Intent to Develop Alberta Offset System QUANTIFICATION PROTOCOL FOR BIOCHAR PROJECTS

Please contact Climate Change Central with any questions or clarification of requirements at contact@climatechangecentral.com.

This Intent to Develop an Alberta Offset System Quantification Protocol document is intended to provide Alberta Environment with an overview of the proposed protocol idea to demonstrate how this protocol will meet the requirements of the Alberta Offset System. The protocol developer is required to present this information to Alberta Environment and **must** receive approval in concept for the protocol before the protocol idea will be considered for development in the Alberta Offset System.

Familiarity with and general knowledge of the Alberta Offset System is required prior to initiating a protocol. Information on the Alberta Offset System is available on the Carbon Offset Solution website (http://carbonoffsetsolutions.climatechangecentral.com) and on the Alberta Environment website (http://environment.alberta.ca/02275.html).

Alberta Environment will review the submitted information in order to assess and provide feedback on the following elements:

- How the proposed protocol meets the eligibility criteria in section 7 of the *Specified Gas Emitters Regulation;*
- Applicability of the proposed protocol against purpose and intent of the Alberta Offset System;
- Baseline adoption levels and credit potential for Alberta;
- Baseline, project condition, and key assumptions for the proposed protocol;
- Key stakeholders and technical experts in the field; and
- Relevant science and technical information

General Description of the Proposed Protocol[1]

The production and use of biochar offers great potential for greenhouse gas emission reductions, removal of carbon dioxide from the atmosphere through carbon capture and sequestration, and renewable energy production. The mechanisms for achieving emission reductions from the production or use of biochar extend across the project lifecycle.

During biochar production, feedstocks are heat-processed in the absence of oxygen (otherwise known as pyrolysis) for a sufficient period as to render a significant portion of the carbon in the material

[1] **Some important notes to consider:**

- *Protocols should be based on best available science;*
- *Follow the ISO 14064:2 standard processes – specifically addressing principles of conservativeness, completeness, relevance, consistency with others, accuracy and be complete transparency in development and descriptive processes; and*
- *Be very clear with respect to the Measurement, Monitoring and Verification requirements to allow little interpretation.*

stabilized as a solid biochar (which has a mean residence time in soils on the order of 1,000 to 10,000 years). The intent of the Biochar Protocol is to account for the long-term stability of carbon within solid biochar produced during pyrolysis, and the greenhouse gas emissions that are mitigated by using pyrolysis as a treatment process instead of business as usual feedstock management approaches.

Biochar is produced through the pyrolysis of organic feedstocks in the absence of oxygen. Potential feedstocks include forestry and agriculture crops and residues, municipal solid wastes (the organic component), livestock wastes, and other sources of organics. Under business as usual, these feedstocks would otherwise be burned or decompose. Burning releases carbon dioxide and black carbon (BC), while decomposition releases carbon dioxide (during aerobic decomposition), methane (during anaerobic decomposition) or nitrous oxides under fluctuating decomposition conditions (aerobic / anaerobic).

Biochar has many post-pyrolysis uses, in addition to the Protocol's crediting approach of accounting for the GHG mitigation benefits of biochar production using pyrolysis, as compared to the business as usual burning or decomposition of feedstocks. After pyrolysis, the biochar can then be used as an additional tool in land management and/or agriculture. For example, biochar may be applied to agricultural soils, where it can improve soil quality (moisture and nutrient retention); it may be used as a product for turfgrass establishment; it may be used in land restoration; or it may be used as a means of mitigating water pollution. In each situation, biochar containing stabilized carbon is nearly permanently sequestering the fixed carbon therein. In some cases, the biochar may be stored permanently as fill in mining operations or similar applications to traditional carbon capture and storage (CCS) techniques. The use of biochar as a solid biofuel would not be considered applicable to these project types, as there is no permanent sequestration of the carbon once it has been burned.

During the pyrolysis process, various energy-rich gas and liquid streams may be produced. These energy streams may be used to offset the use of fossil fuels, to produce electricity, or may be used parasitically within the pyrolysis process.

The development of this protocol is part of a larger biochar protocol development effort for North America, which will later extend into the VCS (Voluntary Carbon Standard). This effort contemplates the development of protocols under both the AOS and Voluntary Carbon Standard to provide broad coverage across Canada and the US. This protocol development effort has already included a number of stakeholder engagement processes through a series of webinars and workshops at the 2010 US Biochar Initiative and International Biochar Initiative annual conferences. Full information on the development effort is available from www.biocharprotocol.org. This website includes all documentation presented during webinars (including videos of the webinars), as well as presentation slides from the US Biochar Initiative.

