General Application

(The General Application applies to everyone, all applicants should complete this)

Company or organization name

VAULTED ORGANICS (“VAULTED”) which will be created to hold two current entities, Advantek Cavern Solutions LLC and GeoEnvironment Technologies LLC)

Company or organization location (we welcome applicants from anywhere in the world)

Houston, Texas

Name of person filling out this application

Omar Abou Sayed

Email address of person filling out this application

[redacted]

Brief company or organization description

<10 words

Scaled carbon removal through geologic sequestration of organic waste

1. Overall CDR solution (All criteria)

a. Provide a technical explanation of the proposed project, including as much specificity regarding location(s), scale, timeline, and participants as possible. Feel free to include figures and system schematics.

<1500 words

VAULTED is building the platform to geologically sequester carbon-filled organic waste at scale. Our sequestration technology allows us to safely inject a range of organic waste streams (biosolids, primary sludge, manure, agricultural waste, or inedible food waste) into subsurface formations. We put carbon back underground, permanently (1,000+ years).

We inject *under-utilized* organic wastes, preventing GHG emissions from the specific waste tons that would have unnecessarily decomposed. Organic wastes are plentiful – 500B+ tons produced annually in the US alone, with >45% of that waste already formally captured and aggregated. VAULTED is leveraging the massive legacy investments already made to capture & aggregate carbon: our sewage systems, manure troughs, agricultural supply chains, and landfill waste management systems. We estimate the total net carbon removal potential across our organic waste streams to be 55 megatons per year in the US, and ~3.7 gigatons per year globally. Abundance aside, that unused organic waste also has meaningful carbon content (on average, raw waste is ~33% CO_2e), and is relatively cheap.

Our magic is in our suite of patented, proprietary geologic sequestration technologies, which leverage injection wells to sequester organic waste in subsurface formations permanently. Unlike other sequestration technologies, we can inject solid-heavy slurries without plugging wells by creating or dilating fissures in the injection interval, or accessing other subsurface cavern-like spaces. This means the ability to sequester organic waste with little to no processing, making our solution highly efficient and the carbon removed ~98% negative.

VAULTED is in the early days of building a geologic carbon sequestration platform that permanently removes 10 million tons of carbon, annually, by 2040 (~1,000 operational wells). This scale will be realized through our platform model – we'll partner with a variety of large industrial players who produce organic waste, and set up a network of wells across the country to efficiently sequester it. This can be done efficiently at scale – for reference, there are more than 170,000 injection wells in the US alone. We've been conducting a full scale demonstration with the first of many partners, the city of Los Angeles (without carbon credits). That pilot has proven the technological efficacy of the system, but has shown that accelerating scale up requires carbon removal credits.

To rapidly scale carbon removal, VAULTED is reimagining the business model. Instead of being one of several companies getting paid to manage municipal waste, with CDRs we can flip the model – becoming a purchaser of raw organic waste to feed merchant facilities we'll develop to sequester carbon permanently. This business model innovation will allow us to scale faster by buying co-located land, permitting our own wells, and utilizing organic waste from various large industrial partners. However, it necessitates a reliance on carbon removal offsets for revenue in lieu of tipping fees.

VAULTED is making the leap from a niche experimental biosolid injection business to building the platform with the largest potential for rapid global carbon storage. With Stripe's purchase, we would open a new well (name: AM5) which would pilot the new platform model - aggregating and processing not only biosolids, but also manure and agricultural waste for additional, highly negative, carbon removal. AM5 was permitted Class V well as of February 2022 in Reno County, Kansas, and has a total well capacity of 225k tons of wet organic waste, equating to 35k tons of CO_2e sequestered.

Our feedstock: Underutilized organic waste

VAULTED will procure and sequester organic waste from across biosolids, sewage and septage, manure, food, and agricultural waste. Within each of those waste types, there are certain tons which are relatively useful; offsetting traditional fertilizer usage (manure) or producing bio-energy to offset fossil fuel usage (biomethane from anaerobic digesters). But within each waste type, there are also significant tonnage which do not serve a highly functional purpose – sent to landfills or left to unnecessarily rot, and thereby releasing carbon and methane into the atmosphere. VAULTED is selective in procuring the latter tons, ensuring that permanent carbon removal was the highest and best use for that specific ton of waste injected.

Biosolids

In the US today, 22% of biosolids are landfilled, 50% are land applied, and 16% are incinerated.While larger landfills are mandated to capture the methane emissions, estimates show ~34% of total methane generated by US landfills still escapes to the atmosphere. Biosolids ending up in landfills emit .46 - 1.48 tons of CO_2e / ton of dry biosolids. Biosolids that are incinerated can offset fossil fuel use through bio-energy, but still contribute .49 tons CO_2e / ton dry solids. Biosolids that are land applied can be used to offset traditional fertilizer needs, but still emit .12-.28 CO_2e tons/ dry ton of biosolids.

Manure

In the US today, 5% of manure is landfilled, 8% goes through AD (anaerobic digestion), and 88% is land applied. The landfill manure, as with biosolids, generates methane & CO_2 from the ~34% of GHGs which are emitted (not captured). Most large animal operations store manure prior to application, in pits and lagoons, posing environmental risks from seepage, flooding, or catastrophic failure (example: 110 pig lagoons released waste into the environment after Hurricane Florence). While manure can be used to offset traditional fossil fuel fertilizer use, there are challenges to that in scaled practice. The USDA issued a report to congress citing that "opportunities for widespread manure substitution [of fertilizer] are limited". Manure is less nutrient dense than traditional fertilizer and is inhomogeneous, making it hard for farmers to adopt as a replacement – not having the precise combination of nutrients needed for specific crops and fields. Given its relatively low nutrient value, it is currently not economical for farmers to transport the manure more than ~20 miles. As commodity production is becoming more specialized, feedlots and crop growing is increasingly segregated and distant. Thus, in areas with large feedlots, localized excess manure poses a challenge - manure is applied at a rate that far exceeds the land's capability to absorb it. That causes excess nutrient runoff, contaminating local water streams and leading to dead zones. Because we can co-locate our wells with large feedlots, we can leverage the excess manure, minimizing the harmful runoff effects. We would not source tons of manure scheduled for AD, given its biogas potential use. In these cases, we would instead source the residual undigestible carbon (equivalent to the biosolids which remain post digestion at sewage treatment plants).

Food waste

In the US, 28% of *all food*, and 56% of food waste ends up in a landfill. That equates to 40 billion tons of food waste that ends up in US landfills yearly, generating massive methane emissions. That food waste decomposes in the landfill, where it, once again, emits methane and CO_2 from the ~35% of the gas not captured.

Ag Waste

Globally, 140B tons of waste biomass is produced annually. Certain crops, specifically rice straw, sugar cane bagasse, and corn stover are produced at scale but have little value for energy production. Only 20% of rice straw is estimated to be commercially used. In general, they are commonly burned in the field or left to rot. We would target this collected but unused waste biomass, not the tonnage used for BECCs (bio energy and carbon capture).

All of the above lifecycle analysis was for the US. If we look globally, especially to developing countries, the additionality of our solution becomes even more clear, as even a smaller percentage of organic waste is recycled by industry. This speaks to the large potential of organic waste sequestration globally, as well as the cumulative additionality of the solution.

Our first organic waste pilot well: Los Angeles

Our first full-scale pilot facility named TIRE (Figure 1), situated in the city of Los Angeles, has been operational since 2008 in the Terminal Island Wastewater Recycling Plant. The wells are permitted as Class V (experimental), and have been used exclusively for piloting biosolids sequestration. The facility has allowed us to test and hone the geologic sequestration technology on our first organic waste stream, proving efficacy and safety of the technology while contributing substantially to groundwater protection, odor reduction, and elimination emissions related to drying, hauling, and decomposition of biosolids that would otherwise be land applied.

