ISOMETRIC

River Alkalinity Enhancement 1.0.0 Protocol

Public Consultation Summary

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Context

Isometric held a public consultation on its River Alkalinity Enhancement 1.0.0 Protocol to receive stakeholder input on this Protocol and associated Modules.

The public consultation was announced on the 26 of March, 2025. The period of consultation lasted 30 days, with the final day as the 26 of April, 2025.

After the initial public consultation, the feedback received was considered for incorporation into the Protocol and associated Modules. All stakeholders have received responses to the submitted feedback.

This document summarizes the feedback received during the public consultation and the revisions included as a result of the comments. Content in italics and brackets are excerpts from the public consultation version of the Protocol to give the reader necessary context behind the comment.

We thank all participants for their time.

Summary of feedback received

Theme	Feedback	Resolution	Section
River Alkalinity Enhancement 1.0.0 Protocol			
General understanding of RAE	*[which the CO2 captured is durably stored for over 1000 years]* Does this mean counterfactual feedstock weathering/carbonation requires 1000-year modelling? Consequently, does this bias for natural, slow geochemical CDR (ERW and RAE) with higher theoretical CO2 uptake potential over quicker engineered geochemical CDR (direct air capture w. ex-situ CO2 mineralisation) with more certainty? Could there be a world where the delivery of more verifiable CDR near-term is better than the same amount of CDR spread across longer timeframes, especially if it comes with additional uncertainty? My assumption is that the money is constant and limited so perhaps quicker CDR and measurable delivery is preferable to scale the industry.	The modeling of counterfactual feedstock weathering/carbonation must estimate weathering that would occur over 1000-years. It's important to distinguish between the feedstock weathering from the CDR scenario and counterfactual feedstock weathering for eligible waste feedstocks. Feedstock weathering in the CDR scenario is measured ex-post which does not bias slower geochemical CDR activities over faster reactions. Uncertainty discounting is also integrated into calculations of net CDR across all pathways. There are many factors that impact the scalability of a CDR pathway, and ultimately a portfolio of solutions are required to meet global climate mitigation targets.	1

	[pollution-related river acidification and preserving habitat for some pH-sensitive species] Presumably, it is difficult to gain benefits from CDR and water neutralisation from pollution.	Acid neutralization in rivers can be a climate solution in addition to ecosystem restoration and pollution mitigation. Crediting of RAE activities requires demonstration of four pillars of additionality (financial, common practice, environmental and regulatory). See Section 2.5.3 in the Isometric Standard for more details.	1
	[relatively short timescales.] Is this always favourable?	Turbulent mixing of rivers means it is constantly re-equilibrating with the atmosphere, which is generally favorable for MRV using observations and direct measurement.	1
	[where turbulent mixing allows for equilibration with the atmosphere and storage of CO2 in the form of dissolved inorganic carbon (DIC, predominately as bicarbonate and carbonate).] This is true. If alkalinity is added locally, turbulent mixing often causes local CO2 degassing rather than DIC/alkalinity dispersal in water. Is turbulent mixing always what you want, particularly if you have fine particles, thin film, and diffusion-limited systems? I guess this is more descriptive rather than instructive, so perhaps unimportant.	There are some instances where lower turbulence may have greater retention of CO2 in river systems generally. This Protocol assesses the difference between the CDR intervention and counterfactual scenario. Regardless of the turbulence over the river, the net removal is determined based on the direct measurement of feedstock dissolution and retention of DIC in the river.	1

