty in our assumptions, we have also analyzed the sensitivity of the net cash flows over 40 years to varying carbon prices (Table 4.3). For this analysis we consider carbon prices of \$5.00-\$40.00/ton with the low end of the range representing current voluntary market prices, and the high end of the range representing the central estimate for the social cost of carbon<sup>8</sup> as well as the minimum carbon price suggested by some economists to achieve sufficient GHG reductions to avoid the worst impacts of climate change<sup>9</sup>.

**Table 4.3. Sensitivity of 40-Year Net Cash Flows to Carbon Prices**

Carbon Price	Low	Mid	High
\$5.00/ton	-\$750,000	-\$327,122	\$808,042
\$10.00/ton	-\$750,000	\$95,755	\$2,366,083
\$15.00/ton	-\$750,000	\$518,633	\$3,924,125
\$20.00/ton	-\$750,000	\$941,510	\$5,482,167
\$40.00/ton	-\$750,000	\$2,633,021	\$11,714,334

For reference the shaded boxes correspond to our base case carbon price assumptions for each scenario.

As illustrated above, net cash flows are negative at all carbon price assumptions for the Low Scenario. In the Mid Scenario, net cash flows are positive at prices of \$10.00/ton and higher, while net cash flows are significantly positive in the High Scenario at all carbon prices from \$5.00/ton and higher.

Of course, this is a simplified analysis and carbon prices will likely vary within the forty-year crediting period. However, the above table can be used to understand the upper limit of net cash flows if carbon prices were to immediately increase and be sustained through the entire crediting period.

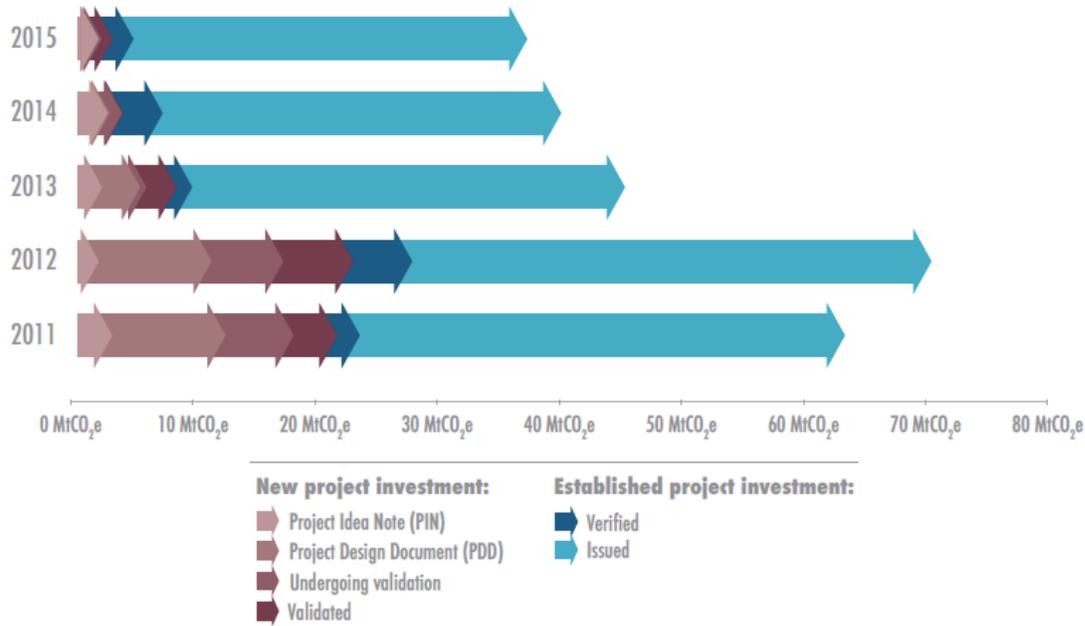
<sup>8</sup> <https://www.edf.org/true-cost-carbon-pollution>

<sup>9</sup> <https://insideclimatenews.org/news/31052017/carbon-price-paris-climate-agreement-economists-stern-stiglitz>

## 4.5 Structuring carbon financing

In the past, it was common for some buyers to provide upfront financing to carbon projects in the way of an advance payment. However, as some projects either failed to be registered or failed to produce the anticipated amount for credits, offset buyers generally prefer to pay upon delivery of issued offsets (see Figure 4.1 below).