The global scale for potential emissions reductions from biochar production and usage is estimated to be at the gigaton scale. It is this potential that has stirred such excitement for biochar project development. As of this date, there is a paucity of Canada- and Alberta-based research on biochar technology implementation and uses, however research and industrial activity is increasing.

To this point, a Prairie Biochar Network is being developed by Alberta Innovates Technology Futures (Alberta Research Council) and the Saskatoon Research Council being co-led by Anthony Anyia and Miguel Providenti. The Prairie Biochar Network Project is being developed with the intention of fostering biochar and pyrolysis technology, research and implementation as well as creating more optimal opportunities for the production and use of biochar within the Prairie Provinces through supporting protocol and other policy development.

There is further interest in biochar's potential through ongoing research on pyrolysis technology and agricultural applications at the Alberta Innovates Technology Futures Vegreville research facilities, with additional studies conducted by the Northern Alberta Institute of Technology, Olds College, and the University of Alberta. Within Alberta, research on biochar has included standard agricultural soil amendment practices, suitability as a green roof and horticultural growth medium, and the potential for biochar as a means of soils remediation.

In the context of Alberta, there is significant opportunity for developing biochar projects. There are substantial supplies of agricultural and forestry feedstocks – including Mountain Pine Beetle killed forests, forest harvesting slash piles, agricultural crop residues and waste byproducts. There are also vast agricultural and forestry land, and reclamation sites that would be available for, and benefit from, the incorporation of biochar, for the additional soil amendment benefits, above and beyond the credits gained from pyrolysis production.

Current industrial production of biochar is minimal, but would be encouraged by the development of an emission offset quantification protocol. Further, there are biochar projects under development – seeking funding from numerous sources including the CCEMC.

Although the range of throughput varies with project type, a typical throughput for a commercial facility is 2-4 tonnes dry matter per hour. Thus a mid-range project may include the handling of 50 tonnes of organic feedstock per day, generating approximately 15 tonnes of biochar. Counting only the carbon sequestration benefit from stabilization of carbon in biochar, there would be approximately 50 tonnes per day of GHG emission reduction – or approximately 20,000 tonnes of CO2e per year. Adding on diversion of feedstocks from landfill or renewable energy production, this value increases substantively. Larger projects are contemplated, yielding evermore material quantities of emission reductions within Alberta, along with the co-benefits from improved soils.

Intent

The intent of the protocol is to provide a detailed quantification methodology for the emission reductions achieved from typical biochar projects. The quantification methodology will address the lifecycle emissions covering projects from feedstock through biochar use.

Baseline

There are a wide range of feedstocks relevant to biochar projects. These include forestry residues, agriculture crop residues, the organic component of municipal solid waste, livestock waste and other sources of organic materials. Given the range of sources of material, the baseline condition for their handling is defined in the protocol relative to the range of aerobic and anaerobic decomposition conditions relevant to each feedstock.

- Many of the feedstock materials would decompose under aerobic conditions such that the carbon dioxide would return to the atmosphere as part of the biogenic carbon cycle. In the agricultural sector, this could include the composting of agricultural residues and their reapplication to the land. In the forestry sector, this could include the decomposition of forestry residues on the forest floor, or the combustion of the material where there is no energy recovery.

- Where suitable and significant evidence can be produced to meet the requirements of the Alberta Offset System, these materials may otherwise undergo anaerobic decomposition – either under controlled or uncontrolled conditions (i.e. in landfills). For some organic waste streams such as food wastes or other organic streams collected from industrial, commercial, institutional and residential sources, these materials may either be disposed of in landfill (with or without landfill gas capture), composted, or incinerated.

As may be appropriate, the baseline condition may also include the use of fossil fuels to generate heat, power, and/or electricity that the clean energy streams generated during biochar production can replace. The stream of energy production from biochar may include electricity on the grid as well as liquid fossil fuel and natural gas usage for heat and power. The baseline condition, however, does not include the combustion of solid fossil fuels (i.e. coal) for which biochar may be used as a substitute.

There is precedent under the Alberta Offset System for each of the baseline conditions discussed previously.