Additionality	Applicability should exclude projects mandated or funded for acid mitigation (e.g., Scandinavian liming programs) unless the carbon removal is additional.	Thank you for this comment. Confirming that projects already mandated or funded for acid mitigation would not qualify as additional under the Isometric Standard. The baseline scenario for River Alkalinity Enhancement projects under this Protocol are the dynamic, real-time river conditions in the absence of the River Alkalinity Enhancement project. If there is pre-existing river liming, the River Alkalinity Enhancement project would only encompass the additional alkalinity enhancement above existing regulatory requirements or financing. Projects which are deemed non-additional become ineligible for crediting. Please refer to Section 2.5.3 of the Isometric Standard for the complete set of criteria used to determine project additionality.	4
	[Characterize feedstock prior to usage according to the Rock and Mineral Feedstock Characterization Module v1.0, to ensure eligibility of feedstock selection and ecological suitability.] Does the alkalinity source need to be mineral? Could electrochemical or photochemical methods be used, realizing that they may not make as much sense without the saltwater...	The Protocol is currently written with mineral alkalinity enhancement in mind. However, there is no applicability criteria that excludes other sources of alkalinity. Please get in touch to discuss the specific applicability of this Protocol to alternate sources of alkalinity.	4
	[The river's downstream floodplain for 1-year flood must not be >20% of the river width.] Who gets to define the 1-yr flood? Where is the river width for this requirement measured? At the dosing location?	This criteria has been reframed and simplified to "Desert basins, closed lake systems, and ephemeral rivers that sink into karst or alluvial fans before reaching the coast are	4

		ineligible". The purpose is to narrow the scope of projects to exorheic basins (where discharge flows to the ocean, as opposed to groundwater recharge or evaporation).	
	[not applicable] This would be more clear if it read, "Dosing at locations with downstream wastewater treatment facilities discharging directly into rivers may be eligible, subject to Isometric and VVB approval." then the additional monitoring and quantification framework edits requirements.	Thank you, we have accepted the change.	4
	["There must be no hydraulic features which increase the mean transit time by 1 day between the dosing location and river mouth."] Increase the mean relative to what? Do you mean features that contribute more than 1 day to the mean residence time?	This is the correct interpretation. The language has been clarified.	4
	It's not clear how multiple projects in a single catchment area would be handled if these involve different proponents.	Thank you for the comment. We have included text in the Pre-deployment section requiring disclosure of co-located projects. Project Proponents must also disclose changes to land use which may contribute to changes in baseline river chemistry throughout the duration of the project.	4
	[dosing in different rivers within the same watershed] Do they have to use the same feedstock? That validation could be a real doozy!	Yes, the feedstock must be the same. The language has been clarified.	8.1
Ecosystem monitoring	The Protocol must mandate environmental impact assessments for projects in new regions. This should include monitoring of	Thank you for the comment. All projects are required to conduct an environmental and social risk assessment in	6.3.1

	aquatic ecosystems (fish, macroinvertebrates, etc.).	adherence with [Section 3.7 of the Isometric Standard](). Previously studied sites may have existing information which can be used to inform monitoring and risk mitigation strategies. Regardless, ecosystem monitoring for all projects must span sensitive zones along the river and be tailored to the specific ecology of the site, with input from subject matter and local expertise.	
pH threshold	It should also specify that rivers already near neutral or alkaline may not be suitable for RAE projects until further investigation.	We have not specifically excluded rivers above a certain pH threshold. As part of Pre-deployment requirements, Project Proponents must describe the alkalinity dosing plan, and how it adheres to safety thresholds and minimizes water contamination and accumulation in sediments. A recommended safety threshold on downstream river pH is 9. The project specific threshold will depend on site-specific factors. In addition to ensuring ecosystem safety, since feedstocks will dissolve faster in lower pH rivers and applicable projects are limited to river reaches that discharge to the ocean in < 1 week, early projects will likely target acidic rivers.	
Feedstocks	Specifically limestone? It feels relevant to mention the range of feedstocks that have well understood impacts	Thank you for the comment. Limestone is an applicable feedstock for River Alkalinity Enhancement with the most extensive body of research on impacts. Other feedstocks such as	6.3.1