**Figure 4.1. Offsets Transacted by Project Stage, 2011-2015**



In the case of the HRR project, the registration and delivery risks will be considered as high by most buyers as there is little track record for tidal wetlands restoration projects in the carbon market so far. That said, it may be possible to receive grant funding to cover some or all of the carbon project development costs and the costs for the first monitoring event (\$225,000) given the wider benefits of kick-starting these types of project in the market. If these initial costs are covered by a grant, then the project would generate net cash flows of +\$0.3 million in the Mid Scenario with a payback period of 20 years, and net cash flows of +\$4.0 million and be immediately cash flow positive in the High Scenario. Net cash flows would still be negative in the Low Scenario. See section 6 for further discussion of funding partners.

# 5.0

## Legal feasibility

### 5.1 Ownership of carbon rights and grouping

The VCS requires the project proponent (owner) to demonstrate carbon ownership by a right of use. For land use projects, a right of use can arise by virtue of property rights in land of the project area, or by an enforceable and irrevocable agreement with the land owner that transfers such rights to the project proponents.

In the case of the HRR project, the primary landowner of the project area is the National Park Service (NPS) that owns 615 acres. However, there are a number of private organizations and individuals that also own land that would be part of the project area. In total, these landowners own 390 parcels that total 391 acres. A list of the property types is included in Table 5.1 below.

**Table 5.1. Non-Federal Property Types in the HRR Project Area<sup>10</sup>**

Property Type	Number of Parcels	Number of Acres
Residential	320	171
Commercial	10	*
Undeveloped	27	*
Municipality	20	*
Conservation, Non-Profit	10	*
Chequessett Yacht and Country Club	*	37
Total	390	391

\*Not available

Therefore, to claim emission reductions for the entire HRR project area within a single carbon project, it will be necessary for the project developer (see section 6) to secure agreements with all landowners that transfer carbon rights on their lands. In this way, a single project can be developed that covers the entire project area.

If a landowner does not enter into an agreement to transfer carbon rights from its property(ies) to the project proponent, then the associated property(ies) could not be

<sup>10</sup> Final Environmental Impact Study, page 171

included in the project area. In order to meet the applicability conditions of the methodology, it would also be necessary to document that the hydrological connectivity of these properties to the project area will not lead to an increase in emissions (which should be the case since restoration is likely reducing methane emissions and increasing carbon sequestration in soils by an amount greater than any carbon emissions from the loss of biomass).

Of course, landowners will likely need incentives to enter into such agreements. For some (like the NPS), it may be sufficient to know that the revenues from the sale of offsets would help fund ongoing monitoring for the HRR project. For others, a small carbon payment may be necessary and effective in securing participation, although the relatively low level of emission reductions per acre over the first 40 years of the project and the uncertainty in these amounts will make it difficult to make a significant upfront payment. Back-end loaded payments, based on the level of emission reductions, may be combined with a small upfront payment and also offer continuing incentives for landowners to comply with the conditions in their landowner agreements.

It will also be important for all landowners to understand any responsibilities that come with the carbon project. Typically, property owners need to grant access to their property if a monitoring plot is installed on their land. More importantly, property owners need to agree to forego certain activities that would lead to a potential increase in GHG emissions. In the case of the HRR project, wetland regulations prevent further development or alteration of these areas. However, prohibited activities will need to be identified and detailed in the agreements with landowners. These activities could include but are not limited to the following:

- No nitrogen fertilizers
- No development (to the extent not already prohibited by law)
- No alteration of hydrology (i.e., ditching or dikes) (to the extent not already prohibited by law)

### *Grouping*

If it is difficult to secure the participation of all affected landowners at the start of the project, it is also possible to structure the HRR project as a grouped project to allow the addition of land and landowners to the project subsequent to project validation. In order to be added to the grouped project, the new land (project instance) must meet the criteria contained in the grouped project design document that is validated. These criteria must be established in advance to ensure that the carbon accounting approach in the project design appropriately covers the new project instance and include criteria related to the geography, baseline conditions, additionality, and project activity that will be implemented.

The main benefit of grouping is that it allows expansion of a project after validation with minimal cost. The main consideration of grouping is that one landowner's adverse actions can negate the benefit achieved by the rest of the project. Therefore, it is important to ensure execution and enforcement of landowner agreements that prevent these types of adverse actions and avoid this scenario.

In theory, other tidal restoration projects near Cape Cod, for example in Rhode Island, with similar baseline conditions, could be added to a grouped project along with the HRR project. However, given that the HRR project already involves multiple stakeholders, and is first of its kind, it may be advisable to keep this initial project simple and limited to those landowners in the HRR project area.

