Attachment H-3

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PRELIMINARY ASSESSMENT OF THE COUNTY OF SAN DIEGO LOCAL DIRECT INVESTMENT PROGRAM

COUNTY OF SAN DIEGO
SAN DIEGO, CALIFORNIA

RAMBOLL ENVIRON

CONTENTS

TABLES

ACRONYMS AND ABBREVIATIONS

ACR	American Carbon Registry
CAP	Climate Action Plan
CAPCOA	California Air Pollution Control Officers Association
CAR	Climate Action Reserve
CARB	California Air Resources Board
CDM	Clean Development Mechanism
CEQA	California Environmental Quality Act
CO_2e	carbon dioxide equivalents
EO	Executive Order
GHG	greenhouse gas
GIS	geographic information system
LA	Los Angeles
LFG	landfill gas
MT	metric tons
PDS	Planning & Development Services
RPS	Renewable Portfolio Standard
SALM	Sustainable Agricultural Land Management
SanGIS	San Diego's regional GIS data warehouse
SB	Senate Bill
VCS	Verified Carbon Standard
WWTP	Wastewater Treatment Plant

EXECUTIVE SUMMARY

The County of San Diego (County) published a draft Climate Action Plan (CAP) in August 2017[1] to identify emission reduction strategies that will be required to meet the State's greenhouse gas (GHG) reduction goals. The CAP proposes a wide range of strategies, measures, and supporting efforts that will help the County reduce GHG emissions. One measure that is part of the County's CAP is *Measure T-4.1: Establish a Local Direct Investment Program*. Under this measure, the County would fund/implement and register local direct investment projects on one or more recognized GHG offset registries. A description of this measure is included on page 3-38 of the CAP. These projects would follow approved GHG emission reduction protocols from registries acknowledged or approved by governing bodies in the State of California to calculate the amount of GHG reductions generated by each project's activity. GHG reductions resulting from the local direct investment projects would effectively result in net emission reductions for the County. The County's CAP anticipates that it can achieve a reduction of 190,262 metric tons (MT) carbon dioxide equivalents (CO_2e) in 2030 under this measure.

The purpose of this analysis is to assess the County's local direct investment program by evaluating the possible approaches to obtain GHG reductions. To do this, Ramboll Environ conducted a survey of various protocols from four GHG offset registries to determine applicability to the unincorporated areas of San Diego and the local direct investment program. Calculations were then performed to determine a range of potential GHG emission reductions achievable for a protocol or protocol group. The survey also included a high-level cost effectiveness analysis that identified for each protocol or protocol group a range of unit costs (in $/MT CO_2e) and identified a range of aggregate costs that reflect the relative costs between the protocols to achieve a 190,262 GHG reduction by 2030.

Ramboll Environ identified the protocols applicable to the unincorporated county and grouped them into five main protocol sectors: agriculture, energy efficiency/production, land use management, landfill/waste management, and transportation. Ramboll Environ then developed a range for the potential emission reductions for each protocol group. Ramboll Environ estimates that the County could obtain 50,100 to 198,800 MT in CO_2e reductions via a local direct investment program. A range is presented because it is possible that reductions may occur through alternative regulatory mechanisms, so while they could still be realized, they may not occur through the County's local direct investment program.

The costs required to achieve these reductions include the direct costs (i.e., capital costs, operation and maintenance costs) of the offset projects, the costs associated with listing the projects and associated offsets in registries, and the implementation costs for creating, managing, and developing a local direct investment program. Ramboll Environ estimates that direct costs may reach $14 to $55 million in 2030 as the County builds its program to meet the 2030 GHG reduction goal. The total implementation cost will depend on the pace at which the County chooses to pursue reductions between now and

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[1] Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: November 2017.

2030. Per-project registry costs are estimated to be in the range of $56,000 to $218,000. Estimates for implementation costs for the County are being developed separate from this report. All of these cost estimates will depend on the types of projects that the County ultimately pursues, and how and when they choose to implement them. The cost information can aid in future implementation planning and provides a perspective on the relative costs between protocols, and the additional contributors to the costs required to pursue a local direct investment program.

1. INTRODUCTION

In 2005, California established goals to reduce greenhouse gas (GHG) emissions in the State to: 1) 2000 levels by 2010, 2) 1990 levels by 2020, and 3) 80 percent below 1990 levels by 2050 through Executive Order (EO) S-3-05. In 2006, these goals were further reinforced with the passage of Assembly Bill 32 (AB 32), the Global Warming Solutions Act of 2006. AB 32 sets the same overall GHG emissions reduction goals as EO S-3-05 while further mandating that the California Air Resources Board (CARB) develop and maintain a scoping plan that includes market mechanisms and adoption and enforcement of regulations to achieve “real, quantifiable, cost-effective reductions of greenhouse gases.” In 2015, a new interim goal was established through Executive Order B-30-15 to reduce GHG emissions in California to 40 percent below 1990 levels by the year 2030. In 2016, this interim goal became law with the passage of Senate Bill 32 (SB 32).

The County of San Diego (County) published a draft Climate Action Plan (CAP) in August 2017[2] to identify emission reduction strategies that will be required for the County to meet the State’s GHG reduction goals. The CAP proposes a wide range of strategies, measures, and supporting efforts that will help the County reduce GHG emissions. One measure that is part of the County’s plan is *Measure T-4.1: Establish a Local Direct Investment Program*. Under this measure, the County would fund/implement and register local direct investment projects on one or more recognized GHG offset registries. These projects would follow approved GHG emission reduction protocols to calculate the amount of offsets generated by each project’s activity. Many of these protocols were listed in Appendix B of the Draft Supplemental Environmental Impact Report (SEIR) and described in Chapter 2.7 of the SEIR. GHG offsets resulting from the local direct investment projects would ultimately be retired, effectively resulting in net emission reductions for the County. Overall, the County anticipates that it can achieve a reduction of 190,262 metric tons (MT) carbon dioxide equivalents (CO_2e) in 2030 under this measure.

The overall purpose of this analysis is to assess the County’s local direct investment measure (Measure T-4.1) by determining the possible approaches for obtaining the level of GHG reductions stipulated by the CAP through local direct investment. To do this, protocols[3] from four GHG offset registries were assessed to determine if they were applicable to the unincorporated county. Calculations were then performed to determine the range of potential emission reductions achievable by each applicable protocol or protocol group. The cost-effectiveness data (in \$/MT CO_2e) was incorporated into the analysis to provide a perspective on the relative costs by protocol, and on the potential financial commitment needed to achieve these reductions.

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[2] Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: November 2017.

[3] Note, some registries use the term “methodologies” rather than “protocol”; however, the methodology documents are the same in concept and were also included in this review.

2. BACKGROUND

Currently, there are several different GHG offset registries in existence. Each of these registries develops its own protocols for estimating emission reductions, or adopts parts of or full protocols from other registries. Industry, or other bodies, can then implement projects that follow these protocols in order to accrue offsets to be listed and tracked through the relevant registry. These offsets can then be retired (resulting in a net reduction in GHG emissions), or sold on the open market as a commodity. The County does not intend to purchase offsets generated by other entities.

The protocols assessed in this analysis came from the following GHG offset registries: Climate Action Reserve (CAR),[4] American Carbon Registry (ACR),[5] Verified Carbon Standard (VCS),[6] and the California Air Pollution Control Officers Association (CAPCOA) GHG Reduction Exchange (CAPCOA GHG Rx).[7] These registries were chosen because they have been acknowledged or approved by governing bodies in the State of California. For example, three of the four registries, CAR, ACR, and VCS, were chosen because they have been approved by CARB to help administer certain parts of CARB's Compliance Offset Program, which generates offsets for use in CARB's Cap and Trade Program.[8, 9] The fourth registry, CAPCOA GHG Rx, was chosen because it has been recognized by air districts throughout California for use in California Environmental Quality Act (CEQA) mitigation and CAP implementation. Additional information regarding these registries is provided below and was circulated for public review in Chapter 2.7 and Appendix B of the Draft SEIR:

- American Carbon Registry (ACR) – The ACR is a non-profit organization founded in 1996 as the first private voluntary GHG registry in the world. Its mission is to create confidence in the environmental and scientific integrity of offsets to improve offset quality and to accelerate emission reduction actions. ACR registers offset projects from around the world.

- Climate Action Reserve (CAR) – The CAR began as the California Climate Action Registry, and was created by the State of California in 2001 to address climate change through the voluntary calculation and public reporting of GHG emissions. Eventually, this platform transitioned to one of calculating and reporting GHG emission reductions. CAR serves markets across North America, and in 2015, the registry issued 60 percent of the CARB offsets, and registered 83 percent of the projects that were issued CARB offsets.

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4 More information available at: http://www.climateactionreserve.org/. Accessed: November 2017.

5 More information available at: http://americancarbonregistry.org/. Accessed: November 2017.

6 More information available at: http://www.v-c-s.org/. Accessed: November 2017.

7 More information available at: http://www.capcoa.org/ghg-rx/. Accessed: November 2017.

8 More information available at: https://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm. Accessed: November 2017.

9 However, it is important to note that CARB does not allow all of the protocols on these registries to be used for its Compliance Offset Program. It is also important to note that Measure T-4.1 in the CAP allows for offsets that are generated outside of CARB's Compliance Offset Program. The County's local direct investment measure is not bound by the Cap and Trade Program.

- Verified Carbon Standard (VCS) – The VCS is a non-profit organization founded in 2005. It is the world's largest voluntary carbon offset market. It has registered more than 1,300 GHG reduction projects worldwide, which have reduced or removed over 185 million MT CO_2e.
- California Air Pollution Control Officers Association GHG Reduction Exchange (CAPCOA GHG Rx) – CAPCOA is a non-profit association of air pollution control officers from all 35 of the local air quality agencies in California. It was formed in 1976 to promote clean air and provide a forum for sharing of knowledge, experience, and information among air quality agencies. CAPCOA developed the GHG Rx in 2015 to provide a low cost forum for buying and selling GHG offsets for CEQA mitigation, implementing local CAPs, and other voluntary actions. It is operated cooperatively by the air districts that have elected to participate, and projects are limited exclusively to California.

3. METHODOLOGY

The following steps were used to assess the local direct investment measure, Measure T-4.1, in the County's draft CAP.

3.1 Protocol Review

This analysis began with a review of all of the adopted protocols that were posted on the websites of the four selected registries as of August 2017. Each protocol was then assessed for the following characteristics:

- Whether the geographic scope of the protocol covers the unincorporated county

  Protocols were reviewed to determine if they applied to a specific geographic area. If unincorporated San Diego was not in the geographic area of the protocol, the protocol was excluded from further analysis. For example, the 'British Columbia Forest Carbon Offset Methodology' from VCS only applies to projects in British Columbia; therefore, this protocol was excluded from further analysis.

- Whether the activities and/or sources[10] subject to the protocol exist in the unincorporated county

  The activities/sources governed by each protocol were reviewed to determine if they have the potential to exist in unincorporated San Diego. This was partially determined by noting whether or not the activities/sources were included in the emission inventory for the draft CAP.[11] Any protocols related to activities/sources that were determined not to exist and likely would continue not to exist or were outside of the jurisdictional control of the County, were excluded from further analysis. For example, there is currently no commercial rice cultivation in unincorporated San Diego. Since rice cultivation is tied to a very particular climate and land use, it was assumed that commercial rice cultivation would continue to not exist in San Diego . Therefore, protocols related to rice cultivation were excluded from further analysis.

- Whether the reductions from the protocol are already captured by measures or strategies in the County's draft CAP (in part or fully)

  Protocols related to activities/sources determined to exist in unincorporated San Diego were assessed to evaluate if emission reductions from those sources were already captured by strategies and measures in the County's draft CAP. If it was determined that a draft CAP measure would be seeking reductions from the same activity/source as a protocol, only emission reductions in excess of those proposed in the draft CAP were considered for further analysis.

[10] Activities can generally be defined as actions that result in the increase or decrease of emissions, whereas sources are entities that produce emissions.

[11] Sources were generally excluded from the CAP emission inventory if it was determined that the County had little jurisdictional control over the GHG emissions from those sources. For more information on which sources were excluded from the CAP emission inventory, see Section 2.4.2 of Appendix A of the draft 2017 CAP. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: November 2017.

Lastly, similar protocols were grouped together for ease of analysis. The goal of this protocol review was to identify protocols that could be implemented in the unincorporated county and achieve emission reductions outside of those already stipulated in the draft CAP.

3.2 Emission Reductions

For each group of protocols determined applicable to the unincorporated county, a range of potential emission reductions were estimated using engineering calculations or other documented calculations. When feasible, the same emission factors and assumptions that were used to produce the emission inventory and emission reductions in the draft CAP (from Appendices A and C) were used to generate the potential emission reduction estimates. When it was not feasible to use engineering calculations, emission reductions obtained by similar-type projects listed on the chosen registries or found through literature review were used.

For protocols that were dependent on land acreage, Geographic Information System (GIS) shape files were obtained from SanGIS.[12] ArcMap version 10.3 was used to display the data and determine land acreage by land use type in unincorporated San Diego.

As a first step, maximum possible reductions were estimated without consideration of protocol overlap or activity/source penetration rate. Then literature review and engineering judgment were used to develop a range for the potential emission reductions from each protocol group via local direct investment. A range is presented because it is possible that reductions may occur through alternative regulatory mechanisms, so while they could still be realized, they may not occur through the County's local direct investment program. For example, the State of California may one day make it mandatory for dairy farms to install digesters for manure management. While this regulatory action would reduce GHG emissions in the unincorporated county, it would also make it so that the County could no longer pursue those reductions through a protocol. While it is possible that additional GHG reductions are obtainable beyond those estimated here, we have included conservative high-end estimates based on the information available at this time. For instance, for many of the land management protocols Ramboll Environ assumed that it would be possible for the County to apply projects on 0.5% to 5% of eligible land. It is possible that once the County begins to develop its program it may find that larger percentages of land are available. See Section 4 for more details.

3.3 Cost Analysis

The cost-effectiveness of each group of protocols deemed applicable to the unincorporated county was determined by assembling cost data in the form of $/MT CO_2e (i.e., the cost of obtaining 1 MT reduction of CO_2e). Most of these data were obtained through a literature search; however, when data were not readily available in units of $/MT CO_2e, a cost metric was derived using proposed project assumptions (e.g., factors such as project lifetime, project size, etc.). This cost research focused on direct

[12] SanGIS is the home San Diego's regional GIS data warehouse. Available at: http://www.sangis.org/. Accessed: November 2017.

costs. Costs related to the registering and listing of projects on a registry were evaluated separately and are discussed in Section 5.1.2.

Once the direct cost data was assembled, it was evaluated for applicability to the unincorporated county. Examples of “low” applicability data include data published more than 20 years ago, data from foreign or developing nations, and data in which the economic benefits of the project were also included.[13] Low applicability data was removed when multiple cost data points were available.

[13] Because the County is likely not going to be in position as the beneficiary for many of the local direct investment projects it would be funding/implementing, this analysis does not include the economic benefits of those projects in a cost-effectiveness analysis.

4. OVERVIEW OF ESTIMATED REDUCTIONS

4.1 Results Summary

As discussed previously in Section 1, the County seeks to achieve an emission reduction of 190,262 MT CO_2e in 2030 under its local direct investment measure (Measure T-4.1). The purpose of this analysis was to assess the possible approaches for obtaining the level of GHG reductions stipulated by the CAP for this measure. By following the methodology presented in Section 3, Ramboll Environ identified the protocol groups applicable to the unincorporated county and developed a range of the potential emission reductions for each protocol group.

As shown in Table 1, which presents the protocols applicable to the unincorporated county, their potential reductions, and estimated costs, Ramboll Environ estimates that the County could obtain anywhere from 50,100 to 198,800 MT in CO_2e reductions in 2030 through implementation of a local direct investment measure. The range in this estimate is related to the propagation of uncertainties in the reduction estimates for the individual protocol types.

4.2 Protocol Review and Exclusion

As discussed in Section 3.1, the analysis of protocols began with a review of all of the adopted protocols that were posted as of August 2017 on the websites of the selected registries. This consisted of 18 protocols from CAR, 26 protocols from ACR, 43 protocols from VCS, and 17 protocols from the CAPCOA GHG Rx Program, for a total of 104. The majority of the protocols from the CAPCOA GHG Rx Program had considerable overlap with the protocols of the other three registries. Of the 104 protocols from the listed registries, eight protocols were excluded from further analysis because they were non-specific and referenced methodologies already included under other protocols or because they were a compilation of emission estimation tools, rather than an emission reduction methodology. Thirty-two protocols were identified as being related to activities/sources that do not exist in the unincorporated county. This group included the protocols focused on geographic areas outside of the unincorporated county. Twelve protocols were identified as being related to activities/sources that likely exist in the unincorporated county, but are not captured in the emission inventory of the draft CAP.[14] These protocols were primarily related to stationary/industrial sources and emissions from ozone depleting substances. The remaining 52 protocols were identified as applicable to the unincorporated county and were evaluated for their potential to generate GHG emission reductions in 2030. A brief description of each of the 104 protocols is presented in column G of Table 2, which includes the applicability determination for each protocol.

4.3 Overview of Protocols

The 52 protocols identified as applicable to the unincorporated county were grouped into five main protocol sectors: agriculture, energy efficiency/production, land use management, landfill/waste management, and transportation. These protocols and their

[14] See Section 2.4.2 of Appendix A of the draft 2017 CAP for additional information on why certain emission sources were excluded from the emission inventory. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: November 2017.

estimated potential reductions are discussed in greater detail by protocol sector in the sections below.

4.3.1 Agriculture

In the unincorporated areas of San Diego, agricultural activities were the source of 163,696 MT CO_2e, or 5 percent of the draft CAP emissions inventory for 2014. As shown in the CAP, this emissions level is expected to continue through 2050. Protocols in the agriculture category include those that reduce GHG emissions through the adoption of sustainable land use practices and through changes to how livestock manure is handled and treated. The applicable protocols in this category were grouped into the following sub-categories:

- Nitrogen Fertilizer Management
- Manure Management (Biogas Control Systems and Solids Management)[15]
- Sustainable Agricultural Land Management (SALM)

For the categories of Nitrogen Fertilizer Management and Manure Management, GHG reductions are achieved through reducing or capturing emissions. Through practices like installing biogas collection systems and adjusting fertilizer application techniques, farmers can reduce their GHG outputs. In contrast, certain SALM practices reduce GHGs in a different way by sequestering carbon that is already in the atmosphere. One example of such a practice is composting on cropland. By using compost to increase the organic matter content of soil on agricultural lands, the plants, fungi, and other organisms present around the crops can grow, absorbing carbon from the atmosphere while doing so.

The general method for estimating reductions associated with agriculture projects started with first identifying the amount of GHG emissions for a specific inventory source (e.g., Soil Management), determining what activities from the selected protocol could generate reductions, and then finding real-world examples of these types of projects, noting the degree of reductions they achieved (usually as a percentage of their respective GHG outputs) and applying this factor to the entire source category. Finally, various activity rates from 5% to 75% were assumed based on the best engineering judgment for how widespread these projects could become. The details of the calculations that went into determining potential reductions for each of the protocols explored are presented in Tables 3-1 to 3-4. Combined, four groupings of agriculture protocols are estimated to achieve between 15,500 and 38,300 MT CO_2e in reductions in 2030, with the largest reductions coming from the SALM protocol. The reduction estimates for the SALM protocol assume GHG sequestration (i.e., the long-term storage of CO_2 or other forms of carbon) will occur through the use of organic compost on croplands. The final quantity of reductions achieved via the SALM protocol will depend on various factors including the availability of quality compost and the willingness of farmers to implement this practice in the unincorporated county.

[15] This sub-category includes the "U.S. Livestock" protocol from the Climate Action Reserve and the variations of that protocol permitted in the CAPCOA GHG Rx program, and “Revisions to AMS-III.Y to Include Use of Organic Bedding Material” from the Verified Carbon Standard.

4.3.2 Energy Efficiency / Production

Protocols in the energy efficiency and production category include those that reduce GHG emissions through enhanced energy supply efficiency as a displacement of more carbon intense electricity generation or through energy efficiency investments in residential, commercial, or industrial sectors. Increasing or improving energy efficiency is one of the most common ways to achieve GHG reductions in the energy efficiency and production protocol category. By implementing the energy efficiency and production protocols, emission reductions may be quantifiable based on the amount of energy saved. The protocols in this category were grouped into the following sub-categories:

- New cogeneration facilities
- Weatherization of buildings
- Energy efficiency and solid waste diversion
- Campus clean energy and energy efficiency

Emission reductions for new cogeneration facilities rely upon the amount of energy that can be exported to the grid for the San Diego area, which would displace the 2030 non-Renewable Portfolio Standard (RPS) electricity. For the campus clean energy and energy efficiency protocol, potential GHG reduction rates were extracted from similar type projects in the VCS registry. For other sub-categories, given the similarity of the measures assumed in these protocols and various draft CAP measures, additional reductions were estimated using the same information and parameters included in the CAP. Where needed, engineering judgment was used to determine the magnitude of energy efficiency penetration, which could be included in the quantification of the protocol sub categories. Tables 3-5 to 3-8 present the potential emission reductions as well as detailed calculation assumptions for the energy efficiency and production protocols.[16] Combined, ten groupings of energy efficiency and production protocols are estimated to achieve between 15,400 and 56,500 MT CO_2e in reductions in 2030, with the largest reductions coming from the cogeneration sub-category.

4.3.3 Land Use Management

Protocols in the land use management category include those that reduce GHG emissions through the maintenance or modification of the natural environment. By implementing the land use management protocols, emission reductions may be quantifiable for current activities or for changes to land management practices in the unincorporated county. The protocols in this category were grouped into the following sub-categories:

- Avoided forest degradation
- Avoided forest deforestation
- Conservation of grassland
- Improved forest management
- Improved grassland management

[16] Detailed calculations have not been included for selected protocols that had a low level of estimated reductions (i.e., Protocols 21-24, 26-27).

- Afforestation and reforestation of degraded lands
- Restoration of wetlands
- Sequestration (tree planting)
- Grazing land management
- Composting addition to grazed grasslands

Emission reductions for each sub-category were estimated based on the average of similar type projects in the CAR, ACR, and VCS registries. Site-specific field measurements will allow for more precise calculations of the GHG reduction potential from the land use management protocols. If prior project information was not available in the registries, a literature search was performed to find other existing projects, which had quantified emission reductions.

Land use acreage in the unincorporated county was determined using County GIS information in order to estimate the applicable land areas, and the amount of feasible GHG reductions from that land. The following shape files from SanGIS were used to estimate acreage:

- **Municipal_Boundaries.shp**. This shape file contains parcels organized by city, municipal boundary, jurisdictional boundary, and County of San Diego. Data was used to determine the boundary of unincorporated San Diego.
- **Conserved_Lands.shp**. This shape file contains an inventory of the land in San Diego that is conserved for the purposes of protecting the open space and natural habitats. Data was used to determine which areas of the unincorporated county are already in a conservation program.
- **Eco_vegetation_cn.shp**. This shape file illustrates the vegetation communities and disturbed areas throughout the unincorporated county. Data was used to determine the acreage of forest, grassland, and fields/pastures.
- **Wetlands.shp**. This shape file illustrates the locations of wetlands, riparian, deep-water, and aquatic habitats in the unincorporated county. Data was used to determine the acreage of estuarine wetlands. Estuarine wetland was used as an approximation of area, which could undergo wetland restoration.

Engineering judgment was used to determine the fractions of acreage, which could be included in the quantification of the protocol sub categories. Tables 3-9 to 3-18 present the potential emission reductions from land use management protocols. Combined ten groupings of land use protocols are estimated to achieve between 14,900 and 93,400 MT CO_2e in reductions in 2030, with the largest reductions coming from the conservation of grassland and avoided forest degradation protocols. The final reductions obtained through these protocols will depend on the availability of suitable land, and the productivity/carbon capacity of that land.

4.3.4 Landfill / Waste Management

Protocols in the landfill and waste management category include those that reduce GHG emissions associated with the waste emissions in the CAP. Per the CAP emission inventory, waste-related activities were the source of 359,290 MT CO_2e emitted to the atmosphere in the unincorporated county in 2014. This includes emissions from various subcategories such as landfill gas emissions and wastewater treatment. Altogether, emissions from solid waste and wastewater sources accounted for about 12% of the CAP emission inventory for 2014. These levels are estimated to increase through 2050 as the unincorporated county's population grows.

Ramboll Environ reviewed protocols in various registries relevant to reducing waste-related GHG emissions and two categories were selected based on their relevance to the unincorporated county and their potential to realize GHG reductions. These two categories are emissions from:

- Organic Waste Digestion
- Landfill Gas Capture and Destruction/Use

The Organic Waste Digestion category was selected because of the opportunity for obtaining GHG reductions by installing digesters at wastewater treatment plants (WWTPs) where they are currently lacking (as manifested by the "WWTPs without anaerobic digestion" emissions category in the CAP inventory). Similarly, the Landfill Gas Capture and Destruction/Use was selected because according to the CAP there are some landfills in the unincorporated county where landfill gas (LFG) collection systems are not currently in place, indicating opportunities for GHG reductions.

For both of these waste categories, GHG reductions are achieved through capturing and eliminating methane. In wastewater treatment, this is done by installing a digester that processes sludge to convert the organic matter into carbon dioxide and methane. The methane produced is then flared to eliminate the methane. Although carbon dioxide is released, the net amount of CO_2e is reduced because the methane, which has a much higher global warming potential, is destroyed. The concept is similar for landfills, although a digester is not needed since the LFG generated is already a mix of carbon dioxide and methane. By installing a LFG control system, the methane can be collected and flared to prevent its release.