Our full scale pilot project currently takes <15% of Los Angeles's biosolid waste (without carbon offset monetization), proving our technology's ability to operate. However, we have been unable to meaningfully increase our volume allocation or site count due several competing considerations. Within LA, cost has historically been a factor – legacy disposal options were fully depreciated, resulting in lower fully burdened costs despite higher marginal costs (though we are now fully competitive on a price per ton basis) – but there are other political and structural impediments to scaling permanent waste sequestration. That the incentives for municipalities are not designed to pursue permanent carbon sequestration. Rather, they are focused on attempting to reuse organic waste and on allocating volume to numerous vendors to diversify risk. Moreover, larger municipalities often use large EPC firms to create their organic waste strategies, and these EPCs aren't incentivized to deploy ultra-low capex technologies. (Additionally, cities' costs of capital are low, which enables a biasing towards high capex technologies). New technologies also face hurdles in being adopted by municipalities who face political and institutional hesitancy to "be the one that goes first." That the city of LA overcame these barriers is noteworthy and should be celebrated as a model for other cities as they consider their ESG and climate pledges.

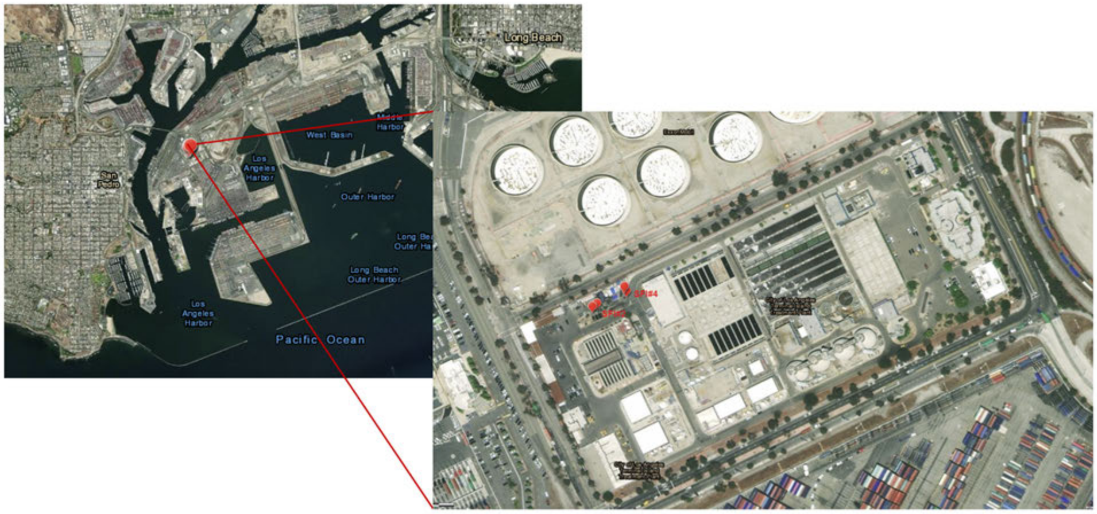


Figure 1. TIRE Project Location

The TIRE Facility in LA has been permitted since November 2006 by EPA as a Class V Experimental municipal biosolids waste injection facility. Injection operations commenced in July 2008. Today, 205 metric tons per operating day of equivalent wetcake biosolids are injected on average into a single well.

For biosolids injection, the slurry is prepared by mixing sewage, sludge, brine, and/or biosolids. Once the influent screening from the sewer lines is done at the headworks (removing inorganic materials such as rags, plastics, stones, etc.), the sewage is technically able to be slurrified. (In LA, though we are allowed more by permit, we typically only inject organics in the form of biosolids). Sourcing organics as close to the headworks as possible reduces the emission of harmful gasses (such as Nitrous oxide, methane, hydrogen sulfide, and carbon dioxide associated with each stage of sewage treatment while ensuring the most carbon is available for sequestration.

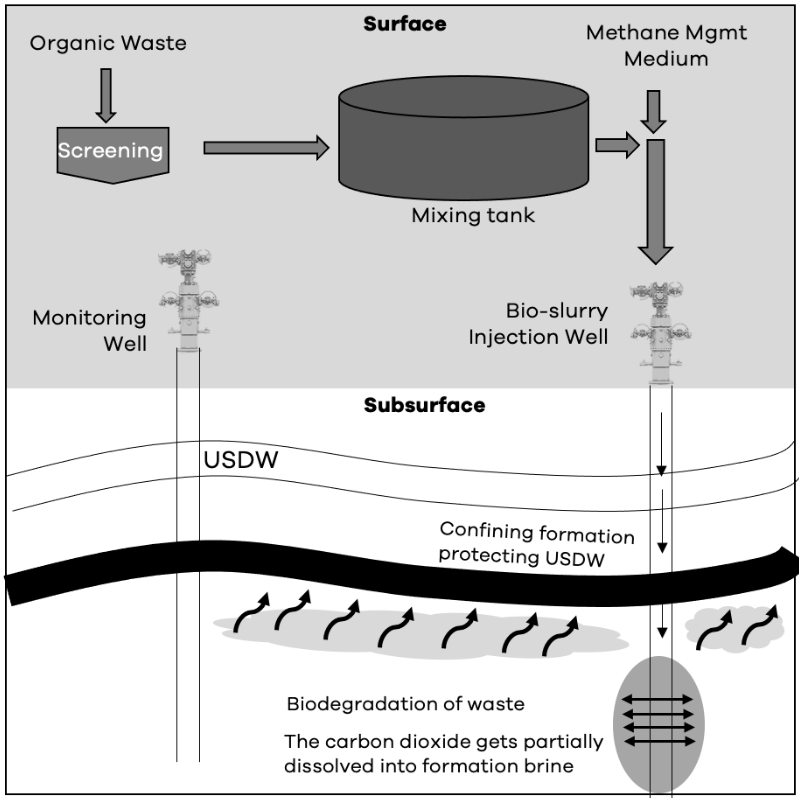


Figure 2. Biosolids Injection Process

As at TIRE, a biosolids injection facility can be co-located within the boundaries of the Wastewater Treatment Facility (WWTF) due to its small area requirement, typically less than a half acre of surface when co-located. The sludge and biosolids produced in the WWTF can be injected within its premises. Containment of the injected fluid at TIRE has been demonstrated through advanced pressure analysis, fiber optic temperature monitoring, well logging, and microseismic monitoring. As of February 2022, TIRE facility has safely injected 445,000 MT of biosolids, avoiding a total of 1 Million MT CO2e (considering methane factor for 100 years).

The standalone carbon removal well: AM5 (Kansas)

We plan to open a new permitted Class V well, AM5, to pilot the broader carbon-removal platform model. AM5 targets to bring in biosolids (25%), manure (50%), as well as agricultural waste (25%) streams, process them, and sequester them permanently. One of a group of nearly 60 salt caverns in Reno County, Kansas that we control, AM5 has a total well capacity of 225k tons of wet organic waste, equating to 35k tons of CO2e sequestered. Across all our caverns, the site has a total capacity of 3.4 million tons of wet organic waste.

In Kansas, we will not only pilot new organic waste streams, but also undertake additional research to pilot methane production prevention techniques subsurface (details in 2d).

In AM5, the organic waste will be mixed with saturated brine and injected through the inner tubing string into the open hole cavern space, brine from within the cavern will then be displaced and circulated to the surface between the inner tubing and casing (Figure 3).

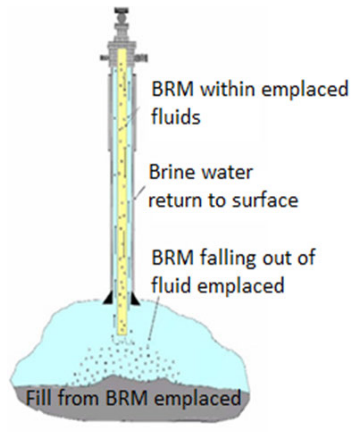


Figure 3. Kansas emplacement process

b. What is your role in this project, and who are the other actors that make this a full carbon removal solution? *(E.g. I am a broker. I sell carbon removal that is generated from a partnership between DAC Company and Injection Company. DAC Company owns the plant and produces compressed CO_2. DAC Company pays Injection Company for storage and long-term monitoring.)*

<50 words

VAULTED provides permanent and secure storage in subsurface formations for organic waste. We partner with organic waste producers (waste water reclamation plants, farms, landfills, etc.) to procure the waste, but plants do the job of initially capturing the carbon upstream. We operate the facility and monitor real-time injection operations.

c. What are the three most important risks your project faces?

