CO_2 UTILIZATION IN CONCRETE - REMOVALS & REDUCTIONS - CARBONCURE - U.S. PROJECT #1

Document Prepared by Carbonomics, LLC

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1 PROJECT DETAILS

1.1 Summary Description of the Implementation Status of the Project

This project activity will capture waste CO2 which would have otherwise been emitted into the atmosphere, or atmospheric CO2 which would otherwise be in the atmosphere, and utilize that gas as a feedstock in the production of concrete. These project activities reduce greenhouse gas (GHG) emissions by mineralizing CO2 via the production of concrete. This manufacturing process has the additional benefit of requiring less Portland cement, which further reduces emissions, because the cement production process is highly energy and carbon intensive. The project activity will take place at the location where the concrete is first manufactured (mixed with cement, water, aggregates, etc.).

During this monitoring period, from 1 January, 2019 to 31 December, 2021, the GHG emission reductions have totaled 14,581 tCO2eq.

1.2 Sectoral Scope and Project Type

Sectoral Scopes 4 and 6. This is a grouped project.

1.3 Project Proponent

Organization name	CarbonCure Technologies Inc
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Title	Business Operations and Credit Inventory Manager, Carbon Finance
Address	42 Payzant Avenue, Dartmouth, NS B3A 1K7, Canada
Telephone	+1 438 927 4418
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1.4 Other Entities Involved in the Project

Organization name	Carbonomics, LLC
Role in the Project	Consultant

Contact person	Seth Baruch
Title	President
Address	5077 Blackhawk Drive, Danville, CA 94506
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1.5 Project Start Date

November 6, 2018.

Note that the project start date is November 6, 2018 as this was the date CarbonCure equipment was installed at the facilities. However, there was an initial commissioning and data-gathering phase for the first project instances, which required some adjustments to the monitoring approach. Thus, to be conservative, CarbonCure did not start seeking credits until January 1, 2019.

1.6 Project Crediting Period

6 November, 2018-5 November, 2025: 7-years twice renewal.

1.7 Project Location

Project location in and around Georgia, South Carolina & North Carolina. See Appendix I for greater detail.

1.8 Title and Reference of Methodology

VM0043, Methodology for CO2 Utilization in Concrete Production, V.1.

1.9 Participation under other GHG Programs

This project activity is not part of any other GHG program.

1.10 Other Forms of Credit

This project activity is not part of any emissions trading program nor is it obtaining any other form of environmental credit.

1.11 Sustainable Development Contributions

This specific project contributes to UN SDG 9 in addition to SDG 13. SDG 9 refers to building "resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation". Specifically, we refer to Goal 9.4: *By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.* This project will produce concrete that both uses CO2 that would otherwise be emitted to the atmosphere (or is currently in the atmosphere) and requires lower amounts of carbon-intensive Portland Cement.

Table 1: Sustainable Development Contributions

Row number	SDG Target	SDG Indicator	Net Impact on SDG Indicator	Current Project Contributions	Contributions Over Project Lifetime
1)	9.4	Resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.	As a result of this project, new buildings and other infrastructure is using low-carbon concrete, thus helping to make a hard-to-decarbonize industry more sustainable.	During this monitoring period, 3.6 million cubic yards of concrete was produced by the project activity, resulting in 17,386 metric tonnes fewer tons of Portland cement used. This concrete was used in 1,350 buildings and other infrastructure (bridges, sidewalks, parking lots, etc.).	As this is the first monitoring period, the cumulative impacts are the same as the column to the left.
2)	13.2.2	Total greenhouse gas emissions per year.	Implemented activities to lower cement usage, which is very carbon-intensive and injected waste CO2 into concrete.	This project reduced GHG emissions by 14,581 tons.	As this is the first monitoring period, the cumulative impacts are the same as the column to the left.

2 SAFEGUARDS

2.1 No Net Harm

There are no negative environmental impacts associated with this project. This project is taking place at existing concrete manufacturing facilities, so no new facilities are being constructed that could potentially have environmental impacts, and the equipment used to capture CO2 is modular and can be retrofit directly into the existing facility.

2.2 Local Stakeholder Consultation

- CarbonCure considers the following entities to be stakeholders in the use of concrete made with CO2 mineralization: concrete producers, architects, engineers, building owners, contractors, local government officials and regulators
- CarbonCure regularly engages with all stakeholders to inform them of the benefits of lower carbon concrete and to obtain approval to use CO2 mineralization in concrete for commercial and public sector projects. This engagement is conducted directly through lunch and learns or similar meetings, and more broadly through sponsorship and participation through industry associations, conferences, and events.
- Feedback from stakeholders is captured through centralized customer resource management tools (e.g. Salesforce), direct feedback collected from CarbonCure-hosted webinars, and through written correspondence from individuals and project teams that have been engaged.

3 IMPLEMENTATION STATUS

3.1 Implementation Status of the Project Activity

During the monitoring period as it relates to the facilities CarbonCure has included in this report, which began 1 January, 2019 and ended on 31 December, 2021, the number of facilities using CarbonCure equipment totaled 43 sites. On the start-date, there were 25 facilities that began using CarbonCure equipment. Additional sites were added throughout the monitoring period, but there were no other changes to the project. This report covers the first monitoring period of the grouped project. More facilities will be added in future reports, including those from other concrete producers that are currently using our technologies but were deliberately not included in this first report.

3.2 Deviations

3.2.1 Methodology Deviations

CarbonCure equipment itself does use electricity, and VM0043 requires direct metering or use of utility bills to quantify the amount of this electricity. However, the actual amounts used are very small and difficult to meter individually. Thus, CarbonCure will provide to the VVB an alternative method. This involves direct metering of a portion of CarbonCure devices and coming up with a conservative estimate, based on a representative sample of direct measurements, of kWhs used per unit of CO2 injected into the concrete.

More specifically, CarbonCure has undertaken a number of tests at different concrete production facilities. These tests were conducted at the five separate concrete production facilities. These tests were conducted at facilities in diverse locations, representing different variables that could potentially account for different levels of electricity usage, such as climate.