The general method for estimating reductions achieved through projects in this category starts with first identifying the amount of GHG emissions present at both landfills without LFG control systems and WWTPs without digesters. Then, to determine the degree of emission reductions achievable, examples of these types of projects and the percentage reductions they achieved were relied upon. This percentage factor was then applied to the total emissions estimates for the identified sources. Finally, various penetration rates from 25% to 75% were assumed based on the best engineering judgment for how widespread these projects could become. The details of the calculations that went into determining potential reductions for each of the protocols explored are presented in Tables 3-19 and 3-20. [17] Combined three groupings of landfill/waste management protocols are estimated to achieve between 2,800 and 4,900 MT CO_2e in reductions in 2030. The low amount of estimated reductions from this category is primarily tied to the fact that the County is already seeking significant reductions from this sector through Measure SW-1.1 in the CAP.

[17] Detailed calculations have not been included for selected protocols that had a low level of estimated reductions (i.e., Protocol 89).

4.3.5 Transportation

Protocols in the transportation category include those that reduce GHG emissions by reducing the number and length of vehicle trips through smarter land use planning, increasing the use of alternative modes of transportation, and encouraging a shift to electric and alternatively-fueled vehicles. On-road internal combustion transportation is the largest contributor to the unincorporated county's GHG emissions.

Emissions from on-road transportation sources accounted for 45 percent of the draft CAP emissions inventory for 2014. Emissions from off-road sources contributed another one percent of total emissions in 2014. The protocols in this category were grouped into the following sub-categories:

- Fuel switch from gasoline to ethanol in flex-fuel vehicle fleets
- Energy efficiency from lightweight pallets
- Carpooling
- Improved efficiency of mobile machinery (i.e., off-road equipment)
- Improved efficiency of vehicle fleets
- Installation of truck stop electrification

Emission reductions for transportation protocols are derived from the baseline inventory levels established in the draft CAP. Additional information is also obtained from EMFAC2014 for unincorporated San Diego. Where needed, engineering judgment was used to determine the magnitude of transportation fuel/energy efficiency penetration, which could be included in the quantification of the protocol sub-categories. Tables 3-21 to 3-23 present the potential emission reductions as well as detailed calculation assumptions for fuel/ transportation energy efficiency protocols. Combined four groupings of transportation protocols are estimated to achieve between 1,500 and 5,700 MT CO_2e in reductions in 2030. There are a relatively low number of transportation-related protocols, thus the overall reductions are limited.

5. OVERVIEW OF COSTS

There are several costs involved in the implementation of a local direct investment program. First, there are the direct costs related to the individual projects, which can include initial capital investments, ongoing operation and maintenance costs, and taxes. These direct costs may vary for different protocol types. Some protocol direct costs may be resource intensive due to the need to buy land, while others may include costs to purchase, install equipment, and/or replace equipment at the end of its useful life. Other costs associated with a local direct investment program are those related to putting individual projects through the registry process in order to verify emissions reductions. These costs are discussed in detail in Section 5.1.2. Finally, implementation of the local direct investment program requires some overhead costs incurred by the County. Estimates for implementation costs for the County are being developed separate from this report.

5.1.1 Direct Costs

The cost-effectiveness part of this analysis focused on direct costs of the individual project types. It is important to note that macroeconomic costs such as stakeholder/industry costs and the broader, overall economic impact of the individual project types and the local direct investment program is not addressed here. It is possible that action on these protocols may increase, decrease, or shift other economic activity from ancillary markets within the unincorporated county and it’s possible that the County could have shared costs in implementing action for a particular protocol; the evaluation of such effects was beyond the scope of this analysis. Furthermore, the research of direct costs is based on numerous assumptions and extrapolation from other related projects. The actual costs may vary from the estimates discussed when a specific protocol is pursued due to the more site (and time) specific information at that time. The cost information presented below provides a comparative perspective on the costs to generate offsets by each protocol. The direct cost data assembled for each of the protocol types are discussed by protocol group in the sections below.

5.1.1.1 Agriculture

When estimating the costs involved with reducing GHGs via agricultural activities, case studies and other current projects at farms around California and internationally were reviewed. Based on their applicability to the selected protocols, the results of these studies were used to estimate costs for implementing similar projects at farms in unincorporated San Diego. Factors such as the location where the projects took place, the years the projects were conducted, and the activities involved were all considered when determining their applicability towards the protocols selected for the unincorporated county.

The direct costs involved for these projects were estimated in one of three ways. The most straightforward method required no calculation, extracting the cost per MT CO_2e reduced from the sample project’s report (or other form of literature). The second method consisted of calculating the cost per MT by dividing the overall project cost by the GHG reductions it was estimated to achieve. Finally, for the composting projects (as part of the SALM protocol), cost estimates were based on the total cost to purchase, transport, and spread the compost across croplands. Based on this cost and the general estimate for compost's potential to sequester carbon, the cost per MT CO_2e reduced could be found. The full details for these estimations can be found in Table 4.

Costs per metric ton of CO_2e reduced vary among the protocol types. In general, the most inexpensive agricultural carbon reductions were found for projects involving livestock manure emissions. Case studies for these types of projects revealed that while they may require significant initial capital investments to construct and install the digester systems, the reductions they can achieve lead to relatively inexpensive costs per MT CO_2e of around $10. In contrast, certain projects cost much more to achieve similar reductions. For example, composting as part of the SALM protocol is estimated to cost anywhere between $359 and $1,257 per MT CO_2e reduced. Even though these kinds of projects do not involve expensive capital investments, they are still costly because they require a significant amount of compost to be purchased, transported, and spread across crop fields. Additionally, because compost feedstocks can come from a variety of different sources, their prices vary dramatically, hence the wide range of the GHG reduction cost estimate. Another category, which exhibits some variation in cost estimates, is soil management. Because different activities can be implemented as part of this protocol, varied costs will result. Examples of GHG-reducing soil management activities include using different types of fertilizer and changing the timing or way the fertilizer is applied to crops in order to use less. In the end, it will be up to the farmer to decide what activities to pursue based on the types of crops present and the local farming conditions.

5.1.1.2 Energy Efficiency / Production

Costs per MT CO_2e for energy efficiency and production projects were obtained from literature review of similar type projects when available or else derived from the total project costs and the associated GHG reductions. Of the literature reviewed for energy efficiency and production protocols, the cost data generally includes a one-time capital or investment cost; however, cost data points did not always account for the ongoing costs such as those related to operating and maintenance. Detailed cost data is provided in Table 4.

While cost data was generally available for all protocol sub-categories, there was also a variance between costs of the same sub-category. This is due to differences in types of costs included, scale of the projects in the source documents, efficiency measures implemented, and assumptions used when calculating the $/MT CO_2e metric. For example, costs for new cogeneration facilities can vary dramatically depending on the technology used in the system design, which ultimately affects capacity and efficiency of the plant. In some cases, total costs incorporate the savings produced as a result of energy efficiency.

Most of the unit costs for the energy efficiency and production reductions were generally consistent among the categories, with the least expensive costs being related to projects under the "Campus Clean Energy and Energy Efficiency" protocol. In particular, the cheapest reductions were associated with the installation of vending misers (i.e., energy efficiency devices for vending machines).

The most expensive unit costs were associated with the weatherization of single- and multi-family homes. Costs and reductions will vary by project, depending on the reductions available and availability of technology. Ultimately, the costs associated will depend on which energy savings practices the County or other entity are able to pursue.

5.1.1.3 Land Use Management

Costs for land use management protocol projects were obtained from literature review of similar type projects. As these projects can be implemented in nearly any location, at least one data point was available for each protocol sub-category. Factors such as the project location, the years the projects were conducted, and the activities involved were all considered when determining their applicability towards the protocols selected for the unincorporated county. Cost data is provided in Table 4.

Land use management costs include capital costs for activities such as land purchase, tree planting, and site preparation and ongoing costs such as maintenance and rental payments. The location of the project in the data source may also affect costs depending on availability of resources in that location. In general, the least expensive land use management reductions were found for projects involving improved land management. These project types do not always require a capital cost for land purchase or extensive labor and materials. Projects which require more labor and materials, such as restoration of wetlands and planting of trees, are generally more expensive due to land and materials needs.

While cost data was generally available for all protocol sub-categories, there was also a variance between costs of the same sub-category. This is due to differences in types of costs included, location of the projects in the source documents, and assumptions used when calculating the $/MT CO_2e metric.

5.1.1.4 Landfill / Waste Management

When estimating the costs for reducing GHGs via waste management activities, case studies and other current projects from around California and the rest of the world were reviewed. Based on their applicability to the selected protocols, the results of these studies were used to estimate costs for implementing similar projects at landfills and in communities in unincorporated San Diego. Factors such as the locations where the projects took place, the years they were conducted, and the activities involved were all considered when deciding on their applicability.

The direct costs involved for these projects were estimated in one of three ways. The most straightforward method required no calculation at all, and simply involved extracting the cost per MT CO_2e reduced from the sample project's report (or other form of literature). The second method consisted of calculating the cost per MT by dividing the overall project cost by the GHG reductions it was estimated to achieve. Finally, for the biochar-related projects, cost estimates were based on the cost to produce biochar from organic feedstocks. Based on this cost and the general estimate for biochar's potential to sequester carbon, the cost per MT CO_2e reduced could be found. The full details for these estimations can be found in Table 4.

Costs per metric ton of CO_2e reduced vary from project type to project type and even among projects of the same type. For example, cost estimates for reductions from capturing landfill gas are largely dependent on the size of the landfill and how much LFG is captured by its control system. Two of the projects analyzed had a massive difference in costs: $1.49/MT CO_2e versus $129/MT CO_2e. The reason for this large disparity is because the less expensive LFG control system also captures much more methane compared to the other, more expensive one. The amount of methane captured is based on factors like the amount of waste-in-place at the landfill and the efficiency of the system. These such factors will need to be considered when designing similar systems at landfills in the unincorporated county in order to ensure that the most cost-effective model is pursued.

Considering the variable cost for reductions achieved by LFG control systems, it can be assumed with more confidence that waste management reductions from producing biochar are less expensive. These reductions are also less compared to those from the biomass waste-to-energy protocols because instead of burning the biomass to produce energy (and CO_2 as a byproduct), the carbon is sequestered in the form of recalcitrant biochar.

5.1.1.5 Transportation

Cost-effectiveness data for GHG mitigation options in the transportation category were obtained from literature review of similar type projects when available or else derived from the total project costs and the associated GHG reductions. Cost data for transportation protocols were often not clear if they represented average/on-going costs or lifetime cost based on the implementation of a particular mitigation strategy. A summary of cost-effectiveness data is provided in Table 4.

While cost data was generally available for all protocol sub-categories, there was a variance within the costs of the same sub-category. This is due to differences in types of costs included, scale of the projects in the source document, efficiency measures implemented, and assumptions used when calculating the $/MT CO_2e metric. For example, while evaluating the cost data for GHG reductions using *Carpooling methodology*, the Cap and Trade Annual Report states the cost over project lifetime as $2,427/MT CO_2e, while the GHG Cost Effectiveness Study for LA County Metropolitan Transportation Authority (Metro) states the cost as $78/MT CO_2e. The former data includes cost derived from three projects that involved purchasing zero or near zero-emission vehicles for use in car-sharing programs for residents of disadvantaged communities; whereas, the latter data represents administrative costs, marketing and outreach, and financial incentives to commuters, and vanpool subsidies given to employees. Additionally, in some cases, the cost per metric ton of GHG reduced turns into savings per metric ton of GHG reduced (i.e., a negative cost for GHG emissions reduced). Whether or not the County is ultimately the beneficiary for some of these programs will determine if those savings are realized.

In general, the “improved efficiency of vehicle fleets” protocol type had the lowest $/MT CO_2e unit costs of the transportation protocols. Per the protocol, fleet efficiency would need to be improved through eco-drive systems, air conditioning system improvements, use of low viscosity oils, and transmission improvements in medium-duty (MD) and heavy-duty (HD) vehicles. In general, these projects do not involve extensive capital investments and will provide ongoing cost savings through reductions in fuel usage. The most expensive transportation protocol type was “transport energy efficiency from lightweight pallets.” The high cost associated with this protocol was primarily due to the assumption that, at least at the outset, the County would have to subsidize or purchase the lightweight pallets in order to get fleets to integrate them into their supply chain.

Because of the high estimated costs, this protocol was removed from further consideration at the current time.

5.1.2 Registry Costs

When a project lists with a registry, there are several steps for this process and costs associated with these steps. During the preparation phase, the typical steps involved in obtaining offsets by implementing a protocol project are:

1. Conducting a feasibility study, gathering all relevant project information, and setting up a monitoring plan;
2. Preparing the project application;
3. Receiving validation by the registry, sometimes by a third party in addition to the registry; and
4. Officially enrolling the project with the registry.

In some cases, there are costs associated with negotiating a purchase agreement and/or identifying a broker for the sale of the offsets; however, the County may avoid these costs since they will be retiring the offsets that they generate.

Once the project is operational, there will be ongoing monitoring and verification of the emission reductions. The frequency of monitoring and verification will depend on the project type and is based on the requirements outlined in each protocol. The County may choose to monitor the reductions internally, or they may have an outside party, such as a consultant, conduct the monitoring.

The range of costs for each of these steps may vary widely depending on the type of project, the registry, and the specific steps and documents required by the registry; however, here are some estimated ranges provided by Clean Development Mechanism (CDM):[18]

- Feasibility study - $5,900 to $47,000;
- Project preparation - $23,000 to $70,500;
- Project approval - $18,000 to $47,000;
- Registration - $5,900 to $35,000; and
- Monitoring and verification - $3,500 to 18,000.

Total Cost - $56,300 to $217,500.

These costs would likely apply on a per-project basis and thus could be a significant part of the overall costs for the local direct investment program, especially for the protocol types that involve consolidating emission reductions from many individual projects in order to achieve the overall emission reductions sought by the County.

[18] Clean Development Mechanism. 2004. Climate Change: Guide to the Kyoto Protocol Project Mechanisms. Second Edition. Table 1. Available at: https://wbcarbonfinance.org/docs/b_en_cdm_guide_ld.pdf. Accessed: November 2017.

6. CONCLUSION

The County seeks to achieve an emission reduction of 190,262 MT CO_2e in 2030 under its local direct investment measure (Measure T-4.1). The purpose of this analysis was to assess this measure by determining the possible approaches for obtaining the level of GHG reductions stipulated by the CAP. By following the methodology presented in Section 3, Ramboll Environ identified the protocol groups applicable to the unincorporated county and developed a range of the potential emission reductions for each protocol group. As shown in Table 1, Ramboll Environ estimates that the County could obtain anywhere from 50,100 to 198,800 MT in CO_2e reductions via a local direct investment measure. The range in this estimate is related to the assumptions in the reduction estimates for the individual protocol types, and also reflects the possibility that reductions may occur through alternative regulatory mechanisms, so while they could still be realized, they may not occur through the County's local direct investment measure.

As discussed in Section 5, there would be several costs involved in the County's implementation of the local direct investment measure. These costs include the direct costs of the projects, the costs associated with listing the projects and associated offsets in registries, and the administrative costs for creating, managing, and developing a local direct investment program. Table 1 shows that that the direct costs may reach $14 to $55 million in 2030 as the County builds its program to meet the 2030 reduction goal. The total implementation cost will depend on the pace at which the County chooses to pursue reductions between now and 2030. Section 5.1.2 shows that the per-project registry costs will likely be in the range of $56,000 to $218,000. All of these costs will depend on the types of projects that the County ultimately pursues and how and when they choose to implement them. The cost information can aid in future implementation planning and provides a perspective on the relative costs between protocols, and the additional contributors to the costs required to pursue a local direct investment program.

TABLES

Table 1. Summary of Reductions and Direct Costs
County of San Diego
Preliminary Assessment of Local Direct Investment Program

								REASONBLE HIGH REDUCTIONS	
No.	REGISTRY	PROTOCOL / METHODOLOGY NAME	PROTOCOL SECTOR	REASONABLE LOW REDUCTIONS (MT/year)	REASONABLE HIGH REDUCTIONS (MT/year)	UNIT COST LOW ($/MT)	UNIT COST HIGH ($/MT)	TOTAL COST LOW [1] ($/year in 2030)	TOTAL COST HIGH [1] ($/year in 2030)
3	Verified Carbon Standard	Quantifying N_2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction	Agriculture	2,000	6,500	$50	$143	$325,000	$929,500
4	American Carbon Registry	Reduced Use of Nitrogen Fertilizer on Agricultural Crops	Agriculture						
5	Climate Action Reserve	U.S. Livestock	Agriculture	5,000	14,800	$7	$14	$103,600	$207,200
6	CAPCOA GHG Rx	Climate Action Reserve U.S. Livestock Project Protocol Version 4.0	Agriculture						
7	CAPCOA GHG Rx	Revised Compliance Offset Protocol Livestock Projects	Agriculture						
8	Verified Carbon Standard	Adoption of Sustainable Agricultural Land Management (SALM)	Agriculture	7,800	15,700	$442	$808	$6,939,400	$12,685,600
9	Verified Carbon Standard	Revisions to AMS-III.Y to Include Use of Organic Bedding Material	Agriculture	700	1,300	$52	$81	$67,600	$105,300
			AGRICULTURE SUB-TOTAL	**15,500**	**38,300**				
16	Verified Carbon Standard	New Cogeneration Facilities Supplying Less Carbon Intensive Electricity to Grid and/or Hot Water to One or More Grid Customers	Energy Efficiency/Production	10,000	29,400	$10	$210	$294,000	$6,174,000
17	Verified Carbon Standard	Weatherization of Single Family and Multi-Family Buildings	Energy Efficiency/Production	3,700	18,500	$123	$445	$2,275,500	$8,223,250
18	CAPCOA GHG Rx	Weatherization of Single Family and Multi-Family Buildings	Energy Efficiency/Production						
19	Verified Carbon Standard	Energy Efficiency and Solid Waste Diversion Activities within a Sustainable Community	Energy Efficiency/Production	400	1,900	$22	$110	$41,800	$209,000
20	Verified Carbon Standard	Campus Clean Energy and Energy Efficiency	Energy Efficiency/Production	1,000	5,000	$15	$367	$74,250	$1,832,592.59
21	Verified Carbon Standard	Methodology for Installation of Low-Flow Water Devices	Energy Efficiency/Production	300	500	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2
22	American Carbon Registry	Switch from non-renewable biomass for thermal applications	Energy Efficiency/Production	0	50	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2
23	American Carbon Registry	Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass	Energy Efficiency/Production	0	50	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2
24	American Carbon Registry	Low greenhouse gas emitting safe drinking water production systems	Energy Efficiency/Production	0	50	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2
26	CAPCOA GHG Rx	Biomass Waste for Energy Project Reporting Protocol	Energy Efficiency/Production	0	1,000	$155	$236	$155,000	$235,500
27	CAPCOA GHG Rx	Improvement of the Efficiency of a Natural Gas-Fired Boiler or Process Heater	Energy Efficiency/Production	0	50	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2
			ENERGY EFFICIENCY/PRODUCTION SUB-TOTAL	**15,400**	**56,500**				
40	Verified Carbon Standard	Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects	Land Use Management	1,700	17,000	$33	$80	$567,166	$1,360,000
41	Verified Carbon Standard	REDD+ Methodology Framework (REDD-MF)	Land Use Management						
42	Verified Carbon Standard	Methodology for Avoided Unplanned Deforestation	Land Use Management	900	8,600	$33	$80	$286,919	$688,000
43	American Carbon Registry	Reducing Emissions from Deforestation and Degradation (REDD) – Avoiding Planned Deforestation	Land Use Management						
44	Verified Carbon Standard	Methodology for Avoided Ecosystem Conversion	Land Use Management	SEE NOTE 3	SEE NOTE 3	SEE NOTE 3	SEE NOTE 3	SEE NOTE 3	SEE NOTE 3
45	Climate Action Reserve	Grassland	Land Use Management	3,100	31,200	$2	$303	$60,528	$9,438,000
46	American Carbon Registry	Avoided Conversion of Grasslands and Shrublands to Crop Production	Land Use Management						
48	American Carbon Registry	Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	Land Use Management	700	6,600	$2	$12	$11,461	$77,851.61
50	CAPCOA GHG Rx	CAPCOA GHG Rx Forestry Protocol #2: 100-year Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration	Land Use Management						
51	American Carbon Registry	Afforestation and Reforestation of Degraded Lands	Land Use Management	1,600	16,200	$6	$24	$95,947	$386,370

Table 1. Summary of Reductions and Direct Costs
County of San Diego
Preliminary Assessment of Local Direct Investment Program

								REASONBLE HIGH REDUCTIONS	
No.	REGISTRY	PROTOCOL / METHODOLOGY NAME	PROTOCOL SECTOR	REASONABLE LOW REDUCTIONS (MT/year)	REASONABLE HIGH REDUCTIONS (MT/year)	UNIT COST LOW ($/MT)	UNIT COST HIGH ($/MT)	TOTAL COST LOW [1] ($/year in 2030)	TOTAL COST HIGH [1] ($/year in 2030)
52	Verified Carbon Standard	Methodology for Coastal Wetland Creation	Land Use Management	200	700	$30	$134	$20,778.72	$93,520
53	CAPCOA GHG Rx	Coastal Wetland Creation	Land Use Management						
54	Verified Carbon Standard	Methodology for Tidal Wetland and Seagrass Restoration	Land Use Management						
55	American Carbon Registry	Restoration of California Deltaic and Coastal Wetlands	Land Use Management						
56	CAPCOA GHG Rx	Quantifying Greenhouse Gas Reductions from Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and the Coast of California	Land Use Management						
57	Climate Action Reserve	Urban Tree Planting	Land Use Management	4,500	6,000	$101	$711	$608,564	$4,265,400
58	Verified Carbon Standard	Soil Carbon Quantification Methodology	Land Use Management	300	3,400	$95	$510	$323,000	$1,734,000
59	Verified Carbon Standard	Methodology for the Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing	Land Use Management						
60	American Carbon Registry	Grazing Land and Livestock Management	Land Use Management	500	900	$7	$95	$6,521	$85,298
61	Verified Carbon Standard	Methodology for Sustainable Grassland Management (SGM)	Land Use Management						
62	American Carbon Registry	Compost Additions to Grazed Grasslands	Land Use Management	1,400	2,800	$5	$40	$13,067	$112,000
63	CAPCOA GHG Rx	Methodology for Compost Additions to Grazed Grasslands	Land Use Management						
			LAND USE MANAGEMENT SUB-TOTAL	**14,900**	**93,400**				
83	Climate Action Reserve	Organic Waste Composting	Landfill/Waste Management	SEE NOTE 4	SEE NOTE 4	SEE NOTE 4	SEE NOTE 4	SEE NOTE 4	SEE NOTE 4
84	Climate Action Reserve	Organic Waste Digestion	Landfill/Waste Management	600	1,700	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2
85	CAPCOA GHG Rx	Organic Waste Digestion Project Protocol	Landfill/Waste Management						
86	Climate Action Reserve	U.S Landfill	Landfill/Waste Management	2,200	2,200	$129	$129	$283,800	$283,800
87	American Carbon Registry	Landfill Gas Destruction and Beneficial Use Projects	Landfill/Waste Management						
88	American Carbon Registry	Landfill Methane Collection and Combustion	Landfill/Waste Management						
89	CAPCOA GHG Rx	Biochar Production Project Reporting Protocol	Landfill/Waste Management	0	1,000	$62	$150	$62,000	$150,000
			LANDFILL / WASTE MANAGEMENT SUB-TOTAL	**2,800**	**4,900**				
98	Verified Carbon Standard	Fuel Switch from Gasoline to Ethanol in Flex-Fuel Vehicle Fleets	Transportation	1,000	1,900	$759	$759	$1,441,340	$1,441,340
100	Verified Carbon Standard	Methodology for Carpooling	Transportation	100	1,500	$78	$2,608	$116,325	$3,912,150
101	Verified Carbon Standard	Revisions to AMS-III.BC (Improve Efficiency of Vehicle Fleets) to Include Mobile Machinery	Transportation	100	1,000	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2	SEE NOTE 2
102	American Carbon Registry	Improved Efficiency of Vehicle Fleets	Transportation	300	1,300	$32	$83	$41,600	$107,900
			TRANSPORTATION SUB-TOTAL	**1,500**	**5,700**				
			TOTAL	**50,100**	**198,800**			**$14,215,167**	**$54,737,572**

Notes:
[1] Total costs are an estimation based on a review of available data and may include published lifetime, operations and maintenance, one-time-only, and initial costs. These estimates are intended to provide a perspective on the relative costs between protocols. These estimates do not constitute a detailed financial analysis. That level of analysis will be performed at a later date.
[2] Cost estimates were not generated for the protocols with lower estimates of potential emission reductions.
[3] Reductions from Protocol 44 overlap with reductions from Protocols 42 and 43, which are related to avoided deforestation, and Protocols 45 and 46, which are related to avoided grassland conversion.
[4] Composting is already a diversion measure under CAP measure SW-1.1 and the SD County's Strategic Plan to Reduce Waste. GHG reductions from compost application on croplands and grazing lands are considered under other protocols.