## 5.2 Authority to transfer carbon rights

In the case of private organizations and individuals, both typically have the authority to transfer carbon rights or carbon offsets to another party (buyer) without explicit authority. However for public agencies, like the National Park Service, it is important to understand if the agency involved has the requisite authority to transfer such rights.

Because the carbon markets are still new, it is not surprising that the transfer of carbon rights is not explicitly included in the mandates of public land management agencies. That said, there have been carbon offset projects on public lands (state and federal) that offer insight and precedent into the authority of these agencies to enter into these projects.

Some of the most relevant carbon offset projects are the reforestation projects that have been implemented on U.S. Fish and Wildlife Service (USFWS) and state lands in the Southeast and lower Midwest of the United States. From 1998 to 2010, about 80,000 acres of agricultural lands that were owned by the USFWS (and part of National Wildlife Refuge system) and state land management agencies were reforested and restored to bottomland hardwood forests.

Funding for these efforts were provided by private companies, mainly from the utility industry, in return for the carbon rights related to any emission reductions resulting from the reforestation activities. Funding covered the cost of site preparation and planting, long-term management, and in some cases, a portion of the land acquisition costs (in cases where land was acquired by a third-party NGO and donated to the USFWS or relevant state agency). Two of the largest of these projects were subsequently registered as voluntary carbon projects and emission reductions from these projects are being monitored and reported by the funding partners.

In both cases, the USFWS and/or state agencies signed agreements that allowed the funding partner to claim the reporting rights to the carbon emission reductions. The funding was characterized as a donation that was subject to the condition that the funder would be allowed to report any carbon benefits associated with the trees planted on these lands. USFWS authority to enter into this type of arrangement was derived from the Fish and Wildlife Coordination Act of 1956 which authorizes the USFWS *to accept donations for the benefit of the USFWS, and that such gifts may be subject to restrictions or conditions when deemed by the Secretary of the Interior to be in accordance with law and compatible with the purpose for which acceptance is sought* (16 U.S.C. 742f(b)(1)). The Coordination Act also authorizes the USFWS to provide assistance to, and cooperate with, Federal, State, and public or private agencies and organizations in the development, protection, rearing, and stocking of all species of wildlife, resources thereof, and their habitat (16 U.S.C. 661). The National Wildlife Refuge System Administration Act of 1966 also authorizes the USFWS to accept donations of funds to acquire or manage lands or interests therein (16 U.S.C. 668dd(b)(2)).

Similar to the carbon based reforestation projects, the HRR project will occur on land that is owned by an agency of the Department of Interior. It also involves restoration of land that was acquired with the objective of preservation for fauna and flora. If the project moves forward, it may also be possible to structure a long-term management payment to the NPS to satisfy any requirements that donations be used for acquisition or management of lands. See Figure 10 in section 6.1 for illustrative schematic.

In the case of the HRR project, if the carbon project is otherwise considered feasible, it will be important for the internal counsel at the Department of the Interior to provide its opinion on the authority granted to the NPS to enter into a potential sale or transfer of carbon offsets generated on NPS lands, including the authority of the NPS to accept donations with conditions (Directors Order #21- Donations and Fundraising).

In addition to existing regulations regarding donations, we note that the Department of Interior was instructed in the fall 2015 to develop “program guidance regarding the use of mitigation projects and measures on lands administered by bureaus or offices of the Department through a land-use authorization, cooperative agreement, or other appropriate mechanism that would authorize a project proponent to conduct actions, or otherwise secure conservation benefits, for the purpose of mitigating impacts elsewhere.”<sup>11</sup> While mitigation differs from carbon offsetting in some respects (e.g., mitigation is mandatory, offsetting is not), this guidance may

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<sup>11</sup> [Presidential Memo: Mitigating Impacts on Natural Resources from Development and Encouraging Related Private Investment](#)

still be relevant to the analysis of the authority of the NPS to develop the HRR project as a carbon offset project.