<300 words

While we operate an experimental biosolids injection operation today, there are key risks we need to manage to build a scaled carbon storage platform company:

1) The overall CDR market growth. We have a carbon removal technology that has the ability to scale rapidly, removing 1M tons of CO2e annually by 2030. The market today for high quality, permanent, carbon removal is quite small (<3% of a $1B voluntary carbon market), and buyers spend on average less than <$10/ton. To be able to scale our carbon removal, the willingness to pay from corporate buyers must substantially increase on both a $/ton and a tonnage basis.

2) Ability to permit new facilities close to source materials. Adoption of many carbon removal technologies assumes the ability to permit new injection wells, with such permitting requiring public acceptance. In the case of urban WWTPs, it may be challenging to permit new wells.

3) Technical risk on handling new waste streams. We will need to adapt our waste pretreatment methods to handle contaminants in new waste streams, including handling pathogens (as would be found in raw sewage and septage) and fibers (as would be prevalent in manures and some inedible food waste).

d. If any, please link to your patents, pending or granted, that are available publicly.

- Method for biosolid disposal and methane generation (US06,409,650) (expired)
- Slurrification and Disposal of Waste by Pressure Pumping into a Subsurface Formation (US10,633,953, US11,078,757)
- Quantifying a Reservoir Volume and Pump Pressure Limit (US10,578,766)
- Optimizing Waste Slurry Disposal in Fractured Injection Operations (US10,975,669, 11,156,063)

We have three additional provisional patents pending related to organic or CO2 waste injection, along with numerous foreign equivalents issued and pending related to the above.

e. Who's the team working on this? What's your team's unfair advantage in building this solution? What skills do you not yet have on the team today that you are most urgently looking to recruit?

<300 words

Our unfair advantage is in our deep expertise in the science of injecting solids laden fluids. This expertise is built upon more than 40 years of patented, published, and proprietary knowledge deriving from experience injecting slurries in other contexts. The core techniques were developed in the mid-1980's by, among others, Dr. Ahmed Abou-Sayed, the co-founder of VAULTED's parent company, Advantek Waste Management Services (Advantek). Historically, it was mainly used to sequester waste arising from the drilling of hydrocarbon exploration and production wells.

VAULTED has been utilizing the technology in our full scale pilot project in LA for over a decade. Advantek's 60+ full time and contracted employees already have the operational and technical experience to operate the technology at scale. Besides our CEO, Omar Abou-Sayed, the management team includes experts in developing, operating, and monitoring injection wells. Together, we have the vision to drive this technology in a new direction, this time to catalyze massive climate impact. Omar has more than 20 years of experience founding and growing companies in heavy industry, and the management team includes key other international experts in the field of slurry and fluid injection. Our networks and prior experience position us to secure large industrial partners to scale the platform.

To realize our larger carbon removal platform vision, VAULTED is looking to hire business developers in each organic waste category (manure, food, agriculture, etc) to help us secure partnerships, and scale our carbon procurement.

2. Timeline and Durability (Criteria #4 and Criteria #5)
    a. Please fill out the table below.

	Timeline for Offer to Stripe
Project duration *Over what duration will you be actively running your DAC plant, spreading olivine, growing and sinking kelp, etc. to deliver on your offer to Stripe? E.g. Jun 2022 - Jun 2023. The end of this duration determines when Stripe will consider renewing our contract with you based on performance.*	*<10 words* June 2022 - Dec 31 2023 (AM5)
When does carbon removal occur? *We recognize that some solutions deliver carbon removal during the project duration (e.g. DAC + injection), while others deliver carbon removal gradually after the project duration (e.g. spreading olivine for long-term mineralization). Over what timeframe will carbon removal occur?* *E.g. Jun 2022 - Jun 2023 OR 100 years.*	*<10 words* Sept 31 2022 - Dec 31 2023
Distribution of that carbon removal over time *For the time frame described above, please detail how you anticipate your carbon removal capacity will be distributed. E.g. "50% in year one, 25% each year thereafter" or "Evenly distributed over the whole time frame". We're asking here specifically about the physical carbon removal process here, NOT the "Project*	*<50 words* 16% in 2022 (Q4) 84% in 2023 (full year)

duration". Indicate any uncertainties, eg "We anticipate a steady decline in annualized carbon removal from year one into the out-years, but this depends on unknowns re our mineralization kinetics".	Directly scales with tons injected (ramps up as we secure more waste partners)
Durability *Over what duration you can assure durable carbon storage for this offer (e.g, these rocks, this kelp, this injection site)? E.g. 1000 years.*	*<10 words* 1,000+ years

b. What are the upper and lower bounds on your durability claimed above in table 2(a)?

1,000+ years to hundreds of millions of years

c. Have you measured this durability directly, if so, how? Otherwise, if you're relying on the literature, please cite data that justifies your claim. *(E.g. We rely on findings from Paper_1 and Paper_2 to estimate permanence of mineralization, and here are the reasons why these findings apply to our system. OR We have evidence from this pilot project we ran that biomass sinks to D ocean depth. If biomass reaches these depths, here's what we assume happens based on Paper_1 and Paper_2.)*

<200 words

We have directly measured and simulated the durability of our own wells to know the minimum durability of our sequestration technology. We rely on external literature to understand the upper bounds on possible durability.

For measurement of our own wells, a compositional reservoir simulator is used to predict the injectate plume growth over a selected period of time for . We performed simulations for up to 1000 years after shut-in, showing that CO_2 remains confined into the injection formation. In addition to simulation, we do measurements at every stage of the operation.

After drilling the injection well, core analysis was conducted and confirmed the presence of the containment layer - impermeable shale, which prevents vertical upward migration. Additionally, petrophysical wireline log was conducted and analyzed to confirm well integrity and verified that no fissures are created in the containment shale. The diffusion coefficient of CO_2 (and methane) are exceedingly low through shale, enabling functionally permanent sequestration provided the wellbore itself has integrity or, after its useful life, is properly plugged. In our salt caverns, the salt is impermeable and exists at a depth where it is no longer buoyant. Thus, so long as our wells have integrity or, after their useful lives, are property plugged, we can ensure essentially permanent sequestration.

On a daily basis, we have continuous temperature measurements that confirm the vertical containment of the injectate plume within the injection formation. Every month, a pressure fall-off test is conducted and analyzed to confirm the confinement of the injectate plume at the far-field region (no communication with a leaky fault or an offset well). Every quarter, we simulate the injectate plume and confirm the growth by matching pressure in the monitoring wells. This technique helps us confirm the lateral extent of the injectate plume.

The broader literature gives us an idea of what the duration could be. Simulations of CO2 geological injection finds durability of 10,000+ years, while modeled diffusion of CO2 or methane under thick shales suggests ~12 million years of durable storage.

d. What durability risks does your project face? Are there physical risks (e.g. leakage, decomposition and decay, damage, etc.)? Are there socioeconomic risks (e.g. mismanagement of storage, decision to consume or combust derived products, etc.)? What fundamental uncertainties exist about the underlying technological or biological process?

<200 words

GHGs can be produced underground through decomposition. The evidence we have of GHGs generated at TIRE indicate that our design and monitoring precautions successfully prevent any leakage. Indeed, CO2 dissolves into formation brine at reservoir conditions, while methane is immobilized within the pore space where generated until there is sufficient aggregated methane to overcome the residual gas saturation (a criteria is unlikely to have been at TIRE based on our monitoring and confirmed by reservoir modeling).

However, external shocks (such as an earthquake) could occur, which could open pathways for mobile GHGs to surface. To precaution against this, VAULTED will undertake R&D into reducing or immobilizing GHGs generated underground.