		dolomite or silicate rocks and minerals have also been previously deployed for acid mitigation.	
Stakeholder engagement	Maybe the requirement is that all of these groups MUST be considered and justification for their exclusion must be in the PDD. Otherwise it's hard to verify if the necessary groups have been engaged or if the supplier just did the absolute minimum. This could end up dicey because the justifications for not including people would be public, but maybe it would force better stakeholder engagement?	Thank you for the comment. Stakeholder engagement will be verified against the requirements in Section 3.5 in the Isometric Standard. Some aspects of Stakeholder engagement reporting may not be publicly disclosed to protect the privacy of external parties.	6.4
Bed measurements	*[Required for all projects]* It seemed like this was recommended from the third paragraph of Section 11.4	Thank you for identifying this. Monitoring of the river bed is recommended and may be required at sensitive locations. The Protocol text has been updated to reflect this.	11.6
Quantification approach	*["This Protocol only quantifies CDR which results in pre-equilibrated alkalinity being transported to oceans as DIC via the river drainage network."]* Not clear what pre-equilibrated means precisely in this context. Pre-equilibrated to what conditions?	This Protocol only accounts for alkalinity that is equilibrated and results in an observed increase in riverine DIC export to the ocean. Alkalinity enhancement that will result in net uptake in the ocean domain is not credited under this Protocol. Readers interested in quantification of ocean uptake should refer to the Ocean Alkalinity Enhancement Protocol.	4
	Would this include if the river bed is an alkaline rock itself? Presumably adding alkalinity could decrease natural rock weathering to some extent? Not sure how significant this would be...	Alkalinity enhancement may decrease natural rock weathering. This effect is incorporated into the quantification approach since direct measurements downstream of weathering will integrate the impacts of feedstock weathering	7.3

		and any reduction in natural weathering.	
	Why isn't the upstream DIC used for the CDR scenario? It seems like it should be: CDR = downstream DIC (measured) - upstream DIC Baseline = downstream DIC (modeled) - upstream DIC -> gross CDR = CDR - Baseline then upstream DIC cancels so gross CDR = downstream DIC (measured) - downstream DIC (modeled) I might be missing something here...	As the comment points out, upstream DIC measurement cancels out between the CDR and counterfactual scenarios in the net CDR equation, which is why it does not appear in the net CDR equation. Upstream measurements are used as inputs to the short-range river DIC model to estimate downstream DIC in the counterfactual.	8.1
Quantification approach - Alkalinity	[*Maximum Removal Potential from Alkalinity Flux* *Assuming full dissolution of the feedstock and no downstream losses, the increased alkalinity export from the river mouth will be the amount of alkalinity added to the river. As a theoretical maximum, the following condition must be true:*] We understand that the current Protocol calculates carbon removal based on DIC and uses alkalinity as a supplementary check. However, we believe it is also possible to reverse this approach—calculating removal based on alkalinity and using DIC for verification. This is because many of the ocean models already developed to estimate carbon removal use alkalinity as the primary input. Allowing removal to be calculated based on alkalinity could lower monitoring costs and potentially increase the number of users applying this Protocol. On the other hand, we recognize that calculating CDR based on DIC is a conservative approach and offers the advantage of providing carbon credits that are perceived as more trustworthy and reassuring for buyers.	Thank you for these comments. Quantification via conservative alkalinity is permissible and the Protocol has been updated to reflect this. "Alkalinity can be determined via acid titration to the CO2 equivalence point or cation/anion charge balance"	8.4

	[This Protocol only quantifies CDR which results in pre-equilibrated alkalinity being transported to oceans as DIC via the river drainage network. Additional uptake of CO2 that occurs in the open ocean is not eligible for crediting under this Protocol.] It may be valuable to include an additional option that allows CDR to be calculated from increased alkalinity, as demonstrated in Beerling et al. (2020). While DIC remains a central metric, providing a parallel pathway based on conservative alkalinity could enhance the flexibility and applicability of the Protocol across a wider range of project settings.		4
	[thus only DIC that is exported from the river to the ocean is eligible for crediting.] Using DIC measurements as a basis for crediting makes sense, but including the option to calculate CDR from conservative alkalinity(Renforth et al., 2017) as well could help make the Protocol more flexible and accessible for a wider range of project sites.		4
	[Any undissolved feedstock may dissolve in the open ocean environment (depending on local saturation states) and enhance alkalinity downstream. This will result in increased pH, total alkalinity (TA), and potentially facilitate additional carbon uptake via gas exchange if the alkaline-enriched waters remain in contact in the atmosphere. As outlined in Section 4, additional uptake of CO2 that occurs in the open ocean is not eligible for crediting under this Protocol.] While it may be challenging to account for additional CO_2 uptake resulting from feedstock dissolution in the open ocean, underestimation due to pre-equilibrium between added conservative alkalinity and DIC can be effectively avoided by allowing CDR calculations based on alkalinity. This approach is especially relevant in countries with small land areas and steep mountainous terrain, where rivers are often short and fast-flowing.		7.2.1