Project Condition

The project condition is the processing of the organic feedstocks through a pyrolysis process, in the absence of oxygen, for the production of biochar. The biochar can then be used in land management, increasing the carbon content and beneficial properties of the soil or for other environmental remediation purposes, and permanently sequestering the fixed carbon therein. In some cases, the biochar may be stored permanently as fill in mining operations or similar uses.

The carbon sequestration occurs relative to the amount of carbon stabilized during pyrolysis, and maintained through the storage and/or use of the biochar. The sequestration of the fixed carbon in biochar can be quantified using laboratory analysis of suitable precision. The emission reduction is real, as the content of biochar is quantifiable, substantively fixed, and unavailable for further decomposition – as such, rendering the emission reduction permanent. The emission reduction is verifiable once the biochar, as tested, is deposited within soil or otherwise implemented in its end use.

The beneficial uses of the energy streams that are not parasitically used within the feedstock handling and pyrolysis processes would also be considered as part of the project condition. However, the use of biochar as a solid biofuel would not be considered as applicable to these project types as there is no sequestration of carbon when biochar is combusted.

Any additional soil carbon sequestration thought to be attributable to the interaction of biochar in the soil and soil processes, plants and microbes will not be considered applicable to these project types.

Applicability

The intended users of the protocol are those developing and operating biochar projects in Alberta that are not considered as regulated facilities as per the Specified Gas Emitters Regulation. Users may be seeking alternative approaches to waste management or energy production, or be interested in producing biochar as an end product.

Regulatory Requirements

There are no regulations uniquely applicable to biochar projects in Alberta. There are a number of regulations that would be applicable to various aspects of the projects. These regulations do not mandate biochar production or use. However, these regulations would indirectly impact various elements of feedstock supply and biochar usage within a given biochar project. In brief, these other regulatory frameworks would include:

Forestry:	Regulations on the collection and handling of forest residues.
Waste Management:	Regulations on the handling of organic waste streams from industrial, institutional, commercial, and residential sources.
Agriculture:	Use of fertilizers and soil amendments.

With no regulations mandating the implementation of biochar projects, these projects are also considered surplus. However, the regulations related to the handling of the feedstock must be considered in light of the addressing the appropriate baseline for the feedstock handling.

Additionality

Biochar projects can result in real, quantifiable, and verifiable reductions in greenhouse gas emissions and increased sequestration of carbon. The emission reductions achieved through the diversion and handling of feedstocks are similar to those under the composting, anaerobic digestion, landfill gas, landfill bioreactor, and other project types already accepted under the AOS. The emission reductions associated with the beneficial use of the energy streams from biochar production are covered under a number of these protocols as well as the protocols for renewable energy projects (wind, solar, etc.). The rules for demonstrating the additionality of these emission reduction mechanisms, including those within the revised draft Alberta guidance will be considered in the protocol.

As only the first commercial-scale biochar projects are initiating development in Alberta, this activity would be well beyond business as usual. Therefore, all emission reductions and removals associated with the biochar production would not otherwise have occurred in the absence of the project. The additionality associated with the handling of the feedstocks and energy production would be in keeping with other related protocols in Alberta.

Barriers

Pyrolysis is a well-established process, and technologies appropriate for biochar production already exist, having been used for other purposes to this date (typically optimized for waste minimization, or the production of bio-oil or syngas). However, there are very few commercial operations currently focused on biochar production at the industrial or commercial scale. Scaling the technology is difficult, especially when considering the change from batch to continuous system operation. Further challenges of feedstock and process consistency through automating the process (batch or otherwise) to yield more consistent output must also be addressed. As such, there are numerous technical barriers associated with project development which are being addressed through the development of early projects.

Also, since the markets for biochar as a soil amendment, a green roof and horticultural product, as a tool for remediation and otherwise are largely unproven, there is risk in project development such that there may not be sufficient demand for the end-product. Further, none of the emerging technologies have a significant track record of efficacy. As such, there are multiple market barriers to the development of these projects which are being overcome as part of early projects.

In sum, these technical and market barriers are similar to the development of any other new technology and project type. Recognition of the greenhouse gas benefits of this technology is important for supporting the development of these projects within Alberta – both in terms of attracting interest and capital to these projects. In real terms, these benefits encourage large emitters to support the development of the technology and the marketplace to accept one of the environmental benefits of biochar.

