Proceedings of the Nova Scotian Institute of Science (2025)
Volume 54, Part 1, pp. 273-304

CONSIDERATION OF CLIMATE CHANGE IN NOVA SCOTIAN ENVIRONMENTAL ASSESSMENTS: A CRITICAL REVIEW AND RECOMMENDATIONS FOR IMPROVEMENT

LENA FINE[1*] AND SEAN R. HAUGHIAN[1,2]

[1]Biology Department, Dalhousie University, Life Sciences Centre, 6287 Alumni Crescent Halifax, NS B3H 4R2

[2]Biology Department, Saint Mary's University 923 Robie Street, Halifax, NS B3H 3C3

ABSTRACT

This study evaluates how climate change (CC) is considered in recent environmental assessments (EA) in Nova Scotia, Canada. We assessed 38 EA reports covering six project types: wind farms, road expansions/utility corridors, quarries, mines, green hydrogen plants, and waste treatment facilities. Reports were scored based on 4 or 5 questions in each of four categories: coverage of basic CC science, greenhouse gas (GHG) accounting, greenhouse gas mitigation, and CC adaptation. Wind farms and road expansion/utility corridor projects scored the highest across most categories, particularly in GHG accounting and mitigation. Quarry expansions and waste treatment facilities scored poorly, with quarry projects receiving the lowest scores in GHG accounting and adaptation. Common weaknesses included inadequate enforcement of mitigation measures and a lack of consideration for carbon sequestration in GHG accounting. Green hydrogen production plants demonstrated strengths in renewable energy sourcing but lacked comprehensive GHG accounting and basic CC science. Mines, though reporting well on basic climate-change science and CC adaptation, had inadequate GHG accounting and mitigation. Environmental assessment practices have improved slightly but can be better aligned with Nova Scotia's climate action goals. Planners need better integration of sequestration, more consistent accounting, and more consistent enforcement of mitigation strategies.

Keywords: Greenhouse gas accounting; climate mitigation; climate adaptation; carbon sequestration

* Author to whom correspondence should be addressed: sean.haughian@smu.ca

INTRODUCTION

Environmental assessment (EA) is an important prerequisite for development in much of the modern world. In its ideal form, it ensures that developers are appropriately accounting for and planning to mitigate the potential harms that their project could do to communities and ecosystems within the project's area of influence. It also offers governments a considerable amount of evidence upon which they may subsequently base legally defensible decisions to manage development in an optimal way, or prevent "reckless or inadequately informed actions", when such work is not in the best interests of its citizens (Barrow 1997). Specific regulations concerning EA vary among jurisdictions, but in Nova Scotia, proponents are usually required to provide information on (1) baseline geology, water and air quality, biodiversity (usually focused on rare, at-risk, or culturally significant species), and culturally significant uses of the landscape, (2) expected changes to the baseline that are inferred, estimated, or projected based on the proposed development, (3) whether the expected changes are "significant", and (4) proposed mitigation or compensation measures that address any harmful impacts from the proposed development (Province of Nova Scotia 1995).

Although it has not historically been addressed by EA processes, Climate Change (CC) is among the most urgent and important environmental harms caused by human activity in the 21st century, and our response to it could benefit from being integrated into the EA process (MacKinnon *et al.* 2018). The effects of CC are increasingly apparent and harmful in Canada and around the world. Compared to historic conditions mean annual temperatures, frost-free periods, and prolonged summer weather have all increased significantly (Garbary & Hill 2021, Vincent *et al.* 2018). These changes have driven shifts in the distribution of plant and animal populations (Pecl *et al.* 2017, Rubenstein *et al.* 2023, Schumacher *et al.* 2022) and of the pathogens and pathogen-vectors that affect them (Gilbert 2021). Moreover, CC has increased the frequency and intensity of natural disturbances such as wildfires, droughts, floods, hurricanes, and tropical storms, leading to substantial damage to human infrastructure and losses of life (Insurance Bureau of Canada 2024, Jain *et al.* 2024, Mekis *et al.* 2015, Ollerhead 2023). Given the prominent place of the EA process in determining whether or how projects should proceed while considering environmental and human harms, CC should be explicitly addressed as part of the EA process (MacKinnon *et al.* 2018). Indeed, Nova Scotia adopted mandatory reporting of greenhouse gases for projects with emissions over 50,000 t CO_2 equivalents per year in 2018, for consistency with federal changes to EA regulations (Quantification, Reporting and Verification Regulations Made under Section 112Q of the Environment Act, 2018). Climate-change consideration in the EA process appears to have improved since 2019, but is inconsistent, and so a more empirical approach was needed to determine how well EA writers are doing, and whether their work can be further improved.