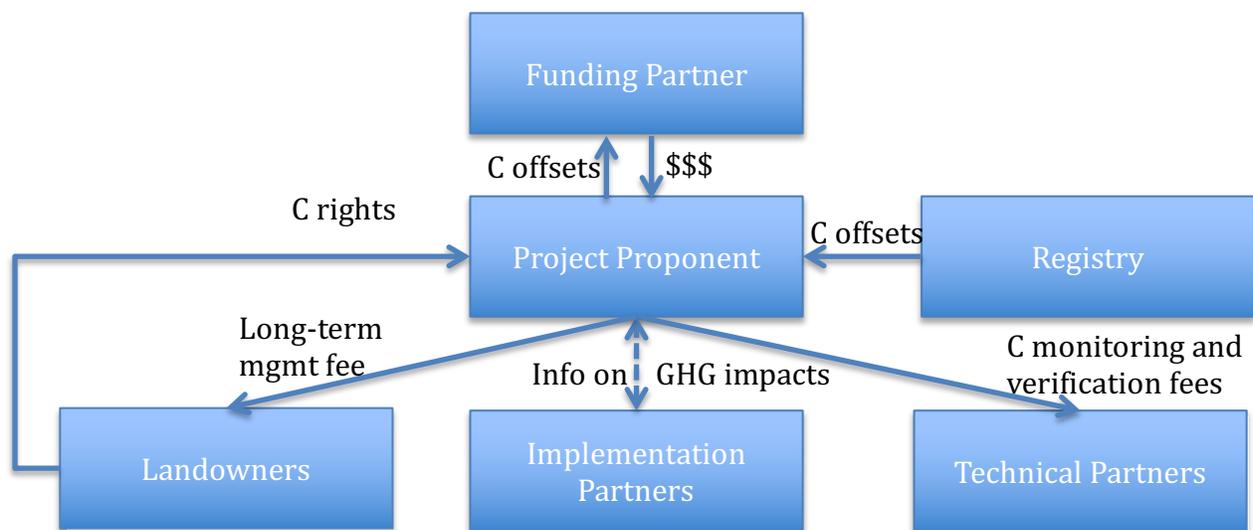
# 6.0

## Organizational feasibility

### 6.1 Generalized Organizational Design

The key participants in land based carbon projects consist of the project proponent, landowners, implementation partners, technical partners, and funding partners. We discuss the roles of each of these participants with respect to the HRR project in the sections below. If the project moves forward, agreements between participants that spell out roles and responsibilities will need to be drafted.

**Figure 6.1: Generalized organizational structure for HRR carbon project**



### 6.2 Project Proponent

The project proponent plays a central role in the project, coordinating the efforts with each of the other participants. The responsibilities of the project proponent include:

- Developing and entering into agreements with landowners regarding restoration, ongoing management, monitoring responsibilities, and related compensation;
- Working with implementation partners to communicate the GHG impacts of the implementation actions and decisions;
- Working with technical partners to develop and validate project design, and register the carbon project;
- Working with technical partners to undertake carbon monitoring (monitoring, third-party verification, credit issuance from registry); and
- Working with funding partners to secure grant funding and to enter into and complete carbon offset sales (marketing, executing sales agreements, transferring credits in registry, receiving and distributing sales proceeds).

In a large number of cases, project proponents for land-based carbon projects have been non-governmental organization (NGOs). These organizations have experience working with local communities and landowners, and in many cases have been able to form strong ties with technical research partners. While government agencies have also led the project development in some cases, NGOs are especially well-suited to undertake carbon based restoration work given their access to philanthropic and grant funding and their stronger brand recognition with consumers and potential buyers of voluntary credits.

In the case of the HRR project, Restore America's Estuaries could be a logical choice to serve as the project proponent, in particular, to secure additional grant funding and to lead the technical development and sale of offsets from the carbon project.

### 6.3 Landowners

The role of the landowners will be spelled out in the landowner agreement and may include, but may not be limited, to the following responsibilities:

- Providing authority to project developer to develop the carbon project and sell carbon offsets;
- Managing site by avoiding prohibited activities (for example, no activities that result in drainage, no fertilizer applications); and
- Providing access to technical partners for monitoring.

The landowners in the HRR project include the NPS and a number of private individuals and organizations as discussed earlier in section 5.1.

## 6.4 Implementation Partners

The role of the implementation partners would be:

- Implement the prescribed restoration measures, including initial restoration and ongoing management.

With respect to the HRR project, the Town of Wellfleet (who will own bridge and tide gate) and Friends of Herring River (who will manage the level of tidal flows – at Mill Creek and Chequessett Road, and who could manage landowner relations for the carbon project) would be considered implementation partners. The National Park Service (NPS), who is carrying out the restoration activities, could also be considered an implementation partner.

## 6.5 Technical Partners

We divide the role of technical partners into research partners, technical consultants, and third-party validation and verification bodies (VVBs).