Permanence

The emission reductions that may be associated with the feedstock diversion (i.e. from landfill) and the beneficial use of net energy from biochar production are established as permanent in other AOS protocols. There is no risk of reversal associated with these activities.

The sequestration of the fixed portion of carbon in biochar is also permanent – as long as the material can be shown that it cannot be combusted. The biochar can be analyzed to ascertain what percentage of its mass is fixed as stable carbon as a result of pyrolysis, and thus unavailable for further decomposition. All other carbon in the biochar is assumed to be available for conversion to carbon dioxide, once in the soil. Once the biochar is incorporated in the soil or used for other environmental remediation or land use, it cannot feasibly be removed from the soil/biochar blend. As such, there is no risk of reversal for the permanently fixed portion of the biochar.

More information on the measurement and permanence of sequestered carbon is available from the technical and market primers on the www.biocharprotocol.org website.

Leakage

The potential for leakage associated with this project type is linked to the increased yields of crops on lands treated with biochar (positive leakage – i.e conservative). This increased yield is typically linked to a number of processes in the soil, from improved cation exchange capacity through to increased soil moisture retention. The greenhouse gas benefits from this increased yield are not easily quantified given the variance in effect from field to field and across application rates.

Further, the literature suggests that soils with biochar incorporated within them have lower requirements for fertilizer. Again, this is positive leakage. However, the reductions in fertilizer application are to be excluded from the protocol for capture within a nitrogen emission reduction protocol, given the complexities and interrelationships among practices that impact on nitrous oxide emissions from agricultural soils.

Both of these sources of positive leakage are beyond the scope of the Biochar emission quantification protocol, and shall not be included in current emissions reduction crediting.

Conservativeness

A level of conservativeness consistent with the other, similar, AOS protocols will be applied to the accounting for feedstock handling and diversion as well as beneficial use of energy components of the protocol. These methods for considering conservativeness are well understood and easily leveraged into this protocol.

For the assessment of carbon sequestered, there will be a number of layers of conservativeness applied. These will include conservative assumptions that **only the carbon that can be definitively shown through testing as fixed and unavailable for decomposition in the biochar will be assumed to be permanent**. All other carbon in the biochar will be assumed to return to the atmosphere immediately upon incorporation in the soil. This is conservative, as not all of this carbon would likely reach the atmosphere, since some would be bound through biological processes, and other carbon may not be available based on the physical properties of the soil/biochar blend and environmental conditions of the site. Further, any biochar that cannot be clearly shown as not being combusted will be assumed to achieve no sequestration of carbon.

Aggregation

Biochar projects are not likely to result in aggregation projects in Alberta for a number of reasons. Firstly, these projects are contemplated to be completed at a sufficient scale as to support credit creation on a project-by-project basis. Secondly, each biochar project is likely to be a unique combination of feedstock, process configuration and use of end-products (biochar and energy). Therefore, site-specific consideration of the applicability of each of the emission reduction mechanisms as well as documentation of the project will be required.

Where aggregation is required, in smaller and distributed projects, the issues associated with aggregation would be no different than in the existing AOS protocols for energy efficiency and tillage. In these projects, the projects must meet equivalent standards for data capture and record keeping. For biochar projects, there would need to be some commonalities between feedstocks, technologies, end-product and co-product uses to support aggregation. Aspects of the protocol that would support aggregated projects will be outlined in the flexibility mechanisms for the protocol.

Verification

The emission reductions achieved under biochar projects will be verifiable. There will be records kept on the source, handling and processing of each feedstock. This will extend to the alternate use of the feedstock to assess whether it would have decomposed aerobically or anaerobically. The documentation requirements will be mandated in the protocol to be the highest level required across similar AOS protocols – incorporating the lessons learned under the composting protocol.

Documentation on the beneficial uses of the co-products from biochar production will also be kept. This will include the amount of biochar produced and its handling right through to end-use allocation. It will also include metering of any net energy production from the biochar project that is used for a beneficial purpose. Again, these records will be kept as per the highest requirements across similar AOS protocols.

As such, the requirements to verify a biochar project will be no more onerous than projects covered under the current AOS protocols such as landfill gas or anaerobic biodigestors. However, we will work to include the lessons learned from other protocols to tighten the data requirements – looking forward to the requirement for reasonable level of assurance.