Earlier Nova Scotian EA regulations conferred no legal responsibility on proponents to consider CC (Nova Scotia, 2001). Attempts to encourage developers to consider CC in EAs (Nova Scotia Environment 2011, The Federal-Provincial-Territorial Committee on CC and Environmental Assessment 2003) met with little uptake, being based almost entirely on voluntary guidelines and recommendations. Moreover, much uncertainty likely still exists among EA professionals as to how and when to incorporate CC considerations into the EA process (Jiricka *et al.* 2016), particularly when projects are too small to require GHG reporting for large emitters.

The goals of this study are two-fold: (1) to examine Nova Scotian EAs published after legislative changes in 2018 to assess how effectively they have incorporated CC considerations into the EA process; and (2) to provide recommendations as to how regulators and industry can improve. The review of these EAs is approached through the consideration of four main categories: (1) the basic science of CC, (2) accounting for GHG emissions, (3) mitigation of GHG emissions, and (4) adaptation planning.

METHODS

To assess the consideration of CC in Nova Scotian EAs, 38 EA reports from the period 2018-2023 were studied and scored using standardized criteria. EA reports were obtained from the Nova Scotia government's web page of recent environment and CC projects, where all EAs are posted as public documents (Nova Scotia Department of Environment and Climate Change 2024). To improve representativeness within sectors, and to minimize bias across sectors, we sought to include either (a) all EAs of that project type from 2022 and 2023, or (b) as many EAs of a given class as were available from between 2018 and 2023. For project types with adequate representation (≥ 5) in the 2018-2023 period, we additionally reviewed at least two EA reports from prior to 2018, to evaluate changes in report quality since legal changes in GHG reporting requirements were enacted.

As EA reports typically are hundreds of pages in length, we focused our review on specific sections of each individual EA that might contain significant information pertinent to the scoring criteria we applied. Generally, sections highlighting project impacts on airborne pollution, emissions, or air quality were studied in all reports. To ensure that atypical report structure did not cause important information to be overlooked, keyword searches were also used to find relevant information in each report, including such terms as "greenhouse gas", "GHG", "climate change", "carbon", and "CO_2".

Reports were scored based on four categories: CC basics, GHG accounting, GHG mitigation, and CC adaptation (Table 1). Within each category, a suite of 4 or 5 questions were scored, and the sum of these scores was used to generate an overall score for that category. A score system was created for this study where questions were given scores ranging from 0 to 1 on questions that yielded a binary (yes/no) answer and -1 to 1 on questions that required some judgement, with 1 denoting unbiased assessment based on published standards, 0 being unbiased but haphazard or neglected, and -1 being self-serving.

In all categories, we first asked whether the category was mentioned or acknowledged at some place in the report. The bar for a point on this question was intentionally low to contextualize other responses within those categories; reports that failed to include more detailed information on GHG accounting or mitigation because the report writers failed to consider CC entirely could be discriminated from those that made erroneous assumptions, for example.

For the category "CC basics", we additionally asked: (1) is CC acknowledged as a problem, (2) were obfuscating or misleading statements absent, (3) were federal or provincial guides to considering CC cited (Nova Scotia Environment 2011, Province of Nova Scotia 2020, The Federal-Provincial-Territorial Committee on CC and Environmental Assessment 2003), and (4) was other pertinent literature cited? The answers to these questions helped us to understand whether the report writers and proponents were relying on current and accurate information or perhaps had outdated and/or ideologically motivated understandings of CC.

The GHG accounting category included four additional questions: (1) are GHG accounting estimates reasonable, (2) are GHG accounting assumptions appropriate, (3) is GHG sequestration considered, and (4) is significance determination appropriate? Because our expertise is not in life-cycle analysis for determining GHG footprints, determining whether estimates were reasonable depended upon whether obvious aspects of the project were considered by accounting practices, rather than critiquing specific accounting values. For example, we did not critique the specific GHG-equivalent values applied to each tonne of steel or concrete but rather noted whether such values were present and appeared to be based on literature or international standards. Similarly, in determining whether assumptions were appropriate, we looked for evidence that the writers scaled up materials and operating impacts using reference projects of a similar size or using previous experience as a guide to making such calculations. Consideration of GHG sequestration on the landscape prior to project development was self-evident, and we simply looked for the presence of such values in the report. For significance determination, we examined whether projects were comparing themselves to objective, published criteria based on literature or industry standards (e.g., Murphy and Gillam 2013).