Measurements for system energy/power usage breakdown were based on the phases of injection, including idle periods. The calculations show two examples using the peak power consumption to provide a conservative energy usage profile to avoid undercalculating: 1) all days - assuming the system is on 24/7 with no days off and 2) days used - assuming the system only had power the days it was used. The power consumption was calculated during an injection (peak power usage) by measuring the voltage supplied and the current of each enclosure separately. The current measurement was completed with an electrical line splitter to multiply the current value by 10X which was reported and corrected for. The results are provided in the table below:

Max energy usage per day using 117 W measurement during injection										
	Producer 1		Producer 2		Producer 3		Producer 4		Producer 5	
Max Energy usage per day	2.808	kWh	2.808	kWh	2.808	kWh	2.808	kWh	2.808	kWh
Energy per kg CO_2/Day (days used)	0.0711	kWh	0.0302	kWh	0.0954	kWh	0.0276	kWh	0.0817	kWh
Energy per kg CO_2/Day (all days)	0.0995	kWh	0.0432	kWh	0.1316	kWh	0.0350	kWh	0.1221	kWh

To be conservative, CarbonCure will use the highest of the numbers across all the projects, representing the highest potential level of project emissions associated with electricity usage. The testing above indicates that the highest value is 0.1316 kWhs of electricity per kg of CO2 injected into the process. CarbonCure believes this is an accurate, and conservative way to estimate electricity usage. CarbonCure does not believe these numbers will change throughout the year based on the type of equipment used.

As concrete producers can have many different mix designs with the same or similar compressive strength performance, CarbonCure has aggregated mix designs into CarbonCure Mix Designs based on various industry standard criteria and application. These are outlined in Appendix III of the Project Description. Carboncure Mix Designs are used in addition to the below deviations.

An additional deviation has been made to Equation 3 in the VM0043 methodology. As concrete producers can have many different mix designs which are similar in performance, the number of tests required to compare individual baseline and project mix designs to determine the cement cut is not practically feasible given the quantity or necessary given the similarities in mix design performance. As a result, CarbonCure will: a) conduct the testing (in accordance with the testing procedure listed in Appendix II of VM0043) for baseline and project CarbonCure Mix Designs that comprise 50% or more of the production volume; b) for the CarbonCure Mix Designs that this testing was conducted for, use the results of the testing data to quantify the cement cut; c) for the CarbonCure Mix Designs that this testing was not conducted for, CarbonCure will use the average cement cut from (b) (that is, the CarbonCure Mix Designs that conducted the testing) and apply a 1 standard deviation deduction to ensure conservatism. This approach provides a robust, accurate and conservative approach that is also practically feasible.

Similarly, a deviation is applied to the requirement for compressive strength tests. As outlined in VM0043 compressive strength tests are required to assess that the strength of concrete remains the same or greater than the baseline scenario. These tests are performed to provide evidence of strength to producers and concrete producers then go on to sell their concrete commercially. As concrete producers can have many different mix designs which are similar in performance and compressive strength, the number of tests required to compare individual baseline and project mix designs to determine the compressive strength is not practically feasible given the quantity or necessary given the similarities in mix design performance and compressive strength. As a result, CarbonCure will conduct the testing at the producer or in a lab (in accordance with the testing procedure listed in Appendix II of VM0043) for baseline and project CarbonCure Mix Designs that comprise 50% or more of the production volume, ensuring a robust, accurate and conservative approach that is also practically feasible.

Moreover, a slight adjustment to the calculation of the emissions associated with the processing of CO_2 has been made; Equation 12 in the VM0043 methodology. The injected CO_2 into concrete is used here rather than the value of total CO_2 transported to a facility, as the emission reduction calculation is done on a Ticket level based on each truck load of concrete poured rather than as the total value transported to a facility. This change is made as CarbonCure does not receive any information around the total CO_2 transported to facilities. Evidence can be provided to VVBs that total CO_2 transported is injected into concrete as facilities do use CO_2 for other purposes.

For conservative purposes, CarbonCure treats instances where the CO2 source of plants has not yet been identified (CO2 suppliers can keep this information confidential) the same as it would if the CO2 source were a geological well. In these instances, CarbonCure includes an added_emissions_tonnes value for the portion of the injected CO2 that is not mineralized. For further details on the inclusion of this calculation please follow notes mentioned in sections 5.1 & 5.2.

3.2.2 Project Description Deviations

There are no deviations outside of the deviations noted in the project description for this monitoring period.

3.3 Grouped Projects

Because this is the first monitoring report, there are no additional project instances other than what is covered in this monitoring period.

4 DATA AND PARAMETERS

4.1 Data and Parameters Available at Validation

Data / Parameter	EFcement
Data unit	tCO2e/t of cement
Description	Emission factor for the production of Portland cement
Source of data	Project proponent and/or cement production facilities
Value applied	889 kgCO2e/t of cement, 902 kgCO2e/t of cement, 922 kgCO2e/t of cement or 1,040 kgCO2e/t but this may vary as more plants are added to the project
Justification of choice of data or description of measurement methods and procedures applied	Option 2 is being used because Option 1 – Plant Specific Data – is not practical in this case, since producers will source cement from many different plants and in varying quantities from year to year. The plants in the initial project will be using a combination of the industry average for the emission factor of cement that is 1,040 kg of CO2 equivalent per tonne of cement for any time before 2021-03-12 or 922 kg of CO2 equivalent per tonne of cement for any time period where credits are generated after this date. Similarly, for the plants in the initial project, the value for type I/II cement from Holcim - Holly Hill, which has a GHG intensity of 889 kg of CO2 equivalent per tonne of cement is also used or the value for type III which has a GHG intensity of 902 kg of CO2 equivalent per tonne of cement. The EPD and Industry Average documentation will be made available to the VVB upon project validation. Similarly, for the plants in the initial project, the value for industry averages may change based on the year of credit generation. Note that this number does not include the 12% discount for use of Option 2 (EPDs) and this discount is accounted for separately in the appendix I in VM0043.
Purpose of Data	Calculation of baseline emissions.
Comments	N/A

Data / Parameter	$EF_{CO2,i}$
Data unit	Tonne of CO2 per tonne-mile
Description	Emission factor for mode of transport.