Table 2. Protocol Reduction Potential Summary Matrix
County of San Diego
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PROTOCOL NO.	REGISTRY	PROTOCOL / METHODOLOGY NAME	VERSION	DATE	PROTOCOL SECTOR	BRIEF DESCRIPTION	ARE PROJECTS OF THIS TYPE ALREADY BEING PROPOSED IN THE CAP?		PROTOCOL ELIGIBLE FOR DIRECT INVESTMENT MEASURE?	REDUCTION ESTIMATE (MT/year)[1]	REDUCTION ESTIMATION METHODOLOGY	REFERENCES
A	B	C	D	E	F	G	H		I	J	K	L
1	Climate Action Reserve	Mexico Livestock	2.0	9/29/2010	Agriculture	Not applicable.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
2	Climate Action Reserve	Nitrogen Management	1.1	1/17/2013	Agriculture	Projects following this protocol reduce the annual rate of synthetic nitrogen fertilizer applied at their sites. Not applicable to CA, as only central U.S. is included.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
3	Verified Carbon Standard	Quantifying N_2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction	1.1	9/30/2013	Agriculture	Projects following this protocol quantify N_2O emission reductions achieved through reducing the amount of nitrogen fertilizer applied to croplands. Accurate quantification of N_2O emissions encourages the application of nitrogen fertilizer at economically optimum rates while utilizing BMPs for fertilizer type, placement, and timing of application.	No		YES	2,200 - 6,500	Grouped Protocol: Nitrogen Fertilizer Management • 50% reduction in N_2O possible through individual activities (delta-institute.org). Each activity is associated with a 50% reduction, so 50% overall is feasible. • Soil Management Emissions = 17,271 MT CO_2e/year (CAP 2030 Inventory) • 50% * 17,271 MT CO_2e/year = 8,636 MT CO_2e/year • Reduction range assumes 25 to 75% of farming operations can implement these practices.	http://delta-institute.org/delta/wp-content/uploads/Nitrogen-fertilizer-management-climate-factsheet_FINAL.compressed.pdf
4	American Carbon Registry	Reduced Use of Nitrogen Fertilizer on Agricultural Crops	1.0		Agriculture	Projects following this protocol aim to reduce project GHG emissions associated with nitrogen fertilizer use compared to baseline levels by following fertilizer BMPs established federally or by individual state departments.	No		YES			
5	Climate Action Reserve	U.S. Livestock	4.0	1/23/2013	Agriculture	Projects following this protocol reduce methane emissions from livestock operations by installing a biogas control system that captures methane from manure treatment and storage facilities. The methane is then treated or used in a variety of ways, including combustion onsite or offsite. (Specific to operations in the U.S.)	Partially, see measure T-1.2		YES	5,000 - 14,800	Grouped Protocol: Manure Management (Biogas Control Systems) • Manure Management emissions, % CO_2e from CH_4 = 84.5% (CAP 2014 Inventory) • 87% reduction in CH_4 feasible with biogas control system (BCS) (epa.gov): • Manure Management Emissions = 26,865 MT CO_2e/year (CAP 2030 Inventory) • 84.5% * 87% * 26,865 MT CO_2e/year = 19,750 MT CO_2e/year • Reduction range assumes 25 to 75% of operations can install a BCS.	https://www.epa.gov/sites/production/files/2014-12/documents/biogas_recovery_systems_screenres.pdf
6	CAPCOA GHG Rx	Climate Action Reserve U.S. Livestock Project Protocol Version 4.0	4.0	2/8/2017	Agriculture	Duplicate Protocol	Partially, see measure T-1.2		YES			
7	CAPCOA GHG Rx	Revised Compliance Offset Protocol Livestock Projects	1.0	12/10/2014	Agriculture	Duplicate Protocol	Partially, see measure T-1.2		YES			
8	Verified Carbon Standard	Adoption of Sustainable Agricultural Land Management (SALM)	1.0	12/21/2011	Agriculture	Projects following this protocol estimate and monitor GHG emissions of project activities that adopt SALM practices, such as manure management, use of cover crops, planting trees, and composting crop residuals for reuse in the field.	Partially, see measure A-2.1/2.2; SW-1.1		YES	7,800 - 15,700	• Assumes projects following SALM practices will increase the soil organic carbon content of croplands through composting. Other SALM practices are already covered by other protocols. • 2.04 MT CO_2e/year reduced/sequestered per acre cropland composted (1,097 MT / 537 acres for Modoc Ranch; Carbon Cycle Institute, epa.gov) • 76,711 acres cropland in unincorporated SD County (SanGIS, 2017) - 67,522 acres of orchards/vineyards - 9,189 acres of row crops • 76,711 acres*2.04 MT CO_2e/acre/year = 156,708 MT CO_2e/year • Reduction range assumes 5 to 10% of farming operations will add compost to cropland. • Could also include reductions related to cover crops (0.4 - 0.6 MT CO_2e/acre/year).	https://www.epa.gov/sites/production/files/2016-11/documents/cba2016-creque_increasing_carbon_capture_on_californias_working_lands.pdf
9	Verified Carbon Standard	Revisions to AMS-III.Y to Include Use of Organic Bedding Material	1.0	1/18/2013	Agriculture	The original United Nations CDM protocol that this revises describes activities that can reduce methane production from anaerobic manure management systems by removing volatile solids from the manure stream before treatment. It requires that these solids are further treated, used, or disposed in a way that results in lower methane emissions.	No		YES	700 - 1,300	• Manure Management Emissions = 26,865 MT CO_2e/year (CAP 2030 Inventory) • Assume 100% of these emissions come from volatile solids in manure (CAR U.S. Livestock protocol) • Assume separator removes 50% of volatile solids (conservative; clemson.edu) • Assume treatment of solids reduces volatile solids emissions by 50% (conservative; ncbi.nih.gov) • 26,865 MT CO_2e * 50% * 50% = 6,716 MT CO_2e/year • Range assumes 10 to 20% of farming operations can implement these practices. • NOTE: Reductions could overlap with U.S. Livestock Protocol Reductions.	https://www.clemson.edu/extension/camm/manuals/publications/dairy_liquid_solid_separation.pdf http://www.climateactionreserve.org/how/protocols/ https://www.ncbi.nlm.nih.gov/pubmed/28355494
10	Verified Carbon Standard	Tool for the Demonstration and Assessment of Additionality in VCS Agriculture. Forestry and Other Land Use (AFOLU) Project Activities	3.0	2/1/2012	Agriculture	Projects following this protocol follow a stepwise approach to determining if certain proposed project activities are considered "additional" or not for AFOLUs. The four steps are identifying alternative land use scenarios to the AFOLU project activity, performing an investment analysis to determine economic/financial appeal, performing a barriers analysis, and performing a common practice analysis.	N/A		NO, OTHER	N/A	• Protocol is not a specific GHG reduction project. It is a methodology to determination additionality.	

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PROTOCOL NO.	REGISTRY	PROTOCOL / METHODOLOGY NAME	VERSION	DATE	PROTOCOL SECTOR	BRIEF DESCRIPTION	ARE PROJECTS OF THIS TYPE ALREADY BEING PROPOSED IN THE CAP?		PROTOCOL ELIGIBLE FOR DIRECT INVESTMENT MEASURE?	REDUCTION ESTIMATE (MT/year)[1]	REDUCTION ESTIMATION METHODOLOGY	REFERENCES
A	B	C	D	E	F	G	H		I	J	K	L
11	Climate Action Reserve	Rice Cultivation	1.1	6/3/2013	Agriculture	Projects following this protocol incorporate one or more rice cultivation activities designed to reduce methane emissions. These activities include dry seeding with delayed flooding and post-harvest rice straw removal and bailing.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
12	American Carbon Registry	Rice Management Systems	1.0		Agriculture	Projects following this protocol aim to reduce GHG emissions by adopting various project activities at rice growing operations, including straw baling and removal, early drainage (at least 5 days earlier than conventional methods), increased water/energy use efficiency, and intermittent flooding. These activities may be combined with a reduction in N fertilization rate for additional emissions reductions.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
13	CAPCOA GHG Rx	CAPCOA GHG Rx Rice Protocol #1: Voluntary Emission Reductions in Rice Management Systems	1.1	9/2/2015	Agriculture	DUPLICATE PROTOCOL	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
14	CAPCOA GHG Rx	CAPCOA GHG Rx Rice Protocol #2: Rice Cultivation Project Protocol	1.1	9/2/2015	Agriculture	DUPLICATE PROTOCOL	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
15	CAPCOA GHG Rx	CAPCOA GHG Rx Rice Protocol #3: Compliance Offset Protocol Rice Cultivation Projects	1.0	9/2/2015	Agriculture	DUPLICATE PROTOCOL	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
16	Verified Carbon Standard	New Cogeneration Facilities Supplying Less Carbon Intensive Electricity to Grid and/or Hot Water to One or More Grid Customers	1.0	5/3/2011	Energy Efficiency/Production	Projects following this protocol must construct and operate a new gas fired cogeneration plant which is connected to the electrical grid and where all the electricity produced other than that required to operate the cogeneration facility is exported to the grid. Additionally, this methodology is only applicable to cases in which the steam and/or hot water that is to be displaced by the project activity is either produced for export to a steam/hot water grid or is drawn from a steam/hot water grid.	No		YES	10,000 - 29,400	• 6.7 MMT CO_2e reduction for 4,000 MW CoGen or 30,142,000 MWh (arb.ca.gov; Table 7; assuming 80% CoGen capacity and 7% transmission line loss) • 2030 Electricity Demand = 299,113 MWh (after CAP measure reductions; derived from CAP Appendices A and C) • 299,113 MWh * 6.7 MMT CO_2e / 30,142,000 MWh = 66,487 MT CO_2e/year • Reduction range assumes CoGen-produced electricity will replace between approximately 15% and 44% of the 2030 SD County electricity demand (after other CAP measure reductions); equivalent to 5.8 and 17.5 MW, respectively. • Reality Check: - 1,661 MW of new exported CoGen in California in 2030 (energy.ca.gov; Table 1, Medium Case) - 7% of new exported CoGen or 116 MW in SDG&E territory (energy.ca.gov; Table 3, assumes percentage stays constant through 2030)	http://www.energy.ca.gov/renewables/tracking_progress/documents/combined_heat_and_power.pdf http://www.arb.ca.gov/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf
17	Verified Carbon Standard	Weatherization of Single Family and Multi-Family Buildings	1.1	10/10/2012	Energy Efficiency/Production	Projects following this protocol must cover "Weatherization of Dwellings", i.e. energy efficiency measures directed at reducing the consumption of energy within a Dwelling; for e.g., (not all inclusive) adding/improving insulation, air sealing, and replacing appliances and central heating/cooling components.	Yes, see measure E-1.1, measure E-1.2, measure E-1.3		YES	3,700 - 18,500	Grouped Protocol: Weatherization of Single Family and Multi-Family Buildings • Assume same GHG emission reductions per % as CAP Measure E-1.3 in 2030 (3,694 MT CO_2e). • Reduction range assumes energy efficiency improvements can be achieved in an additional 1 to 5% of the existing housing stock.	
18	CAPCOA GHG Rx	Weatherization of Single Family and Multi-Family Buildings	1.1	11/3/2016	Energy Efficiency/Production	Duplicate Protocol	Yes, see measure E-1.1, measure E-1.2, measure E-1.3		YES			
19	Verified Carbon Standard	Energy Efficiency and Solid Waste Diversion Activities within a Sustainable Community	1.0	2/20/2012	Energy Efficiency/Production	Projects following this protocol must quantify direct and indirect GHG emission reductions for grouped projects (multiple project activities into a single, combined project that adds new instances over time), where energy efficiency and solid waste diversion activities have been initiated.	Yes, see measure E-1.1, E 1.2, E-1.3, E-1.4, SW-1.1		YES	400 - 1,900	• Assume majority of protocol-related reductions are covered by CAP measures or other protocols except for improvements in efficiency of industrial processes. • 2030 Energy-related Emissions = 415,654 MT CO_2e (CAP Appendix C; after legislative reductions and CAP measures). • Percent of 2030 energy-related emissions assumed to be due to industrial processes: 9% (CAP Appendix A; industrial % of 2014 electricity emissions). • 415,654 MT CO_2e/year * 9% = 37,408 MT CO_2e/year • Reduction range assumes 1 to 5% in efficiency improvements can be achieved in the industrial sector. • NOTE: Reductions could overlap with Cogeneration Protocol Reductions.	

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A	B	C	D	E	F	G	H		I	J	K	L
20	Verified Carbon Standard	Campus Clean Energy and Energy Efficiency	1.0	2/12/2014	Energy Efficiency/Production	Projects following this protocol must reduce GHG emissions through the implementation of clean energy and/or energy efficiency activities at college and school campuses in the United States.	No		YES	1,000 - 5,000	• <1,000 - 33,900 MT CO_2e/year per campus reduction estimate reflects the range of the 9 projects listed on VCR. • Reduction range assumes energy efficiency initiatives can be implemented at 1 to 5 small college campuses in unincorporated SD County. • NOTE: Reductions could overlap with existing CAP measures and the Cogeneration Protocol Reductions.	http://www.vcsprojectdatabase.org/#/home
21	Verified Carbon Standard	Methodology for Installation of Low-Flow Water Devices	1.0	11/14/2014	Energy Efficiency/Production	Projects following this protocol must comply with all applicability conditions set out in CDM methodology AMS-II.M, for demand-side energy efficiency activities for installation of low-flow hot water savings devices. Projects can occur in residential and non-residential buildings, but not industrial buildings.	Partially, see measure W-1.1		YES	300 - 500	• Calculation assumes GHG reductions related to use of higher efficiency shower heads (2 gpm --> 1.8 gpm) and bathroom faucets (1.2 gpm --> 0.8 gpm) in **new residential development**. • Calculation assumes GHG reductions related to use of higher efficiency shower heads (2.5 gpm --> 1.8 gpm), bathroom faucets (1.8 gpm --> 1.2 gpm), and kitchen faucets (1.8 gpm --> 1.5 gpm) in **existing residential development**. • Calculation assumes GHG reductions related to use of higher efficiency bathroom faucets (1.8 gpm --> 1.5 gpm) in **new non-residential development**. • Calculation assumes GHG reductions related to use of higher efficiency bathroom faucets (1.8 gpm --> 1.5 gpm) in **existing non-residential development**. • GHG emissions per million gallons of water = 2.31 MT CO_2e (CAP Appendix C). • Reduction range assumes measures have 100% penetration in new development and 1 to 5% penetration in existing development. • NOTE: Reductions could overlap with Cogeneration Protocol Reductions.	https://www.usgbc.org/Docs/Archive/General/Docs6493.pdf https://www.ladbs.org/docs/default-source/publications/code-amendments/2016-calgreen_complete.pdf?sfvrsn=6 https://www.usgbc.org/node/2600210?return=/credits/healthcare/v4/water-efficiency LEED (2009) WE Prerequisite 1
22	American Carbon Registry	Switch from non-renewable biomass for thermal applications	2.0		Energy Efficiency/Production	Projects following this protocol must displace the use of non-renewable biomass by introducing renewable energy technologies, for example, biogas stoves, solar cookers, passive solar homes, switching to renewable fuels (e.g., compressed biomass, green charcoal, etc.) in existing stoves, and renewable energy-based drinking water treatment technologies (e.g. sand filters followed by solar water disinfection; water boiling using renewable biomass).	No		YES	<1,000	• Protocol is geared towards third-world countries where non-renewable biomass is a main fuel source in homes. Reductions would be *de minimus*.	
23	American Carbon Registry	Energy Efficiency Measures in Thermal Applications of Non-Renewable Biomass	1.0		Energy Efficiency/Production	Projects following this protocol must incorporate efficiency improvements in thermal applications of non-renewable biomass, for example, high efficiency biomass fired cook stoves or ovens or dryers and/or energy efficiency improvements in existing biomass fired cook stoves or ovens or dryers.	No		YES	<1,000	• Protocol is geared towards third-world countries where non-renewable biomass is a main fuel source in homes. Reductions would be *de minimus*.	
24	American Carbon Registry	Low greenhouse gas emitting safe drinking water production systems	1.0		Energy Efficiency/Production & Water	Projects following this protocol must incorporate low GHG emitting water purification systems to provide safe drinking water (SDW). Water purification technologies that involve point-of use (POU) or point-of-entry (POE) treatment systems for residential or institutional applications such as systems installed at a school or a community center are included. For example, (not all inclusive) water filters (e.g., membrane, activated carbon, ceramic filters), solar energy powered ultraviolet (UV) disinfection devices, solar disinfection techniques, photocatalytic disinfection equipment, pasteurization appliances, chemical disinfection methods (e.g., chlorination), combined treatment approaches (e.g., flocculation plus disinfection). The methodology is also applicable to water kiosks that treat water using one or more of the following technologies: chlorination, combined flocculant/disinfection powders and solar disinfection.	No		YES	<1,000	• Protocol is geared towards third-world countries where public distribution networks supplying safe drinking water are unavailable. Reductions would be *de minimus*.	
25	American Carbon Registry	Conversion of High-Bleed Pneumatic Controllers in Oil & Natural Gas Systems	1.1		Energy Efficiency/Production	Projects following this protocol must retrofit or convert high-bleed pneumatic controllers to low-bleed pneumatic controllers, for the purpose of methane emission reductions. *(Most pneumatic instruments and controllers in the NG industry are powered by NG, and these controllers are designed to discharge methane to the atmosphere as a part of normal operations. Pneumatic controllers can be designed to bleed at both high and low bleed-rates.)*	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	N/A		

Table 2. Protocol Reduction Potential Summary Matrix
County of San Diego
Preliminary Assessment of Local Direct Investment Program

PROTOCOL NO.	REGISTRY	PROTOCOL / METHODOLOGY NAME	VERSION	DATE	PROTOCOL SECTOR	BRIEF DESCRIPTION	ARE PROJECTS OF THIS TYPE ALREADY BEING PROPOSED IN THE CAP?		PROTOCOL ELIGIBLE FOR DIRECT INVESTMENT MEASURE?	REDUCTION ESTIMATE (MT/year)[1]	REDUCTION ESTIMATION METHODOLOGY	REFERENCES
A	B	C	D	E	F	G	H		I	J	K	L
26	CAPCOA GHG Rx	Biomass Waste for Energy Project Reporting Protocol	6.3	1/13/2017	Energy Efficiency/Production	Projects following this protocol will quantify GHG emission reductions associated with diverting biomass which would have otherwise been disposed of through open burning, decay in the field, or in landfills, and instead processing it through either combustion or gasification to produce usable energy. The protocol provides accounting, reporting, and monitoring procedures for accomplishing this.	No		Yes	<1,000	• 0.374 MT CO_2e/MT waste in landfill (CAP, Appendix A) • 206,733 = tons/year organic waste landfilled less organics reduced due to CAP Measure SW-1.1 (CAP, Appendix C) • Assume 50% of waste is from "sustainable harvesting operations" (protocol requirement) • 206,733 tons/year * (1 MT/1.102 tons) * 50% * 0.374 MT CO_2e/MT waste = 35,081 MT CO_2e/year • Note, the majority of waste in SD County is sent to landfills that have landfill gas capture (and destruction). The energy resulting from the combusted biogas will be offseting much cleaner energy in 2030.	
27	CAPCOA GHG Rx	Improvement of the Efficiency of a Natural Gas-Fired Boiler or Process Heater	1.0	2013	Energy Efficiency/Production	Projects following this protocol will quantify GHG emission reductions (mostly CO_2 for this protocol) associated with improved efficiency of boilers and process heaters. The protocol establishes a method for quantifying these reductions.	Partially, T-4 mentions "boiler efficiency" as an option for local projects to offset GHG emissions.		Yes	<1,000	• Protocol can't be used for projects on or after January 1, 2015. Identifying past projects would be difficult and would likely result in *de minimus* reductions.	
28	Climate Action Reserve	Coal Mine Methane	1.1	10/26/2012	Industry	Projects following this protocol must install and operate any device, or set of devices, that results in the destruction of methane gas that would otherwise have been vented to the atmosphere from an active underground coal mine, as well as Mine Safety and Health Administration (MSHA) Category III trona mines.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
29	Climate Action Reserve	Mexico Boiler Efficiency	1.0	11/1/2016	Industry	Not Applicable Projects following this protocol must retrofit existing boilers by installing new efficiency improvement technologies or the installation of new boilers that demonstrate greater efficiency than conventional alternatives. Eligible boilers must have a capacity of 9.8 MW (33.5 MMBtu/h) or greater. All components of the physical boundary of each project must be located in Mexico.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
30	Climate Action Reserve	Nitric Acid Production	2.1	6/21/2016	Industry	Projects following this protocol must install nitrous oxide (N_2O) abatement technology at an existing, upgraded and/or relocated nitric acid plant (NAP) that results in the reduction of N_2O emissions that would otherwise have been vented to the atmosphere. A facility may contain more than one project if it contains multiple nitric acid plants.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
31	Verified Carbon Standard	Calculating Emission Reductions from Jet Engine Washing	1.0	4/27/2011	Industry	Projects following this protocol must utilize on-wing jet engine washing as a means of increasing engine thrust efficiency and reducing CO_2 emissions. All engines become contaminated through normal operation leading to restricted airflow, higher exhaust gas temperature, and increased fuel consumption. By eliminating engine contamination, engine washings improve propulsive efficiency measured as a decrease in thrust specific fuel consumption or TSFC, resulting in decreased emissions of carbon dioxide (CO_2).	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	N/A		
32	Verified Carbon Standard	Interception and Destruction of Fugitive Methane from Coal Bed Methane (CBM) Seeps	1.0	6/14/2011	Industry	Projects following this protocol must capture and destroy methane which would otherwise be released to the atmosphere from coal bed outcroppings. Projects using this methodology will be implemented on coal seams or where exposed coal bed outcroppings exist having documented coal bed methane seeps.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
33	Verified Carbon Standard	Reduction of GHG Emissions in Propylene Oxide Production	1.0	9/9/2013	Industry	Projects following this protocol must incorporate processes which requires less GHG-intensive reagents and requires less energy for the production of Propylene Oxide (PO) compared to other production processes. The GHG emission reductions can be achieved from the use of Hydrogen Peroxide-based Propylene Oxide (HPPO) technology.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		

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A	B	C	D	E	F	G	H		I	J	K	L
34	Verified Carbon Standard	Methodology for Pavement Application using Sulphur Substitute	1.0	5/15/2015	Industry	Projects following this protocol must achieve GHG emissions reductions by the substitution of a proportion of the bitumen binder used in conventional hot asphalt paving with a sulphur product. The use of a sulphur product in place of a portion of bitumen binder reduces required quantities of aggregate and bitumen, reduces fuel usage due to reduced mix production temperatures and reduces GHG emissions from the hot mix plant stack and paving.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	N/A		
35	Verified Carbon Standard	Methodology for Precast Concrete Production using Sulphur Substitute	1.0	5/15/2015	Industry	Projects following this protocol must achieve GHG emissions reductions by the substitution of calcium and/or magnesium carbonate-derived cement, known as Portland cement, with an alternative binder, such as a modified heated sulphur product, during the production of concrete and other concrete-based products such as pre-cast pipe, paving stones, slabs and tanks. The production of calcium and/or magnesium carbonate-derived cement (often from limestone) is known to release significant amounts of GHG emissions.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	N/A		
36	Verified Carbon Standard	Revisions to ACM0008 to Include Pre-drainage of Methane from an Active Open Cast Mine as a Methane Emission Reduction Activity	1.0	3/31/2009	Industry	Projects following this protocol must remove Coal bed methane (CBM) and Coal Mine Methane (CMM) during pre-mining stages.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
37	Verified Carbon Standard	Revisions to ACM0008 to Include Methane Capture and Destruction from Abandoned Coal Mines	1.0	7/19/2010	Industry	Projects following this protocol must incorporate Coal Mine Methane (CMM), Abandoned Mine Methane (AMM) and Ventilation air methane (VAM) capture, utilization and destruction project activities at a working and abandoned/decommissioned coal mines, where the baseline is the partial or total atmospheric release of the methane and the project activities includes methods to treat the gas captured.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
38	American Carbon Registry	Recycling of Transformer Oil	1.0		Industry	Projects following this protocol must achieve GHG emissions reductions by recycling transformer oil used in transformers that are used and operated by electric utility customers and large industrial companies that would otherwise be combusted, thus generating CO_2 emissions.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	15,000 - 45,000	• Reduction estimate reflects the range of annual values from the one project (ACR 223) listed on ACR.	http://americancarbonregistry.org/how-it-works/registry-reports
39	American Carbon Registry	Carbon Capture and Storage Projects	1.0		Industry	Projects following this protocol must capture, transport and inject anthropogenic CO_2 during enhanced oil recovery (EOR) operations into an oil and gas reservoir located in the US or Canada where it is sequestered. With respect to the capture of CO_2, eligible CO_2 source types include: electric power plants equipped with pre-combustion, post-combustion, or oxy-fired technologies; industrial facilities (for example, natural gas production, fertilizer manufacturing, and ethanol production); polygeneration facilities (facilities producing electricity and one or more of other commercial grade byproducts); and direct air capture (DAC) facilities.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A	• Protocol is tied to enhanced oil recovery (EOR). There doesn't appear to be active oil extraction in San Diego County (cafrackfacts.org; conservation.ca.gov).	
40	Verified Carbon Standard	Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects	2.2	3/17/2017	Land Use Management	This protocol provides procedures for quantifying emission reductions and/or removals from activities aimed at reducing unplanned deforestation and forest degradation of the mosaic (multi-age) configuration.	Possibly, if land would otherwise be converted. See measure T-1.1		YES	1,700 - 17,000	Grouped Protocol: Avoided Forest Degradation • 4 MT CO_2e reduced/sequestered per acre forest conserved per year (Existing projects from VCS, ACR, CAR databases) • 85,324 acres forest in unincorporated SD County (SanGIS, 2017) • 85,324 acres * 4 MT CO_2e/acre/year = 341,296 MT CO_2e/year • Reduction range assumes 0.5 to 5% of acreage conserved.	https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=111 http://americancarbonregistry.org/how-it-works/registry-reports http://www.vcsprojectdatabase.org/#/home
41	Verified Carbon Standard	REDD+ Methodology Framework (REDD-MF)	1.5	3/9/2015	Land Use Management	This protocol applies to project activities that reduce emissions from forest degradation, reforestation, and revegetation activities.	Possibly, if land would otherwise be converted. See measure T-1.1		YES			