The GHG mitigation category asked four additional questions: (1) whether there were expected behavioral changes for project staff or operations to improve GHG mitigation, (2) whether there were technological-based solutions for GHG mitigation included in project design, (3) whether offsets and/or compensations with regard to GHG mitigation were planned, and (4) whether enforcement of GHG mitigation activities was present. Behavioural reductions in GHGs could include, for example, company policies against unnecessary vehicle idling or efficiency improvements through 2-way hauling. Technological mitigations could include, for example, upgrading of equipment to high-efficiency standards, or supplying power from renewable sources. Offsets or compensations could include such activities as financially supporting tree planting initiatives or research on climate solutions or donating land with a high GHG sequestration or storage value for protection. Enforcement of mitigation activities included providing evidence of company policies and practices that ensured staff would be compliant and that goals would be tracked and met, such as integrating compliance with said policies into performance reviews for staff.

The final category was CC adaptation. Within it, we asked three additional questions: (1) whether any behavioural adaptations were planned, (2) whether any technological adaptations were included in the project design, and (3) whether any projections or tools were used to determine the need for adaptations. Behavioural adaptations included explicit articulation of modified work practices related to environmental health and safety concerns for staff that stemmed from CC impacts, such as taking more frequent breaks and having access to water during extreme heat or ensuring that staff were trained in emergency protocols to respond to severe weather. Hypothetically, behavioural adaptations could also include initiatives to promote employee mental health and cope with climate anxiety, but based on the experience of the authors, such adaptations were extremely unlikely to be articulated in an EA report and therefore were not explicitly searched for. Technological adaptations included specific technologies that solved climate-related environmental health and safety problems for staff and project infrastructure, such as improved heating and cooling systems in buildings. Finally, we looked for evidence that the writers used climate projections or other tools (e.g., flood risk maps, fire-smart assessments) to develop a nuanced understanding of what specific behavioural or technological adaptations may be required.

In addition to the categories and questions upon which we focused our critique of EA reports, our initial workplan included a fifth category of CC consideration, which was "how does CC interact with the project to impact other valued environmental components within the study area?" After conducting our review, we decided to exclude this category because it was data deficient, not having been mentioned in a single report.

After EAs were examined and scored based on these criteria, common strengths, weaknesses, and opportunities were highlighted using descriptive statistics, and these were used to inform recommendations regarding potential areas of improvement.

Table 1 The four categories being scored and the criteria that make up each category

Criteria	CC basics	Greenhouse Gas Accounting	Greenhouse Gas Mitigation	CC adaptation
1	CC was mentioned	Some form of greenhouse gas accounting was shown	Some form of GHG mitigation is planned	Some form of adaptation to future climates planned
2	CC was acknowledged as a problem	Accounting estimates were reasonable	Behavioral reductions present	There were specific behavioural (including geospatial) changes
3	Obfuscating/ misleading statements were absent	Accounting assumptions were appropriate	Technological-based reductions present	Technological CC adaptation was present/considered
4	Nova Scotia's guide to considering CC & reporting standards was used	Sequestration was considered	There were any offsets/ compensations	Projections/tools were used
5	Other literature was used and cited	Significance determination was appropriate	There was any enforcement of greenhouse gas mitigation	-

RESULTS

We reviewed 38 EA reports of six project types: green hydrogen & ammonia production plants (n=2), mines (n=3), quarries (n=7), road expansions/ utility corridors (n=7), wind farms (n=12), and waste treatment facilities (n=7). Modal scores for all questions within each CC category are reported in Appendix A, and a list of the projects we reviewed is provided in Appendix B.

Road expansion and utility corridor projects performed better than most other project types, except for on CC adaptation, where they tied wind farms and mines for the lowest overall scores. Citing more provincial EA documentation, accounting for changes to the carbon sequestration capacity of the landscape, and proposing carbon offset activities to mitigate emissions helped these reports to stand out amongst other project types. Modal scores ranging from 3 to 5 in different categories for combined scores of 16/19 overall (Fig 1). Although there was considerable variability among projects, one report stood out for its high scores on GHG mitigation and CC adaptation, the "Highway 101 Cambridge Interchange and Connector Road Project" (WSP Consulting 2023). On GHG accounting and CC basics, the "Highway 101 Digby to Marshalltown Corridor Project" (Stantec Consulting Ltd. 2017) scored the best.