Source of data	See table in Section 8 from EPA Center for Corporate Climate Leadership
Value applied	0.00023 - until March 2020 0.000223 – March 2020 – April 2021 0.000233 – April 2021 onwards (Assumed mode will be truck, values may vary based on year)
Justification of choice of data or description of measurement methods and procedures applied	This is an accurate and simplified default for considering the emission factors of different modes of transport.
Purpose of Data	Calculation of project emissions.
Comments	N/A

Data / Parameter	Default factor for amount of energy required to capture, treat and compress a tonne of CO2
Data unit	kWh/tonne
Description	Default factor for amount of energy required to capture, treat and compress a tonne of CO2
Source of data	See Appendix V of VM0043
Value applied	200 kWh/tonne of CO2 processed
Justification of choice of data or description of measurement methods and procedures applied	See Appendix V of VM0043
Purpose of Data	To provide an option for determining project emissions from capturing CO2 if that information is not available from the CO2 supplier.
Comments	

Data / Parameter	Default efficiency of mineralization
Data unit	Ratio
Description	Amount of CO2 injected into the process that gets mineralized into the concrete.
Source of data	See Appendix V*I in VM0043*
Value applied	0.60
Justification of choice of data or description of measurement methods and procedures applied	See Appendix VI in VM0043
Purpose of Data	In some cases, one concrete manufacturer may be producing too many mix designs for the testing to be feasible or practical. In this case, project proponents must use a default based on the percentage of CO2 injected into the process (as determined by a meter) and actually mineralized.
Comments	This parameter indicates the *efficiency of mineralization*. There have been tests done on this efficiency as outlined in Appendix V of VM0043. These tests show quite a range of results in terms of the efficiency of the uptake of CO2 into the concrete, and there appears to be little correlation between the efficiency of mineralization and the percent dosing of CO2. However, the lowest test result is at 76%, meaning that three-quarters of the CO2 that is injected into the process actually gets mineralized into the concrete. At a conservative default, the assumed efficiency of mineralization will be set at 60%.

4.2 Data and Parameters Monitored

Data / Parameter:	Qcement,i,p,y
Data unit:	Tonne

Description:	Quantity of Portland cement used in the project for concrete produced using a project mix design *i* in year y.
Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	Use standard weighing procedures to determine mass of cement used to produce concrete over the course of year Y.
Frequency of monitoring/recording:	Measured continuously.
Value applied	The values applied will vary based on each CarbonCure mix design for a given facility. As this is a grouped facility with multiple facilities and hundreds of mix designs this data is provided directly to the VVB upon validation.
Monitoring equipment	Scales
QA/QC procedures to be applied:	Note that frequency of calibration is based on DOT laws based on which region facilities are in the USA. As this is a grouped project various calibration frequency will be applied to different project instances. For the first project instance the GDOT requires calibration to occur every 6-months.
Purpose of data:	Calculation of baseline and project emissions.
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	QCement,b,i,test n
Data unit:	Tonne
Description:	Quantity of Portland cement used to prepare baseline compressive strength test specimen n for concrete produced using a mix design that results in a concrete of equivalent compressive strength to project mix design *i.*
Source of data:	CarbonCure and Individual Concrete Producer

Description of measurement methods and procedures to be applied:	See Appendix II of VM0043
Frequency of monitoring/recording:	Once per project crediting period for the Corporation's (or Division's) CarbonCure Mix Designs that comprise 50% or more of the product volume.
Value applied	The values applied will vary based on each CarbonCure mix design for a given facility. As this is a grouped facility with multiple facilities and hundreds of mix designs this data is provided directly to the VVB upon validation.
Monitoring equipment	Scales
QA/QC procedures to be applied:	See Appendix II of VM0043
Purpose of data:	Calculation of baseline emissions by comparing the amount of cement in the project activity concrete and the amount of cement that would be required in the baseline concrete.
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	QCement,p,i,test n
Data unit:	Tonne
Description:	Quantity of Portland cement used to prepare project compressive strength test specimen n for concrete produced using project mix design *i*
Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	See Appendix II of VM0043

Frequency of monitoring/recording:	Once per project crediting period for the Corporation's (or Division's) CarbonCure Mix Designs that comprise 50% or more of the product volume.
Value applied	The values applied will vary based on each CarbonCure mix design for a given facility. As this is a grouped facility with multiple facilities and hundreds of mix designs this data is provided directly to the VVB upon validation.
Monitoring equipment	Scales
QA/QC procedures to be applied:	See Appendix II of VM0043
Purpose of data:	Calculation of baseline emissions by comparing the amount of cement in the project activity concrete and the amount of cement that would be required in the baseline concrete.
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	QCO2,meter,y
Data unit:	Tonne
Description:	Amount of CO2 injected in year *y* to produce concrete, as determined by a flow meter.
Source of data:	CarbonCure
Description of measurement methods and procedures to be applied:	The use of calibrated flow meters. Calibration must be conducted according to the equipment manufacturer's specifications. The amount of CO2 must be metered before entering the production process and must be subject to standard calibration and QA/QC procedures for the measurement of critical data variables.
Frequency of monitoring/recording:	Data must be monitored continuously and recorded on at least a daily basis.
Value applied	For the first crediting period the values applied are listed below. 2019 – 51.1 2020 – 129.7 2021 - 255.8

Monitoring equipment	Flow meter
QA/QC procedures to be applied:	The use of calibrated flow meters. Calibration is conducted according to the equipment manufacturer's specifications (FUTEK), once a year. The amount of CO_2 must be metered before entering the production process and must be subject to standard calibration and QA/QC procedures for the measurement of critical data variables.
Purpose of data:	Calculation of baseline emissions when measuring how much CO2 was injected into the concrete and for project emissions when determining emissions from processing.
Calculation method:	N/A
Comments:	Project proponents may use a mass-flow meter to measure mass of CO2. The meter is embedded into the CarbonCure equipment.

Data / Parameter:	$Q_{Concrete,i,p,y}$
Data unit:	Tonne
Description:	Quantity of concrete produced by the project for project mix design *i* in year y.
Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	Standard procedures to weigh concrete product, standard industry practice for all concrete suppliers.
Frequency of monitoring/recording:	Continuous
Value applied	The values applied will vary based on each CarbonCure mix design for a given facility. As this is a grouped facility with multiple facilities and hundreds of mix designs this data is provided directly to the VVB upon validation.

Monitoring equipment	Scales
QA/QC procedures to be applied:	Standard procedures to ensure accuracy of weighing methods, including manufacturer-recommended calibrations for measuring devices, which will be every three months. Project proponents will keep clear records of all concrete produced and used at construction sites, which can be presented to the validation/verification body.
Purpose of data:	Calculation of baseline emissions
Calculation method:	N/A
Comments:	CarbonCure will list for each producer the number of design mixes that will be considered for emission reduction calculations and the approximate percentage those design mixes comprise of the entire facility's production. This information will be provided to the VVB.