We will spend the first 3 months of the project, pre-injection, exploring actions that could reduce subterranean GHG production including:

- Flushing using saline brines available from onsite RO processes which can arrest bacterial activity
- Seeding the reservoir with anaerobic methanotrophic bacteria to consume methane
- Where possible, eliminating the traditional addition of bacteria from the sludge treatment processes to reduce upstream emissions and underground GHG production
- Catalyzing reactions to convert underground GHGs into a liquid form (e.g. using iron).

Once injection starts, we will closely study the actual GHG production of the AM5 well to see how it differs from the L.A. site - we predict that due to the high concentration of salt in AM5, significantly less GHG will form in the cavern.

e. How will you quantify the actual permanence/durability of the carbon sequestered by your project? If direct measurement is difficult or impossible, how will you rely on models or assumptions, and how will you validate those assumptions? *(E.g. monitoring of injection sites, tracking biomass state and location, estimating decay rates, etc.)*

<200 words
 	
We can and will directly measure the CO2 sequestered in our wells. We currently utilize multiple measurement techniques:
 	
1. At our Kansas cavern, pressure gauges at the injection wells and monitoring wells on the facility boundary allow us to ensure no material escapes the caverns. We will regularly conduct sonar surveys within the cavern wells to understand remaining capacity and to ensure injected materials are accounted for.
2. In non-cavern reservoirs such as LA, we use a combination of indirect techniques to ensure the wellbore maintains integrity and the confining layer is not breached. These techniques include:
    a. Temperature logs to confirm injected material is confined in the target zone
    b. Advanced pressure fall off analysis which helps identify the reservoir boundaries and confirm they do not change during the injection period, as well as the extent of the inner and outer mobility zones (which can measure plume size).
    c. Reservoir simulation which predicts pressure distribution, residual gas saturation threshold, and plume extent, which we can history match with pressures derived from our injection, fall off tests, and at our monitoring wells.

3. Gross Capacity (Criteria #2)

   a. Please fill out the table below. All tonnage should be described in metric tonnes here and throughout the application.

	Offer to Stripe (metric tonnes CO_2) over the timeline detailed in the table in 2(a)
Gross carbon removal Do not subtract for embodied/lifecycle emissions or permanence, we will ask you to subtract this later	*E.g. XXX tCO_2* 9,506 tons of CO2e
If applicable, additional avoided emissions e.g. for carbon mineralization in concrete production, removal would be the CO_2 utilized in concrete production and avoided emissions would be the	*E.g. XXX tCO_2* 10,247 tons of CO2e (considering methane factor for 100 years)

emissions reductions associated with traditional concrete production	

b. Show your work for 3(a). How did you calculate these numbers? If you have significant uncertainties in your capacity, what drives those? *(E.g. This specific species sequesters X tCO_2/t biomass. Each deployment of our solution grows on average Y t biomass. We assume Z% of the biomass is sequestered permanently. We are offering two deployments to Stripe. X*Y*Z*2 = 350 tCO_2 = Gross removal. OR Each tower of our mineralization reactor captures between X and Y tons CO_2/yr, all of which we have the capacity to inject. However, the range between X and Y is large, because we have significant uncertainty in how our reactors will perform under various environmental conditions)*

<150 words

- In 2022, we will sequester 1,361 tons of wet waste per month. In 2023, we will sequester 2,042 tons of wet waste per month. Total of 28,595 tons of wet waste sequestered under the project duration.
- The AM5 well will sequester a mix of organic waste types (25% biosolids, 25% pig manure, 25% cow manure, 25% agricultural waste)
- On average, the organic waste we sequester is 33.24% CO2e / ton of wet waste
- Multiplying out for 2022 + 2023:
    - 28,595 tons of wet waste x .3324% = 9,493 tons of CO2e

c. What is your total overall capacity to sequester carbon at this time, e.g. gross tonnes / year / (deployment / plant / acre / etc.)? Here we are talking about your project / technology as a whole, so this number may be larger than the specific capacity offered to Stripe and described above in 3(b). We ask this to understand where your technology currently stands, and to give context for the values you provided in 3(b).

 # metric tonnes CO_2/yr

The AM5 well alone could sequester a total of 122,577 tons of wet organic waste. With the same carbon % as above, that would equate to 40,750 tons of carbon sequestered in AM5 over its 4 year injection life (average of 10,187 tons of CO2e/year).

In addition to AM5, VAULTED controls another 50+ caverns of similar size.

d. We are curious about the foundational assumptions or models you use to make projections about your solution's capacity. Please explain how you make these estimates, and whether you have ground-truthed your methods with direct measurement of a real system (e.g. a proof of concept experiment, pilot project, prior deployment, etc.). We welcome citations, numbers, and links to real data! *(E.g. We assume our sorbent has X absorption rate and Y desorption rate. This aligns with*

[Sorbent_Paper_Citation]. Our pilot plant performance over [Time_Range] confirmed this assumption achieving Z tCO_2 capture with T tons of sorbent.)

<200 words

As the AM5 well site is secured and permitted, we know the wet waste tonnage capacity outright. However, we make two foundational assumptions to calculate our overall CO2e tonnage capacity from the well.

1) The carbon content of organic waste streams. We currently source from external literature the carbon content of each organic waste stream – biosolids, primary sludge, agricultural waste, pig & cow manure, and food waste. While this gives a solid estimate of the CO2e capacity, organic waste streams are inhomogeneous. We will thus have to directly measure the specific carbon content of tonnage from each waste partner to ensure correct specific measurement.
2) Our ability to secure organic waste at scale. We will need to forge new, robust partnerships with a variety of organic waste producers to be able to scale our carbon removal. We have budgeted for this a premium $ / ton for each waste type to ensure we can secure the needed tonnage of organic waste.

e. Documentation: If you have them, please provide links to any other information that may help us understand your project in detail. This could include a project website, third-party documentation, project specific research, data sets, etc.

- *http://www.geoenvtech.com/*
- *Microsoft PowerPoint - 19winter-o.sayed.pptx (nacwa.org)*
- *An Economic, Technical And Environmental Feasibility Study ... (environmental-expert.com)*

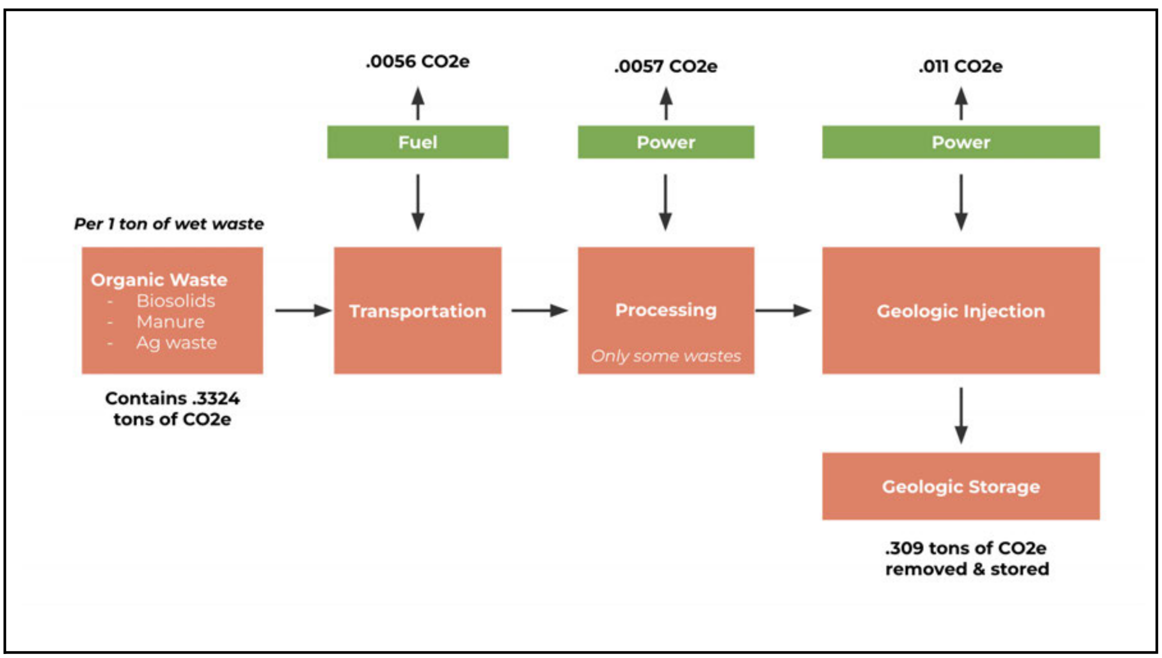
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

a. Please fill out the table below to help us understand your system's efficiency, and how much your lifecycle deducts from your gross carbon removal capacity.