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A	B	C	D	E	F	G	H		I	J	K	L
42	Verified Carbon Standard	Methodology for Avoided Unplanned Deforestation	1.1	12/3/2012	Land Use Management	This protocol is for estimating GHG emissions of project activities that avoid unplanned deforestation. These projects include controlled logging, fuel wood collection, or charcoal production. In this protocol, planned deforestation is not included in the baseline emissions estimate.	Possibly, if land would otherwise be converted. See measure T-1.1		YES	900 - 8,600	Grouped Protocol: Avoided Forest Deforestation • 4 MT CO_2e reduced/sequestered per acre forest conserved per year (Existing projects from VCS, ACR, CAR databases) • 42,815 acres of unconserved forest in unincorporated SD County (SanGIS, 2017) • 42,815 acres * 4 MT CO_2e/acre/year = 171,260 MT CO_2e/year • Reduction range assumes 0.5 to 5% of acreage conserved.	https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=111 http://americancarbonregistry.org/how-it-works/registry-reports http://www.vcsprojectdatabase.org/#/home
43	American Carbon Registry	Reducing Emissions from Deforestation and Degradation (REDD) – Avoiding Planned Deforestation	1.0		Land Use Management	This protocol is applicable to REDD projects which avoid planned deforestation. Planned deforestation is legally authorized and documented to be converted to non-forest land.	Possibly, if land would otherwise be converted. See measure T-1.1		YES			
44	Verified Carbon Standard	Methodology for Avoided Ecosystem Conversion	3.0	6/6/2014	Land Use Management	This protocol applies to projects which prevent conversion of forest, grassland, and shrubland to a non-forest or non-native state.	Possibly, if land would otherwise be converted. See measure T-1.1		YES	REDUCTIONS ALREADY COUNTED IN OTHER PROTOCOLS	Grouped Protocol: Avoided Forest Deforestation Grouped Protocol: Conservation of Grassland • 4 MT CO_2e reduced/sequestered per acre forest conserved per year (Existing projects from VCS, ACR, CAR databases) and 6.2 MT/acre of grassland conserved per year (climatetrust.org) • 42,815 acres of unconserved forest in unincorporated SD County (SanGIS, 2017) • 100,792 acres of unconserved grassland in unincorporated SD County (SanGIS, 2017) • (42,815 acres * 4 MT CO_2e/acre/year) + (100,792 acres * 6.2 MT CO_2e/acre/year) = 796,170 MT CO_2e/year	https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=111 http://americancarbonregistry.org/how-it-works/registry-reports http://www.vcsprojectdatabase.org/#/home https://climatetrust.org/wp-content/uploads/2014/07/Evaluation-of-Avoided-Grassland-Conversion-and-Cropland-Conversion-to-Grassland-as-Potential-Carbon-Offset-Project-Types-.pdf
45	Climate Action Reserve	Grassland	2.0	1/18/2017	Land Use Management	Projects following this protocol prevent emissions of GHGs to the atmosphere by conserving eligible grassland project area, thus preventing land conversion and crop cultivation in those areas.	Possibly, if land would otherwise be converted. See measure T-1.1		YES	3,100 - 31,200	Grouped Protocol: Conservation of Grassland • 6.2 MT CO_2e reduced/sequestered per acre of grassland conserved per year (climatetrust.org) • 100,792 acres of unconserved grassland in unincorporated SD County (SanGIS, 2017) • 100,792 acres * 6.2 MT CO_2e/acre/year = 624,910 MT CO_2e/year • Reduction range assumes 0.5 to 5% of acreage conserved.	https://climatetrust.org/wp-content/uploads/2014/07/Evaluation-of-Avoided-Grassland-Conversion-and-Cropland-Conversion-to-Grassland-as-Potential-Carbon-Offset-Project-Types-.pdf
46	American Carbon Registry	Avoided Conversion of Grasslands and Shrublands to Crop Production	1.0		Land Use Management	Projects following this protocol reduce GHG emissions by preventing the conversion of grasslands and shrublands to annual crop production. Conversion to other uses other than cropland is not covered in this protocol.	Possibly, if land would otherwise be converted. See measure T-1.1		YES			
47	Verified Carbon Standard	Methodology for Improved Forest Management through Extension of Rotation Age	1.2	8/29/2013	Land Use Management	Projects following this protocol increase CO_2 capture in forests through improved forest management practices. In particular, extension of rotation age of a forest before harvesting.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A	• Large-scale logging does not occur in unincorporated SD County.	
48	American Carbon Registry	Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	1.2		Land Use Management	This protocol applies to projects which improve forest management above baseline conditions. Projects must be located on non-federally owned forestland in the U.S.	No		YES	700 - 6,600	Grouped Protocol: Improved Forest Management • 3.1 MT CO_2e reduced/sequestered per acre forest managed per year (Existing projects from VCS, ACR, CAR databases) • 42,815 acres of forest not in preserved areas in unincorporated SD County (SanGIS, 2017) • 42,815 acres * 3.1 MT CO_2e/acre/year = 132,726 MT CO_2e/year • Reduction range assumes 0.5 to 5% of acreage managed.	https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=111 http://americancarbonregistry.org/how-it-works/registry-reports http://www.vcsprojectdatabase.org/#/home
49	American Carbon Registry	Improved Forest Management (IFM) for U.S. Timberlands	1.0		Land Use Management	This appears to be an older version of IFM for Non-Federal U.S. Forestlands. This protocol applies to projects which improve forest management above baseline conditions. Projects must be located on non-federally owned forestland in the U.S.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A	• Large-scale logging does not occur in unincorporated SD County.	
50	CAPCOA GHG Rx	CAPCOA GHG Rx Forestry Protocol #2: 100-year Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration	1.0	5/1/2013	Land Use Management	Duplicate Protocol	No		YES	REDUCTIONS ALREADY COUNTED IN OTHER PROTOCOLS	Grouped Protocol: Improved Forest Management	

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County of San Diego
Preliminary Assessment of Local Direct Investment Program

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A	B	C	D	E	F	G	H		I	J	K	L
51	American Carbon Registry	Afforestation and Reforestation of Degraded Lands	1.2		Land Use Management	This protocol applies to afforestation and reforestation American Carbon Registry project activities implemented on degraded lands.	No		YES	1,600 - 16,200	• 3.8 MT CO_2e reduced/sequestered per acre forest restored per year (Existing projects from VCS, ACR, CAR databases) • 85,324 acres of forest in unincorporated SD County (SanGIS, 2017) • 85,324 acres * 3.8 MT CO_2e/acre/year = 324,231 MT CO_2e/year • Reduction range assumes 0.5 to 5% of acreage qualifies as degraded and is restored.	https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=111 http://americancarbonregistry.org/how-it-works/registry-reports http://www.vcsprojectdatabase.org/#/home
52	Verified Carbon Standard	Methodology for Coastal Wetland Creation	1.0	1/30/2014	Land Use Management	Projects following this protocol provide GHG benefits through substrate establishment and vegetation establishment in order to create new wetlands that have previously been degraded. These projects must meet the definitions of total or estuarine, open water, and degraded wetland before activities are implemented.	No		YES	200 - 700	Grouped Protocol: Restoration of Wetlands • 12.5 MT CO_2e reduced/sequestered per acre wetland restored (ca-ilg.org; cwc.ca.gov; adaptationprofessionals.org) • 264 acres of estuarine wetlands in unincorporated SD County (SanGIS, 2017) • 264 acres * 12.5 MT CO_2e/acre = 3,300 MT CO_2e • Reduction range assumes 5 to 20% of acreage restored.	http://www.ca-ilg.org/post/wetlands-restoration-greenhouse-gas-reduction-program https://cwc.ca.gov/Documents/2013/05_May/May2013_Agenda_Item_8_Sherman_Twitchell_Presentation1.pdf https://adaptationprofessionals.org/wp-content/uploads/bp-attachments/1472/carbonflyer02_22_08.pdf
53	CAPCOA GHG Rx	Coastal Wetland Creation	1.0	7/6/2016	Land Use Management	Duplicate Protocol	No		YES			
54	Verified Carbon Standard	Methodology for Tidal Wetland and Seagrass Restoration	1.0	11/20/2015	Land Use Management	This protocol applies to projects which reduce GHG emissions through restoration of tidal wetlands. Such projects include creating, restoring, and/or managing hydrological conditions, sediment supply, salinity characteristics, water quality, and/or native plant communities.	No		YES			
55	American Carbon Registry	Restoration of California Deltaic and Coastal Wetlands	1.0		Land Use Management	This methodology applies to projects which reduce GHGs by 1) reducing soil organic carbon oxidation on subsided/drained agriculture lands, 2) increasing soil organic carbon storage by restoring tidal and non-tidal wetlands.	No		YES			
56	CAPCOA GHG Rx	Quantifying Greenhouse Gas Reductions from Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and the Coast of California	1.0	7/6/2016	Land Use Management	Duplicate Protocol	No		YES			
57	Climate Action Reserve	Urban Tree Planting	2.0	6/25/2014	Land Use Management	This protocol applies to projects in areas where trees have not been harvested with commercial interest 10 years prior, and new trees are planted.	Yes, See measure A-2.1 and A-2.2		YES	4,500 - 6,000	• 0.0354 MT/tree/year (CalEEMod) • 2030 GHG reductions from CAP measure A-2.1 = 1,244 MT CO_2e/year • 2030 GHG reductions from CAP measure A-2.2 = 1,735 MT CO_2e/year • Reduction range assumes a number of trees equivalent to 150% to 200% of the County's CAP commitment under A-2.1 and A-2.2.	http://www.caleemod.com/
58	Verified Carbon Standard	Soil Carbon Quantification Methodology	1.0	11/16/2012	Land Use Management	This protocol applies to projects which aim to improve soils, including changes to agricultural practices, grassland and rangeland restorations, soil carbon protection and accrual benefits from reduced erosion, grassland protection projects, and treatments designed to improve diversity and productivity of grassland and savanna plant communities.	No		YES	300 - 3,400	Grouped Protocol: Improved Grassland Management • 0.49 MT CO_2e reduced/sequestered per acre grassland managed per year (scientificamerican.com; nature.com) • 137,951 acres of grassland in unincorporated SD County (SanGIS, 2017) • 137,951 acres * 0.49 MT CO_2e/acre/year = 67,595 MT CO_2e/year • Reduction range assumes 0.5 to 5% of acreage managed.	https://www.scientificamerican.com/article/carbon-cowboys/ https://www.nature.com/articles/ncomms7995
59	Verified Carbon Standard	Methodology for the Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing	1.0	7/16/2015	Land Use Management	This protocol applies to projects which alter the grouping, timing, and season of grazing or alter fire frequency and/or intensity in ways that sequester soil carbon.	No		YES			
60	American Carbon Registry	Grazing Land and Livestock Management	1.0		Land Use Management	This protocol provinces guidance for estimating GHG emissions caused by activity shifting and market-effects leakage related to grazing land and livestock management activities.	No		YES	500 - 900	Grouped Protocol: Grazing Land Management • 0.49 MT CO_2e reduced/sequestered per acre managed per year (scientificamerican.com; nature.com) • 18,890 acres of field and pasture in unincorporated SD County (SanGIS, 2017) • 18,890 acres * 0.49 MT CO_2e/acre/year = 9,256 MT CO_2e/year • Reduction range assumes 5 to 10% of acreage managed.	https://www.scientificamerican.com/article/carbon-cowboys/ https://www.nature.com/articles/ncomms7995
61	Verified Carbon Standard	Methodology for Sustainable Grassland Management (SGM)	1.0	4/22/2014	Land Use Management	Projects following this protocol reduce GHG emissions through sustainable grassland management, including improved grazing animal rotation, limiting the number of grazing animals on degraded pastures, and restoration of severely degraded land.	No		YES			

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A	B	C	D	E	F	G	H		I	J	K	L
62	American Carbon Registry	Compost Additions to Grazed Grasslands	1.0		Land Use Management	Projects following this protocol will reduce GHGs through the application of compost to grazed grasslands. This results in the following processes: 1) avoidance of anaerobic decomposition, 2) direct increase in soil organic carbon content, and 3) indirect increase in soil organic carbon sequestration.	No		YES	1,400 - 2,800	• 1.5 MT CO_2e reduced/sequestered per acre composted per year (sandiegoreader.com) • 18,890 acres of field and pasture in unincorporated SD County (SanGIS, 2017) • 18,890 acres * 1.5 MT CO_2e/acre/year = 28,335 MT CO_2e/year • Reduction range assumes 5 to 10% of acreage composted.	https://www.sandiegoreader.com/news/2016/oct/17/ticker-mega-composter-santa-ysabel/#
63	CAPCOA GHG Rx	Methodology for Compost Additions to Grazed Grasslands	1.0	41983	Land Use Management	Duplicate Protocol	No		YES			
64	Verified Carbon Standard	Methodology for Improved Forest Management through Reduced Impact Logging	1.0	4/28/2016	Land Use Management	Projects following this protocol reduce GHG emissions from logging activities (timber felling, skidding, and hauling) by improved practices, such as directional felling and improved harvest planning.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A	• Large-scale logging does not occur in unincorporated SD County.	
65	Verified Carbon Standard	Methodology for Improved Forest Management: Conversion from Logged to Protected Forest	1.3	4/28/2016	Land Use Management	This protocol focuses on estimating GHG reductions resulting from improved forest management projects which protect forests that would be logged in the absence of the project.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A	• Large-scale logging does not occur in unincorporated SD County.	
66	Climate Action Reserve	Forest	4.0	6/28/2017	Land Use Management	Projects following this protocol increase removals of CO_2 from the atmosphere, or reduce/prevent emissions of CO_2 to the atmosphere through increasing/conserving forest carbon stocks. This includes reforestation, improved forest management, and avoided conversion of forestland to non-forest land-use.	Partially, See measures T-1.1, A-2.1, and A-2.2		NO, OTHER	N/A	• Protocol is all encompassing. Individual measures are addressed in the more specific protocols.	
67	CAPCOA GHG Rx	CAPCOA GHG Rx Forestry Protocol #1: Compliance Offset Protocol U.S. Forest Projects	1.0	5/1/2013	Land Use Management	Duplicate Protocol	Partially, See measures T-1.1, A-2.1, and A-2.2		NO, OTHER	N/A	• Protocol is all encompassing. Individual measures are addressed in the more specific protocols.	
68	CAPCOA GHG Rx	CAPCOA GHG Rx Forestry Protocol #3: Forest Project Protocol	3.3	5/1/2013	Land Use Management	Duplicate Protocol	Partially, See measures T-1.1, A-2.1, and A-2.2		NO, OTHER	N/A	• Protocol is all encompassing. Individual measures are addressed in the more specific protocols.	
69	Climate Action Reserve	Urban Forest Management	1.0	6/25/2014	Land Use Management	This protocol applies to projects located in urban areas which reduce GHG emissions through improved forest management, planting of additional trees, avoiding tree removals, and other management activities.	Partially, See measures A-2.1, and A-2.2		NO, OTHER	N/A	• Protocol is all encompassing for urban area activities. Individual measures are addressed in the more specific protocols.	
70	American Carbon Registry	REDD Methodology Modules	1.0		Land Use Management	This is not a protocol. The modules and tools called upon in this document are applicable to project activities that reduce emissions from planned and unplanned deforestation, and for activities to reduce emissions from forest degradation.	N/A		NO, OTHER	N/A	• This is not a protocol.	
71	Climate Action Reserve	Mexico Forest	1.4	1/18/2017	Land Use Management	Not applicable	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
72	Verified Carbon Standard	Methodology for Conservation Projects that Avoid Planned Land Use Conversion in Peat Swamp Forests	1.0	8/23/2010	Land Use Management	Projects following this protocol prevent emissions of GHGs into the atmosphere by conserving eligible tropical peat forest land uses.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
73	Verified Carbon Standard	Methodology for Conversion of Low-productive Forest to High-productive Forest	1.2	7/23/2013	Land Use Management	Projects following this protocol prevent emissions of GHGs into the atmosphere by Improved Forest Management projects in evergreen tropical rainforests. Ex. avoiding emissions from re-logging a forest and rehabilitation of previously logged-over forest.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
74	Verified Carbon Standard	Methodology for Calculating GHG Benefits from Preventing Planned Degradation	1.0	3/21/2011	Land Use Management	This protocol focuses on estimating GHG reductions resulting from improved forest management projects which protect forests that would be logged in the absence of the project. Upon implementation of the project, no removals shall occur in the forest area. This protocol applies to tropical forests, except peat swamp forests.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
75	Verified Carbon Standard	Improved Forest Management in Temperate and Boreal Forests (LtPF)	1.2	7/23/2013	Land Use Management	Projects following this protocol are located in temperate and boreal domain forest lands. These projects reduce emissions through improved forest management protecting forests that would be logged in the absence of the project.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		

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A	B	C	D	E	F	G	H		I	J	K	L
76	Verified Carbon Standard	Methodology for Rewetting Drained Tropical Peatlands	1.0	7/10/2014	Land Use Management	This protocol applies to projects which reduce GHG through rewetting drained peatlands in tropical climatic regions. The project area must exist within Malaysia, Indonesia, Brunei or Papua New Guinea.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
77	Verified Carbon Standard	Methodology for Avoided Forest Degradation through Fire Management	1.0	5/8/2015	Land Use Management	This methodology applies to projects that implement preventative early burning activities in miombo woodlands in the Eastern Miombo ecoregion of Africa.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
78	Verified Carbon Standard	British Columbia Forest Carbon Offset Methodology	1.0	12/8/2015	Land Use Management	Not applicable	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
79	Verified Carbon Standard	Methodology for Rewetting Drained Temperate Peatlands	1.0	7/17/2017	Land Use Management	This protocol applies to projects which reduce GHG through rewetting drained peatlands in temperate climatic regions. Typically, these peatlands were drained for forestry, peat extraction, or agriculture.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
80	Verified Carbon Standard	Performance Method for Reduced Impact Logging in East and North Kalimantan	1.0	4/28/2016	Land Use Management	Not applicable	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
81	American Carbon Registry	Restoration of Degraded Wetlands of the Mississippi Delta	2.0		Land Use Management	Not applicable	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
82	Climate Action Reserve	Mexico Landfill	1.1	9/13/2011	Landfill/Waste Management	Not applicable.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
83	Climate Action Reserve	Organic Waste Composting	1.1	7/29/2013	Landfill/Waste Management	Projects following this protocol will reduce eligible waste streams from entering landfills by utilizing an aerobic composting operation to create usable compost, while following BMPs. Eligible waste includes food waste and non-recyclable food soiled paper.	Yes, see measure SW-1.1		YES	REDUCTIONS ALREADY COUNTED IN OTHER PROTOCOLS	• Composting is already a diversion measure under CAP measure SW-1.1 and the SD County's Strategic Plan to Reduce Waste. GHG reductions from compost application on croplands and grazing lands are considered under other protocols.	http://www.sandiegocounty.gov/content/dam/sdc/dpw/SOLID_WASTE_PLANNING_and_RECYCLING/Files/Final_Strategic%20Plan.pdf
84	Climate Action Reserve	Organic Waste Digestion	2.1	1/16/2014	Landfill/Waste Management	Projects following this protocol will utilize a biogas control system (BCS) with methane destruction to digest eligible wastes, diverting them from anaerobic treatment and other disposal systems. Eligible wastes include organic and agro-industrial wastewater.	No		YES	600 - 1,700	Grouped Protocol: Organic Waste Digestion • Since organic solid waste treatment is already covered by other protocols/CAP measures, only reductions from wastewater are calculated here. • 2,400 MT CO_2e/year for WWTP without digestion (CAP Inventory, 2030). • Assume 100% capture of methane (cornerstoneeg.com) • Assume 95% reduction of CO_2e (conversion from CH_4 to CO_2) • 2,400 MT CO_2e/year * 100% * 95% = 2,280 MT CO_2e/year • Reduction range assumes 25 to 75% of wastewater operations can implement these changes.	http://www.cornerstoneeg.com/2017/03/01/biogas-energy-recovery-california-wastewater-treatment-plant-lessons-learned/
85	CAPCOA GHG Rx	Organic Waste Digestion Project Protocol	2.1	1/3/2017	Land Use Management	Duplicate Protocol	No		YES			
86	Climate Action Reserve	U.S Landfill	4.0	6/29/2011	Landfill/Waste Management	Projects following this protocol will install a system for capturing and destroying methane gas emitted from landfill operations. The methane will be burned onsite or offsite or used for vehicle fuel.	No		YES	2,200	Grouped Protocol: Landfill Gas Capture and Destruction/Use • Waste-in-place emissions from Landfills without LFG Capture = 3,086 MT CO_2e/year (CAP 2030 Inventory; Borrego and Viejas Landfills) • Landfill gas capture rate = 75% (CAP, Appendix A) • Methane destruction efficiency = 96% (CAR U.S. Landfill Protocol; Table C.2, Open Flare) • 3,086 MT CO_2e/year * 75% * 96% = 2,222 MT CO_2e/year • Assume diversion activities would not take full effect until 2030. • Would obtain additional reductions from future waste placement at Borrego Landfill; however, these emissions would be substantially reduced by CAP diversion activities under SW-1.1.	http://www.climateactionreserve.org/how/protocols/
87	American Carbon Registry	Landfill Gas Destruction and Beneficial Use Projects	1.0		Landfill/Waste Management	Projects following this protocol will collect and combust landfill gas in order to reduce GHG emissions at landfill operations, in order to generate carbon offset credits. This protocol provides a methodology and guidelines for quantifying these emission reductions and converting them into offset credits.	No		YES			
88	American Carbon Registry	Landfill Methane Collection and Combustion	1.3		Landfill/Waste Management	Projects following this protocol will collect and combust landfill gas in order to reduce GHG emissions at landfill operations. This is achieved through he installation of a gas collection system which conveys methane to a flare or gas utilization project on site.	No		YES			
89	CAPCOA GHG Rx	Biochar Production Project Reporting Protocol	3.4	9/28/2015	Landfill/Waste Management	Projects following this protocol will quantify GHG emission reductions associated with biochar production through thermochemical conversion processes. The protocol provides accounting, reporting, and monitoring procedures for accomplishing this.	No		Yes	<1,000	• 0.374 MT CO_2e/MT waste in landfill (CAP, Appendix A) • 206,733 = tons/year organic waste landfilled less organics reduced due to CAP Measure SW-1.1 (CAP, Appendix C) • 206,733 tons/year * (1 MT/1.102 tons) * 0.374 MT CO_2e/MT waste = 70,162 MT CO_2e/year • Note, the majority of waste in SD County is sent to landfills that have landfill gas capture (and destruction).	