Data / Parameter:	Qelec,y
Data unit:	MWh
Description:	Quantity of incremental, additional electricity from the grid in year y used to power the equipment needed to operate the project activity in year y (MWH)
Source of data:	CarbonCure and Individual Concrete Producer
Description of measurement methods and procedures to be applied:	See Section 3.6
Frequency of monitoring/recording:	See Section 3.6
Value applied	For the first crediting period the values applied are listed below. 2019 – 6.7 2020 – 17.1 2021 – 33.7

Monitoring equipment	Electricity meter
QA/QC procedures to be applied:	N/A as defaults will be used as described in Section 3.6.
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	EFelec
Data unit:	tCO2e/MWH
Description:	Emission intensity of electricity used to transport CO2 and at the project facility.
Source of data:	US EPA eGrid
Description of measurement methods and procedures to be applied:	eGrid emissions factor published by the US Environmental Protection Agency for the US sub-region where the facility is located (latest available information) may be used. This will be used for determining the emissions intensity of the 200 kWh/ton default. Note that these may vary depending on the year of credit generation.
Frequency of monitoring/recording:	Annual
Value applied	For the first project these values are SRSO, SRVC & SRTV. For SRSO these values are: 1027.93 lb/MVh, 969.16 lb/MVh, 949.7 lb/MVh. For SRVC these values are: 743.33 lb/MVh, 675.42 lb/MVh, 623.11 lb/MVh. For SRTV these values are: 1031.54 lb/MVh, 860.18 lb/MVh, 834.18 lb/MVh. Taking into account the region and year that the credit was generated in.
Monitoring equipment	NA
QA/QC procedures to be applied:	NA
Purpose of data:	Calculation of project emissions

Calculation method:	N/A
Comments:	N/A

Data / Parameter:	Miles transported in year y by mode *i*
Data unit:	Miles
Description:	Miles of shipped CO2 to the project site by mode *i*.
Source of data:	CO2 supplier, transporter and CarbonCure
Description of measurement methods and procedures to be applied:	The company supplying or transporting the CO2 should provide data to project proponents about the total miles driven to the final destination. If the exact location of where each canister/tank of CO2 was filled cannot be precisely determined by the CO2 supplier, a reasonable and conservative estimate will be provided based on ALL locations where the particular CO2 supplier is obtaining its gas. Suppliers may obtain CO2 from multiple sources, and this may be difficult to track. However, if the supplier knew that the furthest location away was X miles, and that is the maximum, that number could be used for all CO2 because it would be the most conservative.
Frequency of monitoring/recording:	Annual
Value applied	The values applied will vary for each facility, as this is a grouped project there is a large number of facilities and as a result values are provided to the VVB for each given verification.
Monitoring equipment	Google maps or odometers
QA/QC procedures to be applied:	Records from CO2 supplier or transporter should be available at project verification.
Purpose of data:	Calculation of project emissions.
Calculation method:	N/A

Comments:	N/A

Data / Parameter:	QCO2,supplied,t,i
Data unit:	Tonne
Description:	Amount of CO2 injected in ticket t into the concrete production process, as determined by a flow meter (tCO2) at the project activity location. This value is then rolled up for a given year where relevant.
Source of data:	Amount of CO2 injected into a ticket, and aggregated for a given year where relevant.
Description of measurement methods and procedures to be applied:	Telemetry system installed onsite at producer plant that measures exact quantity of CO2 injected into concrete.
Frequency of monitoring/recording:	Annual
Value applied	For the first crediting period the values applied are listed below. 2019 – 51.1 2020 – 129.7 2021 – 255.8
Monitoring equipment	N/A
QA/QC procedures to be applied:	N/A
Purpose of data:	Determination of project emissions associated with transporting CO2 to the project site.
Calculation method:	N/A

Comments:	The *CO2 <u>supplied</u> to the facility* is here assumed to equal the total amount of CO2 injected into concrete. CarbonCure has confirmed this by running numerous tests to compare total CO2 injected into concrete with total value of CO2 transported to a facility, this will be available upon request to the VVB. Additionally, where requested CarbonCure will provide proof that producers are not using CO2 except for CarbonCure operations. The deviation noted here is included in the deviation section, and simply takes into account the feasibility of acquiring CO2 sales records for all facilities. Project proponents must demonstrate that the captured CO2 is coming from a waste source where the gas would – in the absence of the project activity – be emitted. The project proponent should obtain an attestation from the supplier of the CO2 or provide other evidence that the captured CO2 would not have otherwise been used.

4.3 Monitoring Plan

The Monitoring Plan will comprise of the following elements:

1. Quantity of Concrete produced: The cornerstone of any concrete producer's business is producing ready-mix concrete and bringing it to job sites. As such, the company is well acquainted with the method to quantify both the volume of concrete (in cubic yards) as well as mass (in tons). The producer will measure their concrete production by scales used as standard industry practice in the concrete industry. The scales in the plants are measured by weight to achieve the volume desired, and the companies generally have QC software that allows the company to convert the volumes to mass/weight. The scales are calibrated by a third party at least once per year. Calibration reports at all facilities will be made available to the VVB upon request. Quantities of concrete produced will be provided by CarbonCure Mix Design, with weighing records specified by CarbonCure Mix Design (see below).
2. Amount of cement that concrete would have otherwise been required: The producer will be able to determine the cement content in the project activity concrete by the amount of cement mixed in. Most producers have a well-established way to precisely measure the cement content of their concrete. However, an important component of this part of the monitoring plan is establishing how much cement would have otherwise been used. To

do this, CarbonCure and the producers will do the following

a. Define CarbonCure Mix Designs: For each Corporation, CarbonCure will provide, in a database made available to the VVB, a listing of each CarbonCure Mix Design that the Corporation's facilities will produce. If the same CarbonCure Mix Design is used at multiple facilities for the Corporation, that will be indicated. CarbonCure will indicate which CarbonCure Mix Design was used, based on its criteria (design strength (psi), cement type (e.g., type I/II), % SCMs, blend of aggregates (e.g. coarse+fine), strength enhancing admixtures (e.g. Xseed)) - and provide a specific identification number for that CarbonCure Mix Design. New CarbonCure Mix Designs can be added over time by a Corporation, and that information will be provided to the verifier upon each verification. The defined CarbonCure Mix Designs can be found in the Appendix III in the Project Description.