Wind farms received some of the best overall scores of all project types. Not only were wind farm projects found to be highly considerate of CC, including extensive GHG accounting sections, but they also had the advantage of claiming the production of renewable energy during the operational phase to mitigate any GHG emissions created during the construction phase. Most wind farm projects performed well in all categories except for CC adaptation, where there was a consistent lack of stated technological adaptation (specifically) to CC. Although this adaptation may have been included in wind-turbine design, it was not stated in the reports. On the CC basics and adaptation, the Ellershouse 3 Wind Project (Strum Consulting Ltd. 2023a) performed best, while the Mersey River Wind Farm (Strum Consulting Ltd. 2023b) performed best on GHG Accounting and Mitigation.

Green hydrogen and ammonia production plants were found to have room for improvement in their EAs about reporting on CC basics and GHG accounting. They scored the lowest in the "CC basics" category, obtaining total scores of 2 in that category. They tied roads and corridors for the highest median scores (3) for both the GHG mitigation and CC adaptation categories (Fig 1), due in large part to such aspects as relying on renewable power sources and applying behavioural mitigations and adaptations.

In terms of how they reported on both the basic science of CC and how they proposed to adapt to future climates, mines were comparable to the highest-scoring projects: they referred to relevant provincial literature and avoided obfuscation. Mine EA reports also included technological or behavioural adaptations in their plans that showed adaptation to climate impacts such as greater flood potential around roads or higher peak temperatures.

However, mines, quarries, and waste treatment facilities had the lowest scores for GHG accounting and mitigation, where points were lost for self-serving significance determinations, a total absence of relevant information, or a lack of technological mitigations or offsets

(Fig 1). In the case of mines, these low scores primarily resulted from inappropriate assumptions or self-serving significance determination for accounting, and from a lack of technological or offset-based mitigations. For example, the significance of GHG emissions for all mines was determined to be "negligible", based on minimum thresholds for significance determination that varied across projects from 1-8% of provincial emissions. These thresholds appeared to have been chosen either haphazardly or based on the amount that would individually threaten the province's GHG reduction goals. Proposed GHG mitigations were limited to low-effort behavioural modifications of staff, such as preventing idling and maintaining equipment in good working order. No enforcement of such behaviours was proposed, and no commitments were made to technological enhancements that would further reduce GHG emissions.

Quarry expansion projects had the lowest modal scores of all project types, in fact receiving a negative median or modal score in the GHG accounting category and not achieving a combined score higher than 4 in any category (Fig 1). Most of the quarry EAs failed even to mention anything related to GHG accounting. Quarry EAs also received lower scores than all other project types for CC adaptation. Waste treatment projects scored similar to quarries as a group for GHG accounting and CC adaptation, but were more consistent in omitting GHG accounting information entirely. Waste treatment projects performed slightly better than quarries in articulating the basic science of CC, but were highly variable across projects, with scores ranging from 0-5. Waste treatment projects fared slightly worse in mitigation efforts than quarry expansions. The best scoring waste treatment project on CC Basics was the Arlington Heights Asbestos Disposal Facility (East Coast Aquatics Inc. 2017).

Wind farms, waste treatment facilities, and road or utility corridor expansions had sufficient numbers of reports from the 2018-2023 period, and so two additional reports were reviewed from prior to 2018 for each of these project types, spanning the years 2016-2017. From these comparisons across time periods, only wind farm EA reports showed a change in how effectively they considered CC. Between pre- and post-2018 periods, wind farm climate consideration scores in EA reports improved by 9 points, or 47%. Prior to 2018, there was almost no mention of GHG accounting or adaptation for wind farm projects, and very little mention of mitigation.

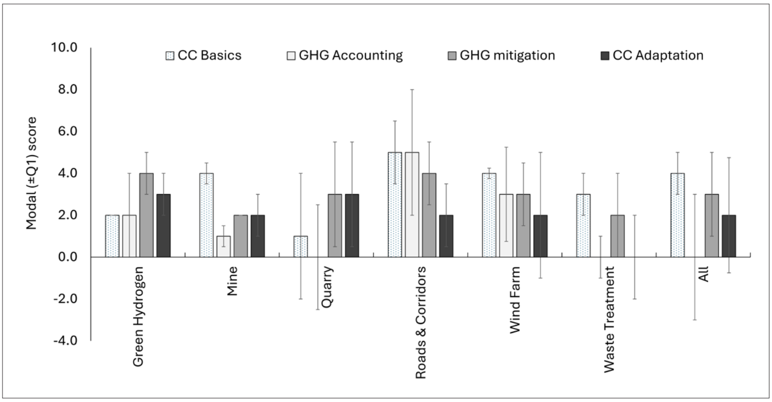

Fig 1 **Modal scores of different EA types out of four or five (environmental effect factor-dependent) regarding four categories: CC basics, GHG accounting, GHG mitigation, and CC adaptation.**