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A	B	C	D	E	F	G	H		I	J	K	L
90	Climate Action Reserve	Mexico Ozone Depleting Substances	1.1	4/28/2015	Ozone Depleting Substances	Not applicable.	No		NO, SOURCE/ ACTIVITY NOT IN SD COUNTY	N/A		
91	Climate Action Reserve	Ozone Depleting Substances	2.0	6/27/2012	Ozone Depleting Substances	Projects following this protocol will undertake activities that result in the destruction of eligible ODSs, which in turn leads to GHG emission reductions. The protocol provides guidelines for calculating GHG reductions based on the types and amounts of ODSs that are destroyed.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	20,000 - 300,000 per project per year	• Reduction estimate reflects the range of approximately 70 projects listed on CAR and ACR.	https://thereserve2.apx.com/myModule/rpt/myrpt.asp?r=111 http://americancarbonregistry.org/how-it-works/registry-reports
92	American Carbon Registry	Destruction of Ozone Depleting Substances and High-GWP Foam	1.0		Ozone Depleting Substances	Projects following this protocol will quantify GHG emission reductions associated with the destruction of high global warming potential ODSs, foam blowing agents, and insulation foams that contain blowing agents.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY			
93	American Carbon Registry	Replacement of SF6 with Alternate Cover Gas in the Magnesium Industry	2.1		Ozone Depleting Substances	Projects following this protocol will quantify GHG emission reductions associated with transitioning to the use of alternative cover gases in lieu of sulfur hexafluoride at magnesium metal casting operations.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	87,000 per project per year	• Reduction estimate reflects the one project (ACR 261) listed on ACR.	http://americancarbonregistry.org/how-it-works/registry-reports
94	American Carbon Registry	Transition to Advanced Formulation Blowing Agents in Foam Manufacturing and Use	1.0		Ozone Depleting Substances	Projects following this protocol will quantify GHG emission reductions associated with transitioning to the use of certified reclaimed HFC refrigerants and advanced refrigeration systems. The protocol contains guidelines for quantifying these emission reductions and converting them into carbon offset credits, which act as an incentive to the manufacturers to replace their traditional refrigeration systems.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	13,000 per project per year	• Reduction estimate reflects the one project (ACR 348) listed on ACR.	http://americancarbonregistry.org/how-it-works/registry-reports
95	American Carbon Registry	Use of Certified Reclaimed HFC Refrigerants and Advanced Refrigeration Systems	1.0		Ozone Depleting Substances	Projects following this protocol will quantify GHG emission reductions associated with replacing older style blowing agents that contain high GWP chemicals and ODSs with low GWP chemicals and no ODSs. The protocol contains guidelines for quantifying these emission reductions and converting them into carbon offset credits, which act as an incentive to the manufacturers to replace their old-style blowing agents.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	8,000 per project per year	• Reduction estimate reflects the one project (ACR 310) listed on ACR.	http://americancarbonregistry.org/how-it-works/registry-reports
96	Verified Carbon Standard	Infrared Automatic Refrigerant Leak Detection Efficiency Project Methodology	1.1	3/17/2017	Ozone Depleting Substances	Projects following this protocol will install infra-red, real time leak detection systems on refrigeration equipment in order to reduce leaks of HFC refrigerants. The protocol offers a methodology for calculating the GHG emission reductions associated with detecting and stopping HFC refrigerant leaks.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY	N/A		
97	Verified Carbon Standard	Recovery and Destruction of Ozone-Depleting Substances (ODS) from Products	1.0	9/20/2011	Ozone Depleting Substances	Projects following this protocol will undertake activities that result in the destruction of eligible ODSs, which in turn leads to GHG emission reductions. The protocol provides guidelines for calculating GHG reductions based on the types and amounts of ODSs that are destroyed.	No		NO, SOURCE/ ACTIVITY NOT IN CAP INVENTORY			

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A	B	C	D	E	F	G	H		I	J	K	L
98	Verified Carbon Standard	Fuel Switch from Gasoline to Ethanol in Flex-Fuel Vehicle Fleets	1.0	6/18/2012	Transportation	Projects following this protocol must aim at complete substitution of gasoline or gasoline blends by ethanol (guarantee exclusive consumption) in commercial fleets of flex-fuel vehicles only.	No		YES	1,000 - 1,900	• Passenger + Light Duty (LD) Truck Emissions = 697,489 MT CO_2e/year (CAP, Appendix A, 2030) • Medium Duty (MD) Truck Emission = 137,402 MT CO_2e/year (CAP, Appendix A, 2030) • Emission reductions to Passenger and LD Truck emissions due to related CAP measures: 4,154 MT CO_2e (T-1.1), 1,677 MT CO_2e (T-1.2), 77 MT CO_2e (T-2.1), 13,949 MT CO_2e (T-1.3), 2,180 MT CO_2e (T-2.2), 5,581 MT CO_2e (T-2.3), 1,454 MT CO_2e (T-2.4), 866 MT CO_2e (T-3.3), and 3,673 MT CO_2e (T-3.3). • Passenger + Light Duty (LD) Truck Emissions after CAP reductions = 663,878 MT CO_2e/year (CAP, Appendix A, 2030) • % of Passenger + LD Truck VMT that is Ethanol Flex-Fuel Fleet VMT in 2030 = 1% (eia.gov; Table 42, Table 47) • % of MD Truck VMT that is Ethanol Flex-Fuel Vehicles in 2030 = 9% (eia.gov; Table 50); assume 50% are fleet vehicles • Assume 30% reduction in tailpipe emissions for conversion from gasoline to E100 in flex fuel vehicles (scirp.org). • (663,878 MT CO_2e/year * 1%)+(137,402 MT CO_2e/year * 9% * 50%) * 30% = 3,847 MT CO_2e/year • Reduction range assumes 25 to 50% of flex-fuel fleets covert to E100. • Note, E100 is not commercially available in California.	https://file.scirp.org/pdf/JEP_2016051113592899.pdf https://www.eia.gov/outlooks/aeo/tables_ref.php
99	Verified Carbon Standard	Transport Energy Efficiency from Lightweight Pallets	1.0	11/6/2012	Transportation	Projects following this protocol must reduce GHG emissions from the transportation of freight on truck fleets by reducing the weight of pallets transported, hence reducing fuel consumption. Emission reductions claimed under this methodology are only related to increased fuel efficiency due to the use of lightweight pallets.	No		NO, OTHER	N/A	• Protocol implementation was determined to be cost-prohibitive.	
100	Verified Carbon Standard	Methodology for Carpooling	1.0	4/17/2015	Transportation	Projects following this protocol must reduce GHG emissions by using carpools for commuting to and from work, as facilitated by the use of a Carpool Management and Monitoring System (CMMS) that enables a community of people to more effectively engage in carpooling.	Partially, see measure T-2.2, measure T-2.3		YES	100 - 1,500	• Passenger and LDT1 VMT = 2,186,461,667 (CAP, Appendix A, 2030) • Approximate VMT reductions due to related CAP measures: 20,090,000 (T-1.1), 8,110,000 (T-1.2), 370,000 (T-2.1), 67,460,000 (T-1.3), 10,540,000 (T-2.2), 26,990,000 (T-2.3), 7,030,000 (T-2.4), 1,020,000 (T-3.3), and 13,250,000 (T-3.3). • Passenger and LDT1 VMT (after CAP reductions) = 2,031,601,567 • Per protocol, emission reductions can only occur commuting purposes (i.e., non-residential VMT reduction) • Percent of household VMT for commuting = 28% (CAP Measure T-2.2; AASHTO 2013) • Percent commute reduction due to ride sharing = 5% (CAP Measure T-2.2, CAPCOA) • CAP GHG reduction per mile = 0.000207 MT CO_2/mile (CAP Measure T-2.2, 2030) • 2,031,601,567 VMT * 28% * 5% * 0.000207 MT CO_2/mile = 5,888 MT CO_2e/year • Reduction range assumes 1 to 25% of existing commuting VMTs will implement ride sharing.	
101	Verified Carbon Standard	Revisions to AMS-III.BC (Improve Efficiency of Vehicle Fleets) to Include Mobile Machinery	1.0	4/24/2013	Transportation	Projects following this protocol must implement GHG emission reductions through improved efficiency of mobile machinery (equipment which is not fixed at a specific site but can be moved around either under its own power or with assistance when engineering specifications or logistics dictate, e.g., *moving a loader using a lo-bed rather than driving the loader to the destination*).	Partially, see measure T-3.1, measure T-3.2, measure A-1.1		YES	<1,000	• Opportunities for improving off-road equipment fleet efficiency are more limited than those for more mobile vehicle fleets, which can take advantage of improved aerodynamic design, lighter frame design, and low-rolling resistance tires for achieving significant GHG reductions.	
102	American Carbon Registry	Improved Efficiency of Vehicle Fleets	2.0		Transportation	Projects following this protocol must reduce transportation emissions through improved efficiency of vehicle fleets using American Carbon Registry (ACR) approved methodology or Clean Development Mechanism (CDM) approved methodology. ACR methodology would allow idling stop devices on vehicles other than Heavy Duty Vehicles, and measures other than idle reduction to reduce fuel usage and engine emissions. These additional measures include eco-drive systems, tire-rolling resistance improvements, AC system improvements, use of low viscosity oils, aerodynamic drag reduction improvements, and transmission improvements.	Partially, see measure T-3, measure T-3.4		YES	300 - 1,300	• CARB rule requires improved tires and aerodynamic technologies for HD tractor trailers (arb.ca.gov); therefore, efficiencies would need to be gained through eco-drive systems, AC system improvements, use of low viscosity oils, and transmission improvements. • Improvements would need to be beyond what would be required by EPA-NHTSA Phase 1 and Phase 2 standards (MY 2014 and later). • Heavy Duty (HD) + Medium Duty (MD) Truck Emissions = 351,041 MT CO_2e/year (CAP, Appendix A, 2030) • Based on EMFAC2014, approx. 9.5% of 2030 HD + MD emissions for SD County are from pre-MY 2014 trucks, for which additional improvement can be achieved. • Transmission/engine improvements = 15% improvement in efficiency (theicct.org). • 351,041 MT CO_2e/year * 9.5% * 15% = 5,000 MT CO_2e/year. • Reduction range assumes 5 to 25% of applicable HD + MD VMT could be impacted.	https://www.arb.ca.gov/regact/2008/ghghdv08/ghgfro.pdf http://www.theicct.org/sites/default/files/HDV_Workshop_10Nov2011_TIAX.pdf https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812177-commedhdtruckfueleffictechcoststudy.pdf

PROTOCOL NO.	REGISTRY	PROTOCOL / METHODOLOGY NAME	VERSION	DATE	PROTOCOL SECTOR	BRIEF DESCRIPTION	ARE PROJECTS OF THIS TYPE ALREADY BEING PROPOSED IN THE CAP?		PROTOCOL ELIGIBLE FOR DIRECT INVESTMENT MEASURE?	REDUCTION ESTIMATE (MT/year)[1]	REDUCTION ESTIMATION METHODOLOGY	REFERENCES
A	B	C	D	E	F	G	H		I	J	K	L
103	American Carbon Registry	Truck Stop Electrification	1.1		Transportation	Projects following this protocol must install truck stop electrification (TSE) technologies as an idling emission reduction solution for locations where extended idling occurs. These technologies allow a driver to shut down the main propulsion engine of the diesel truck, eliminating all of the emissions associated with diesel engine idling.	No		NO, OTHER	N/A	• California's Commercial Vehicle Idling Regulation prohibits heavy-duty diesel vehicles from idling more than 5 minutes when stopped within California's borders; therefore, TSE projects in California likely would not pass the "Regulatory Surplus Test" in the protocol.	https://www.arb.ca.gov/msprog/truck-idling/truck-idling.htm
104	CAPCOA GHG Rx	Case by Case Project Protocol	1.0		Other		N/A		NO, OTHER		• Protocol is non-specific	

Notes: [1] Reduction estimates are rounded to the nearest 100 metric tons.

Table 3-1. Reduction Calculation for Fertilizer Management
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Agriculture
Protocol Title:	Grouped Protocol: Nitrogen Fertilizer Management[1] (Protocols 3 and 4)
Brief Description:	Projects following these protocols quantify N_2O emission reductions achieved through the reduction/optimization of nitrogen fertilizer usage by following BMPs such as adjusting fertilizer type, placement, and timing of application.

Quantity	Description
17,271	*MT CO_2e/year emissions from Soil Management category (2030)* [2]
50%	Assumed emissions reductions achieved by following fertilizer BMPs[3]
8,636	Potential MT CO_2e/year reduced
25%	Assumed rate of crop operations adopting fertilizer BMPs, lower estimate[4]
75%	Assumed rate of crop operations adopting fertilizer BMPs, higher estimate[4]
2,159	MT CO_2e/year reduced at 25% implementation
6,477	MT CO_2e/year reduced at 75% implementation

Abbreviations:

BMP	Best Management Practice
CO_2e	carbon dioxide equivalent emissions
N_2O	nitrous oxide
MT	metric ton

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Quantifying N_2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reduction" from the Verified Carbon Standard and "Reduced Use of Nitrogen Fertilizer on Agricultural Crops" from the American Carbon Registry.

[2] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[3] Millar, Neville, et al., 2014. Management of Nitrogen Fertilizer to Reduce Nitrous Oxide (N_2O) Emissions From Field Crops. Michigan State University. Extension Bulletin E3152. November. Available at: http://delta-institute.org/delta/wp-content/uploads/Nitrogen-fertilizer-management-climate-factsheet_FINAL.compressed.pdf. Accessed: October 2017.

[4] Since many commercial farming operations already perform some level of fertilizer management, this protocol was assumed to have a relatively high implementation rate. The range in adoption reflects the possibility that some operations may already be implementing fertilizer BMPs and/or that some crops may not be amenable to changes in fertilizer application.

Table 3-2. Reduction Calculation for Manure Management (BCS)
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Agriculture
Protocol Title:	Grouped Protocol: Manure Management (Biogas Control Systems)[1] (Protocols 5, 6, and 7)
Brief Description:	Projects following these protocols reduce methane emissions from livestock operations by installing a biogas control system that captures methane from manure treatment and storage facilities. The methane is then treated or used in a variety of ways, including combustion onsite or offsite.

Quantity	Description
26,865	*MT CO_2e/year emissions from Manure Management category (2030)* [2]
84.5%	Portion of CO_2e emissions from CH_4[2]
87%	CH_4 emission reductions achieved through use of BCS[3]
19,750	Potential MT CO_2e/year reduced
25%	Assumed rate of livestock operations installing new BCSs, lower estimate[4]
75%	Assumed rate of livestock operations installing new BCSs, higher estimate[4]
4,937	MT CO_2e/year reduced, at 25% implementation
14,812	MT CO_2e/year reduced, at 75% implementation

Abbreviations:

BCS	biogas control system
CH_4	methane
CO_2e	carbon dioxide equivalent emissions
MT	metric ton

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "U.S. Livestock" from the Climate Action Reserve and the variations of this protocol permitted in the CAPCOA GHG Rx program.

[2] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[3] U.S. Environmental Protection Agency. 2011. Market Opportunities for Biogas Recovery Systems at U.S. Livestock Facilities. November. Available at: https://www.epa.gov/sites/production/files/2014-12/documents/biogas_recovery_systems_screenres.pdf. Accessed: October 2017.

[4] Since the State of California has an ongoing interest in promoting this technology,[5] this protocol was assumed to have a relatively high implementation rate. The range in adoption reflects the possibility that some operations may already have a BCS in place or that installing a BCS will be cost-prohibitive even with reasonable incentives.

[5] As manifested by the California Air Resources Board's *Dairy and Livestock Subgroup #2: Fostering Markets for Digester Projects* . Available at: https://www.arb.ca.gov/cc/dairy/dsg2/dsg2.htm. Accessed: October 2017.

Table 3-3. Reduction Calculation for SALM
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Agriculture
Protocol Title:	VCS: Adoption of Sustainable Agricultural Land Management (Protocol 8)
Brief Description:	Projects following this protocol estimate and monitor GHG emissions of project activities that adopt SALM practices, such as manure management, use of cover crops, planting trees, and composting crop residuals for reuse in the field. Specifically, these estimates are for GHG sequestration resulting from the use of organic compost on croplands.

Quantity	Description
1,097	MT CO_2e/year reduced/sequestered (potential) at Modoc Ranch (N. California Case Study)[1]
537	Acres of cropland at Modoc Ranch[1,2]
2.04	MT CO_2e/year reduced/sequestered per acre at Modoc Ranch
76,711	*Acres of cropland in unincorporated SD County*[3]
156,708	Potential MT CO_2e/year reduced/sequestered
5%	Assumed portion of cropland composted, lower estimate[4]
10%	Assumed portion of cropland composted, higher estimate[4]
7,835	MT CO_2e/year reduced/sequestered at 5% implementation
15,671	MT CO_2e/year reduced/sequestered at 10% implementation

Abbreviations:

CO_2e	carbon dioxide equivalent emissions
GHG	greenhouse gas
MT	metric ton
SALM	sustainable agricultural land management
SD	San Diego
SOM	soil organic matter
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Carbon Cycle Institute. 2016. Carbon Farming - Increasing Carbon Capture on California's Working Lands. Available at: https://www.epa.gov/sites/production/files/2016-11/documents/cba2016-creque_increasing_carbon_capture_on_californias_working_lands.pdf. Accessed: October 2017.

[2] Acres of cropland to which compost is applied to reach a Soil Organic Matter (SOM) content of 5%.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Because applying compost at a commercial scale would be relatively resource-intensive, this protocol was assumed to have a relatively low implementation rate. In addition, the range in adoption reflects the possibility that some crops may not be amenable to compost additions and that the County's organics processing facilities may not be able to meet the full demand for quality compost.

Table 3-4. Reduction Calculation for Manure Management (Solids)
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Agriculture
Protocol Title:	VCS: Revisions to AMS-III.Y to Include Use of Organic Bedding Material (Protocol 9)
Brief Description:	Projects following this protocol reduce methane production from anaerobic manure management systems by removing volatile solids from the manure stream before treatment. It requires that these solids are further treated, used, or disposed in a way that results in lower methane emissions.

Quantity	Description
26,865	*MT CO_2e/year emissions from Manure Management category (2030)* [1]
100%	Portion of manure emissions from volatile solids[2]
50%	Portion of volatile solids removed during separation[3]
50%	Assumed portion of CO_2e emissions reduced through treating volatile solids[4]
6,716	Potential MT CO_2e/year reduced
10%	Assumed rate of livestock operations installing new manure separation systems, lower estimate[5]
20%	Assumed rate of livestock operations installing new manure separation systems, higher estimate[5]
672	MT CO_2e/year reduced at 10% implementation
1,343	MT CO_2e/year reduced at 20% implementation

Abbreviations:

CO_2e	carbon dioxide equivalent emissions
MT	metric ton
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[2] Climate Action Reserve. 2013. U.S. Livestock Project Protocol. Ver 4.0. January. Available at: http://www.climateactionreserve.org/how/protocols/. Accessed: October 2017.

[3] Chastain, J.P., et al., 2001. Effectiveness of Liquid-Solid Separation for Treatment of Flushed Dairy Manure: A Case Study. Applied Engineering in Agriculture. Vol. 17(3), p. 343-354. Available at: https://www.clemson.edu/extension/camm/manuals/publications/dairy_liquid_solid_separation.pdf. Accessed: October 2017.

[4] VanderZaag, A.C., et al., 2017. Potential Methane Emission Reductions for Two Manure Treatment Technologies. Environmental Technology. April 26. p. 1-8. Available at: https://www.ncbi.nlm.nih.gov/pubmed/28355494. Accessed: October 2017.

[5] Range in adoption reflects the possibility that some operations may already have solids separation processes in place. Overall implementation rate also reflect the possible overlap with potential reductions from the installation of a biogas control system (under a separate protocol type).

Table 3-5. Reduction Calculation for Cogeneration
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Energy Efficiency/Production
Protocol Title:	VCS: New Cogeneration Facilities Supplying Less Carbon Intensive Electricity to Grid and/or Hot Water to One or More Grid Customers (Protocol 16)
Brief Description:	Projects following this protocol must construct and operate a new gas-fired cogeneration plant which is connected to the electrical grid and where all the electricity produced other than that required to operate the cogeneration facility is exported to the grid. Additionally, this methodology is only applicable to cases in which the steam and/or hot water that is to be displaced by the project activity is either produced for export to a steam/hot water grid or is drawn from a steam/hot water grid.

Quantity	Description
0.22	MT CO_2e reduced per MWh displaced by cogeneration[1]
299,113	*MWh/year electricity demand after CAP measure reductions (2030)* [3,4]
15%	percent of 2030 SD County electricity demand provided by newly developed cogeneration, lower estimate[5]
44%	percent of 2030 SD County electricity demand provided by newly developed cogeneration, higher estimate[5]
9,973	MT CO_2e/year reduction for new cogeneration in SD County, lower estimate
29,352	MT CO_2e/year reduction for new cogeneration in SD County, higher estimate

Abbreviations:

CAP	Climate Action Plan
CHP	combined heat and power
CO_2e	carbon dioxide equivalent emissions
GWh	gigawatt-hour
MT	metric ton
MW	megawatt
MWh	megawatt-hour
SD	San Diego
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Estimate developed from an analysis in the First Update to the Climate Change Scoping Plan[2] which states that 4000 MW of installed CHP in 2020 will be enough to displace approximately 30,000 GWh of electricity demand from other power generation sources, resulting in reductions of 6.7 million MT CO_2e.

[2] California Air Resources Board, et al., 2014. First Update to the Climate Change Scoping Plan. May. Available at: https://www.arb.ca.gov/cc/scopingplan/document/updatedscopingplan2013.htm. Accessed: October 2017.

[3] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[4] County of San Diego. 2017. Climate Action Plan. Draft. Appendix C. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[5] Reduction range is based on a judgement regarding availability of opportunities to install cost-effective cogeneration systems by 2030 and for such systems to result in lower greenhouse gas emissions. The assumed percentages are conservatively low compared to estimates by the State of California for new cogeneration generation in 2030.

Table 3-6. Reduction Calculation for Weatherization
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Energy Efficiency/Production
Protocol Title:	Grouped Protocol: Weatherization of Single Family and Multi-Family Buildings[1] (Protocols 17 and 18)
Brief Description:	Projects following this protocol must weatherize dwellings (i.e., energy efficiency measures directed at reducing the consumption of energy within a dwelling); energy efficiency measures may include adding/improving insulation, air sealing, and replacing appliances and central heating/cooling components.

Quantity	Description
1%	Assumed percentage of existing residential buildings in unincorporated county 2030 that will be retrofitted to meet 2016 Energy Efficiency Standards, lower estimate[2]
5%	Assumed percentage of existing residential buildings in unincorporated county 2030 that will be retrofitted to meet 2016 Energy Efficiency Standards, higher estimate[2]
3,694	MT CO_2e/year reduced from energy efficiency improvements in the existing residential building stock, lower estimate[3]
18,470	MT CO_2e/year reduced from energy efficiency improvements in the existing residential building stock, higher estimate[3]

Abbreviations:

CAP	Climate Action Plan
CO_2e	carbon dioxide equivalent emissions
MT	metric ton
VCS	Verified Carbon Standard

Notes:

[1] Protocols represented include "Weatherization of Single Family and Multi-Family Buildings" from the Verified Carbon Standard and the CAPCOA GHG Rx program.

[2] The participation rate assumptions are based on the extrapolation of those made under CAP Measure E-1.3 and the assumption that additional participation will be achieved through this protocol.

[3] Reduction estimates per % participation are assumed to be the same as those estimated for CAP Measure E-1.3 in 2030.[4] Note, the CAP estimate includes emission reductions from both the residential and commercial sectors, while the protocol solely focuses on reductions from the residential sector.

[4] County of San Diego. 2017. Climate Action Plan. Draft. Appendix C. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

Table 3-7. Reduction Calculation for Sustainable Communities
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Energy Efficiency/Production
Protocol Title:	VCS: Energy Efficiency and Solid Waste Diversion Activities within a Sustainable Community (Protocol 19)
Brief Description:	Projects following this protocol must quantify direct and indirect GHG emission reductions for grouped projects (multiple project activities into a single, combined project that adds new instances over time), where energy efficiency and solid waste diversion activities have been initiated. Since many of these energy efficiency and solid waste diversion activities are offered under other protocols, these reduction estimates focus solely on the measures unique to this protocol--that is, improvements in efficiency of industrial processes.

Quantity	Description
415,654	*MT CO_2e/year emissions from Energy category after legislative reductions and CAP measures (2030)* [1]
9%	Percent of 2030 energy-related emissions assumed to be due to industrial processes[1,2] (industrial % of 2014 electricity emissions)
1%	Assumed 1% in efficiency improvements can be achieved in the industrial sector[3]
5%	Assumed 5% in efficiency improvements can be achieved in the industrial sector[3]
374	MT CO_2e/year reduced at 1% improvement
1,870	MT CO_2e/year reduced at 5% improvement

Abbreviations:

CAP	Climate Action Plan
CO_2e	carbon dioxide equivalent emissions
GHG	Greenhouse Gas
MT	metric ton
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[2] Assumed to be equivalent to the percentage of 2014 electricity emissions attributed to industry.

[3] The assumed reduction range is based on the possibility that energy efficiency projects may overlap with reductions pursued via other protocols (e.g., new cogeneration).

Table 3-8. Reduction Calculation for Campuses
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Energy Efficiency/Production
Protocol Title:	VCS: Campus Clean Energy and Energy Efficiency (Protocol 20)
Brief Description:	Projects following this protocol must reduce GHG emissions through the implementation of clean energy and/or energy efficiency activities at college and school campuses in the United States.

Quantity	Description
<1,000 - 33,900	*MT CO_2e/year reduction range per campus; the reduction estimate reflects the range of the 9 projects listed on the VCS Project Database*[1]
1,000	MT CO_2e/year reduced, lower estimate[2]
5,000	MT CO_2e/year reduced, higher estimate[2]

Abbreviations:

CAP	Climate Action Plan
CO_2e	carbon dioxide equivalent emissions
GHG	Greenhouse Gas
MT	metric ton
SD	San Diego
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Available at: http://www.vcsprojectdatabase.org/#/home. Accessed: September 2017.

[2] Reduction range assumes energy efficiency initiatives can be implemented at 1 to 5 small college campuses in unincorporated SD County. Range also takes into account that reductions under this protocol could overlap with existing CAP measures and with other energy efficiency protocols (e.g., new cogeneration).

Table 3-9. Reduction Calculation for Avoided Land Degradation
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	Grouped Protocol: Avoided Forest Degradation[1] (Protocols 40 and 41)
Brief Description:	Projects following these protocols quantify emission reductions from activities involving reforestation, revegetation, and avoided forest degradation.

Quantity	Description
4	MT CO_2e reduced/sequestered per acre per year[2]
85,324	*Acres of forest in unincorporated SD County* [3]
341,296	MT CO_2e reduced/sequestered across SD County per year
0.5%	Low end range of acreage conserved[4]
5%	High end range of acreage conserved[4]
1,706	Low end MT CO_2e/year reduced/sequestered
17,065	High end MT CO_2e/year reduced/sequestered

Abbreviations:

ACR	American Carbon Registry
CAR	Climate Action Reserve
CO_2e	carbon dioxide equivalent emissions
MT	metric ton
REDD	Reducing Emissions from Deforestation and Forest Degradation
SD	San Diego
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects" and "REDD+ Methodology Framework" from the VCS.

[2] Sequestration rate based on similar projects in the VCS, ACR, and CAR registry databases.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-10. Reduction Calculation for Avoided Deforestation
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	Grouped Protocol: Avoided Forest Deforestation[1] (Protocols 42, 43, and 44)
Brief Description:	Projects following these protocols quantify emission reductions from activities (e.g., protecting land, implementing controlled logging), which prevent planned and unplanned conversion of forest to a non-forest or non-native state.

Quantity	Description
4	MT CO_2e reduced/sequestered per acre per year[2]
42,815	*Acres of unconserved forest in unincorporated SD County*[3]
171,260	MT CO_2e reduced/sequestered across SD County per year
0.5%	Low end range of acreage conserved[4]
5%	High end range of acreage conserved[4]
856	Low end MT CO_2e/year reduced/sequestered
8,563	High end MT CO_2e/year reduced/sequestered

Abbreviations:

ACR	American Carbon Registry
CAR	Climate Action Reserve
CO_2e	carbon dioxide equivalent emissions
MT	metric ton
REDD	Reducing Emissions from Deforestation and Forest Degradation
SD	San Diego
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Methodology for Avoided Unplanned Deforestation" and "Methodology for Avoided Ecosystem Conversion" from the VCS and "Reducing Emissions from Deforestation and Degradation - Avoiding Planned Deforestation" from the ACR.

[2] Sequestration rate based on similar projects in the VCS, ACR, and CAR registry databases.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-11. Reduction Calculation for Grassland Conservation
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	Grouped Protocol: Conservation of Grassland[1] (Protocols 44, 45, and 46)
Brief Description:	Projects following these protocols quantify emission reductions from activities which prevent conversion of grassland and shrublands to cropland or other non-native state.