b. VM0043 requires that the baseline and project samples have an equivalent level of compressive strength, and CarbonCure and the individual producer will conduct these tests for at least three baseline and three project samples for the CarbonCure Mix Designs that comprise 50% or more of production. The process for conducting these tests is provided in Appendix III in the Project Description. These tests will take place across the Coproration's plants (unless the same mix is used across multiple sites, in which case the testing procedure has to be done only once), and the results for each CarbonCure Mix Design will be sent to CarbonCure and archived in a central database that will be made available to the VVB. CarbonCure Mix designs can yield slightly different compressive strength results based on test results. As a result, if multiple tests are conducted on the same CarbonCure Mix Design then an average of all tests is taken to determine the cement reduction of the CarbonCure Mix design. As concrete producers can have many different mix designs which are similar in performance, mix designs will be aggregated into CarbonCure Mix Designs based on their criteria (design strength (psi), cement type (e.g., type I/II), % SCMs, blend of aggregates (e.g. coarse+fine), strength enhancing admixtures (e.g. Xseed)), resulting in multiple mix designs leveraging the same compressive strength testing. To ensure an approach that is robust, accurate and conservative but also practically feasible, CarbonCure will conduct this testing for the CarbonCure Mix Designs that comprise 50% or more of production. The VVB will also be allowed to visit any of the project sites and review any of the tests (within the monitoring report 2-year period), testing procedures and the personnel who conducted them. This testing data will be archived for a period of two years after each monitoring report.

c. For each CarbonCure Mix Design, CarbonCure and the producer will develop a baseline mix – an equivalent concrete product that would be used for the same application but which would not have included any of the technologies or materials from the project activity. In other words, the reference concrete product is what would have been produced in the baseline scenario, using previous levels of cement. These reference amounts will contain the baseline levels of cement which are integral to determining the cement cuts. To determine the value of cement cuts, the difference between the baseline and project scenarios is used. CarbonCure will arrive at these amounts by one of two ways: 1) for the CarbonCure Mix Designs that this testing noted above was conducted for, use the results of the testing data to quantify the cement cut; or 2) for the CarbonCure Mix Designs that this testing was not conducted for, CarbonCure will use the average cement cut from (1) but apply a 1 standard deviation deduction to ensure conservatism.

3. Quantity of CO2 used:

    a. CO2 injection will be used to further reduce the amount of cement content required. This element of the Monitoring Plan will require CarbonCure to measure, through a flow meter, the amount of CO2 that is injected into the process. This will happen at each site. The flow meter data will be provided by site, but it will not be necessary to measure the CO2 flow by mix design because the CO2 injected is determined in aggregate. However, that data will be exported by each site on a daily basis, into a centralized data management that will be maintained by CarbonCure at its headquarters.
    b. Transport-related emissions must also be taken into account. CarbonCure will have a system that accounts for how much CO2 is delivered to each site – and exactly how far that site is from the source. This is important because this data parameter is measured in tonne-miles. For example, if a shipment of 10 tons of CO2 is shipped to a facility that is 84 miles away from the CO2 source, the central system will record 840 tonne-miles (10*84). CarbonCure will know exactly how many tons of CO2 will get delivered to each site and will know exactly how many miles that site is from the CO2 source. Thus tonne-miles can be easily calculated. The central CarbonCure team will keep track of CO2 sales to each facility throughout the project year and will convert that to tonne-miles on a monthly basis. This will be cross checked by CO2 supply sale records to each facility, which can be spot-checked by the verifier.
    c. Calibration for the equipment that measures the amount of CO2 injected into the concrete mix will occur during the course of the project. Each CarbonCure system is calibrated by comparing the metered CO2 via a flow model versus the weight change from a CO2 tank that is on four load cells in the CarbonCure manufacturing facility. The data from the calibration is aggregated to confirm that the flow model is +/-5% of what the load cells have sensed. Calibration is completed once before the equipment is deployed to facilities. Additional calibration can be done based on the performance of the equipment.

4. Quantity of cement actually used: In its normal course of business, every concrete producer tracks – at every one of its facilities – both the cement content of its concrete and everything else – water, aggregates, etc., which go into every truck before it goes to

a job site. Each component of the concrete is weighed separately before it is mixed. All of this weight data is archived, so the producer will know how much cement went into each unit of concrete that is sent to each customer location. The demonstration of this data management system will be provided upon project validation, and a verifier will be able to randomly spot check individual records (eg: quantity of cement mixed with Concrete Project Design X on Day Y, which went in a truck to Job Site Z).

5. All other calculations: CarbonCure has retained Carbonomics to assist with data management, monitoring reports, and overall assistance with assuring the yield of carbon offsets. Carbonomics will work with CarbonCure to prepare data in accordance with this Project Description and VM0043 and complete monitoring reports prior to each verification. As such, Carbonomics will be able to monitor for changing parameters, such as updated eGrid factors.

In instances of non-conformity, the below actions will be taken to ensure that the data is monitored and calculated accurately.

Points of Vulnerability and QA/QC: Most of the data required for this project are handled as a matter of course for concrete producers and CarbonCure, such as concrete quantities and cement purchases – essentially normal supply chain management and product sales. The potential weak points relate to transferring that data from each of the facilities to a centralized database that will be reviewed by a VVB. Again, the key data includes:

- List of CarbonCure Mix Designs and justification for specifying a specific mix design within the CarbonCure Mix Designs
- Developing a reference baseline sample and measuring the compressive strength of that sample and the project sample for the CarbonCure Mix Designs that comprise 50% or more of production
- Concrete produced, delineated by CarbonCure Mix Design
- Cement quantities actually used
- CO_2 usage, transport, and electricity consumption of the CO_2 injection equipment

These are not a large number of data variables but if they occur across many facilities and multiple mix designs, there is potential for human error. The following QA/QC procedures will be put in place:

- CarbonCure has built in quality assurance into their Technical Services team that uses standard operating procedures to capture baseline data. A data management system will be established to transfer data for all key parameters to the overall project manager at CarbonCure for this activity. Frequent double checking of the data that gets exported to the central management system will take place, as will a system to automatically flag anomalies if, for example, there are unexplained data swings – outside of established parameters – that would indicate an error.

- Cross-checks will take place, such as what the central database says for CO_2 deliveries and comparing that to invoices from the CO_2 supplier. And if the flow meter data from CarbonCure differs substantially from CO_2 purchase records at a specific site, the central team will be able to spot it. In cases when data differences cannot be reconciled, CarbonCure will use the data that leads to the more conservative estimation of emission reductions.

- The central CarbonCure team will also make sure that key records related to the measurement equipment itself are archived and available, particularly calibration reports for meters and other key measurement devices. All calibration will take place in accordance with the recommendations of the measurement device manufacturer. A list of measurement devices at each site will be provided to the VVB upon project validation.