	Offer to Stripe (metric tonnes CO_2)
Gross carbon removal	*Should equal the first row in table 3(a)* 9,506 tons of CO2e

Gross project emissions	*Should correspond to the boundary conditions described below this table in 4(b) and 4(c)* 198 tons of CO2e
Emissions / removal ratio	*Gross project emissions / gross carbon removal: should be less than one for net-negative carbon removal systems, e.g. the amount emitted is less than the amount removed* 2.09%
Net carbon removal	*Gross carbon removal - Gross project emissions* 9,308 tons CO2e

b. Provide a carbon balance or "process flow" diagram for your carbon removal solution, visualizing the numbers above in table 4(a). Please include all carbon flows and sources of energy, feedstocks, and emissions, with numbers wherever possible *(E.g. see the generic diagram below from the CDR Primer, Charm's application from 2020 for a simple example, or CarbonCure's for a more complex example).* If you've had a third-party LCA performed, please link to it.



c. Please articulate and justify the boundary conditions you assumed above: why do your calculations and diagram include or exclude different components of your system?

<100 words

- We do not include any emissions for the raw organic waste itself. That waste would have been produced with or without VAULTED, and was a waste product of complex yet essential upstream systems.
- We did not include any emissions associated with subsurface GHG management we might pursue. We could not get comfortable with an estimate given its early stage of R+D, but estimate it would not be a significant contributor to the overall emissions of the system.
- We did include: Transportation fuel emissions, processing energy emissions (for certain waste types, not biosolids), and injection energy emissions

d. Please justify all numbers used in your diagram above. Are they solely modeled or have you measured them directly? Have they been independently measured? Your answers can include references to peer-reviewed publications, e.g. Climeworks LCA paper.

<200 words

- We have directly measured the energy demand of geologic sequestration through our current wells in LA and Kansas. We assume this energy demand to be relatively consistent across waste types.
- We have modeled the carbon content of the organic waste types (see paper links below). We do note that organic waste carbon % can vary even within the waste type. We will undertake direct measurement of carbon in the organic waste upon starting sequestration.
- We have estimated fuel usage based on type of waste and its approximate distance from the AM5 well (mapping out volume of organic waste producers and their respective distances from the well).
- We have modeled the energy emissions of processing certain types of waste, but these are rougher estimates, and part of the R+D will be better understanding the exact processing needs of each new waste stream.
- Full calculation here:

1	**Production Step per Waste Type**						
			Use Rate	**Unit**	**LCI Data**	**Unit**	**Emissions (ton CO2 / ton waste)**
		Biosolids	1	ton waste / ton waste	0	ton co2/ton wa	0
		Raw Sewage	1	ton waste / ton waste	0	ton co2/ton wa	0
		Pig Manure	1	ton waste / ton waste	0	ton co2/ton wa	0
		Cow Manure	1	ton waste / ton waste	0	ton co2/ton wa	0
		Ag Waste	1	ton waste / ton waste	0	ton co2/ton wa	0
		Food Waste	1	ton waste / ton waste	0	ton co2/ton wa	0
2	**Transportation**						
	Fuel Efficiency		150	ton miles / gallon			
	Distance	Biosolids	100	miles			
		Raw Sewage	100	miles			
		Pig Manure	50	miles			
		Cow Manure	50	miles			
		Ag Waste	75	miles			
		Food Waste	75	miles			
	Fuel Consum	Biosolids	0.6666666667	gallons / ton of waste	10.16	kg CO2/gallon	0.0074678427
		Raw Sewage	0.6666666667	gallons / ton of waste	10.16	kg CO2/gallon	0.0074678427
		Pig Manure	0.3333333333	gallons / ton of waste	10.16	kg CO2/gallon	0.0037339213
		Cow Manure	0.3333333333	gallons / ton of waste	10.16	kg CO2/gallon	0.0037339213
		Ag Waste	0.5	gallons / ton of waste	10.16	kg CO2/gallon	0.0056008820
		Food Waste	0.5	gallons / ton of waste	10.16	kg CO2/gallon	0.0056008820
2	**Processing**	Biosolids	0	MJ/ton of waste	102.5	g CO2/MJ	0
		Raw Sewage	0	MJ/ton of waste	102.5	g CO2/MJ	0
		Pig Manure	50	MJ/ton of waste	102.5	g CO2/MJ	0.0056493438
		Cow Manure	50	MJ/ton of waste	102.5	g CO2/MJ	0.0056493438
		Ag Waste	48.6	MJ/ton of waste	102.5	g CO2/MJ	0.005491162222
		Food Waste	150	MJ/ton of waste	102.5	g CO2/MJ	0.01694803155
3	**Injection**						
		Electric Power	102	MJ/ton of waste	102.5	g CO2/MJ	0.01152466145

4 **Storage**					
Biosolids	Waste Solids Content	28%	ton solids / ton waste		
	Dry Waste Carbon Con	34%	ton C / ton waste dry		
	Waste Carbon Content	9.55%	ton C / ton waste		
	Molar Mass CO2	0.44	g/mol		
	Molar Mass Carbon	0.12	g/mol	-0.351	
				-0.332	Total Carbon Removed
				0.0541	Negativity Ratio
Raw Sewage	Waste Solids Content	28%	ton solids / ton waste		
	Dry Waste Carbon Con	37%	ton C / ton waste dry		
	Waste Carbon Content	10.36%	ton C / ton waste		
	Molar Mass CO2	0.44	g/mol		
	Molar Mass Carbon	0.12	g/mol	-0.381	
				-0.362	Total Carbon Removed
				0.0499	Negativity Ratio
Pig Manure	Waste Solids Content	20%	ton solids / ton waste		
	Dry Waste Carbon Con	41%	ton C / ton waste dry		
	Waste Carbon Content	8.26%	ton C / ton waste		
	Molar Mass CO2	0.44	g/mol		
	Molar Mass Carbon	0.12	g/mol	-0.303	
				-0.283	Total Carbon Removed
				0.0503	Negativity Ratio
Cow Manure	Waste Solids Content	15%	ton solids / ton waste		
	Dry Waste Carbon Con	35%	ton C / ton waste dry		
	Waste Carbon Content	5.19%	ton C / ton waste		
	Molar Mass CO2	0.44	g/mol		
	Molar Mass Carbon	0.12	g/mol	-0.191	
				-0.170	Total Carbon Removed
				0.0800	Negativity Ratio
Ag Waste	Waste Solids Content	24%	ton solids / ton waste		
	Dry Waste Carbon Con	55%	ton C / ton waste dry		
	Waste Carbon Content	13.20%	ton C / ton waste		
	Molar Mass CO2	0.44	g/mol		
	Molar Mass Carbon	0.12	g/mol	-0.485	
				-0.451	Total Carbon Removed
				0.0353	Negativity Ratio
Food Waste	Waste Solids Content	18%	ton solids / ton waste		
	Dry Waste Carbon Con	51%	ton C / ton waste dry		
	Waste Carbon Content	8.96%	ton C / ton waste		
	Molar Mass CO2	0.44	g/mol		
	Molar Mass Carbon	0.12	g/mol	-0.329	
				-0.312	Total Carbon Removed
				0.0520	Negativity Ratio

e. If you can't provide sufficient detail above in 4(d), please point us to a third-party independent verification, or tell us what an independent verifier would measure about your process to validate the numbers you've provided.