### *Research Partners*

The role of the research partner(s) would include:

- Collecting (or overseeing collection) of data to determine baseline emissions;
- Collecting (or overseeing collection) of data to monitor and determine project emissions; and

In the case of the HRR project, research partners are likely to include those organizations already participating on the Science team of the BWM project such as USGS, Waquoit Bay National Estuarine Research Reserve, Marine Biological Laboratory, and the University of Rhode Island.

### *Technical Consultants*

The role of the third-party consultant(s) would include:

- Assisting in preparation of project design documentation required to register projects and monitoring documentation required to receive issued credits.

In the case of the HRR project, TerraCarbon is an example of third-party consulting firms that specializes in land use and forestry carbon projects and that could assist in

the preparation of project design and monitoring documentation and support the validation and verification process.

#### *Third Party VVBs*

The role of the third-party VVBs would include:

- Auditing documentation related to the design of the project and monitoring of emission reductions (referred to as validation and verification)

Third-party VVBs that have been accredited by the VCS to audit land use and forestry projects and who have experience with US based projects include Aster Global Environmental Solutions (formerly ESI) and SCS.

## 6.6 Registry

The role of the registry is:

- Register the project upon receipt of the project design document and the validation report.
- Issue credits to the project's registry account upon receipt of the monitoring report and verification report.
- Transfer or retire credits as directed by the project developer.

Registries that have been approved by the VCS include IHS market and APX.

## 6.7 Funding Partners

The role of the Funding Partner would be:

- Providing funding to the project through advance payments and/or payments-on-delivery in return for emission reductions rights (credits).

Funding partners would be either the end users of the credits or intermediaries. As discussed in section 2, end users of voluntary credits tend to be larger, consumer facing companies with corporate social responsibility programs. In the U.S., Walt Disney and Microsoft, are two large buyers of offsets from the land use sector.

Intermediaries are organizations that purchase offsets from projects and resell them to companies. Intermediaries include for-profit companies like Natural Capital Partners as well as non-profit companies like Carbonfund and The Climate Trust (who has expressed an interest in the past in supporting blue carbon projects).

# 7.0

## Next steps/Recommendations

We recommend the following next steps before moving forward with a decision to pursue carbon project development, understanding that some of these steps may operate in parallel.

**Table 7.1. Next Steps**

Next Steps
1. Request review and advice from Department of Interior counsel regarding transfer of carbon rights on NPS lands.
2. Collect additional CH <sub>4</sub> data from low salinity systems (<18 ppt) in all strata that cover the HRR project area to narrow the range of potential offsets, and to serve as basis for quantifying CH <sub>4</sub> emissions for the project.
3. Finalize technical approach, including publishing of soil C and CH <sub>4</sub> papers, and additional sea level rise modeling for baseline and with project scenarios.
4. Identify potential grant funding sources to cover costs with initial project development and first monitoring event.
5. If deemed feasible, draft agreements amongst all partners and proceed with project development (after restoration funding is secured).

# 8.0

## Appendices

## Appendix 1 –Applicability Conditions for VCS Methodology for Tidal Wetland and Seagrass Restoration (VM0033)

Applicability Condition	HR Restoration Project
This methodology is applicable under the following conditions:	
<p>1) Project activities which restore tidal wetlands (including seagrass meadows, per this methodology’s definition of tidal wetland) are eligible.</p>	<p>Condition is met.</p> <p>Definition of tidal wetland in the methodology: “A subset of wetlands under the influence of the wetting and drying cycles of the tides (eg, marshes, seagrass meadows, tidal forested wetlands and mangroves).”</p> <p>Project area is tidal marsh (under the influence of wetting and drying cycles of the tides).</p>
<p>2) Project activities may include any of the following, or combinations of the following:</p> <ul style="list-style-type: none"> <li>a) Creating, restoring and/or managing hydrological conditions (eg, removing tidal barriers, improving hydrological connectivity, restoring tidal flow to wetlands or lowering water levels on impounded wetlands)</li> <li>b) Altering sediment supply (eg, beneficial use of dredge material or diverting river sediments to sediment-starved areas)</li> <li>c) Changing salinity characteristics (eg, restoring tidal flow to tidally-restricted areas)</li> <li>d) Improving water quality (eg, reducing nutrient loads leading to improved water clarity to expand seagrass meadows, recovering tidal and other hydrologic flushing and exchange, or reducing nutrient residence time)</li> <li>e) Re-introducing native plant communities (eg, reseeding or replanting)</li> <li>f) Improving management practice(s) (eg, removing invasive species, reduced grazing)</li> </ul>	<p>Condition is met.</p> <p>Project activities includes a combination of a) – restoring hydrological conditions by removing tidal barriers and restoring tidal flow to wetlands - and c) – changing salinity by restoring tidal flow to tidally restricted areas.</p>
<p>3) Prior to the project start date, the project area:</p>	<p>Condition is met.</p>