A very simplified sketch of the overall data management system can be illustrated in the table below:

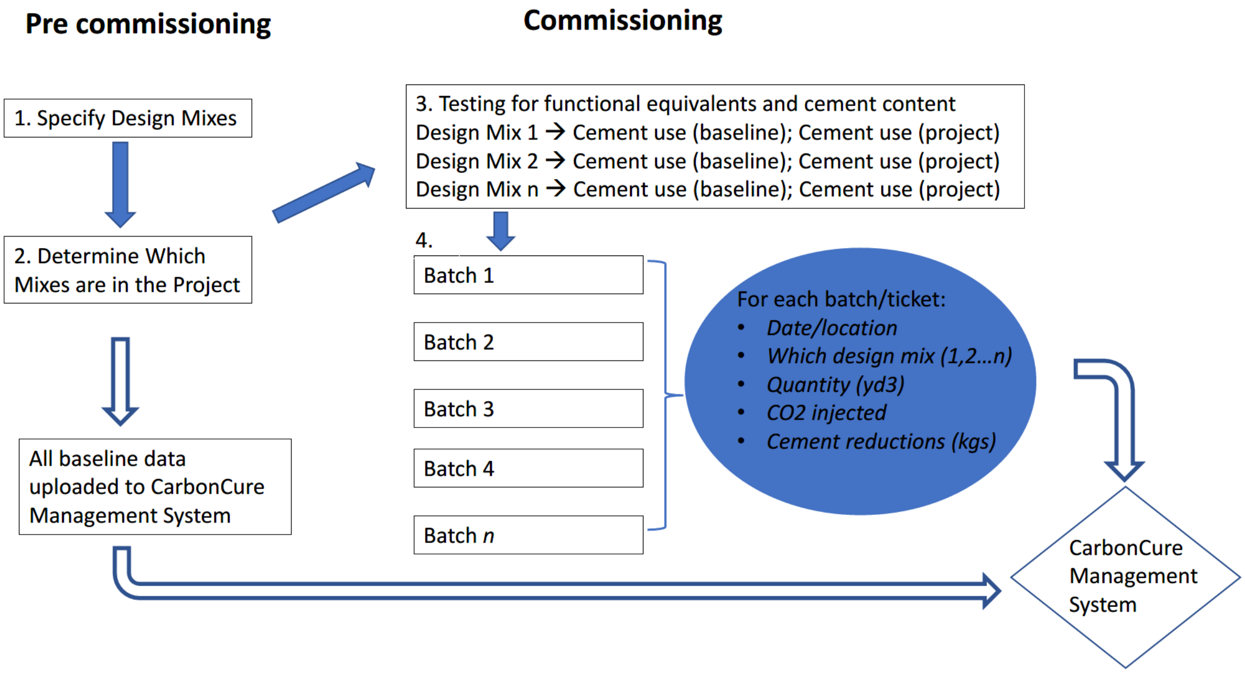
Parameter	Site 1	Site 2	Site n
Design mix 1..n (list each design mix separately)			
Baseline test results 1, 2, 3 (based on its design mix family)			
Project test results 1, 2, 3 (based on its design mix family)			
Quantity of concrete produced by Design Mix 1…n over period X			
Quantity of CO_2 shipped (tons) over period X			
Distance between site and CO_2 source			
Quantity of CO_2 from flow meter			
Estimated amount of electricity used over period X			
EF of grid at site n			
List of measurement devices 1…n			

Latest calibration report for measurement devices 1…n			

CarbonCure has a system in place already with its producers to collect this data through a web portal, which is uploaded to a centralized data management system operated at CarbonCure's headquarters.

When a new facility installs CarbonCure equipment today, the site goes through a pre-commissioning phase, where baseline mix designs are identified and cataloged with the amount of cement, SCMs, etc. included in the design. From there, CarbonCure determines the materiality of each mix design. CarbonCure plans to just focus on the mix designs that make up the majority of the facility's production will be part of the offset project as some mix designs may simply be too small a percentage of a site's production to be worth all the testing. Based on the producer's actual production, CarbonCure may revisit a site after the pre-commssioning phase to complete additional strength testing.

In the commissioning phase, CarbonCure runs trials on these primary mix designs to determine the maximum amount of cement reduction that can take place. After full installation, CarbonCure is then able to track each batch that is produced and goes into a truck on its way to the construction site. This batch data, including the date and location of where the concrete went, is uploaded to the CarbonCure management system. The vast majority of concrete producers have this entire process – from mixing the ingredients to weighing the concrete prior to going into the truck to tracking to the final destination – automated, and thus CSV data can automatically be sent to CarbonCure, without any real human intervention. CarbonCure can track each batch, what mix design it is, what amount of cement is in that batch, etc.



Organization

Various teams at CarbonCure are dedicated to the data collection, processing and storage of credit data. These teams have various levels of expertise in their field, and work in parallel with one another.

All engineering and technical teams work under the SVP of Engineering. The research team works under the SVP of Technical Development. The Carbon Finance team works under the Senior Director of Carbon Finance.

- The Technical Services team at CarbonCure work closely with concrete producers to perform relevant QA/QC tests as well as supporting producers to collect various. This is a trained and skilled team of engineers that are highly familiar with the concrete industry.
- The Software Engineering team works to process the credit data based on the VM0043 methodologies calculation and stores it accordingly. This team follows a typical structure of a Software company, all with high fluency in data engineering and management.
- The Research team performs all relevant calibration monitoring and reporting. This is a team of Engineers that have numerous years of experience in the concrete innovation sphere.
- The Carbon Finance team – and individuals – Casey Leist, Ingy El Kafrawy – will be responsible for leading the monitoring period with various groups within the CarbonCure team. This team has experience in the carbon credit space and the nuances of monitoring, reporting and validation.

5 QUANTIFICATION OF GHG EMISSION REDUCTIONS AND REMOVALS

5.2 Baseline Emissions

Emissions in the baseline scenario are associated with two components. The first component is the emissions associated with the production of Portland cement. The second component is the emissions from the CO_2 that are captured and sequestered in the concrete produced by the project activity.

$$BE_y = BE_{ACU,y} + BE_{CO2,cap,y}$$

Where:

BE_y = Baseline emissions in a given year (y) (tCO_2)

$BE_{ACU,y}$ = Emissions from the production of Portland cement that would have been used in the absence of the project activity (avoided cement usage) (tCO_2e) in year y

$BE_{CO2,cap,y}$ = Emissions from the capture of CO_2 (tCO_2e) in year y

<u>Component 1: Avoided Cement Emissions (BEACU):</u>

The first component of the baseline emissions calculation is the displacement of conventional cement production by the project activity. These baseline emissions are calculated in the equation below. The amount of displacement is calculated by determining the quantity of cement that would have been used in the absence of the project and multiplying that by the emissions factor of the cement.