<100 words

Links to papers on carbon content across waste types:

- https://www.tandfonline.com/doi/abs/10.1080/00103624.2013.744150
- https://www.researchgate.net/figure/Proximate-and-Ultimate-Composition-of-Agricultural-Wastes_tbl1_332091010
- https://www.researchgate.net/figure/Dry-matter-and-carbon-content-of-manure_tbl1_225385126

5. Learning Curve and Costs (Backward-looking) (Criteria #2 and #3)

We are interested in understanding the learning curve of different carbon removal technologies (i.e. the relationship between accumulated experience producing or deploying a technology, and technology costs). To this end, we are curious to know how much additional deployment Stripe's procurement of your solution would result in. (There are no right or wrong answers here. If your project is selected we may ask for more information related to this topic so we can better evaluate progress.)

a. Please define and explain your unit of deployment. *(E.g. # of plants, # of modules)*

<50 words We measure deployments in terms of (a)

# of wells (actively injecting waste)

b. How many units have you deployed from the origin of your project up until today? Please fill out the table below, adding rows as needed. Ranges are acceptable.

Year	Units deployed (#)	Unit cost ($/unit)	Unit gross capacity (tCO_2/unit)	Notes
2008	1	$10M	1.4M tCO2e	L.A. site, biosolids only

c. Qualitatively, how and why have your deployment costs changed thus far? *(E.g. Our costs have been stable because we're still in the first cycle of deployment, our costs have increased due to an unexpected engineering challenge, our costs are falling because we're innovating next stage designs, or our costs are falling because with larger scale deployment the procurement cost of third party equipment is declining.)*

<50 words

Costs declined significantly at greater daily volumes. Sites have high fixed opex but low marginal costs. Once daily fixed costs are covered, incremental tons enjoy margins >90%. Similarly, capex includes expensive fixed components (the surface facility) but low incremental capital to add capacity (by adding wells). Thus, economics improve with high + regular volumes.

d. How many additional units would be deployed if Stripe bought your offer? The two numbers below should multiply to equal the first row in table 3(a).

# of units	Unit gross capacity (tCO_2/unit)
Number	*# tCO_2/unit*

1	9,506 tons of CO2e

6. Cost and Milestones (Forward-looking) (Criteria #2 and #3)

We are open to purchasing high cost carbon removal today with the expectation the cost per ton will rapidly decline over time. We ask these questions to get a better understanding of your potential growth and the inflection points that shape your cost trajectory. There are no right or wrong answers, but we would prefer high and conservative estimates to low and optimistic. If we select you for purchase, we'll expect to work with you to understand your milestones and their verification in more depth. If you have any reservations sharing the information below in the public application format, please contact the Stripe team.

a. What is your cost per ton of CO_2 today?

\$/ton CO_2 \$291 / ton CO2e

b. Help us understand, in broad strokes, what's included vs excluded in the cost in 6(a) above. We don't need a breakdown of each, but rather an understanding of what's "in" versus "out." Consider describing your CAPEX/OPEX blend, non-levelized CAPEX costs, assumptions around energy costs, etc.

<100 words Included in our costs: - Cost of raw waste (~45%) - Transportation, processing & injection (~11%) - Operations & maintenance (~25%) - R&D (methane management and adapting new waste sources) (~6%) - SG&A (insurance, administration, etc) (~6%) - Depreciation (~7%)

c. How do you expect your costs to decline over time? Specifically, what do you estimate your cost range will be as you reach megaton and then gigaton scale? We recognize that at this point, these are speculative and directional estimates, but we would like to understand the shape of your costs over time.

\$/ton CO_2 Megaton scale: \$131 / ton

Gigaton scale: $62 / ton

d. Where are the primary areas you expect to be able to achieve cost declines? E.g., what are the primary assumptions and sensitivities driving your cost projection? What would need to be true for a long-term cost of <$100/ton to be achievable with your technology? (i.e., you are able to negotiate an x% reduction in CAPEX at scale and purchase renewable electricity at $y/kWh)

<300 words

Three main factors can drive our costs down to $62/ton as described above: (a) greater utilization at each facility, (b) greater scale overall, and (C) eliminated R&D costs. Labor costs / ton can be reduced by about 50% with greater utilization, and with greater scale, we can reduce labor content even more through a combination of investments in automation and through greater utilization of shared staffing (such as regional versus site managers). We also believe we can reduce energy spend through larger scale energy purchases, utilization of on-site generated power (solar or, where available, power generated from co-located biogas production), and through higher efficiency equipment. To achieve $62/ton, energy spend per ton would drop by ~1/5th. There are opportunities to reduce G&A / ton through greater scale and utilization. Furthermore, some of our depreciation is not related to throughput (e.g., wells where the limitation on useful life is related to age in the ground). Thus, at full capacity, our depreciation charges / ton drop substantially (by ~⅔). All of these efficiencies taken together deliver a reduction in our costs to the level of $62/ton of CO_2 removed.

e. In a worst case scenario, what would your range of cost per ton be? We've been doing a lot of purchasing over the past few years and have started to see a few pieces that have tripped people up in achieving their projected cost reductions: owned vs leased land, renewable electricity cost, higher vendor equipment costs, deployment site adjustments, technical performance optimization, supporting plant infrastructure, construction overruns, etc. As a result, we'll likely push on the achievability of the cost declines you've identified to understand your assumptions and how you've considered ancillary costs. We would love to see your team kick the tires here, too.

<300 words

Our worst case economically would be a site that was not co-located with an organic waste supplying facility and which was running below full capacity. This would then introduce inefficiencies in several areas such as (1) labor, due to the need for additional staff to handle truck offload and wash outs, (2) land, due to the need for greater onsite storage, driveways and truck offload facilities, and land lease / acquisition costs, and (3) repair, maintenance, and utilities, due to the need to power and maintain the additional equipment needed required to operate on a standalone basis. This case is basically our current near-term cost of $291, with some added buffer around costs of raw waste & processing, adding up to ~$360 / ton due to the accumulated effect of these diseconomies of scale.

f. List and describe up to three key upcoming milestones, with the latest no further than Q2 2023, that you'll need to achieve in order to scale up the capacity of your approach.

Milestone #	Milestone description	Why is this milestone important to your ability to scale? (200 words)	Target for achievement (eg Q4 2021)	How could we verify that you've achieved this milestone?
1	*<100 words* New waste streams secured (partnerships forged)	*<200 words* Critical to forge partnerships with number of organic waste producers in the well area to ensure can meet capacity needs.	Q3 2022	*<100 words* Signed LOIs or POs, # of organic waste tons delivered to AM5
2	*<100 words* New waste stream processing needs assessed	*<200 words* Will need to analyze new waste streams and understand specific processing demands (if any) of each type, to retire risk around capacity & energy usage.	Q4 2022	*<100 words* Actively injecting new waste streams, with direct measurement of respective CO_2 content & processing energy demand.
3	*<100 words* Generated GHG management R+D completed	*<200 words* Critical to de-risk durability of storage, which will indirectly enable scale through risk retirement.	Q3 2022	*<100 words* Direct subsurface methane / CO_2 measurement in AM5

i. How do these milestones impact the total gross capacity of your system, if at all?

Milestone #	Anticipated total gross capacity prior to achieving milestone (ranges are acceptable)	Anticipated total gross capacity after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)

1	*Should match 3(c)* 40,750 tons (over the entire 4 year life of the well)	40,750 tons	*<100 words* Capacity already assumes we can reach outlined scale through securing partnerships.
2	40,750 tons	40,750 tons	*<100 words* No direct effect on capacity
3	40,750 tons	40,750 tons	*<100 words* No direct effect on capacity

g. How do these milestones impact your costs, if at all?

Milestone #	Anticipated cost/ton prior to achieving milestone (ranges are acceptable)	Anticipated cost/ton after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)
1	*Should match 6(a)* $291/ton	$291/ton	*<100 words* $/ton already assumes we can reach outlined scale through securing partnerships.
2	$291/ton	$291/ton	*<100 words* May affect $/ton directly if more or less processing is needed than currently modeled. May go either direction, so leaving flat.
3	$291/ton	$291/ton	*<100 words* Does not change $/ton directly

h. If you could ask one person in the world to do one thing to most enable your project to achieve its ultimate potential, who would you ask and what would you ask them to do?