Ownership

Proving ownership over the emission reductions from biochar projects will need to extend from feedstock acquisition through to the final end-use of the biochar and energy co-products. This will include contractually assigning ownership for all greenhouse gas benefits to the project proponent for values associated with the diversion and handling of the feedstocks as well as from the use of the biochar and energy.

Related Protocols and/or Methodologies

There are currently no protocols in place uniquely for biochar projects. There was an early attempt to develop a protocol through the VCS that became the impetus for this broader effort. For more details on the previous work, please consult www.v-c-s.org website. For more information on the protocol development effort behind this submission, including recorded webinars and background documents, please visit www.biocharprotocol.org.

The elements of a biochar protocol associated with the feedstock handling and beneficial uses of co-produced energy streams are also included within numerous other AOS and CDM methodologies (ex. biogas, biomass, landfill gas, etc.). The unique portion of the protocol covers the quantification of the sequestered (fixed) carbon in biochar.

Other Benefits

There are numerous co-benefits to biochar production. These are primarily seen through the restoration of degraded soils and general soil improvement. Productivity gains have been noted in both the agricultural and forestry sectors, following the use of biochar. Further, there are benefits to incorporating biochar into soils that are being remediated from oil/gas sector development and oil sands operations.

Research is extending to the use of biochar in tailings remediation and as a supplement in animal feed to reduce emissions from enteric fermentation. Examination of these follow-on benefits is predicated on supply of biochar from early project activities.

The development of a GHG emission reduction protocol for biochar will foster continued industrial development of pyrolysis producers, and encourage the development of alternative waste management practices within industries that typically employ decomposition or combustion approaches to address organic-based waste materials. Additionally, encouragement of the production of biochar may prove beneficial for ongoing domestic research initiatives and pilot projects seeking to implement biochar as a technology in agricultural, horticultural and green roofing initiatives.

It has been noted (L. Nadeau, Pers. Comm.) that Alberta lags behind other areas of Canada in green roof implementation, and that biochar can act as an ideal, lightweight, highly-water-holding growth medium for use in green roof applications. Current supply of biochar for green roof research is imported from the USA. By fostering domestic biochar production, the Biochar Protocol may enable more cost-effective green roof development within Western Canada.

Adverse Effects

There are very few potential adverse effects from biochar projects. The principal concern is linked to the potential for off-gases from the pyrolysis process. This can include particulates and other contaminants, if the facility is not properly operated. These concerns would be addressed in Alberta by the existing requirement for operating permits for biochar production facilities that govern the acceptable limits of any potential emissions. To this point, the Alberta Environmental Protection and Enhancement Act address' some concerns regarding the release of substances, including particulate matter.

References

The principal references for this protocol are listed on the www.biocharprotocol.org website and are included as part of the science and market primers therein.

Brown R. 2009. Biochar Production Technology. In. Lehmann, J. and Joseph, S (eds) (2009) Biochar for Environmental Management: science and technology. pp 127-146. Earthscan UK

Chan, K.Y., Van Zwieten, L., Meszaros, I., Downie, A. and Joseph, S. (2007) 'Agronomic values of greenwaste biochar as a soil amendment', Australian Journal of Soil Research, vol 45, pp629-634

Cheng, C., Lehmann, J., Thies, J., and Burton, S. (2008). Stability of black carbon in soils across a climatic gradient J. Geophysical Res. Vol 113. G02027, 10 PP

CCX (Chicago Climate Exchange) (2007) CCX Exchange Offsets and Exchange Early Action Credits, CCX, Chicago, IL,
www.chicagoclimatex.com/docs/offsets/CCX_Rulebook_Chapter09_OffsetsAndEarlyActionCredits.pdf

Clean Development Mechanism (CDM) small-scale methodology AMS-III.L: Avoidance of methane production from biomass decay through controlled pyrolysis and CDM small-scale methodology AMS III.E: Avoidance of methane production from decay of biomass through controlled combustion, gasification or mechanical/thermal treatment. http://cdm.unfccc.int/UserManagement/FileStorage/CDMWF_AM_C7UWTIEMRJ05M3D02XWDW80JN989IP

Davidson, E. A. and Janssens, I. A. (2006) 'Temperature sensitivity of soil carbon decomposition and feedbacks to climate change', Nature, vol 440, pp165-173

Downie, A, Crosky, A and Munroe P. (2009). Physical properties of biochar. in J. Lehmann and S. Joseph (eds) Biochar for environmental management: science and technology. Earthscan. UK.