	From another perspective, rivers where RAE is implemented frequently mix with smaller tributaries, which may introduce fluctuations in DIC levels. In such cases, alkalinity tends to be more stable, offering a more reliable basis for assessment. For these reasons, we believe that providing a secondary pathway that allows for CDR calculation based on conservative alkalinity would significantly enhance the flexibility and applicability of the Protocol.		
	[Under this Protocol, an RAE activity is considered to generate a removal when DIC has been exported to the ocean and stored in excess of the river's baseline DIC export. To meet this criteria, Project Proponent must quantify the additional (above baseline) riverine CO2 storage using direct measurements and, where appropriate, locally calibrated models. This combination ensures that RAE Credits generated using this Protocol reflect ex post carbon storage. This approach will be reviewed and updated as dictated by learnings from scientific research and early stage commercial deployments.] Passive-treatment approaches for wastewater may prove to be more cost-effective than conventional active-treatment methods. However, they often face challenges in fully neutralizing pH to a neutral level. Even in such cases, when conservative-ions are being added, enabling CDR-crediting based on their contribution to ocean-alkalinity could enhance the overall applicability of the Protocol.To address such situations, we propose that the Protocol explicitly include a secondary, complementary pathway allowing CDR-quantification based on conservative-ion-derived alkalinity. This would not replace the DIC-based method, but serve as an additional option.Incorporating this approach would improve the practicality and flexibility of the Protocol, enabling fair application across a wider range of real-world projects.This methodology could potentially be applied to existing treatments such as limestone		8

	channels and slag channels, offering positive impacts for the wastewater treatment industry.		
	[Typically, the ocean has a higher pH than rivers and the increased presence of CO32- in oceans can reduce the total storage of terrestrially exported DIC] Based on the rationale mentioned here for considering losses in the ocean, we understand that there are two possible options: ocean modeling and the approach presented by Renforth et al. (2017). Regardless of which option is selected, it is considered feasible to calculate CO_2 removal based on either DIC or conservative alkalinity (e.g., Renforth et al., 2017; Wang et al., 2022).Therefore, I believe that establishing a calculation method based on conservative alkalinity would enhance the versatility of the Protocol.		8.2.2
Counterfactual feedstock weathering	*[The measurements and model used to calculate counterfactual feedstock weathering must be provided to Isometric and the VVB.]* I'd love to learn what you guys recommend for this.	Modelling using PHREEQC or similar geochemical software can be used to estimate counterfactual feedstock weathering.	8.3.2
	[Models must be justified by empirical data from subsamples of the feedstock] Not sure these hold particularly well for passive air/water carbonation or weathering, where crystallographic structure and microstructure are important.	Mineral dissolution rate laws used in kinetic models are typically based on experimentally determined rate constants, which inherently account for factors such as crystallographic structure and surface properties under controlled conditions. While thermodynamic data define the driving force for dissolution (e.g., via saturation state), the rate constants themselves are empirically derived. Physical microstructures—such as microfractures or cracking—can enhance	8.3.2

		dissolution rates and should be considered on a case-by-case basis due to their system-specific impact.	
	[For this reason, counterfactual weathering needs to be accounted for in the top meter of the tailings pile.] Does weathering mean CO2 mineralisation and dissolution via physical or mechanical means?	In most cases, tailings piles are not mechanically disturbed so weathering is concentrated in the surface layer that is exposed to the atmosphere. If there is mechanical overturning of the tailings pile, counterfactual weathering needs to be accounted for in the entire pile.	8.3.2
	Passive CO2 mineralisation I've seen in natural rocks, olivines and wollastonite, is quite high if exposed to ambient air (higher than commonly thought). These rocks are fairly reactive surficially and seeding with carbonates can increase rates initially. I would think if using waste CaCO3 minerals the CDR potential (max) accounting for losses and counterfactual dissolution would be low-ish over 1000 yrs.	The counterfactual dissolution of waste CaCO3 is likely to be small, however it is included to ensure rigorous accounting of additional carbon removal from the Project Activity.	
	[Carbonate saturation] of what? porewater?	Correct, the carbonate saturation of porewater. This list of parameters has been restructured for clarity.	8.3.2
Estuarine and coastal transformations	Storage permanence assumptions should explicitly consider estuarine and coastal transformations before entering the marine carbon cycle.	Thank you for the comment. Losses of DIC through river transport, and estuarine and coastal transformations are included in Section 8.2.1.2 and Section 8.2.2 respectively. The storage durability of the DIC Storage in Oceans module considers net export of DIC after these losses have been considered.	9