<50 words An existential risk to the CDR ecosystem is the nascent demand for (expensive-ish) carbon removal versus lower quality avoidance offsets. Thus, we'd ask the CEO of a large emitter, e.g., BP's Bernard Looney (Hi!), to purchase only removal credits to fulfill BP's Net Zero goal to create CDR demand and pressure other large emitters to follow.

i. Other than purchasing, what could Stripe do to help your project?

<50 words Beyond a (crucial) purchase, we would benefit from introductions to: 1. Carbon removal experts as we experiment around methane & new waste stream processing 2. Organic waste producers seeking offsets 3. Investors who align with our vision 4. Municipalities Stripe can influence to offer space and volume.

7. Public Engagement (Criteria #7)

In alignment with Criteria 7, Stripe requires projects to consider and address potential social, political, and ecosystem risks associated with their deployments. Projects with effective public engagement tend to do the following:

- Identify key stakeholders in the area they'll be deploying
- Have mechanisms to engage and gather opinions from those stakeholders and take those opinions seriously, iterating the project as necessary.

The following questions are for us to help us gain an understanding of your public engagement strategy and how your project is working to follow the White House Council on Environmental Quality's draft guidance on responsible CCU/S development. We recognize that, for early projects, this work may be quite nascent, but we are looking to understand your early approach.

a. Who have you identified as your external stakeholders, where are they located, and what process did you use to identify them? Please include discussion of the communities potentially engaging in or impacted by your project's deployment.

Generally, our stakeholders include the local injection well regulatory authority and other members of local government, nearby residents within the anticipated radius of injectate migration / influence, and the operator of the facility generating the injectate (i.e., the wastewater treatment plant, farm, etc.). We also work to identify other local environmental

groups with interest in the local ecosphere. For example, when our Los Angeles site was first permitted, in addition to our work with the US EPA Region 9 UIC office and the Bureau of Sanitation, the City and our predecessor entity conducted extensive outreach covering over 200 community activists, environmental leaders, NGO's, elected and appointed community leaders, regulatory officials, regulatory agencies with jurisdictions over the L.A.'s Bureau of Sanitation (above and beyond the USEPA), and academic researchers. Some of the NGO's who were part of this outreach included Santa Monica Bay Keeper (now WaterKeeper), Heal-the-Bay, LA Conservation Corp, and the Port Citizens Advisory Committee (since restructured under other advisory groups), as well as other larger groups such as the Sierra Club, NRDC, and the EDF. In addition, there were more than 53 site visit tours and community presentations including for the Neighborhood Councils (5). For our Kansas site, which is a more rural setting, we held outreach meetings and invited neighboring landowners, state and local representatives, and members of the staff of the Kansas Department of Health and Environment.

b. If applicable, how have you engaged with these stakeholders and communities? Has this work been performed in-house, with external consultants, or with independent advisors? If you do have any reports on public engagement that your team has prepared, please provide. *See Project Vesta's community engagement and governance approach as an example.*

In addition to and in advance of public hearings on pending permits, we have engaged through a combination of direct outreach, technical presentations in public fora, permit hearings, site tours, and publications in technical literature. We do as much as we can in house, though we do retain external advisors to assist as needed, particularly in more urban / larger jurisdictions.

c. If applicable, what have you learned from these engagements? What modifications have you already made to your project based on this feedback, if any?

Different stakeholders have different concerns ranging from: traffic and odors (neighbors), permit duration (wastewater operators), seismicity / groundwater contamination (environmental groups), and pace of scaling (investors). From this feedback, we (1) transitioned to a merchant facility strategy to decouple our pace of growth from the pace of municipal decision making, (2) secured from EPA greater clarity on the long term permit prospects of the solution (e.g., moving to 10 year permits in LA from 5), (3) developed a preference to site new facilities adjacent to existing injectate sources (to reduce trucking and total odors), and (4) reinforced our commitment to develop only those formations with the lowest risk of induced seismicity.

d. Going forward, do you have changes planned that you have not yet implemented? How do you anticipate that your processes for (a) and (b) will change as you execute on the work described in this application?

Our Kansas site is the first site developed under our merchant strategy, and, assuming success with this application, the first where CDRs will be integral with the go to market strategy. We will certainly learn as we engage with potential customers, particularly in how CDR economics may factor in their willingness to pay and their assessment of what to do with their organic waste. Future sites will benefit from the awareness of CDRs during the stakeholder engagement process, which we anticipate will facilitate much broader acceptance.

8. Environmental Justice (Criteria #7)

a. What are the potential environmental justice considerations, if any, that you have identified associated with your project? Who are the key stakeholders?

<100 words While our solution substantially reduces the sources of harm to neighboring communities from the production and disposal of organic wastes at incumbent facilities, there are key areas we focus on to minimize environmental justice concerns with our solution. Among these concerns are the risks of induced seismicity and groundwater contamination, and nuisances such as possible trucking of waste to our sites. The key stakeholders we focus on are residents of neighboring and nearby communities.

b. How do you intend to address any identified environmental justice concerns?

<300 words We address environmental justice concerns by (1) understanding and mitigating the risks of concern, and (2) communicating the net positives our solution brings to the local communities.

1) Where and when possible, we intend to site our facilities adjacent to the waste source facilities. This enables us to minimize the concerns related to trucking traffic and other nuisances. Moreover, by combining the highest standards for well construction, injection zone selection, and injection monitoring, we can bring the risks of groundwater contamination well below the risk from existing incumbent disposal facilities which, in the main, place / spray effluent onto land above groundwater and often deliberately volatilize (through aeration) organic compounds to the atmosphere.
2) The siting of customer facilities which are the sources of organic waste for our sites (and the incumbent landfills / sprayfields where these wastes are currently disposed), raise significant environmental justice concerns. Because our solution takes the organic effluent from these facilities and removes it from the biosphere, we also completely reduce odors associated with their aeration, the pathogens, pharmaceutical compounds, and forever chemicals (like bioaccumulating PFAS / PFOA). As such, our solution substantially reduces the potential harm caused to neighboring communities from the presence of these organic waste source facilities. We believe that it is imperative for waste source sites like wastewater treatment plants and large farms to take active steps to mitigate the harms they cause to the neighborhoods in which they operate, and adopting our solution furthers that aim.

9. Legal and Regulatory Compliance (Criteria #7)

a. What legal opinions, if any, have you received regarding deployment of your solution?

> *<100 words* We have already permitted our solution in two locations, Los Angeles, California and Hutchinson, Kansas. While not a legal opinion per se, the formal permits attest to the legality of our solution.

b. What domestic permits or other forms of formal permission do you require, if any, to engage in the research or deployment of your project? Please clearly differentiate between what you have already obtained, what you are currently in the process of obtaining, and what you know you'll need to obtain in the future but have not yet begun the process to do so.

> *<100 words* We possess all the permits required to inject sewage-derived organic wastes at our California facility, and organic wastes generally at our Kansas facility.
>
> At our Los Angeles facility, potential waste sources are limited by our permit to those sourced from certain municipalities. Should we wish to inject materials sourced from these other entities, we would seek the consent of the City.
>
> For new sites, facilities require at a minimum an injection permit (Class V). Sometimes air emissions permits and or permits for receiving pits are also required. Certain jurisdictions require compliance with zoning or local regulations, like California's CEQA.

c. Is your solution potentially subject to regulation under any international legal regimes? If yes, please specify. Have you engaged with these regimes to date?

> *<100 words* Our domestic sites are not subject to international legal regimes.
>
> When we choose to build new sites in other countries, we will need to confirm the permissibility of deep well injection of organic waste under local laws. For example, we have engaged with the Ministry of Environment for one country in the Middle East where we hope to install our solution to successfully confirm that local laws and regulations do not preclude our solution. Our founding team has significant experience working to gain acceptance of our solution with local regulators both within specific jurisdictions in the United States and internationally.

d. In what areas are you uncertain about the legal or regulatory frameworks you'll need to comply with? This could include anything from local governance to international treaties. For some types of projects, we recognize that clear regulatory guidance may not yet exist.