$$BE_{ACU,y} = \sum_i [Q_{cement,i,b,y} \times EF_{cement}]$$

Where:

$BE_{ACU,y}$ = Emissions from the production of Portland cement that would have been used in the absence of the project (tCO_2e) in year y

Qcement,i,b,y	= Quantity of Portland cement that would have been used in the baseline for concrete produced using a project mix design *i* in year y (metric tonnes). This uses either the mix_level_cement_cut value or where not known will use the corporation_level_cement_cut as detailed below. This is explained further and examples given in Appendix IV of VM0043.
EFcement	= Emissions factor of Portland cement production (tCO2e/metric tonne of cement)

There are three options for determining the emissions factor. For this project, CarbonCure will select Option 2 to determine the emissions factor of the cement – the use of Environmental Product Declarations or EPDs, which ultimately results in a more conservative cement emissions factor due to the 12% discount. The reason is that different producers procure cement from different cement plants, and it's not practical or feasible to collect emissions data from each, across such a large geography. In addition, the quantities purchased vary from year to year, along with the quantities from each cement production facility. All of the plants in the initial project will be using type I/II cement from Holcim - Holly Hill, which currently have a GHG intensity of 889 kg of CO2 equivalent per tonne of cement or type III from Holcim Holly Hill which has a GHG intensity of 902 kg of CO2 equivalent per tonne of cement. There are instances where the industry average value of 1,040 or 922 kg of CO2 is also used. The EPD and relevant documentation for industry average values will be made available to the VVB upon project validation. Note that this EPD does not include the 12% discount that, per the requirements of VM0043, will be applied to project developers using Option 2. This discount is accounted for in the accompanying spreadsheet used to provide an ex-ante estimation of emission reductions throughout the crediting period.

Component 2: Captured CO2 (BECO2,cap): There are two options for determining the amount of CO2 captured and mineralized in the concrete: Option 1: Testing to Determine Quantity of CO2 Stored in the Concrete or Option 2: Using a Default Mineralization Efficiency Factor. *This project will use Option 2, which assumes that 60% of the CO2 injected into the concrete is actually mineralized.*

In addition to the above please see the attached spreadsheet, with relevant notes below;

- All columns should provide relevant formulas to follow calculations, where not included please follow the below:
  - Column P – historical_design_cement uses the mix_level_cement_cut (Column I) when available to determine the baseline cement content if, mix_level_cement_cut (Column I) does not exist it assumes 0
  - Column Q – estimated_design_cement ues the corporation_level_cement_cut (Column J) for all tickets to determine an estimated baseline cement content. The equation is available in the excel sheet.

5.3 Project Emissions

Like baseline emissions, project emissions include the emissions associated with the production of Portland cement used in the project activity concrete, which should be less than cement used in the baseline concrete. Project emissions include any additional electricity or fossil fuels used at the concrete manufacturing facility used by the CO2 injection equipment, as well as the emissions from the processing and transport of the CO2. Project emissions are calculated for every truck load of concrete that is poured (these are referred to as 'Tickets' in the concrete industry). Tickets for the same plant are rolled up and aggregated into a tCO2e GHG emission reduction or removal, and further combined by year. For all formulas noted below note that calculations are first done on the Ticket level. Then, all Tickets that were generated in a given year are aggregated.

Project emissions in year y of the project crediting period will be expressed as below, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PE_y = PE_{cement,y} + PE_{elec,y} + PE_{ffc,y} + PE_{CO2,y} + PE_{\text{added\_emissions\_tonnes}}$$

Where

PE_y	= Project emissions in year y (tCO_2e)
$PE_{cement,y}$	= Emissions from the production of cement used at the project facility in year y (tCO_2e)
$PE_{elec,y}$	= Emissions from the incremental use of electricity by the CO_2 injection equipment at the project facility in year y (tCO_2e)
$PE_{ffc,y}$	= Emissions from the incremental combustion of fossil fuels by the CO_2 injection equipment at the project facility in year y (tCO_2e)

$PE_{CO2,y}$ = Emissions associated with the capture, compression and transport of CO2 to the location where it will be sequestered in concrete in year y (tCO2e).

$PE_{added\_emissions\_tonnes}$ = Emissions associated with CO2 source *where it is not known*, this applies the entire portion of q_CO2_meter at the project facility for the relevant facilities where CO2 is not known

The project emissions from the amount of cement used at the project facility are calculated as follows, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PE_{cement,y} = \sum_i Q_{cement,i,p,y} \times EF_{cement}$$

Where:

$PE_{cement,y}$ = Emissions from the amount of cement used at the project facility in year y (tCO2e)

$Q_{cement,i,p,y}$ = Quantity of Portland cement used in the project for concrete produced using a project mix design *i* in year y (metric tonnes)

EF_{cement} = Emissions for the Portland cement used in the project (tCO2eq/metric tonne of). The same option as described in Section 4.1 will be used.

<u>*For this project, CarbonCure will not be using any additional fossil fuels, such as natural gas, beyond what it would use in the absence of this project activity. There will be a slightly elevated usage in electricity from the CO2 injection equipment itself, but it will be quite small. It will not be directly metered, but CarbonCure will provide an estimation as to how much electricity is typically used per quantity of CO2 injected, as outlined in Section 3.6.*</u>

The project emissions from the use of electricity at the project facility are calculated as follows, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PE_{elec,y} = Q_{elec,y} \times EF_{elec}$$

Where:

$PE_{elec,y}$ = Emissions from the use of electricity at the project facility in year y (tCO_2e)

$Q_{elec,y}$ = Quantity of electricity used by the CO_2 equipment from the grid in year y used to power the equipment needed to operate the project activity in year y (MWH)

EF_{elec} = Emissions intensity of the electricity (tCO_2/MWH)

The project emissions from the capture, compression and transport of CO2 to the facilities will use the second of the two options in VM0043 – the use of a default of 200 kWhs per tonne of CO2 used in the process. The injected CO2 into concrete is used here rather than the value of total CO2 transported to a facility, as the emission reduction calculation is done on a Ticket level based on each truck load of concrete that is poured. Note that for this project, transportation of C02 will likely be done via truck transportation and not by the use of pipelines., Thus a second component to project emissions for truck related transport is outlined below. To convert the 200 kWh/tonne to GHG emissions, CarbonCure will use the EFelec at the facility where the CO2 is processed, using the latest US EPA eGrid emission factors.