Ocean losses	If should = recommended, does the alternative approach need to be approved by Isometric and VVB?	The proposed method for quantifying ocean losses must be described in the PDD and will be subject to Isometric and VVB evaluation through the validation process.	8.2.2.1
	[A dimensionless uptake efficiency term, ηOceanLosses\eta_{OceanLosses}ηOceanLosses can then be calculated as follows:] Why is the inverse of the CDR efficiency calculated from estuarine measurements multiplied by the ocean CDR efficiency for normalization (i.e., $\eta(ocean) \times 1/\eta(river)$)? What is the rationale for multiplying CDR efficiencies (or DIC/Alk ratios) from different locations?	This Protocol only credits net uptake that occurs within the river reach. η(river) reflects the CDR efficiency that has been realized from direct measurements at the river mouth. In the ocean domain, losses are considered but additional uptake is not. The construction of the ocean loss factor ensures that additional uptake in the ocean is not credited and that ocean losses are not overestimated in the case of partial equilibration in the river.	8.2.2.1
	Is the idea that this is calculated once for the project or does it vary temporally (e.g., due to temperature and pCO2)	The Renforth and Henderson (2017) uptake efficiency is based on averaged local ocean conditions. It will change over longer timescales (e.g., seasonal and annual), and is likely to be static over a reporting period (e.g. months).	8.2.2.1
	Applying Renforth and Henderson (2017) is an approximation; ocean conditions could vary and affect efficiency.	This is correct. Renforth and Henderson (2017) is derived from thermodynamic equilibrium of the carbonate system and provides an upper limit on the expected ocean losses, considering the long term conditions of the ocean. Spatially and temporally varying physical and biogeochemical conditions of the ocean	8.2.2.1

		can affect efficiency, and are likely to increase the CDR efficiency.	
	Implicit assumption about CO_2 outgassing must be checked via ocean model or net removals may be overestimated.	Ocean modeling is a useful tool to simulate site specific losses which is included as an option in Section 8.2.2.2. There can be a risk of overestimation of net removals if ocean losses in the counterfactual scenario is overestimated. I using Renforth and Henderson to quantify ocean losses, as described in Section 8.2.2.1, it must be consistently applied between the CDR and counterfactual scenarios.	8.2.2.1
	["Upon discharge to the ocean, re-speciation of DIC may shift the carbonate equilibrium, altering the final efficiency of the alkalinity increase in the river."] Net removal will also be impacted by any subduction prior to equilibration in the counterfactual case.	This is true. Option 2 for ocean losses incorporates the impact of subduction prior to equilibration in both CDR and counterfactual scenarios.	8.2
	[required to identify any additional site-specific sinks of alkalinity] Does this need to be in the PDD?	Yes, this needs to be disclosed in the PDD. Protocol text has been updated to make this explicit.	8.2.1.2.1
Model validation	*[The model may need to be retrained]* If there was dosing during the record rainfall, seems like it would be hard to get new training data, because you would need another record rainfall?	Simple statistical models cannot be used to predict beyond the range of its training data. In the example given, if there was a record rainfall, the model would not be invalidated entirely, it would simply not be valid for use during the period of record rainfall.	8.3.1.1