Applicability Condition	HR Restoration Project
<p>a) Is free of any land use that could be displaced outside the project area, as demonstrated by at least one of the following, where relevant: i) The project area has been abandoned for two or more years prior to the project start date; or ii) Use of the project area for commercial purposes (ie, trade) is not profitable as a result of salinity intrusion, market forces or other factors. In addition, timber harvesting in the baseline scenario within the project area does not occur; or iii) Degradation of additional wetlands for new agricultural sites within the country will not occur or is prohibited by enforced law. OR</p> <p>b) Is under a land use that could be displaced outside the project area (eg, timber harvesting), though in such case emissions from this land use shall not be accounted for. OR</p> <p>c) Is under a land use that will continue at a similar level of service or production during the project crediting period (eg, reed or hay harvesting, collection of fuelwood, subsistence harvesting)</p> <p>The project proponent must demonstrate (a), (b) or (c) above based on verifiable information such as laws and bylaws, management plans, annual reports, annual accounts, market studies, government studies or land use planning reports and documents.</p>	<p>The project satisfies condition a) that no land uses/activities are present in the project area that could be displaced outside the project area as evidenced by ii) no commercially profitable activities or timber harvesting occurs.</p>
<p>4) Live tree vegetation may be present in the project area, and may be subject to carbon stock changes (eg, due to harvesting) in both the baseline and project scenarios.</p>	<p>Condition is met.</p> <p>Live tree vegetation is present and may be subject to carbon stock changes (growth/die-off) in both baseline and project scenarios.</p>
<p>5) The prescribed burning of herbaceous and shrub aboveground biomass (cover burns) as a project activity may occur.</p>	<p>Condition is met.</p> <p>Prescribed burning is permitted by the methodology, and may be part of vegetation management (brush/slash) activities.</p>

Applicability Condition	HR Restoration Project
6) Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, project activities must include a combination of rewetting and fire management.	Not applicable. Project proponent does not intend to claim emission reductions from reduced fire, since project area is not subject to fires.
7) Where the project proponent intends to claim emission reductions from reduced frequency of peat fires, it must be demonstrated that a threat of frequent on-site fires exists, and the overwhelming cause of ignition of the organic soil is anthropogenic (eg, drainage of the peat, arson).	Not applicable. Project proponent does not intend to claim emission reductions from reduce fire, since project area is not subject to fires.
8) In strata with organic soil, afforestation, reforestation, and revegetation (ARR) activities must be combined with rewetting.	Not applicable. No ARR activities without rewetting are planned.
This methodology is not applicable under the following conditions:	
9) Project activities qualify as IFM or REDD.	Condition is met. Project activities (restoration of tidal flows to a wetland) do not qualify as IFM (increasing carbon stocks in an existing forest) or REDD (protecting forest from conversion to non-forest).
10) Baseline activities include commercial forestry.	Condition is met. No commercial forestry activities exist in the project area.
11) Project activities lower the water table, unless the project converts open water to tidal wetlands, or improves the hydrological connection to impounded waters.	Condition is met. Project activities may lower the water table by improving hydrological connection of the tidal marsh.
12) Hydrological connectivity of the project area with adjacent areas leads to a significant increase in GHG emissions outside the project area.	Condition is met. No significant increases in GHG emissions outside the project area are anticipated.
13) Project activities include the burning of organic soil.	Condition is met.

Applicability Condition	HR Restoration Project
	No soils will be burned as part of the project activities.
14) Nitrogen fertilizer(s), such as chemical fertilizer or manure, are applied in the project area during the project crediting period.	Condition is likely met. Remove golf course from project area and demonstrate that no increase in emissions offsite since area that is impacted will be elevated and therefore subject to less N <sub>2</sub> O emissions than pre-project.