Emissions Associated with the Processing of CO2 are illustrated below, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PE_{CO2,processing,t} = Q_{CO2,meter,t} X\ 200\ kWh/tonne\ X\ EF_{elec}$$

$Q_{CO2,meter,y}$ = Amount of CO2 injected in ticket t and aggregated for that year into the concrete production process, as determined by a flow meter (tCO2) at the project activity location.

EF_{elec} = Emissions intensity of the electricity (tCO_2/MWh)

Emissions Associated with the Transport of CO2 are illustrated below, note that the calculation first occurs on the Ticket level and is then aggregated for a given year:

$$PECO2,transport,y = \sum i\ (QCO2,injected,y,i\ x\ miles\ transported,I\ x\ EF\ CO2\ i)$$

PECO2,transport,y = Project emissions associated with the transport of CO2 per ticket in year y (tCO2e).

QCO2,injected,y,i = Amount of CO2 procured from a source in year y and injected into concrete by mode i. (tCO2)

EF CO2 i = CO2 emission factor for mode i (barge, rail, or truck), (tonne/tonne-mile).

Transport Mode	Emissions in $mtCO_2$/tonne-mile
Rail	0.0000231
Waterborne	0.000044
Truck	0.00023 - until March 2020 0.000223 – March 2020 – April 2021 0.000233 – April 2021 onwards
Air	0.00139

For this project, CO2 will be transported by truck, and thus the 0.00023, 0.000223 and 0.000233 figure will be used based on the year that the credit is generated.

In addition to the above please see the attached spreadsheet, with relevant notes below;

- All columns should provide relevant formulas to follow calculations, where not included please follow the below:
  - Column S – is q_elec the amount of electricity used to inject the CO2. It is calculated as the total injected CO2 multiplied by 0.1316 kWh per kg of CO2. The value calculated and explained in the deviation section.

5.4 Leakage

Leakage does not have to be considered in VM0043

5.5 Net GHG Emission Reductions and Removals

Year	**Baseline emissions or removals (tCO_2e)**	**Project emissions or removals (tCO_2e)**	**Leakage emissions (tCO_2e)**	**Net GHG emission reductions or removals (tCO_2e)**
2019	43,296	41,139	0	2,157
2020	93,336	88,723	0	4,613
2021	157,645	149,834	0	7,811
Total	294,277	279,696	0	14,581

1. APPENDIX I: LOCATIONS FOR MONITORING PERIOD

Company	***Plant Name***	***Plant Address***	***Geodetic Coordinates***
Thomas	*Acworth*	*4324 Toonigh Road*	*34.05775, -84.63921*
Thomas	*Anderson*	*1307 GA-140*	*34.34829, -84.67877*
Thomas	*Alpharetta*	*695 Sims Industrial Blvd*	*34.05869, -84.30732*
Thomas	*Athens*	*1020 Winterville Road*	*33.95128, -83.34465*
Thomas	*Atlanta*	*1430 Marietta Blvd*	*33.79381, -84.43244*
Thomas	*Ben Hill*	*2454 Daniel Road Southwest*	*33.68738, -84.51531*
Thomas	*Buckhead*	*740 Lambert Dr.*	*33.81347, -84.36357*
Thomas	*Canton*	*190 Hickory St.*	*33.78296, -84.28439*
Thomas	*Cartersville*	*145 Paga Mine Road*	*34.13962, -84.77476*
Thomas	*Covington*	*7143 Wheat Street Northeast*	*33.60592, -83.84020*

Thomas	*Cumming*	*2009 Ronald Regan Blvd*	*34.15358, -84.14518*
Thomas	*Cumming West*	*4070 Canton Hwy*	*34.23846, -84.23883*
Thomas	*Dawsonville*	*382 Hightower Parkway*	*34.28167, -84.29820*
Thomas	*Doraville*	*2825 Humphries Way*	*33.92646, -84.25228*
Thomas	*Duluth*	*3955 Buford Highway*	*33.97804, -84.16268*
Thomas	*East Savannah*	*42 Forbes Road*	*32.07396, -81.04850*
Thomas	*Gainesville*	*3960 Thurmon Tanner Rd*	*34.21511, -83.88605*
Thomas	*Grayson*	*1095 Ozora Road*	*33.88992, -83.89598*
Thomas	*Hiram*	*1133 Rosedale Drive*	*43.67621, -79.38435*
Thomas	*Jasper*	*615 Gennett Drive*	*34.48621, -84.44749*
Thomas	*Jefferson*	*993 Academy Church Road*	*34.13912, -83.63213*
Thomas	*Kennesaw*	*951 Duncan Road*	*34.26099, -83.37158*
Thomas	*Lawrenceville*	*455 Maltbie Street*	*33.96361, -83.99994*

Thomas	Lithonia	6963 Maddox Road	33.96275, -83.98744
Thomas	Savannah	1724 Old Dean Forest Road	32.08978, -81.19814
Thomas	Stockbridge	605 Rock Quarry Road	33.53112, -84.22354
Thomas	Suwanee	450 Woodward Way	43.66298, -79.36749
Thomas	Tucker	2201 Moon Street	33.84967, -84.22587
Thomas	Tyrone	185 Peggy Lane	33.49704, -84.58248
Thomas	Charlotte	3701 N.Graham Street	35.26784, -80.81737
Thomas	Fuquay Varina	140 Pamela Drive	36.04403, -78.77859
Thomas	Knightdale	507 Old Montague Lane	35.80120, -78.50535
Thomas	Morrisville	220 International Drive	35.83819, -78.82228
Thomas	West Street	1131 N.West Street	41.00035, -73.72858
Thomas	Anderson	124 Moats Fowler Rd.	34.50723, -82.75644
Thomas	Bluffton	28 Benton Field Road	43.70869, -79.47113

Thomas	*Columbia*	*1701 Peeples Street*	*34.06334, -81.05313*
Thomas	*Conway West*	*3442 Mount Pisgah Cemetery Rd.*	*33.92041, -79.05240*
Thomas	*Fountain Inn*	*180 Industrial Boulevard*	*43.71060, -79.35487*
Thomas	*Greenville*	*719 Worley Road*	*34.88108, -82.338991*
Thomas	*Myrtle Beach*	*202 Yeager Avenue*	*33.79148, -78.99017*
Thomas	*N. Charleston*	*1067 Lincoln Avenue*	*33.79735, -79.02593*
Thomas	*Powdersville*	*105 Piedmont Road*	*33.70856, -78.92686*
Thomas	*Spartanburg-New Cut*	*520 State Rd 771*	*34.99167, -82.01308*