	[The short range river DIC model must be re-validated at minimum every 3 years. It is recommended that the model is routinely revalidated by turning off dosing periodically to collect additional data of downstream baseline conditions and compare against baseline model predictions. Episodic re-validation is recommended after extreme events.] Is the implication that they have to stop dosing to re-validate every 3 years, but they can do it more frequently for funzies? Are there any triggers that would require re-validation, other than extreme (weather?) events? Like if a new industrial discharge or intake point opens on the river between the up- and downstream measurement points?	Yes, stopping dosing to re-validate the model must occur at minimum once every 3 years. In practice, we recommend routine re-validation of the model so that the model continues to improve and evolve with long term changes to the river. Changes in land use that alter river chemistry or flow rate, flood events that drastically alter river morphology would require re-validation of the model to establish an updated baseline.	8.3.1.1
Modeling	*["Domain: The model must span the region from the downstream measurement point in Step 1, through the river mouth."]* What about tributaries between the dosing point and the downstream measurement point?	Tributaries can be represented as sources or boundary conditions along the river.	8.2.1.2.3
	Does anything climate-related need to be explicitly included here? I suppose temp will factor into all of the inputs here	Climatic variables have been added to the list of input parameters.	8.2.1.2.2
	Should include relevant characteristic for all downstream tributaries.	Downstream tributaries have been explicitly included in the domain requirements.	8.2.1.2.2
	[submit a detailed description] In the PDD or a supplement to the PDD?	The model description must be included in the PDD. Language has been clarified.	8.2.1.2.3
Modeled CDR	Direct field measurements of pH, DIC, and pCO_2, and if possible TA, must validate modelled carbon removal. Models alone are insufficient. Estuarine carbon dynamics must also be included, as a significant portion of alkalinity and CO_2 uptake can occur downstream.	Thank you for the comment. Indeed models are only as powerful as the observations that are used to validate them. At minimum, models must be validated with direct measurements of the carbonate system for the baseline scenario. Validation of the CDR	8

	[It is recommended to also validate the model during the RAE project scenario with some downstream measurements, if there is a detectable signal.] Does this mean: if there is a detectable signal, you must validate the model with RAE scenario measurements OR validation with RAE measurements optional either way? If the former, the supplier will need to provide evidence that there is or isn't a detectable signal. If that's the case, it would be best to explicitly state that so we don't have to convince them of it after-the-fact.	scenario (RAE activity) at points throughout the river reach is strongly recommended. Carbonate chemistry parameters, inclusive of DIC, must be measured at the river mouth to constrain the riverine export of DIC to oceans. Please note, that future versions of this Protocol may require validation of the CDR activity at more monitoring locations.	8.2.1.2.3
	How is DIC monitored downstream? If quantification relies mainly on modeled transformations and estimated parameters rather than direct field measurements, there is a risk of significant uncertainty in the CO_2 removal result. I recommend requiring direct DIC measurements at critical downstream and upstream locations to validate modeled outcomes.		8.1
Duration of pre-deployment baselining	*[The duration of pre-deployment monitoring should consider:* *the timescales of the risks identified in the environmental risk assessment* *dosing period* *site-specific river travel time* *timescales of natural variability and availability of historical data* *Likewise, post-dosing environmental monitoring should consider:* *the timescales of the risks identified in the projects environmental risk assessment;* *site-specific river travel time;* *dissolution time.]* Is the intention that none of these considerations are actually required? ("should" vs "must")	This has been updated to "must consider, at minimum".	11.1

	I suggest that the baseline must be based on at least 12 months of water chemistry data (TA, pCO_2, DIC, pH) to capture full seasonal variability. In new regions, control sites (untreated rivers or upstream segments) should be mandatory to isolate project impacts from natural environmental variability, as is standard practice in river liming programs in Sweden and Norway.	Thank you for the comment. The duration of pre-deployment monitoring must consider, at minimum: a) the timescales of the risks identified in the environmental risk assessment, b) the duration of the dosing period, c) the site-specific river travel time and d) timescales of natural variability and availability of historical data. For projects without pre-existing baseline data and aiming to dose throughout the year, >12 months of baseline data collection is likely required, depending on the underlying seasonal variability of the site.	7
	Duration of pre-deployment baseline should be sufficient to fully assess seasonal variability.		8.2.1.2.3
Pre-deployment requirements	what does critical mean here?	Critical refers to thresholds for social and ecological safety. The Protocol text has been updated accordingly.	10
	I think this is the only mention of controls - is comparison to a control required?	Control plots are not required. They may be useful to serve as additional monitoring locations for monitoring for model inputs, and must be disclosed in the PDD if intended to be used to fulfil the requirements in this Protocol.	10
	Baseline ecological and chemical conditions must be established covering all seasons before deployment. Monitoring plans must be completed and verified prior to any intervention.	That is correct, baseline ecological and river chemistry conditions, dosing and monitoring plans must be reported in the PDD. These requirements are reflected in the Protocol in Section 10: Pre-deployment Requirements.	11