## Appendix 2 – Technical Approach

Methodology Requirements	Technical Approach for HR
<b>Project boundary</b>	
<ul style="list-style-type: none"> <li>Sea level rise projections should be incorporated into baseline and project scenarios</li> </ul>	<ul style="list-style-type: none"> <li>Revise hydrological modeling done by Woods Hole Group by including projections of relative sea level rise (incorporating accretion and geological subsidence) and impact on groundwater tables and vegetation in the current (baseline) scenario and restoration (project scenario) over 100 years</li> </ul>
<b>Biomass</b>	
<ul style="list-style-type: none"> <li>Trees/shrubs + Herbaceous Vegetation</li> </ul>	
<ul style="list-style-type: none"> <li><u>Trees/shrubs</u> (woody biomass)– Field based measurements, use CDM Tool (<a href="#">AR-14</a>), stratified random sampling to estimate stocks within +/-10% with 90% confidence</li> </ul>	<ul style="list-style-type: none"> <li>Use field-based measurements</li> <li>Will need maps by vegetation class to stratify</li> </ul>
<ul style="list-style-type: none"> <li><u>Herbaceous vegetation</u> (non-woody biomass)– Default factor of 3 tons C/hectare for areas of 100% herbaceous cover</li> </ul>	<ul style="list-style-type: none"> <li>Use default factor</li> </ul>
<b>Soil</b>	
<ul style="list-style-type: none"> <li>SoilCO<sub>2</sub> -Deduction for Allochthonous SoilCO<sub>2</sub> +SoilCH<sub>4</sub> +SoilN<sub>2</sub>O</li> </ul>	
<ul style="list-style-type: none"> <li><u>SoilCO<sub>2</sub></u> can be estimated using 1) proxies (water table depth, subsidence), 2) peer-reviewed published data, 3) default factor (if published data not available, 1.46 t C/ha/yr for tidal marshes with at least 50% crown cover), 4) peer-reviewed published model, 5) field-collected data (soil core within 2 years of project start, if reference plane is used, should be installed at least 4 years before project start), or 6) historical data or chronosequences.</li> </ul>	<ul style="list-style-type: none"> <li>Use field collected soil carbon burial data for each applicable land cover classes (see section 3).</li> </ul>
<ul style="list-style-type: none"> <li><u>Deduction for Allochthonous Soil-CO<sub>2</sub></u> is required to account for the percentage of carbon sequestration related to soil carbon accumulation from offsite sediment that is transported (by water) to the project area.</li> <li>This deduction is not applicable if the approach to SoilCO<sub>2</sub> already discounts the impact of allochthonous carbon.</li> </ul>	<ul style="list-style-type: none"> <li>Collect % of soil that is organic carbon to prove that soils are organic and allochthonous deductions is zero, or to apply formula from methodology to calculate allochthonous carbon</li> </ul>

Methodology Requirements	Technical Approach for HR
<ul style="list-style-type: none"> <li>• Can be set to zero for strata with organic soils (&gt;10 cm of organic surface layer)</li> <li>• Can be conservatively set to zero in baseline; mandatory in project accounting (and applied only to soil layers after the start date) unless demonstrate that it would have been emitted in baseline scenario.</li> <li>• % allochthonous is estimated using 1) published values, 2) field-collected data, or 3) modeling.</li> <li>• For field collected data, need percentage of soil that is organic C (from soil cores) and percentage of deposited sediment that is organic C (from default value, sediment tiles, or collection of suspended sediments in tidal channels or sediment deposits in tidal flats).</li> </ul>	
<ul style="list-style-type: none"> <li>• <u>Soil-CH<sub>4</sub></u> is estimated using 1) proxies, 2) published values, 3) default values (0.011 t CH<sub>4</sub>/ha/yr for &lt;18 ppm, 0.0056 tCH<sub>4</sub> /ha/yr for &gt; 20ppm) in the absence of published values, 4) published models, 5) field collected data, or 6) IPCC emission factors.</li> <li>• Convert CH<sub>4</sub> into CO<sub>2</sub> equivalents.</li> </ul>	<ul style="list-style-type: none"> <li>• Use GHG model and default values for applicable salinity and vegetation; use field data and/or published values for vegetation types not covered by the GHG model or default values.</li> <li>• Current VCS requirement is to use 100-year global warming potentials from IPCC 4<sup>th</sup> Assessment Report (25x GWP for CH<sub>4</sub>); subject to future updates.</li> </ul>
<ul style="list-style-type: none"> <li>• <u>Soil-N<sub>2</sub>O</u> is estimated using same approaches as for Soil-CH<sub>4</sub>.</li> <li>• Can be conservatively excluded from the baseline.</li> <li>• Can be excluded from project emissions if demonstrate that emissions do not increase or are de minimis (e.g. from peer reviewed literature). Must be included if water levels are lowered as part of project activities.</li> <li>• Convert N<sub>2</sub>O into CO<sub>2</sub> equivalents using 100-year global warming potentials from IPCC 4<sup>th</sup> Assessment Report.</li> </ul>	<ul style="list-style-type: none"> <li>• Exclude from baseline due to conservativeness</li> <li>• Exclude from project as de minimis (per Moseman-Valtierra paper in development)</li> <li>• While water levels may be temporarily lowered in the project area in response to unexpected adverse impacts, it is expected that water levels will be raised as a result of the project.</li> </ul>