Quantity	Description
6.2	MT CO_2e reduced/sequestered per acre per year[2]
100,792	*Acres of unconserved grassland in unincorporated San Diego County*[3]
624,910	MT CO_2e reduced/sequestered across SD County per year
0.5%	Low end range of acreage conserved[4]
5%	High end range of acreage conserved[4]
3,125	Low end MT CO_2e/year reduced/sequestered
31,246	High end MT CO_2e/year reduced/sequestered

Abbreviations:

ACR American Carbon Registry
CAR Climate Action Reserve
CO_2e carbon dioxide equivalent emissions
MT metric ton
SD San Diego
VCS Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Methodology for Avoided Ecosystem Conversion" from the VCS, "Grassland" from the CAR, and "Avoided Conversion of Grasslands and Shrublands to Crop Production" from the ACR.

[2] Evaluation of Avoided Grassland Conversion and Cropland Conversion to Grassland as Potential Carbon Offset Project Types. 2014. Available at: https://climatetrust.org/wp-content/uploads/2014/07/Evaluation-of-Avoided-Grassland-Conversion-and-Cropland-Conversion-to-Grassland-as-Potential-Carbon-Offset-Project-Types-.pdf. Accessed: September 2017.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-12. Reduction Calculation for IFM
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	Grouped Protocol: Improved Forest Management[1] (Protocols 48 and 50)
Brief Description:	Projects following these protocols quantify emission reductions from projects that improve forest management above baseline conditions. Projects must be located on non-federally owned forestland in the U.S.

Quantity	Description
3.1	MT CO_2e reduced/sequestered per acre per year[2]
42,815	*Acres of forest not in preserved areas in unincorporated SD County*[3]
132,727	MT CO_2e reduced/sequestered across SD County per year
0.5%	Low end range of acreage managed[4]
5%	High end range of acreage managed[4]
664	Low end MT CO_2e/year reduced/sequestered
6,636	High end MT CO_2e/year reduced/sequestered

Abbreviations:

ACR	American Carbon Registry
CAPCOA GHG Rx	California Air Pollution Control Officers Association Greenhouse Gas Reduction Exchange
CAR	Climate Action Reserve
CO_2e	carbon dioxide equivalent emissions
GHG	greenhouse gas
MT	metric ton
SD	San Diego
U.S.	United States
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Improved Forest Management for Non-Federal U.S. Forestlands" from the ACR, and "100-year Improved Forest Management Methodology for Quantifying GHG Removals and Emission Reductions through Increased Forest Carbon Sequestration" from the CAPCOA GHG Rx program.

[2] Sequestration rate based on similar projects in the VCS, ACR, and CAR registry databases.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-13. Reduction Calculation for Restoration (Forest)
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	ACR: Afforestation and Reforestation of Degraded Lands (Protocol 51)
Brief Description:	This protocol applies to afforestation and reforestation American Carbon Registry project activities implemented on degraded lands.

Quantity	Description
3.8	MT CO_2e reduced/sequestered per acre per year[1]
85,324	*Acres of forest in unincorporated SD County*[2]
324,231	MT CO_2e reduced/sequestered across SD County per year
0.5%	Low end range of acreage restored[3]
5%	High end range of acreage restored[3]
1,621	Low end MT CO_2e/year reduced/sequestered
16,212	High end MT CO_2e/year reduced/sequestered

Abbreviations:

ACR	American Carbon Registry
CAR	Climate Action Reserve
CO_2e	carbon dioxide equivalent emissions
GHG	greenhouse gas
MT	metric ton
SD	San Diego
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Sequestration rate based on similar projects in the VCS, ACR, and CAR registry databases.

[2] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[3] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-14. Reduction Calculation for Restoration (Wetlands)
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	Grouped Protocol: Restoration of Wetlands[1] (Protocols 52, 53, 54, 55, and 56)
Brief Description:	Projects following these protocols quantify emission reductions from activities which create, restore, and/or improve management of wetlands.

Quantity	Description
12.5	MT CO_2e reduced/sequestered per acre per year[2]
264	*Acres of estuarine wetlands in unincorporated SD County*[3]
3,300	MT CO_2e reduced/sequestered across SD County per year
5%	Low end range of acreage restored[4]
20%	High end range of acreage restored[4]
165	Low end MT CO_2e/year reduced/sequestered
660	High end MT CO_2e/year reduced/sequestered

Abbreviations:

ACR	American Carbon Registry
CAPCOA GHG Rx	California Air Pollution Control Officers Association Greenhouse Gas Reduction Exchange
CO_2e	carbon dioxide equivalent emissions
GHG	greenhouse gas
MT	metric ton
SD	San Diego
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Methodology for Coastal Wetland Creation" and "Methodology for Tidal Wetland and Seagrass Restoration" from the VCS, "Restoration of California Deltaic and Coastal Wetlands" from the ACR, and "Coastal Wetland Creation" and "Quantifying Greenhouse Gas Reductions from Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and the Coast of California" in the CAPCOA GHG Rx program.

[2] Sequestration rate based on average of similar type projects.

Institute for Local Government. *Wetlands and Watershed Restoration* . 2016. Available at: http://www.ca-ilg.org/post/wetlands-restoration-greenhouse-gas-reduction-program. Accessed: September 2017.

Wetlands GHG State of The Science. 2013. Available at: https://cwc.ca.gov/Documents/2013/05_May/May2013_Agenda_Item_8_Sherman_Twitchell_Presentation1.pdf. Accessed: September 2017.

United States Geological Survey. *Carbon Capture Farming* . Available at: https://adaptationprofessionals.org/wp-content/uploads/bp-attachments/1472/carbonflyer02_22_08.pdf. Accessed: September 2017.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-15. Reduction Calculation for Urban Tree Planting
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	CAR: Urban Tree Planting (Protocol 57)
Brief Description:	This protocol applies to projects in areas where trees have not been harvested with commercial interest 10 years prior, and new trees are planted.

Quantity	Description
0.0354	MT CO_2e reduced/sequestered per tree per year[1]
35,146	*Total trees planted in 2030 since 2020 due to CAP measure A-2.1* [2]
49,000	*Total trees planted in 2030 since 2017 due to CAP measure A-2.2* [2]
2,979	*MT CO_2e reduced/sequestered across SD County per year*
150%	Low end increase to number of trees planted due to CAP measures A-2.1 and A-2.2[3]
200%	High end increase to number of trees planted due to CAP measures A-2.1 and A-2.2[3]
4,468	Low end MT CO_2e/year reduced/sequestered
5,958	High end MT CO_2e/year reduced/sequestered

Abbreviations:

CAP	Climate Action Plan
CAR	Climate Action Reserve
CO_2e	carbon dioxide equivalent emissions
MT	metric ton
SD	San Diego

Notes:

Text in italics represents the baseline values from which emission reductions are estimated.

[1] CalEEMod User's Guide. Available at: www.caleemod.com. Accessed: September 2017.

[2] County of San Diego. 2017. Climate Action Plan. Draft. Appendix C. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[3] Reduction rate based on expansion of County commitments for tree planting.

Table 3-16. Reduction Calculation for Grassland Management
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	Grouped Protocol: Improved Grassland Management[1] (Protocols 58 and 59)
Brief Description:	Projects following these protocols quantify emission reductions from activities which aim to improve grassland soils through adjustments in agricultural practices (e.g., changing grouping, timing, and season of grazing) and fire frequency (e.g., shifting from late season to early season burning or changing prescribed burn schedules).

Quantity	Description
0.49	MT CO_2e/year reduced/sequestered per acre per year[2]
137,951	*Acres of grassland in unincorporated San Diego County* [3]
67,596	MT CO_2e reduced/sequestered across SD County per year
0.5%	Low end range of acreage managed[4]
5%	High end range of acreage managed[4]
338	Low end MT CO_2e/year reduced/sequestered
3,380	High End MT CO_2e/year reduced/sequestered

Abbreviations:

CO_2e	carbon dioxide equivalent emissions
MT	metric ton
SD	San Diego
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Soil Carbon Quantification Methodology" and "Methodology for the Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing" from the VCS.

[2] Sequestration rate based on average of similar type projects.

Scientific American. *Carbon-Offset Cowboys Let Their Grass Grow* . 2008. Available at: https://www.scientificamerican.com/article/carbon-cowboys/. Accessed: September 2017.

Emerging Land Use Practices Rapidly Increase Soil Organic Matter. 2015. Available at: https://www.nature.com/articles/ncomms7995. Accessed: September 2017.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-17. Reduction Calculation for Grazing Land Practices
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	Grouped Protocol: Grazing Land Management[1] (Protocols 60 and 61)
Brief Description:	Projects following these protocols quantify emission reductions from improved grazing practices, such as adjustments in animal rotation, limits to the number of animals, and duration of grazing.

Quantity	Description
0.49	MT CO_2e reduced/sequestered per acre per year[2]
18,890	*Acres of field and pasture in unincorporated San Diego County*[3]
9,256	MT CO_2e reduced/sequestered across SD County per year
5%	Low end range of acreage managed[4]
10%	High end range of acreage managed[4]
463	Low end MT CO_2e/year reduced/sequestered
926	High End MT CO_2e/year reduced/sequestered

Abbreviations:

ACR	American Carbon Registry
CO_2e	carbon dioxide equivalent emissions
MT	metric ton
SD	San Diego
VCS	Verified Carbon Standard

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Methodology for Sustainable Grassland Management" from the VCS and "Grazing Land and Livestock Management" from the ACR.

[2] Sequestration rate based on average of similar type projects.

Scientific American. *Carbon-Offset Cowboys Let Their Grass Grow*. 2008. Available at: https://www.scientificamerican.com/article/carbon-cowboys/. Accessed: September 2017.

Emerging Land Use Practices Rapidly Increase Soil Organic Matter. 2015. Available at: https://www.nature.com/articles/ncomms7995. Accessed: September 2017.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-18. Reduction Calculation for Compost Additions
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Land Use Management
Protocol Title:	Grouped Protocol: Compost Additions to Grazed Grasslands[1] (Protocols 62 and 63)
Brief Description:	Projects following these protocols will reduce GHGs through the application of compost to grazed grasslands. This results in the following processes: 1) avoidance of anaerobic decomposition, 2) direct increase in soil organic carbon content, and 3) indirect increase in soil organic carbon sequestration.

Quantity	Description
1.5	MT CO_2e reduced/sequestered per acre per year[2]
18,890	*Acres of field and pasture in unincorporated San Diego County*[3]
28,335	MT CO_2e reduced/sequestered across SD County per year
5%	Low end range of acreage composted[4]
10%	High end range of acreage composted[4]
1,417	Low end MT CO_2e/year reduced/sequestered
2,834	High End MT CO_2e/year reduced/sequestered

Abbreviations:

ACR	American Carbon Registry
CAPCOA GHG Rx	California Air Pollution Control Officers Association Greenhouse Gas Reduction Exchange
CO_2e	carbon dioxide equivalent emissions
GHG	greenhouse gas
MT	metric ton
SD	San Diego

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Compost Additions to Grazed Grasslands" from the ACR and "Methodology for Compost Additions to Grazed Grasslands" from the CAPCOA GHG Rx program.

[2] Mega Composter in Santa Ysabel. 2016. Available at: https://www.sandiegoreader.com/news/2016/oct/17/ticker-mega-composter-santa-ysabel/#. Accessed: September 2017.

[3] SanGIS Regional Data Warehouse. Available at: http://www.sangis.org/download/. Accessed: September 2017.

[4] Reduction rate reflects the potential availability of suitable land, and the productivity/carbon capacity of that land.

Table 3-19. Reduction Calculation for Organic Waste Digestion
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Landfill/Waste Management
Protocol Title:	Grouped Protocol: Organic Waste Digestion[1] (Protocol 84 and 85)
Brief Description:	Projects following this protocol will utilize a biogas control system with methane destruction to digest eligible wastes, diverting them from anaerobic treatment and other disposal systems. Eligible wastes include organic and agro-industrial wastewater, though these estimates are specific to wastewater. Protocol requires that collected methane is destroyed.

Quantity	Description
2,400	*MT CO_2e/year emissions from WWTPs without digestion (2030)* [2]
100%	Assumed portion of emissions from CH_4
100%	Portion of CH_4 captured by BCS[3]
95%	CO_2e reduction from flaring CH_4 to produce CO_2
2,280	Potential MT CO_2e/year reduced
25%	Assumed portion of WWTPs implementing new BCSs, lower estimate[4]
75%	Assumed portion of WWTPs implementing new BCSs, higher estimate[4]
570	MT CO_2e/year reduced at 25% implementation
1,710	MT CO_2e/year reduced at 75% implementation

Abbreviations:

BCS	biogas control system
CAPCOA GHG Rx	California Air Pollution Control Officers Association Greenhouse Gas Reduction Exchange
CAR	Climate Action Reserve
CH_4	methane
CO_2e	carbon dioxide equivalent emissions
MT	metric ton
WWTP	wastewater treatment plant

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "Organic Waste Digestion" from the CAR and "Organic Waste Digestion Project Protocol" in the CAPCOA GHG Rx program.

[2] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[3] Cornerstone Environmental Group, LLC. 2017. Biogas Energy Recovery at a California Wastewater Treatment Plant - Lessons Learned. March. Available at: http://www.cornerstoneeg.com/2017/03/01/biogas-energy-recovery-california-wastewater-treatment-plant-lessons-learned/. Accessed: October 2017.

[4] The assumption range is based on the fact that BCS technology is already commonly in use for wastewater treatment, and the possibility that some operations may not be able to install BCS.

Table 3-20. Reduction Calculation for Landfill Gas Capture
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Landfill/Waste Management
Protocol Title:	Grouped Protocol: Landfill Gas Capture and Destruction/Use[1] (Protocol 86, 87, and 88)
Brief Description:	Projects following this protocol will install a system for capturing and destroying methane gas emitted from landfill operations. The methane will be burned onsite or offsite or used for vehicle fuel.

Quantity	Description
3,086	*MT CO_2e/year emissions from landfills without LFG capture systems (2030)*[2]
75%	Rate of gas capture for LFG capture systems[2]
96%	CH_4 destruction efficiency[3]
2,222	MT CO_2e/year reduced[4]

Abbreviations:

CH_4	methane
CO_2e	carbon dioxide equivalent emissions
LFG	landfill gas
MT	metric ton

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] Protocols represented include "U.S. Landfill" from the Climate Action Reserve, "Landfill Gas Destruction and Beneficial Use Projects" from the American Carbon Registry, and "Landfill Methane Collection and Combustion" from the American Carbon Registry.

[2] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[3] Climate Action Reserve. 2011. Landfill Project Protocol. Ver 4.0. June. Available at: http://www.climateactionreserve.org/how/protocols/. Accessed: October 2017.

[4] Assumes LFG capture systems are installed at landfills without such systems by 2030. According to San Diego County's draft 2017 Climate Action Plan, this would include the Borrego and Viejas Landfills.

Table 3-21. Reduction Calculation for Gasoline to Ethanol
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Transportation
Protocol Title:	VCS: Fuel Switch from Gasoline to Ethanol in Flex-Fuel Vehicle Fleets (Protocol 98)
Brief Description:	Projects following this protocol must aim at complete substitution of gasoline or gasoline blends by ethanol (guarantee exclusive consumption) in commercial fleets of flex-fuel vehicles only.

Quantity	Description
697,489	MT CO_2e/year passenger + light-duty truck emissions (2030)[1]
137,402	MT CO_2e/year medium-duty truck emissions (2030)[1]
663,878	*MT CO_2e passenger + light-duty truck emissions (2030) after CAP emission reductions*[2]
1%	% of passenger + light-duty truck VMT that is ethanol flex-fuel fleet VMT in 2030[3]
9%	% of medium-duty truck VMT that is ethanol flex-fuel vehicles in United States in 2030[3]
50%	Assumed percentage of medium-duty truck ethanol flex-fuel VMT that are from fleet vehicles[4]
30%	Assumed percentage reduction in tailpipe emissions for conversion from gasoline to E100 in flex-fuel vehicles[5]
3,847	MT CO_2e/year GHG emission reduction feasible from conversion to E100 in flex-fuel vehicles
962	MT CO_2e/year reduction assumes 25% of flex-fuel fleets convert to E100.[6,7]
1,923	MT CO_2e/year reduction assumes 50% of flex-fuel fleets convert to E100.[6,7]

CAP Emission Reductions	
4,154	MT CO_2e/year (T-1.1 Acquire Open Space Conservation Land - Transportation Emissions Avoided)
1,677	MT CO_2e/year (T-1.2 Acquire Agricultural Easements - Transportation Emissions Avoided)
13,949	MT CO_2e/year (T-1.3 Update Community Plans)
77	MT CO_2e/year (T-2.1 Improve Roadway Segments as Multi modal)
2,180	MT CO_2e/year (T-2.2 Reduce New Non-residential Development Vehicle Miles Traveled)
5,581	MT CO_2e/year (T-2.3 Reduce County Employee Vehicle Miles Traveled)
1,454	MT CO_2e/year (T-2.4 Shared and Reduced Parking in new Non-residential Development)
866	MT CO_2e/year (T-3.3 Develop a Local Vehicle Retirement Program)
3,673	MT CO_2e/year (T-3.4 Reduce the County's Fleet Emissions)

Abbreviations:

CAP	Climate Action Plan
CO_2e	carbon dioxide equivalent emissions
E100	pure ethanol fuel (also known as hydrous ethanol)
MT	metric ton
SD	San Diego
VCS	Verified Carbon Standard
VMT	vehicle miles traveled

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[2] The sum of all the CAP emission reductions is subtracted from the passenger and LD truck emissions total (697,489 MT CO_2e/year) because the CAP measures are predominantly focused on those vehicle types.

[3] Based on Annual Energy Outlook 2017. Percentages for 2030. Tables 42, 47, and 50. Available at: https://www.eia.gov/outlooks/aeo/tables_ref.php. January 2017. Accessed: October 2017.

[4] MD trucks are larger vehicles that are rarely owned for private use. It is conservatively assumed that half of the VMT associated with these trucks would be associated with a commercial fleet.

[5] Based on pump-to-vehicle emissions analysis in: Kommalapati, Raghava, et al., 2016. Life-Cycle Analysis of Bio-Ethanol Fuel Emissions of Transportation Vehicles in Greater Houston Area. Journal of Environmental Protection. Vol. 7, p. 793-804. Available at: https://file.scirp.org/pdf/JEP_2016051113592899.pdf. Accessed: October 2017.

[6] It is important to note that, E100 is currently not available in California for commercial purposes.

[7] Overall implementation rate is based on judgements regarding capital requirements for fleets to perform the fuel switch, the prevalence of flex-fuel fleets in the County, and willingness to convert from gasoline to ethanol.

Table 3-22. Reduction Calculation for Carpooling
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Transportation
Protocol Title:	VCS: Methodology for Carpooling (Protocol 100)
Brief Description:	Projects following this protocol must reduce GHG emissions by using carpools for commuting to and from work, as facilitated by the use of a Carpool Management and Monitoring System (CMMS) that enables a community of people to more effectively engage in carpooling.

Quantity	Description
2,186,461,567	Passenger and LDT1 VMT (CAP, Appendix C, 2030)[1]
2,031,601,567	*Passenger and LDT1 VMT after CAP reductions*[2]
28.0%	Percent of household VMT for commuting (CAP Measure T-2.2; AASHTO 2013)[1]
5%	Percent commute reduction due to ride sharing (CAP Measure T-2.2, CAPCOA)[1,3]
0.000207	MT CO_2e/mile GHG reduction per mile for passenger and LDT1 (CAP Measure T-2.2; 2030)[1]
5,888	MT CO_2e/year GHG emission reductions feasible after CAP reductions
59	MT CO_2e/year reduction assumes 1% of existing commuting VMTs will implement ride sharing[6]
1,472	MT CO_2e/year reduction assumes 25% of existing commuting VMTs will implement ride sharing[6]

Approximate VMT Reductions from CAP	
20,090,000	VMT (T-1.1 Acquire Open Space Conservation Land - New Passenger VMT (since 2020))
8,110,000	VMT (T-1.2 Acquire Agricultural Easements - New Passenger VMT (since 2020))
67,460,000	VMT (T-1.3 Update Community Plans)
370,000	VMT (T-2.1 Improve Roadway Segments as Multi modal)
10,540,000	VMT (T-2.2 Reduce New Non-residential Development Vehicle Miles Traveled)
26,990,000	VMT (T-2.3 Reduce County Employee Vehicle Miles Traveled)
7,030,000	VMT (T-2.4 Shared and Reduced Parking in new Non-residential Development)
1,020,000	VMT (T-3.3 Develop a Local Vehicle Retirement Program)
13,250,000	VMT (T-3.4 Reduce the County's Fleet Emissions)

Abbreviations:

CAP	Climate Action Plan
CAPCOA	California Air Pollution Control Officers Association
CO_2e	carbon dioxide equivalent emissions
GHG	greenhouse gas
MT	metric ton
SD	San Diego
VCS	Verified Carbon Standard
VMT	vehicle miles traveled

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] County of San Diego. 2017. Climate Action Plan. Draft. Appendix C. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[2] The sum of all the CAP VMT reductions is subtracted from the passenger and LDT1 VMT total (2,186,461,567 miles/year).

[3] Reduction based on mitigation measure TRT-3 for commute trip reduction. CAPCOA Quantifying Greenhouse Gas Mitigation Measures. Available at: http://www.capcoa.org/wp-content/uploads/2010/11/CAPCOA-Quantification-Report-9-14-Final.pdf. 2010. Accessed: October 2017.

[4] The implementation rate is based on a judgement regarding ability to change commuter habits, and building upon the CAP commitments to promote ride sharing.

Table 3-23. Reduction Calculation for Improved Vehicle Fleets
County of San Diego
Preliminary Assessment of Local Direct Investment Program

Protocol Category:	Transportation
Protocol Title:	ACR: Improved Efficiency of Vehicle Fleets (Protocol 102)
Brief Description:	Projects following this protocol must reduce transportation emissions through improved efficiency of vehicle fleets using American Carbon Registry (ACR) approved methodology or Clean Development Mechanism (CDM) approved methodology. ACR methodology would allow idling stop devices on vehicles other than Heavy-Duty Vehicles, and measures other than idle reduction to reduce fuel usage and engine emissions. These additional measures include eco-drive systems, tire-rolling resistance improvements, air conditioning system improvements, use of low viscosity oils, aerodynamic drag reduction improvements, and transmission improvements.

Quantity	Description
351,041	*MT CO_2e/year heavy-duty (HD) + medium-duty (MD) truck emissions (2030)* [1]
9.5%	Based on EMFAC2014, approximately 9.5% of 2030 HD + MD emissions for SD County are from pre-MY 2014 trucks, for which additional improvement can be achieved.
15.0%	Assumed percentage improvement in efficiency due to transmission/engine improvements[2]
5,002	MT CO_2e/year GHG reduction feasible from improved efficiency of vehicle fleets
250	MT CO_2e/year reduction assumes 5% of applicable HD + MD VMT could be impacted.[4]
1,251	MT CO_2e/year reduction assumes 25% of applicable HD + MD VMT could be impacted.[4]

Abbreviations:

ACR	American Carbon Registry
CAP	Climate Action Plan
CO_2e	carbon dioxide equivalent emissions
EMFAC	California Air Resources Board Emission Factor Model
GHG	greenhouse gas
HD	heavy-duty
MD	medium-duty
MT	metric ton
MY	model year
SD	San Diego
VMT	vehicle miles traveled

Notes:

Text in italics represents the baseline value from which emission reductions are estimated.

[1] County of San Diego. 2017. Climate Action Plan. Draft. Appendix A. August. Available at: http://www.sandiegocounty.gov/content/sdc/pds/ceqa/Climate_Action_Plan_Public_Review.html. Accessed: October 2017.

[2] Based on the following study, which shows that improvements to heavy-duty vehicle transmissions/engines can lead to at least a 15% improvement in vehicle efficiency. Available at: http://www.theicct.org/sites/default/files/HDV_Workshop_10Nov2011_TIAX.pdf. November 2011. Accessed: October 2017.

[3] The implementation rate is based on a judgement regarding availability of transmission/engine upgrades for commercial fleets and the ability to identify applicable medium-duty and heavy-duty fleets that primarily operate in unincorporated San Diego County.