Remediation requirements	*[Project Proponents must have sufficient remediation plans for restoring water quality conditions prior to discharge in the event that negative environmental impacts result from project activities.]* As with WAE, it's not clear what would be sufficient here? If they mess up and dose too much, how would they restore the water quality conditions, other than by waiting for the alkalinity to reach the ocean?	In some cases, pausing dosing to reduce exposure can be a suitable action to take. In other cases, it may be necessary to recover excess feedstock to remediate the river system.	10
Monitoring for catchment changes	Other changes in the catchment area must be monitored and corrected for in CDR quantification.	Project Proponents must also disclose changes to land use which may contribute to changes in baseline river chemistry throughout the duration of the project.	8.2
	"The "short-range river model" provides an excellent opportunity for continuous monitoring e.g. to identify any changing conditions (such as changes in tributary discharges) that necessitate revalidation of the model." Model could be used for real-time monitoring to detect condition changes and ensure consistency with data.	Thank you for the comment. Both upstream measurements and river mouth measurements are useful in identifying changes to the river catchment which alter the validity of the model. Model validation is required at minimum once every 3 years through comparison of modeled predictions and observed measurements. It is recommended that projects adopt ongoing model validation with real-time observations to adapt with changing conditions. Project Proponents must also disclose changes to land use which may contribute to changes in baseline river chemistry throughout the duration of the project.	8.3.1

Uncertainty	*["Uncertainty; A conservative output value of 1 standard deviation below the mean should be used in the net CDR calculation."]* Better to assess uncertainty per factor and combine appropriately before applying a conservative discount.	Thank you for the comment. Per Section 2.5.7 of the Isometric Standard, credits will be issued at a conservative value of 1 standard deviation below the mean. There are several options for uncertainty propagation, including assessing the uncertainty per factor and combining the uncertainties before applying a conservative discount. If the process model option is used, it is likely to be the last step in the quantification where the distribution of the ensemble output reflects the aggregated uncertainty of the input parameters.	8.2.1.2.3
Units for density	*[mol/kg]* If the instrument reports mol/kg, it may be making an assumption about the solution density already. If that is the case, the density used in this formula should be the density assumed by the instrument or the density of the solution at the temperature of the lab. I think most autosamplers take up a volume of sample rather than a mass (e.g., you use a 25 uL sample loop).	Thank you for the comment. This has been clarified in the Protocol text. "Density must be measured with the tracer concentration. For in situ measurements, it is acceptable to estimate density from other field measurements (e.g., temperature and salinity) or use values from sensors calibrated to manufacturer specifications. For bottle samples, this would be the density of the solution at lab temperature)."	8.2.1
Measurement standards	The Protocol should clarify more precisely which freshwater standards (e.g., ISO, EPA) apply for key measurements such as total alkalinity (TA), pCO_2, and DIC sampling. This ensures consistency and verifiability across projects.	Measurements must follow a standard operating procedure. At this time, this Protocol does not require adherence to a specific standard as different standards may be more appropriate depending on the project region.	2

Updates with changing science	The Protocol should explicitly incorporate new scientific findings, especially field trials of RAE and estuarine monitoring studies, and how they are impacted by alkane addition into future updates.	The Protocol will be reviewed at minimum every 2 years and/or when there is an update to the scientific published literature that would affect net CDR quantification or monitoring and modeling guidelines outlined in this Protocol.	3
Formatting change	Maybe I just need to get new glasses but this figure is really hard to read	Thank you for the comment. The figure has been edited for easier viewing.	8.1
Wording changes	Various typos and text formatting changes.	All suggestions for typos and text formatting changes have been addressed. A definition for short-range river DIC model has been added. Citation has been added. The paragraph on integration with separate practices was removed as it is not relevant for River Alkalinity Enhancement.	