Methodology Requirements	Technical Approach for HR
<b>GHG Emissions from Fossil Fuel</b>	
<ul style="list-style-type: none"> <li>• Use CDM tool (<a href="#">Annex 14</a> to AR-AM0005) to estimate emissions from vehicles and equipment used to implement the restoration.</li> <li>• Can be conservatively excluded from baseline.</li> <li>• Required in the project emissions if more than 5% of net ghg emission reductions.</li> </ul>	<ul style="list-style-type: none"> <li>• Will need to estimate direct consumption (gallons of fuel) or indirect consumption (materials and distance, and fuel efficiency) for all project activities, including dike construction and road raising</li> <li>• Based on the typical emissions of large construction equipment, it is unlikely that GHG emissions from fossil fuels will be significant (&lt;5% of net GHG emission reductions)</li> </ul>
<b>Non-CO<sub>2</sub> Emissions from Prescribed Burning (vegetation)</b>	
<ul style="list-style-type: none"> <li>• CH<sub>4</sub> and N<sub>2</sub>O emissions from incomplete combustion</li> <li>• Use literature values or default factors per IPCC Guidelines on National GHG Inventories</li> </ul>	<ul style="list-style-type: none"> <li>• If prescribed burning is used, then number of acres and amount of biomass subject to the prescribed burn will need to be tracked.</li> </ul>

## Appendix 3 – Phase 1 Estimates

The GHG and financial analyses were also completed for the phase 1 area only (under NPS ownership) to provide further insight into the impact of including additional areas outside of NPS ownership into the HRR project.

As indicated below, the Phase 1 area of the HRR project is estimated to generate approximately 10,000 to 150,000 tons of carbon offsets and net cash flows of -\$0.7 million to \$1.5 million over 40 years across low, medium, and high scenarios.

**Table A3-1. Phase 1 - Land cover classes and areas, projected under baseline and project scenarios from SLAMM modeling (T. Smith, 24 July 2019)**

Land cover	Area (hectares)		
	Baseline Condition	Project Condition #1	Project Condition #2
Upland	1	0	0
Non-tidal Wooded Swamp	80	5	5
Scrub-Shrub Freshwater Wetland	32	7	7
Fresh Emergent Marsh	60	7	7
High Salt Marsh	1	0	40
Low Salt Marsh	23	99	105
Tidal Flat	0	52	16
Beach	0	0	0
Open Water	21	51	41
<b>Total</b>	<b>221</b>	<b>221</b>	<b>221</b>

**Table A3-2. Phase 1 - GHG Emission Reduction Estimates over 40 years (in metric tons CO<sub>2</sub> e)**

Results	Low	Mid	High
Baseline soil emissions (a)	-7,832	31,883	95,701
With project soil emissions (b)	-26,049	-36,530	-70,512
Emissions reductions from the soil pool (c = a-b)	18,217	68,413	166,213
Emissions from the biomass pool (d)	9,158	9,158	8,652
Emission reductions from soil and biomass pool (e = c-d)	9,060	59,255	157,562
Non-permanence buffer (f)	-506	-299	-4,183
<b>Carbon offsets (e+f)</b>	<b>8,554</b>	<b>58,956</b>	<b>153,379</b>

**Table A3-3. Phase 1 - Financial estimates over 40 years**

	<b>Low</b>	<b>Mid</b>	<b>High</b>
Revenues	\$42,768	\$589,561	\$2,300,679
Expenses	-\$750,000	-\$750,000	-\$750,000
Net Cash Flows	-\$707,232	-\$160,439	\$1,550,679
Payback (years)	N/A	N/A	15

**Table A3-4. Phase 1 - Sensitivity of 40-Year Net Cash Flows to Carbon Prices**

<b>Carbon Price</b>	<b>Low</b>	<b>Mid</b>	<b>High</b>
\$5.00/ton	-\$707,232	-\$455,219	\$16,893
\$10.00/ton	-\$664,463	-\$160,439	\$783,786
\$15.00/ton	-\$621,695	\$134,342	\$1,550,679
\$20.00/ton	-\$578,926	\$429,123	\$2,317,572
\$40.00/ton	-\$407,852	\$1,608,246	\$5,385,145