Table 4. Summary of Cost-Effectiveness Data
County of San Diego
Preliminary Assessment of Local Direct Investment Program

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
				Raw Cost Data from Cost Reference ($/MT CO_2e)										
				Range (if provided)										
	Cost Reference Name	**Cost Reference Year**	**Applicable Protocol/Project Type**	**(Low)**	**(High)**	**(Average)**	**Raw Cost Data Type**	**Derived Average or Lifetime Cost[1] ($/MT CO_2e)**	**Cost Assumptions/Derivation**	**Project Lifetime (if known)**	**Cost Year (reference year if unknown)**	**Cost Reference Page/Table**	**Cost Reference Location**	**Other (i.e., notes on project scale, project location, etc.)**
1	U.S. Agriculture's Role in a Greenhouse Gas Emission Mitigation World: An Economic Perspective	2000	**Protocol #3**: Quantifying N_2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reductions **Protocol #4**: Reduced Use of Nitrogen Fertilizer on Agricultural Crops	--	--	$50	Average/ Ongoing Cost	$50	• Value of **$50/MT CO_2e** provided	N/A	1992	5	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.196.4170&rep=rep1&type=pdf	Specific for projects cutting N_2O emissions by reducing anhydrous and total N fertilizer use. Estimated average cost for these projects.
2	Soil Health and Carbon Sequestration in US Croplands: A Policy Analysis	2016	**Protocol #3**: Quantifying N_2O Emissions Reductions in Agricultural Crops through Nitrogen Fertilizer Rate Reductions **Protocol #4**: Reduced Use of Nitrogen Fertilizer on Agricultural Crops	--	--	$143	Average/ Ongoing Cost	$143	• Value of **$143/MT CO_2e** provided	N/A	2016	13	http://food.berkeley.edu/wp-content/uploads/2016/05/GSPPCarbon_03052016_FINAL.pdf	Average cost for GHG reductions through "Nutrient Management" in the U.S.; varies by region.
3	Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds	2017	**Protocol #5**: U.S. Livestock **Protocol #6:** Climate Action Reserve U.S. Livestock Project Protocol Version 4.0 **Protocol #7:** Revised Compliance Offset Protocol Livestock Projects	--	--	$7	Averaged over Project Lifetime	$7	• Value of **$7/MT CO_2e** provided • Report calculated value based on $11.1 million investment earning reductions of 1,538,700 MT CO_2e. • 11,100,000/1,538,700 = $7.21	10 years (2015-2025)	2015	Table ES-2	https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf	Based on California Department of Food and Agriculture's Dairy Digester Research and Development Program. Though specific to dairy cattle, the cost could also apply to manure from other animals.
4	Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds	2017	**Protocol #5**: U.S. Livestock **Protocol #6:** Climate Action Reserve U.S. Livestock Project Protocol Version 4.0 **Protocol #7:** Revised Compliance Offset Protocol Livestock Projects	--	--	$14	Averaged over Project Lifetime	$14	• Verwey-Hanford Dairy Digester Project in CA • $3 million + $4 million = $7 million project cost • 500,000 MT CO_2e reduced over project • 7,000,000/500,000 = **$14/MT CO_2e**	10 years (2015-2025)	2015	92	https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf	Specific to a dairy digester at the Verwey-Hanford Dairy Digester Project in CA. Though specific to dairy cattle, the cost could also apply to manure from other animals.
5	Soil Carbon Sequestration in Victoria	2010	**Protocol #8**: Adoption of Sustainable Agricultural Land Management (SALM)	$359	$1,257	$808	Average/ Ongoing Cost	$808	• Total cost to purchase, transport, and spread compost: $20 - $70 (AUD) per m^3 • Convert to USD (1 AUD = 0.79 USD): $15.8 - $55.3/$m^3$ • 44 kg CO_2e sequestered per m^3 compost • ($15.8/$m^3$)*(1 m^3/44 kg CO_2e)*(1,000 kg/MT) = **$359/MT CO_2e** • ($55.3/m^3)*(1 m^3/44 kg CO_2e)*(1,000 kg/MT) = **$1,257/MT CO_2e**	N/A	2010	9	https://www.parliament.vic.gov.au/images/stories/committees/enrc/soil_carbon_sequestration/submission/Compost_Victoria.pdf	For composting projects in Victoria, Australia
6	Soil Health and Carbon Sequestration in US Croplands: A Policy Analysis	2016	**Protocol #8**: Adoption of Sustainable Agricultural Land Management (SALM)	--	--	$442	Average/ Ongoing Cost	$442	• Value of **$442/MT CO_2e** provided	N/A	2016	13	http://food.berkeley.edu/wp-content/uploads/2016/05/GSPPCarbon_03052016_FINAL.pdf	Average cost for GHG reductions through "Mulching" in the U.S.; varies by region.
7	Evaluation of Dairy Manure Management Practices for Greenhouse Gas Emissions Mitigation in California	2016	**Protocol #9**: Revisions to AMS-III.Y to Include Use of Organic Bedding Material	$52	$81	$67	Averaged over Project Lifetime	$67	• **$52/MT CO_2e** provided for dairies with 1500 adult cows over a 10 year period. • **$81/MT CO_2e** provided for dairies with 700 adult cows over a 10 year period.	10 Years	2016	Table 5.2	http://biomass.ucdavis.edu/wp-content/uploads/2016/06/ARB-Report-Final-Draft-Transmittal-Feb-26-2016.pdf	Cost estimates range from $31/MT for 10,000 cows to $153/MT for 300 cows for solid-liquid separation systems at California dairies. Cost range chosen reflects average size of dairies in SD County.
8	Combined Heat and Power: Essential for a Cost-Effective Clean Energy Standard	2016	**Protocol #16**: New Cogeneration Facilities Supplying Less Carbon Intensive Electricity to Grid and/or Hot Water to One or More Grid Customers	$10	$210	$110	Averaged over Project Lifetime (assumed)	$110	• $/MT values directly provided.	Unknown	2016	Figure 10	https://energy.gov/sites/prod/files/2013/11/f4/chp_clean_energy_std.pdf	Cost estimates range from approximately $10/MT for a 22 MW Biomass CHP system, to $100/MT for a 5 MW natural gas CHP system, to $210/MT for a 2.5 MW natural gas CHP system.
9	Do Energy Efficiency Investments Deliver? Evidence from Weatherization Assistance Program	2015	**Protocol #17 & 18**: Weatherization of Single Family and Multi-Family Buildings	$281	$608	$445	Averaged over Project Lifetime	$445	• $/ton values directly provided, then converted into $/MT.	10 to 20 Years	2015	Table 7	http://e2e.haas.berkeley.edu/pdf/workingpapers/WP020.pdf#page=1	Study evaluated residential energy efficiency program involving >30,000 households in Michigan. Cost ranges include homeowner energy savings; thus the overall cost for the County would be higher. Cost range reflects a time horizon of 10 to 20 years at a 3% discount rate.
10	Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds	2017	**Protocol #17 & 18**: Weatherization of Single Family and Multi-Family Buildings	--	--	$123	Average/ Ongoing Cost	$123	• Value of **$123/MT CO_2e** provided • Report calculated value based on $5.5 million investment earning reductions of 44,300 MT CO_2e. • 5,500,000/44,300 = ~$123/MT CO_2e	N/A	2015	75; Table ES-2	https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf	Program focused on single-family and small multi-family low-income homes. Weatherization and energy efficiency measures included: weather-stripping, insulation, caulking, water heater blankets, window repair or replacement, refrigerator replacement, water heater repair/replacement, heating and cooling system repair/replacement, and solar water heaters.
11	Meeting AB 32: Cost-Effective Green House Gas Reductions in the Residential Sector	2008	**Protocol #17 & 18**: Weatherization of Single Family and Multi-Family Buildings	$176	$353	$265	Averaged over Project Lifetime	$265	• $/ton carbon values directly provided, then converted into $/MT CO_2e.		2008	4	https://www.consol.ws/pdf/Meeting-AB-32-Cost-Effective-Green-House-Gas-Reductions-in-the-Residential-Sector.pdf	Cost assumes that by spending $10,000 to retrofit a 1960s home, one could save 8.5 tons of carbon, at a cost of $588 to $1,176 per ton depending on tax credits and incentives.

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				Range (if provided)										
	Cost Reference Name	Cost Reference Year	Applicable Protocol/Project Type	(Low)	(High)	(Average)	Raw Cost Data Type	Derived Average or Lifetime Cost[1] ($/MT CO_2e)	Cost Assumptions/Derivation	Project Lifetime (if known)	Cost Year (reference year if unknown)	Cost Reference Page/Table	Cost Reference Location	Other (i.e., notes on project scale, project location, etc.)
12	Industrial Energy Efficiency and Climate Change Mitigation	2009	**Protocol #19**: Energy Efficiency and Solid Waste Diversion Activities within a Sustainable Community	$22	$110	$66	Average/ Ongoing Cost (assumed)	$66	• $/ton values directly provided, then converted into $/MT.	Unknown	2030	Table 2	https://link.springer.com/article/10.1007/s12053-008-9032-8	Reduction values specified by industry sector. Industries included: steel, primary aluminum, cement, ethylene , ammonia, petroleum refining, pulp and paper, and other.
13	UC San Diego Embarks on $73 Million Energy Efficiency Program	2009	**Protocol #20**: Campus Clean Energy and Energy Efficiency	--	--	$3,665	"First Year" Cost	$367	• Project cost = $247.4 million • Energy savings = $36 million/year • Assume all energy savings are from electricity • Electricity cost = $0.16/kWh (assumed) • Carbon intensity of electricity = 0.30 MT CO_2e/MWh (CAP Appendix A; 2014) • Assumed 10 year project lifetime for lifetime cost	Unknown	2009	Webpage	http://ucsdnews.ucsd.edu/archive/newsrel/general/11-09Energy.asp	Example initiatives include installing additional energy-efficient lighting, air conditioning controls, and computer servers, and replacing outdated laboratory freezers and other appliances.
14	Campus Sustainability Best Practices	2008	**Protocol #20**: Campus Clean Energy and Energy Efficiency	--	--	$880	"First Year" Cost	$88	• Project cost = $11 million • GHG reductions = 12,500 MT CO_2e/year • Assumed 10 year project lifetime for lifetime cost	Unknown	2008	7	http://www.mass.gov/eea/docs/eea/lbe/lbe-campus-sustain-practices.pdf	Cost and GHG reduction data are related to the installation of a biomass plant by Middlebury College in Vermont.
15	Campus Sustainability Best Practices	2008	**Protocol #20**: Campus Clean Energy and Energy Efficiency	--	--	$149	"First Year" Cost	$15	• Project cost = 90 units * $165/unit = $14,850 • GHG reductions = 100 MT CO_2e/year • Assumed 10 year project lifetime for lifetime cost	Unknown	2008	5	http://www.mass.gov/eea/docs/eea/lbe/lbe-campus-sustain-practices.pdf	Cost and GHG reduction data are related to the installation of vending misers on 90 vending machines at Tufts University in Massachusetts.
16	Campus Sustainability Best Practices	2008	**Protocol #20**: Campus Clean Energy and Energy Efficiency	--	--	$1,717	"First Year" Cost	$172	• Project cost = $10,700,000 • GHG reductions = 6,230 MT CO_2e/year • Assumed 10 year project lifetime for lifetime cost	Unknown	2008	6	http://www.mass.gov/eea/docs/eea/lbe/lbe-campus-sustain-practices.pdf	Cost and GHG reduction data are related to the implementation of a comprehensive energy conservation program at Bridgewater State College in Massachusetts. Initiatives included toilet retrofits, lighting upgrades, and a new heating system for all classrooms and offices.
17	Biomass for Electricity Generation	2016	**Protocol #26**: Biomass Waste for Energy Project Reporting Protocol	$108	$202	$155	Averaged over Project Lifetime	$155	• Levelized (break-even) energy cost of $0.08 - 0.15/kWh energy produced (wbdg.org) • MT CO_2e reduced per kWh energy produced via renewables = 0.000744 (epa.gov) • ($0.08/kWh)*(1 kWh/0.000744 MT CO_2e) = **$108/MT CO_2e** • ($0.15/kWh)*(1 kWh/0.000744 MT CO_2e) = **$202/MT CO_2e**	20+ years (assumed)	2016	"Types and Cost of Technology"	https://www.wbdg.org/resources/biomass-electricity-generation Additional reference: https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references	For purchase and O&M of a biomass-fired power generating system in the 5 to 25 MW range in the U.S.
18	Biomass for Power Generation	2012	**Protocol #26**: Biomass Waste for Energy Project Reporting Protocol	$81	$390	$236	Averaged over Project Lifetime	$236	• Levelized energy cost of $0.06 - 0.29/kWh energy produced (irena.org) • MT CO_2e reduced per kWh energy produced via renewables = 0.000744 (epa.gov) • ($0.06/kWh)*(1 kWh/0.000744 MT CO_2e) = **$81/MT CO_2e** • ($0.29/kWh)*(1 kWh/0.000744 MT CO_2e) = **$390/MT CO_2e**	20+ years (assumed)	2012	ii	https://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-BIOMASS.pdf	For purchase and O&M of a biomass-fired power generating system.
19	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #40:** Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects **Protocol #41:** REDD+ Methodology Framework (REDD-MF) **Protocol #42:** Methodology for Avoided Unplanned Deforestation **Protocol #43:** Reducing Emissions from Deforestation and Degradation (REDD) – Avoiding Planned Deforestation **Protocol #44**: Methodology for Avoided Ecosystem Conversion	--	--	$33	Averaged over Project Lifetime (assumed)	$33	• Average cost per MT carbon = $122.33 • Cost denominator converted to MT CO_2 • $122.33/MT C * 12 g C/44 g CO_2 = **$33/MT CO_2e**	Unknown	2007	55 (PDF pg. 66)	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Project involves riparian buffer extension comprised of mature forest in Washington; the total costs per hectare of setting aside timberland are estimated as the current stumpage value of mature timber on each hectare, assuming the timber is near the optimal rotation age, plus the present value of bare land.
20	A Review of Forest Carbon Sequestration Cost Studies: A Dozen Years of Research	2004	**Protocol #40:** Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects **Protocol #41:** REDD+ Methodology Framework (REDD-MF) **Protocol #42:** Methodology for Avoided Unplanned Deforestation **Protocol #43:** Reducing Emissions from Deforestation and Degradation (REDD) – Avoiding Planned Deforestation **Protocol #44**: Methodology for Avoided Ecosystem Conversion	$10	$150	$80	Averaged over Project Lifetime	$80	• $/MT values directly provided.	Unknown	2004	Abstract	https://link.springer.com/article/10.1023/B:CLIM.0000018503.10080.89	Projects involve general forestry; unable to find basis of costing; potentially an offset cost.

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	Cost Reference Name	Cost Reference Year	Applicable Protocol / Project Type	(Low)	(High)	(Average)	Raw Cost Data Type	Derived Average or Lifetime Cost[1] ($/MT CO_2e)	Cost Assumptions / Derivation	Project Lifetime (if known)	Cost Year (reference year if unknown)	Cost Reference Page / Table	Cost Reference Location	Other (i.e., notes on project scale, project location, etc.)
21	How Costly are Carbon Offsets? A Meta-Analysis of Carbon Forest Sinks	2004	**Protocol #40:** Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects **Protocol #41:** REDD+ Methodology Framework (REDD-MF) **Protocol #42:** Methodology for Avoided Unplanned Deforestation **Protocol #43:** Reducing Emissions from Deforestation and Degradation (REDD) – Avoiding Planned Deforestation **Protocol #44:** Methodology for Avoided Ecosystem Conversion	$13	$71	$42	Averaged over Project Lifetime	$42	• $/ MT C directly provided. • Cost denominator converted to MT CO_2	Unknown	2003	Table 4	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.461.2852&rep=rep1&type=pdf	Average peer reviewed costs for baseline category (avoided deforestation). Costs appear to include land costs, planting costs, and management costs.
22	Evaluation of Avoided Grassland Conversion and Cropland Conversion to Grassland as Potential Carbon Offset Project Types	2014	**Protocol #44**: Methodology for Avoided Ecosystem Conversion **Protocol #45**: Grassland **Protocol #46**: Avoided Conversion of Grasslands and Shrublands to Crop Production	$1	$3	$2	Averaged over Project Lifetime	$2	• $/MT values directly provided. • Assumed IPCC Climate Zone: Warm Temperate Dry • 20 year project lifetime.	20 years	2014	Table 12	https://climatetrust.org/wp-content/uploads/2014/07/Evaluation-of-Avoided-Grassland-Conversion-and-Cropland-Conversion-to-Grassland-as-Potential-Carbon-Offset-Project-Types-.pdf	Estimates for avoided grassland conversion; cost based on Grassland Reserve Programs county-level rental rate data.
23	Economic Analysis of Agricultural Soil Carbon Sequestration: An Integrated Assessment Approach	2001	**Protocol #44**: Methodology for Avoided Ecosystem Conversion **Protocol #45**: Grassland **Protocol #46**: Avoided Conversion of Grasslands and Shrublands to Crop Production **Protocol #58**: Soil Carbon Quantification Methodology **Protocol #59**: Methodology for the Adoption of Sustainable Grasslands through Adjustment of Fire and Grazing	$95	$510	$303	Averaged over Project Lifetime	$303	• $/MT values directly provided.	Unknown	2001	359 (PDF pg .16)	https://ageconsearch.umn.edu/bitstream/31037/1/26020344.pdf	Estimates for converting cropland to grassland in the U.S.; cost based on annual rental payment for land (ranging from $25/ha to $125/ha).
24	Soil Carbon Sequestration Potential of U.S. Croplands and Grasslands: Implementing the 4 per Thousand Initiative	2016	**Protocol #44**: Methodology for Avoided Ecosystem Conversion **Protocol #45**: Grassland **Protocol #46**: Avoided Conversion of Grasslands and Shrublands to Crop Production	$3	$11	$7	Averaged over Project Lifetime	$7	• $/MT values directly provided.	20 years	2016	72A (PDF pg. 5)	https://www.c-agg.org/wp-content/uploads/Chambers_Paustian_Lal_Soil_Carbon_and_4_per_1000-1.pdf	Estimates for grassland carbon sequestration; cost covers activities such as conservation cover, forage and biomass planting, prescribed grazing, and range planting.
25	Food Managed Grazing	2017	**Protocol #60**: Grazing Land and Livestock Management **Protocol #61**: Methodology for Sustainable Grassland Management (SGM)	--	--	$7.25	Averaged over Project Lifetime	$7.25	• Assumes land is already used for conventional grazing • First Costs = $136.95/ha • Sequestration = 0.63 MT CO_2e/ha/year • Lifetime = 30 years (assumed) • $136.95/ha / 0.63 MT/ha/year / 30 years = **$7.25 / MT CO_2e**	30 years (est. from "by 2050")	2017	Methodology Section	http://www.drawdown.org/solutions/food/managed-grazing	Management measures include: improved continuous grazing, rotational grazing, and adaptive multi-paddock grazing.
26	National Management Measures for the Control of Nonpoint Pollution from Agriculture	1991	**Protocol #60**: Grazing Land and Livestock Management **Protocol #61**: Methodology for Sustainable Grassland Management (SGM)	$169	$398	$284	"First Year" Cost	$28	• Values provided in $/acre and converted to $/MT assuming 0.49 MT CO_2e/acre/year (scientificamerican.com; nature.com) • 10 year project lifetime used for lifetime cost	10 years	1991	Table 4e-7	https://www.epa.gov/sites/production/files/2015-10/documents/chap4e.pdf Additional references: https://www.scientificamerican.com/article/carbon-cowboys/ https://www.nature.com/articles/ncomms7995	Cost to establish grazing land (planting seed, lime, and fertilizer)
27	Improved Grazing Land Management	2007	**Protocol #60**: Grazing Land and Livestock Management **Protocol #61**: Methodology for Sustainable Grassland Management (SGM)	--	--	$948	"First Year" Cost	$95	• Values provided in $/acre and converted to $/MT assuming 0.49 MT CO_2e/acre/year (scientificamerican.com; nature.com) • Assumed 10 year project lifetime for lifetime cost	Unknown	2007	315 (PDF pg. 3)	http://teca.fao.org/sites/default/files/technology_files/18_ImprovedGrazingLandManagement_Ethiopia.pdf Additional references: https://www.scientificamerican.com/article/carbon-cowboys/ https://www.nature.com/articles/ncomms7995	Study in Ethiopia; estimate includes establishment cost plus maintenance cost. Establishment includes labor, equipment, materials for creating grazed land. Maintenance includes labor, equipment, materials, and agricultural needs (compost/seeds/etc.)
28	Hastening the Return of Complex Forests Following Fire	2009	**Protocol #51**: Afforestation and Reforestation of Degraded Lands	$66	$526	$296	"First Year" Cost	$10	• Values provided in $/acre and converted to $/MT assuming 3.8 MT CO_2e/acre/year (Existing projects from VCS, ACR, CAR databases) • Assumed 30 year project lifetime for lifetime cost	Unknown	2004	Table 1	https://www.researchgate.net/publication/237727320_Hastening_the_Return_of_Complex_Forests_Following_Fire_Hastening_the_Return_of_Complex_Forests_Following_Fire	Project involves planting of 200 trees per acre of reforested area; costs include initial cost of tree planting and cost of restocking failures. Assumes land is already owned. Does not include maintenance costs.
29	Carbon Sequestration through Reforestation: A Local Solution with Global Implications	2012	**Protocol #51**: Afforestation and Reforestation of Degraded Lands	$7	$41	$24	Averaged over Project Lifetime (assumed)	$24	• $/MT CO_2e values provided directly.	Unknown	2012	8 (PDF pg. 10)	https://semspub.epa.gov/work/HQ/176034.pdf	Study determines the profitability of forests on abandoned mine lands; costs represent those for site preparation and tree planting. Costs do not include land cost.