> *<100 words* The main area of uncertainty for our US deployments is whether states who have their own delegated UIC permitting program will choose to permit our technology using Class V wells or if they will see our technique as fitting within their Class I programs. Class I wells have certain limitations which preclude the injection of slurries with high solids content.

Recognizing the value of our technique, the federal EPA has determined to utilize Class V (experimental / pilot technology) well permits. However, states who hold their own delegated permitting authority may make a different determination, which can take time to overcome and slow down our deployment.

e. Has your CDR project received tax credits from any government compliance programs to-date? Do you intend to receive any tax credits during the proposed delivery window for Stripe's purchase? If so, which one(s)? (50 words)

<50 words We have not received tax credits from any such compliance programs. We do not expect to receive any government tax credits during the proposed delivery window.

10. Offer to Stripe

This table constitutes your offer to Stripe, and will form the basis of our expectations for contract discussions if you are selected for purchase.

	Offer to Stripe
Net carbon removal *metric tonnes CO_2*	*Should match the last row in table 4(a), "Net carbon removal"* 9,308 tons co2e
Delivery window *at what point should Stripe consider your contract complete?*	*Should match the first row in table 2(a), "Project duration"* June 2022 - Dec 31 2023
Price (\$/metric tonne CO_2) *Note on currencies: while we welcome applicants from anywhere in the world, our purchases will be executed exclusively in USD (\$). If your prices are typically denominated in another currency, please convert that to USD and let us know here.*	*This is the price per ton of your offer to us for the tonnage described above. Please quote us a price and describe any difference between this and the costs described in (6).* \$300/ton Rounding slightly (for simplicity) from our projected \$291/ton for the AM5 wel

Application Supplement: Geologic Injection

(Only fill out this supplement if it applies to you)

Feedstock and Use Case (Criteria #6 and 8)

1. What are you injecting? Gas? Supercritical gas? An aqueous solution? What compounds other than C exist in your injected material?

<50 words We inject an aqueous slurry of organic wastes entrained in wastewater. Our approach removes many pollutants present in the waste from the ecosphere, such as PFAS / PFOA and others. EPA has identified >500 pollutants in organic waste, many of which are unregulated, whose impact on human health and the environment it is unable to assess.

2. Do you facilitate enhanced oil recovery (EOR), either in this deployment or elsewhere in your operations? If so, please briefly describe. Answering Yes will not disqualify you.

<50 words We do not facilitate EOR in our operations. In fact, EOR applications were explicitly excluded from our company charter and in the licenses for certain pieces of our technology which we licensed in from other parties.

Throughput and Monitoring (Criteria #2, #4 and #5)

3. Describe the geologic setting to be used for your project. What is the trapping mechanism, and what infrastructure is required to facilitate carbon storage? How will you monitor that your permanence matches what you described in Section 2 of the General Application?

<500 words Our two current sites have very different geologic settings, proving the flexibility of our approach.

Kansas: In Kansas, our facility utilizes salt caverns excavated within the Hutchinson Salt. The Hutchinson Salt is a member of the Wellington formation which is approximately 730 feet thick and about 280 feet in depth. The Hutchinson Salt is approximately 400 feet thick and 485 feet in depth. This is the salt formation in which our caverns were excavated. It is confined between two shale beds. About 250 feet of the Ninnescah shale conformably overlies the Wellington formation; this shale provides an additional confining property to the injection zone below.

In Los Angeles:

Our injection is conducted into the Repetto and the Puente sands between 3,800-7,500ft (1,100-2,280 m). The Repetto is comprised of sands and shales and is at least 3,500ft thick at the Terminal Island site. The porosity and permeability taken from core samples range from 22 to 34% and 12 to 932 mD for the sands and 27 to 29% and <1 to 4mD for the shales. The Puente formation comprises alternating layers of fine to coarse-grained, poorly sorted sandstones, siltstones, and dark brown-gray shales and clays. Our well core samples recorded porosity of 26 to 29%, the permeability of 4 to 100mD for sand, and porosity of about 29% and <5mD for shale. Approximately 800-1,000ft thick shale section of Pico formation was found between 2,100-3,200ft in our four (injection and monitoring) wells, indicating an excellent confining unit to seal the injectate below. Between 3,200-3,800ft are sand shale interbeds of Repetto Formation, ideal as a containment unit. The 600 ft thick alternating sand and shale sections are additional protection that can absorb and prevent fluid migration from passing above this zone.

From an infrastructure standpoint, our Los Angeles facility already includes everything we need to facilitate carbon storage: receiving, processing, injection, and monitoring. The site has some throughput limitations to achieve maximum permitted rates, though our key limit is the City's production and assignment of biosolids to our facility.

In Kansas, our Class V organic waste permit enables us to open one cavern immediately, with more caverns available to be added as we fill the first. We have not yet opened the initial cavern, and will have some work to do to open it and to create a bespoke offload and pumping area for organics separate from the rest of the facility. These costs approach $1M and the approved cavern can be opened within 1-2 quarters. The rest of the infrastructure (permit, washout area, monitoring wells, Class I brine disposal well) are all already in place.

Assurance of permanence is established with real time pressure monitoring, offset monitoring wells, and, in the case of Los Angeles, thermal logging and ongoing modeling.

4. For projects in the United States, for which UIC well class is a permit being sought (e.g. Class II, Class VI, etc.)?

<10 words We utilize Class V permits for our injection.

5. At what rate will you be injecting your feedstock?

Unit volume/unit time

For our proposed project, the AM5 Well, we will inject on average 24,510 tons of wet waste / year. Assuming we're operating 50 weeks a year and 7 days a week, that would be 46.7 tons of wet waste injected / day.

~~*Our maximum rate will be in our Los Angeles facility which is limited by permit to inject initially at a rate of 10 barrels (420 gallons) per minute. However, generally our feedstock to wastewater ratio is below 10%. As such, the feedstock is injected at a rate of closer to 1 bbl (42 gallons) / minute.*~~

Environmental Hazards (Criteria #7)

6. What are the primary environmental threats associated with this injection project, what specific actions or innovations will you implement to mitigate those threats, and how will they be monitored moving forward?

<200 words The primary threat is loss of containment resulting in groundwater contamination. A related threat is if such a breach led to a surface release of subterranean generated GHGs like methane. Other notable risks include the risk of induced seismicity.

Mitigants we have / will implement include:

- Selecting zones that minimize induced seismicity risk such as salt caverns or soft sedimentary layers far from conductive faults and basement rocks
- Cement bond logging to ensure adequate wellbore / earth seal, regular injection relaxation periods to release subsurface stresses
- Automated fall-off testing to detect any change in injection system geometry
- Fiber optic and or downhole microseismic monitoring and full depth monitoring wells (in appropriate cases)
- Annual thermal logging to confirm zonal isolation (in appropriate cases).
- With respect to GHGs generated underground, we will work to establish
  - Whether CO2 or methane are generated in reservoir conditions,
  - Methods to abate methane generation if it is present,
  - And reactions that can transform methane into liquid or solids in situ.

Notable innovations we have implemented include (patented) real-time monitoring coupled with (patented) advanced fall-off testing techniques for assessing the evolution of the subsurface injection system and plume.

7. What are the key uncertainties to using and scaling this injection method?

<200 words Our facilities are already demonstrated at commercial scale. Thus, market adoption is the key uncertainty. Two factors govern our pace: (1) how fast we can permit new facilities, and (2) how fast we can win volume.

For new sites, we have already identified geographies which can support organic waste injection, and catalyzed a comfort letter from EPA to permitting agencies endorsing the use of Class V wells. Thus, key to accelerating the permitting process will be funding for G&A to secure and permit candidate sites.

To win volume, the municipal decision making process is a rate limiter. It can take years to get an RFP for installation of a new technology, in addition to the multi-year permit process. Many municipalities use large EPC firms to create their organic waste strategies and aren't incentivized to deploy ultra-low capex technologies. To circumvent this, we will adopt a merchant strategy, decoupling permitting from municipal decision-making. With permitted sites in hand, we can bid for regular organics management contracts, with a competitive advantage being that we can both eliminate trucking and associated dewatering costs (and

emissions), and utilize CDR credits to fund opex to become their lowest cost option.