Forster, P., Ramaswamy, V., Artaxo, P., Berntsen, T., Betts, R., Fahey, D.W., Haywood, J., Lean, J., Lowe, D.C., Myhre, G., Nganga, J., Prin, R., Raga, G., Schulz, M. and Van Dorland, R. 2007. 'Changes in atmospheric constituents and in radiative forcing' in S. Solomon, D. Qin, M. Manning, Z. Chen, M., Marquis, K.B. Averyt, M. Tignore and H.L. Miller (eds) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, Cambridge, UK

Gaunt, J and Cowie, A. (2009). Biochar, Greenhouse Gas Accounting and Emissions Trading in J. Lehmann and S. Joseph (eds) Biochar for environmental management: science and technology. Earthscan. UK.

Jenkinson, D. S. and Ayabana, A. (1977) 'Decomposition of carbon-14 labelled plant material under tropical conditions', Soil Science Society of America Journal vol 41, pp912-915

Lehmann, J., Czimczik, C., Laird, D., and Sohi, S. (2009) 'Stability of Biochar in Soil' in J. Lehmann and S. Joseph (eds) Biochar for Environmental Management: science and technology. Earthscan UK

Lehmann, J.; Gaunt, J.; Rondon, M. (2006) Biochar sequestration in terrestrial ecosystems – a review. Mit. Adapt. Strat. Global Change, 11, pp 403-427.

Lehmann, J. and Joseph, S (2009). Biochar for environmental management: science and technology. Earthscan, UK

Major, J., Steiner, C., Downie, A. and Lehmann, J. (2009) 'Biochar Effects on Nutrient Leaching' in J. Lehmann and S. Joseph (eds) 2009 Biochar for environmental management: science and technology Earthscan UK

McKenzie, D. C. and So, H. B. (1989) 'Effect of gypsum on vertisols of the Gwydir Valley, New South Wales. 2. Ease of tillage', Australian Journal of Experimental Agriculture, vol 29, pp63-67

McLaughlin, H. Anderson, P. Shields F. and Reed T. (2009) All Biochars are Not Created Equal and How to Tell Them Apart. http://cees.colorado.edu/biochar_characterization.html

Rondon, M. Ramirez, J. A. and Lehmann, J. (2005) 'Charcoal additions reduce net emissions of greenhouse gases to the atmosphere', in Proceedings of the Third USDA Symposium on Greenhouse Gases and Carbon Sequestration, Baltimore, MD, 21-24 March 2005, p208

Van Zwieten, L., Singh, B., Joseph, S., Kimber, S., Cowie, A., and Yin Chan, K. (2009) 'Biochar and Emissions for Non-CO_2 Greenhouse Gases from Soil' in J. Lehmann and S. Joseph (eds) Biochar for environmental management: science and technology

VCS (Voluntary Carbon Standard) (2007) Guidance for Agriculture, Forestry and Other Land Use Projects, VCS http://www.v-c-s.org/docs/Guidance%20for%20AFOLU%20Projects.pdf

Warnock, D. D. Lehmann, J. (2007). 'Mycorrhizal responses to biochar in soil – concepts and mechanisms' Plant & Soil. vol 300. pp9-20

Wood, S. and Cowie, A. (2004) A Review of Greenhouse Gas Emission Factors for Fertilizer Production, IEA Bioenergy Task 38, http://www.ieabioenergy-task38.org/publications/

Wrage, N., van Groeningen, J.W., Oenema, O. and Baggs, E. M. (2005) 'Distinguishing between soil sources of N_2O using a new ^{15}N- and ^{18}O- enrichment method', Rapid Communications in Mass Spectometry, vol 19, pp3298-3306

Yaman, S. (2004) Pyrolysis of biomass to produce fuels and chemical feedstocks. Energy Conv. Manage. 45, pp 651-671.

Yanai, Y., Toyota, K. and Okazaki, M. (2007) 'Effects of charcoal addition on N_2O emissions from soil resulting from rewetting air-dried soil in short-term laboratory experiments', Soil Science and Plant Nutrition, vol 53, pp181-188

Proposed Timing for Submission into the Offset System Review Process

The protocol documentation (draft protocol, minutes from first round of technical review, technical seed documents) will be provided to Alberta Environment and Climate Change Central in time for the February 1, 2011 deadline. The process for review will then follow the broader stakeholder review process under Alberta Environment.