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				Range (if provided)										
	Cost Reference Name	**Cost Reference Year**	**Applicable Protocol/Project Type**	**(Low)**	**(High)**	**(Average)**	**Raw Cost Data Type**	**Derived Average or Lifetime Cost[1] ($/MT CO_2e)**	**Cost Assumptions/Derivation**	**Project Lifetime (if known)**	**Cost Year (reference year if unknown)**	**Cost Reference Page/Table**	**Cost Reference Location**	**Other (i.e., notes on project scale, project location, etc.)**
30	Carbon Sequestration through Reforestation: A Local Solution with Global Implications	2012	**Protocol #51**: Afforestation and Reforestation of Degraded Lands	--	--	$263	"First Year" Cost	$9	• Value provided in $/acre and converted to $/MT assuming 3.8 MT CO_2e/acre/year (Existing projects from VCS, ACR, CAR databases) • Assumed 30 year project lifetime for lifetime cost	Unknown	2012	13 (PDF pg. 15)	https://semspub.epa.gov/work/HQ/176034.pdf	Cost to plant trees/shrubs in arid west and includes costs related to planting trees/shrubs and site prep. Cost does not include land cost.
31	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #51**: Afforestation and Reforestation of Degraded Lands	$5	$20	$13	Averaged over Project Lifetime	$13	• $20 - $75/MT C • Values converted to $/MT CO_2e • 20 year project lifetime	20 years	2007	33 (PDF pg. 44)	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Projects involve converting rangeland to native species; cost includes establishing tree planting, maintenance costs for beginning of plant life, and costs of measuring and monitoring carbon production.
32	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #51**: Afforestation and Reforestation of Degraded Lands	$8	$20	$14	Averaged over Project Lifetime	$14	• $30 - $75/MT C • Values converted to $/MT CO_2e • 20 year project lifetime	20 years	2007	34 (PDF pg. 44)	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Projects involve converting cropland to native species; cost includes establishing tree planting, maintenance costs for beginning of plant life, and costs of measuring and monitoring carbon production.
33	Land Management and Conservation Activities as Potential Offset Projects Under the Northeastern Regional Greenhouse Gas Initiative	2004	**Protocol #51**: Afforestation and Reforestation of Degraded Lands	--	--	$2	Averaged over Project Lifetime	$2	• $550,000 initial investment • 225,000 tons CO_2 over project lifetime • 100 year project lifetime	100 years	2004	4	https://www.rggi.org/docs/land_offsets_final_8_04.pdf	Bayou Pierre Floodplain Reforestation in Louisiana on 500 acres; costs include planting of seedlings and land maintenance/protection.
34	Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds	2017	**Protocol #51**: Afforestation and Reforestation of Degraded Lands	--	--	$6	Averaged over Project Lifetime	$6	• Value of **$6/MT CO_2e** provided • Report calculated value based on $14.7 million investment earning reductions of 2,482,000 MT CO_2e. • 14,700,000/2,482,000 = $6/MT CO_2e	80 years	2017	96; Table ES-2	https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf	Estimate comes from 37 projects and is based on grant funding and implemented costs. Unclear what costs are included.
35	Improved Forested Landscape Management Project (IFLMP)	2014	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	--	--	$8	Averaged over Project Lifetime (assumed)	$8	• Funding = $37,700,000 • 4.5 million MT CO_2e reduced over project • $37,700,000/4,500,000= **$8/MT CO_2e**	Unknown	2014	Project Snapshot	https://www.climateinvestmentfunds.org/projects/improved-forested-landscape-management-project-iflmp	Improved Forested Landscape Management Project in the Democratic Republic of Congo; based on funding, unclear which costs are included.
36	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	--	--	$25	Averaged over Project Lifetime (assumed)	$25	• $/MT Carbon provided for various tree types • Average $/MT Carbon converted to $/MT CO_2e	Unknown	2007	PDF pg. 61	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Average of 15 year increase in rotation age; costs include timberland management (site prep, seedlings, planting, management, contingencies, and administration) and taxes on land values.
37	Conservation and sequestration of carbon: The potential of forest and agroforest management practices	1993	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	--	--	$10	Averaged over Project Lifetime	$10	• Value of **$10/MT CO_2e** provided	50 years	1993	Abstract	http://www.sciencedirect.com/science/article/pii/0959378093900045	Forestation/agroforestry/silviculture; costs seem to include those for establishment and management of forests.
38	Forest management and agroforestry to sequester and conserve atmospheric carbon dioxide	1991	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	$0.27	$3.00	$2	Averaged over Project Lifetime	$2	• $/MT Carbon provided for natural regeneration • Converted to $/MT CO_2e	50 years	1991	Table 2	http://www.fao.org/docrep/u9300e/u9300e0a.htm	Project involves natural regeneration; Costs include site preparation, stock costs, and planting labor plus supervision.
39	How costly are carbon offsets? A meta-analysis of carbon forest sinks	2004	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	$6	$61	$34	Averaged over Project Lifetime	$34	• $/MT Carbon provided • Converted to $/MT CO_2e	Unknown	2003	Table 4	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.461.2852&rep=rep1&type=pdf	Average Peer Reviewed Costs for "Other" category (management, forest management programs that enhance tree growth); costs appear to include land costs, planting costs, and management costs.
40	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	$7	$97	$52	"First Year" Cost (assumed)	$2	• Range of $23-$223 per acre provided for prescription fire activities • Converted to $/MT CO_2e assuming a reduction of 3.1 MT CO_2e/acre/year (Existing projects from VCS, ACR, CAR databases) • Assumed 30 year project lifetime for lifetime cost	Unknown	2003	PDF pg. 70	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Prescription fire; costs are for activities done to control forest fire.
41	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	$32	$323	$177	"First Year" Cost (assumed)	$6	• Range of $100-$1,000 per acre provided for masticate - leave on site fire control method • Converted to $/MT CO_2e assuming a reduction of 3.1 MT CO_2e/acre/year (Existing projects from VCS, ACR, CAR databases) • Assumed 30 year project lifetime for lifetime cost	Unknown	2003	PDF pg. 70	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Masticate - leave on site; costs are for activities done to control forest fire.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
				Raw Cost Data from Cost Reference ($/MT CO_2e)										
				Range (if provided)										
	Cost Reference Name	Cost Reference Year	Applicable Protocol/Project Type	(Low)	(High)	(Average)	Raw Cost Data Type	Derived Average or Lifetime Cost[1] ($/MT CO_2e)	Cost Assumptions/Derivation	Project Lifetime (if known)	Cost Year (reference year if unknown)	Cost Reference Page/Table	Cost Reference Location	Other (i.e., notes on project scale, project location, etc.)
42	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	$32	$242	$137	"First Year" Cost (assumed)	$5	• Range of $100-$750 per acre provided for cut-pile-burn fire control method • Converted to $/MT CO_2e assuming a reduction of 3.1 MT CO_2e/acre/year (Existing projects from VCS, ACR, CAR databases) • Assumed 30 year project lifetime for lifetime cost	Unknown	2003	PDF pg. 70	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Cut-pile-burn; costs are for activities done to control forest fire.
43	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	$34	$90	$62	"First Year" Cost (assumed)	$2	• Range of $105-$280 per acre provided for cut-lop-scatter fire control method • Converted to $/MT CO_2e assuming a reduction of 3.1 MT CO_2e/acre/year (Existing projects from VCS, ACR, CAR databases) • Assumed 30 year project lifetime for lifetime cost	Unknown	2003	PDF pg. 70	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Cut-lop-scatter; costs are for activities done to control forest fire.
44	Carbon Sequestration through Changes in Land Use in Washington: Costs and Opportunities	2007	**Protocol #48**: Improved Forest Management (IFM) for Non-Federal U.S. Forestlands	$181	$527	$354	"First Year" Cost (assumed)	$12	• Range of $560-$1,634 per acre provided for cut-skit-chip-haul • Converted to $/MT CO_2e assuming a reduction of 3.1 MT CO_2e/acre/year (Existing projects from VCS, ACR, CAR databases) • Assumed 30 year project lifetime for lifetime cost	Unknown	2003	PDF pg. 70	http://www.ecy.wa.gov/climatechange/TWGdocs/for/051707FORwestcarb2.pdf	Cut-skit-chip-haul; costs are for activities done to control forest fire.
45	The potential of urban tree plantings to be cost effective in carbon credit markets	2007	**Protocol #57**: Urban Tree Planting	$145	$1,277	$711	Averaged over Project Lifetime	$711	• Range of $/MT CO_2e provided	40 years	2007	Table 5; PDF pg. 9	\\wcirvfps1\projects\A\Ascent\SD County CAP\Technical Work\Cost Analysis\Documents\The potential of urban tree plantings to be cost effective in carbon credit markets.pdf	Colorado case studies involving 232 to 10,000 trees; costs based on planting and maintenance costs per tree. Land costs not included.
46	U.S. Tree Planting for Carbon Sequestration	2009	**Protocol #57**: Urban Tree Planting	$12	$14	$13	"First Year" Cost	$0.44	• Range of $84-$102 per acre provided • Converted to $/MT CO_2e assuming 200 trees/acre and a reduction of 0.0354 MT CO_2e/tree/year (www.caleemod.com) • Assumed 30 year project lifetime for lifetime cost	Unknown	2008	PDF pg. 6	https://fas.org/sgp/crs/misc/R40562.pdf	Tree planting; costs include initial cost of tree planting. Assumes land is already owned. Does not include maintenance costs.
47	How costly are carbon offsets? A meta-analysis of carbon forest sinks	2004	**Protocol #57**: Urban Tree Planting	$14	$189	$101	Averaged over Project Lifetime	$101	• $/MT Carbon provided • Converted to $/MT CO_2e	Unknown	2003	Table 4	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.461.2852&rep=rep1&type=pdf	Average Peer Reviewed Costs for "Other" category (planting, tree planting programs (usually afforestation projects); costs appear to include land costs, planting costs, and management costs.
48	How costly are carbon offsets? A meta-analysis of carbon forest sinks	2004	**Protocol #57**: Urban Tree Planting	$16	$205	$110	Averaged over Project Lifetime	$110	• $/MT Carbon provided • Converted to $/MT CO_2e	Unknown	2003	Table 4	http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.461.2852&rep=rep1&type=pdf	Average Peer Reviewed Costs for "Other" category (agroforestry, projects where trees are planted in fields that continue to be used for crop production or grazing); costs appear to include land costs, planting costs, and management costs.
49	Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds	2017	**Protocol #57**: Urban Tree Planting	--	--	$117	Averaged over Project Lifetime	$117	• Value of **$117/MT CO_2e** provided • Report calculated value based on $15.6 million investment earning reductions of 133,700 MT CO_2e. • 15,600,000/133,700 = ~$117/MT CO_2e	40 years	2017	98; Table ES-2	https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf	Estimate comes from 29 projects and is based on grant funding and implemented costs. Unclear what costs are included.
50	San Diego River Watershed Riparian Restoration Program	2014	**Protocol #52**: Methodology for Coastal Wetland Creation **Protocol #53**: Coastal Wetland Creation **Protocol #54**: Methodology for Tidal Wetland and Seagrass Restoration **Protocol #55**: Restoration of California Deltaic and Coastal Wetlands **Protocol #56**: Quantifying Greenhouse Gas Reductions from Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and the Coast of California	--	--	$1,216	"First Year" Cost (assumed)	$41	• $/acre calculated based on project cost of $5 million and size of 329 acres • Converted to $/MT CO_2e assuming reductions of 12.5 MT CO_2e/acre/year (ca-ilg.org; cwc.ca.gov; adaptationprofessionals.org) • Assumed 30 year project lifetime for lifetime cost	Unknown	2014	Webpage	http://scwrp.org/projects/san-diego-river-watershed-riparian-restoration-program/ Additional references: http://www.ca-ilg.org/post/wetlands-restoration-greenhouse-gas-reduction-program https://cwc.ca.gov/Documents/2013/05_May/May2013_Agenda_Item_8_Sherman_Twitchell_Presentation1.pdf https://adaptationprofessionals.org/wp-content/uploads/bp-attachments/1472/carbonflyer02_22_08.pdf	San Diego River Watershed Riparian Restoration Program; unsure of cost basis.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
				Raw Cost Data from Cost Reference ($/MT CO_2e)										
				Range (if provided)										
	Cost Reference Name	**Cost Reference Year**	**Applicable Protocol/Project Type**	**(Low)**	**(High)**	**(Average)**	**Raw Cost Data Type**	**Derived Average or Lifetime Cost[1] ($/MT CO_2e)**	**Cost Assumptions/Derivation**	**Project Lifetime (if known)**	**Cost Year (reference year if unknown)**	**Cost Reference Page/Table**	**Cost Reference Location**	**Other (i.e., notes on project scale, project location, etc.)**
51	Shepard Canyon Wetlands Restoration Project	2007	**Protocol #52**: Methodology for Coastal Wetland Creation **Protocol #53**: Coastal Wetland Creation **Protocol #54**: Methodology for Tidal Wetland and Seagrass Restoration **Protocol #55**: Restoration of California Deltaic and Coastal Wetlands **Protocol #56**: Quantifying Greenhouse Gas Reductions from Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and the Coast of California	--	--	$1,323	"First Year" Cost (assumed)	$44	• $/acre calculated based on project cost of $21,500 and size of 1.3 acres • Converted to $/MT CO_2e assuming reductions of 12.5 MT CO_2e/acre/year (ca-ilg.org; cwc.ca.gov; adaptationprofessionals.org) • Assumed 30 year project lifetime for lifetime cost	Unknown	2007	Webpage	http://scwrp.org/projects/san-diego-river-watershed-riparian-restoration-program/ Additional references: http://www.ca-ilg.org/post/wetlands-restoration-greenhouse-gas-reduction-program https://cwc.ca.gov/Documents/2013/05_May/May2013_Agenda_Item_8_Sherman_Twitchell_Presentation1.pdf https://adaptationprofessionals.org/wp-content/uploads/bp-attachments/1472/carbonflyer02_22_08.pdf	San Diego River Watershed Riparian Restoration Program; unsure of cost basis.
52	Buena Vista Ecological Reserve	2014	**Protocol #52**: Methodology for Coastal Wetland Creation **Protocol #53**: Coastal Wetland Creation **Protocol #54**: Methodology for Tidal Wetland and Seagrass Restoration **Protocol #55**: Restoration of California Deltaic and Coastal Wetlands **Protocol #56**: Quantifying Greenhouse Gas Reductions from Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and the Coast of California	--	--	$4,008	"First Year" Cost (assumed)	$134	• $/acre calculated based on project cost of $50,100 and size of 1 acre • Converted to $/MT CO_2e assuming reductions of 12.5 MT CO_2e/acre/year (ca-ilg.org; cwc.ca.gov; adaptationprofessionals.org) • Assumed 30 year project lifetime for lifetime cost	Unknown	2014	Webpage	http://scwrp.org/projects/san-diego-river-watershed-riparian-restoration-program/ Additional references: http://www.ca-ilg.org/post/wetlands-restoration-greenhouse-gas-reduction-program https://cwc.ca.gov/Documents/2013/05_May/May2013_Agenda_Item_8_Sherman_Twitchell_Presentation1.pdf https://adaptationprofessionals.org/wp-content/uploads/bp-attachments/1472/carbonflyer02_22_08.pdf	San Diego River Watershed Riparian Restoration Program; unsure of cost basis.
53	Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds	2017	**Protocol #52**: Methodology for Coastal Wetland Creation **Protocol #53**: Coastal Wetland Creation **Protocol #54**: Methodology for Tidal Wetland and Seagrass Restoration **Protocol #55**: Restoration of California Deltaic and Coastal Wetlands **Protocol #56**: Quantifying Greenhouse Gas Reductions from Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and the Coast of California	--	--	$30	Averaged over Project Lifetime	$30	• Value of **$30/MT CO_2e** provided • Report calculated value based on $15.4 million investment earning reductions of 518,800 MT CO_2e. • 15,400,000/518,800 = ~$30/MT CO_2e	50 years	2017	88; Table ES-2	https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf	Estimate comes from 4 projects and is based on grant funding and implemented costs. Unclear what costs are included.
54	Improved grazing land management	2007	**Protocol #62**: Compost Additions to Grazed Grasslands **Protocol #63**: Methodology for Compost Additions to Grazed Grasslands	--	--	$47	"First Year" Cost	$5	• $175 per hectare ($70 per acre) provided for compost and maintenance costs • Converted to $/MT CO_2e assuming a reduction of 1.5 MT CO_2e/acre/year (sandiegoreader.com) • Assumed 10 year project lifetime for lifetime cost	Unknown	2007	PDF pg. 3	http://teca.fao.org/sites/default/files/technology_files/18_ImprovedGrazingLandManagement_Ethiopia.pdf Additional reference: https://www.sandiegoreader.com/news/2016/oct/17/ticker-mega-composter-santa-ysabel/#	This is for a study in Ethiopia and includes base plus maintenance costs for compost. Reduction metric source: https://www.sandiegoreader.com/news/2016/oct/17/ticker-mega-composter-santa-ysabel/#
55	CARBON FARMING: Increasing Carbon Capture on California's Working Lands	2012	**Protocol #62**: Compost Additions to Grazed Grasslands **Protocol #63**: Methodology for Compost Additions to Grazed Grasslands	--	--	$40	Averaged over Project Lifetime (assumed)	$40	• **$40/MT CO_2e** provided	Unknown	2012	Slide 27	hrec.ucanr.edu/files/204257.ppt	The Marin Project; costs include addition of compost, monitoring of carbon levels, securing credits, project validation, and GHG offset assertion.
56	CARBON SEQUESTRATION IN AGRICULTURAL SOILS	2012	**Protocol #60**: Grazing Land and Livestock Management **Protocol #61**: Methodology for Sustainable Grassland Management (SGM) **Protocol #62**: Compost Additions to Grazed Grasslands **Protocol #63**: Methodology for Compost Additions to Grazed Grasslands	$10	$20	$15	Averaged over Project Lifetime (assumed)	$15	• Range of **$10 - $20/MT CO_2e** provided	Unknown	2012	Table 5.2	https://openknowledge.worldbank.org/bitstream/handle/10986/11868/673950REVISED000CarbonSeq0Web0final.pdf;sequence=1	Asia public costs for mature; unsure of cost basis.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
				Raw Cost Data from Cost Reference ($/MT CO_2e)										
				Range (if provided)										
	Cost Reference Name	Cost Reference Year	Applicable Protocol/Project Type	(Low)	(High)	(Average)	Raw Cost Data Type	Derived Average or Lifetime Cost[1] ($/MT CO_2e)	Cost Assumptions/Derivation	Project Lifetime (if known)	Cost Year (reference year if unknown)	Cost Reference Page/Table	Cost Reference Location	Other (i.e., notes on project scale, project location, etc.)
57	Altamont Landfill Gas to Liquefied Natural Gas Project	2010	**Protocol #86**: U.S. Landfill **Protocol #87**: Landfill Gas Destruction and Beneficial Use Projects **Protocol #88**: Landfill Methane Collection and Combustion	--	--	$129	Averaged over Project Lifetime	$129	• $15.5 million project price • Spreading the initial cost out over 20 years: ($15.5 million)/(20 years) = $775,000/year • O&M costs up to 20% initial capital costs per year (irena.org): ($15.5 million)*(20%) = $3.1 million/year • Total annual cost: $775,000 + $3.1 million = $3,875,000/year • Estimated annual GHG reductions = 30,000 MT CO_2e/year • ($3,875,000/year)/(30,000 MT/year) = **$129/MT CO_2e**	20 years (assumed)	2010	"Altamont..."	https://www.epa.gov/lmop/landfill-gas-energy-project-data Additional reference: https://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-BIOMASS.pdf	Altamont Sanitary Landfill in Livermore, CA opened by WM in 2009.
58	Landfill Gas to Energy: Incentives & Benefits	2011	**Protocol #86**: U.S. Landfill **Protocol #87**: Landfill Gas Destruction and Beneficial Use Projects **Protocol #88**: Landfill Methane Collection and Combustion	--	--	$1.49	Averaged over Project Lifetime	$1.49	• $5 million project purchase price • Spreading the initial cost out over 20 years: ($5 million)/(20 years) = $250,000/year • O&M costs up to 20% initial capital costs per year (irena.org): ($5 million)*(20%) = $1 million/year • Total annual cost: $250,000 + $1 million = $1,250,000/year • Estimated GHG reductions = 30,000 MT CH_4/year • ($1,250,000/year)/(30,000 MT CH_4/year) = ($42/MT CH_4)*(1 MT CH_4/28 MT CO_2e) = **$1.49/MT CO_2e**	20 years (assumed)	2008	27	http://etd.fcla.edu/CF/CFE0003960/Amini_Hamid_R_201108_PhD.pdf Additional reference: https://www.irena.org/DocumentDownloads/Publications/RE_Technologies_Cost_Analysis-BIOMASS.pdf	Florida Orange County Landfill
59	Cost-Benefit Analysis of the Biochar Application in the U.S. Cereal Crop Cultivation	2012	**Protocol #89**: Biochar Production Project Reporting Protocol	--	--	$150	Average/ Ongoing Cost	$150	• "Preferred estimate" for the cost to produce biochar = $350/ton • 1 ton biochar sequesters an average of 2.57 tons CO_2 • ($350/ton biochar)*(1 ton biochar/ 2.57 ton CO_2)*(1.1 ton CO_2/MT CO_2) = **$150/MT CO_2e**	N/A	2012	24, 25	http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1004&context=cppa_capstones	Biochar cost based on frequently reported figures for woody waste biomass (as the protocol specifies).
60	Cost-benefit Analysis of Using Biochar to Improve Cereals Agriculture	2014	**Protocol #89**: Biochar Production Project Reporting Protocol	--	--	$120	Average/ Ongoing Cost	$120	• Cost breakdown for biochar production provided and sums to $308/ton. • 1 ton biochar sequesters 2.57 tons CO_2 (umass.edu) • ($308/MT biochar)*(1 MT biochar/2.57 MT CO_2) = **$120/MT CO_2e**	N/A	2014	Figure 5	http://onlinelibrary.wiley.com/doi/10.1111/gcbb.12180/full Additional reference: http://scholarworks.umass.edu/cgi/viewcontent.cgi?article=1004&context=cppa_capstones	Producing biochar in North-Western Europe.
61	The Feasibility and Costs of Biochar Deployment in the UK	2011	**Protocol #89**: Biochar Production Project Reporting Protocol	$49	$74	$62	Average/ Ongoing Cost	$62	• Value range of **$49 - 74/MT CO_2e** provided (geos.ed.ac.uk)	N/A	2011	342	https://www.geos.ed.ac.uk/homes/sshackle/CostsBiochar.pdf	Cost estimates for Midwest U.S. using maize feedstocks.
62	County of San Diego Strategic Plan to Reduce Waste	2017	**Protocol #83**: Organic Waste Composting	$54	$70	$62	Average/ Ongoing Cost	$62	• $133,000 - $172,000/year = estimated cost to implement program which diverts 1,300 to 7,500 tons of organic waste/year • 2,445 MT CO_2e = estimated GHG reductions associated • $133,000/2,445 MT = **$54/MT CO_2e** to $172,000/2,445 MT = **$70/MT CO_2e**	N/A	2017	Figure 4-2	http://www.sandiegocounty.gov/content/dam/sdc/dpw/SOLID_WASTE_PLANNING_and_RECYCLING/Files/Final_Strategic%20Plan.pdf	Cost to "support on-site community/commercial/farm composting." Includes costs from County and "other parties."
63	Blue Print for Green Energy in the Americas	2007	**Protocol #98**: Fuel Switch from Gasoline to Ethanol in Flex-Fuel Vehicle Fleets	--	--	$759	Average/ Ongoing Cost	$759	• Assume cost of E100 will be similar to E85 (~$2) • Gasoline emission factor = 8788 g CO_2/gal • Assume 30% reduction in tailpipe emissions for conversion from gasoline to E100 in flex fuel vehicles (scirp.org)	N/A	2007	Figures 4-6	https://file.scirp.org/pdf/JEP_2016051113592899.pdf	Cost developed assuming County would need to cover the cost of ethanol fuel in order for fleets to convert to it. This assumption is based on the fact that E100 is not readily available in California. Estimate assumes future flex-fuel engines become more efficient at combusting E100.
64	Change the Pallet Congratulates IKEA on 5-Year Anniversary of Globally Changing the Pallet	2017	**Protocol #99**: Transport Energy Efficiency from Lightweight Pallets	$3,500	$8,750	$6,125	Average/ Ongoing Cost	$6,125	• Number of pallets per MT reduction = 35,000,000 pallets/100,000 MT CO_2e = 350 pallets (derived from Ikea case study) • Assume lightweight pallets cost the same as wooden pallets. • Cost of wooden pallet: $10-$25/pallet (thebalance.com). • Assume pallets are used one time then recycled (icleiusa.org).	N/A	2017	Webpage	http://www.prweb.com/releases/ikea-sustainable/shipping-pallet/prweb14006896.htm Additional references: https://www.thebalance.com/how-much-do-pallets-cost-2877857 http://icleiusa.org/change-the-pallet-procurement-specs-reduce-emissions/	Costs developed assuming County would need to cover the cost of the lightweight pallets in order for fleets to use them. Cost range is due to variances in the potential cost of the pallets. County may be able to subsidize pallet costs for fleets rather than having to purchase them outright.
65	Annual Report to the Legislature on California Climate Investments Using Cap-and-Trade Auction Proceeds	2017	**Protocol #100**: Methodology for Carpooling	--	--	$2,427	Average/ Ongoing Cost (assumed)	$2,427	• Value of **$2,427/MT CO_2e** provided • Report calculated value based on $3.0 million investment earning reductions of 1,300 MT CO_2e.	N/A	2017	33; Table ES-2	https://www.arb.ca.gov/cc/capandtrade/auctionproceeds/cci_annual_report_2017.pdf	Cost derived from three projects that involved purchasing zero or near zero-emission vehicles for use in car-sharing programs for residents of disadvantaged communities.

Table 4. Summary of Cost-Effectiveness Data
County of San Diego
Preliminary Assessment of Local Direct Investment Program

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
				Raw Cost Data from Cost Reference ($/MT CO_2e)										
				Range (if provided)										
	Cost Reference Name	Cost Reference Year	Applicable Protocol/Project Type	(Low)	(High)	(Average)	Raw Cost Data Type	Derived Average or Lifetime Cost[1] ($/MT CO_2e)	Cost Assumptions/Derivation	Project Lifetime (if known)	Cost Year (reference year if unknown)	Cost Reference Page/Table	Cost Reference Location	Other (i.e., notes on project scale, project location, etc.)
66	Greenhouse Gas Emissions Cost Effectiveness Study	2010	**Protocol #100**: Methodology for Carpooling	$33	$122	$78	Average/ Ongoing Cost (assumed)	$78	• $/ton CO_2e provided and converted to $/MT	N/A	2009	10 (PDF pg. 16) 21 (PDF pg. 27)	media.metro.net/projects_studies/sustainability/images/GHGCE_2010_0818.pdf	High-end estimate is for LA Metro's vanpool program. Cost estimate represents administrative costs and vanpool subsidies given to employees. Note, if federal funds from FTA's Section 5307 funds are included the program generates money and the cost becomes -$67/ton CO_2 (-$74/MT). Low-end estimate is for LA Metro's Commute Services. LA Metro Commute Services are provided to employers and educational institutions in Los Angeles County. Cost estimate represents administrative costs, marketing and outreach, and financial incentives to commuters.
67	Impacts of Transportation Policies on Greenhouse Gas Emissions in U.S. Regions	2011	**Protocol #100**: Methodology for Carpooling	--	--	$2,608	Average/ Ongoing Cost (assumed)	$2,608	• $/ton CO_2e provided and converted to $/MT	N/A	2006	Table 27; (PDF pg. 63)	http://reason.org/files/cost_effectiveness_policies_reduce_greenhouse_gas_emissions.pdf	Estimates based on cost of a 25% increase in carpool share. Cost estimate presented is for San Diego; costs for other California regions range from $301 to $3,339 per ton CO_2, with the US National average being $2,776/ton CO_2. Estimate may be high since informal agreements between family members or workplace colleagues are not accounted for, and because some regions might have to expand HOV lanes to accommodate more carpools.
68	McKinsey & Company - Reducing U.S. Greenhouse Gas Emissions: How Much at What Cost?	2007	**Protocol #102**: Improved Efficiency of Vehicle Fleets	--	--	-$9	Averaged over Project Lifetime	-$9	• $/ton CO_2e provided and converted to $/MT	Unknown	2005	PDF pg. 65 of full report	https://www.mckinsey.com/business-functions/sustainability-and-resource-productivity/our-insights/reducing-us-greenhouse-gas-emissions	The study looked into technical installations to improve fuel efficiency such as improved aerodynamics, advanced transmissions, improved thermal management, as well as pneumatic blowing and fuel-cell operated auxiliaries; fuel economy packages (inclusion of all upgrades) for medium and heavy trucks would add approximately $5,200 to $9,400 to the cost of a vehicle and could improve miles per gallon by 13% for Medium-Duty vehicles and 6% for Heavy-Duty vehicles by 2030. Cost value is negative because it includes cost savings from improvements in efficiency.
69	Prioritizing Climate Change Mitigation Alternatives: Comparing Transportation Technologies to Options in Other Sectors	2008	**Protocol #102**: Improved Efficiency of Vehicle Fleets	--	--	$83	"First Year" Cost	-$54	• $/MT CO_2e values provided directly.	15 years	2008	70 (PDF pg. 80)	http://escholarship.org/uc/item/5rd41433	The study aggregated results from other studies to make an average emissions reduction and cost-effectiveness determination. Fuel efficiency improvements in vehicle classes 3 through 6 (generally medium duty vehicles) were estimated to reduce CO_2e emissions per mile by approximately 40%. The capital cost effectiveness value of these reductions was estimated at $83/MT CO_2e. Types of improvements to vehicle classes 3 through 6 include engine efficiency upgrades such as gasoline direct injection and diesel turbocharging as well as lower rolling resistance, integrated starter-generator, and improved aerodynamics. The lifetime cost value is negative because it includes cost savings from improvements in efficiency.

Table 4. Summary of Cost-Effectiveness Data
County of San Diego
Preliminary Assessment of Local Direct Investment Program

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
				Raw Cost Data from Cost Reference ($/MT CO_2e)										
				Range (if provided)										
	Cost Reference Name	Cost Reference Year	Applicable Protocol/Project Type	(Low)	(High)	(Average)	Raw Cost Data Type	Derived Average or Lifetime Cost[1] ($/MT CO_2e)	Cost Assumptions/Derivation	Project Lifetime (if known)	Cost Year (reference year if unknown)	Cost Reference Page/Table	Cost Reference Location	Other (i.e., notes on project scale, project location, etc.)
70	Prioritizing Climate Change Mitigation Alternatives: Comparing Transportation Technologies to Options in Other Sectors	2008	**Protocol #102**: Improved Efficiency of Vehicle Fleets	--	--	$32	"First Year" Cost	-$88	• $/MT CO_2e values provided directly.	15 years	2008	72 (PDF pg. 82)	http://escholarship.org/uc/item/5rd41433	The study aggregated results from other studies to make an average emissions reduction and cost-effectiveness determination. Fuel efficiency improvements in vehicle classes 7 and 8 (heavy duty vehicles) were estimated to reduce CO_2e emissions per mile by approximately 34%. The capital cost effectiveness value of these reductions was estimated at $32/MT CO_2e. Types of improvements to vehicle classes 7 and 8 include reduced rolling resistance, engine efficiency upgrades, tractor trailer aerodynamics, lightweight materials, and advanced transmissions. The lifetime cost value is negative because it includes cost savings from improvements in efficiency.

Notes: [1] Values are set equal to Column F when raw cost data is provided as an average/ongoing cost or a cost averaged over the project lifetime. For "first year" costs, average lifetime costs are derived using an assumed project lifetime or other information from the reference document.