DISCUSSION

Of the 38 reports we assessed, wind farms and road expansion/ utility corridor projects tended to have the highest scores, followed closely by green hydrogen and ammonia production plants. The least consideration for CC was in reports for waste treatment sites and quarry expansion projects; mines were intermediate. Wind farms, but not other project types, showed improvements between pre and post- 2018 periods in how much consideration was given to CC in EA reports. Nevertheless, all project types still had both strengths and weaknesses after 2018. Going forward, proponents and consulting firms can learn much from the literature and from each other about how to improve their consideration of CC in future EAs. We highlight some of these opportunities below.

General criticisms

In assessing the EAs of all project types, two specific scoring criteria stood out as weaknesses throughout all project types. The first of these was the "enforcement" criterion within the GHG mitigation category. Not a single assessed EA from any project type scored above zero on this question. The absence of proposed enforcement policies for any climate-change related mitigations or adaptations is concerning, because it suggests that the proposals contained within EA reports may not be reliable. The other criterion in which most project types performed poorly was the "sequestration considered?"

question within the GHG accounting category. Only five out of the 38 assessed EAs scored above zero in this subcategory. This lack of recognition that the pre-existing landscape could have a carbon-sequestering function was surprising, given the emphasis placed on baseline values in most other sections of EA reports (e.g., water & air quality, presence of at-risk species, etc.). Development of standardized carbon flux models for Nova Scotian ecosystems, in collaboration with industry and government, may improve such reporting in the future, but in the interim, consultants are encouraged to examine the many published sources from which estimates of pre-existing carbon sequestration could be obtained (Gallant *et al.* 2020, Kendall *et al.* 2021, Smyth *et al.* 2024).

Specific criticisms by project type

Road expansion/utility corridors

Road expansion projects have one of the highest GHG emission factors of the six evaluated project types due to the quantity of emissions released by asphalt production (Ma *et al.* 2016), and by the high emissions associated with heavy construction equipment. Nevertheless, some additional strategies could be used to reduce projected emissions. The heavy equipment and vehicles that are used in the construction of roadways and utility corridors can be chosen based on their efficiency or ability to generate as few GHG emissions as possible (Avetisyan *et al.* 2012). Moreover, the raw materials that are used to produce asphalt are not equal in terms of carbon emissions (Anthonissen *et al.* 2016), and where possible, material sources should be optimized to reduce GHGs through the construction phases of the projects. In addition, EA report writers should more consistently consider projected changes in transportation efficiency, such as anticipated reductions in vehicle idling, when evaluating projected CO2 emissions through the life-cycle of the infrastructure created (WSP Consulting 2023).

Wind farms

Wind farms performed consistently well in most categories, but were variable in others, and still have room for improvement. Although the small amounts of GHG emissions generated by wind turbine maintenance (Padey *et al.* 2012) are mostly negligible when compared against comparable emissions from fossil-fuel generated energy, they must nevertheless be reported as part of the carbon accounting for a project. In addition, wind farm proponents should consider reporting on whether their designs are adapted to projected changes in the frequency of severe wind and weather events with CC, such as increased frequency of hurricanes.

Green hydrogen and ammonia production

Green hydrogen & ammonia production plants are a relatively new type of renewable energy development that is being introduced in Nova Scotia. Production of green hydrogen can be carried out through "cracking" or hydrolysis of ammonia; this is a carbon-free way of producing energy that does not generate greenhouse gases if the initial energy source is from renewable power, such as wind turbines or photovoltaic generators (Rizi and Shin 2022).

Some additional coverage of the state of the climate in NS or Canada, with recent references to IPCC or federal and provincial reports on the attribution and impacts of CC, are likely needed to improve report rigour for Green Hydrogen projects. In addition, more in-depth consideration of pre-existing GHG sequestration on the landscape, as well as detailed GHG accounting through a combination of life-cycle analysis, projected energy use, literature review, or comparison to similar projects, could significantly improve the proponents' ability to account for (and therefore mitigate) GHGs over the lifetime of the project. Some additional consideration of what constitutes "significant" in the context of a project of this size is also likely needed. Although green power projects such as these may have a large up-front GHG footprint, they are often favourable overall by reducing long-term emissions relative to those generated by conventional energy sources for the same amount of energy. Nevertheless, this expectation should not exempt a project from providing an unbiased assessment of its significance in the context of provincial energy needs and emissions projections.

Mines

In recent years, a renewed interest in gold mining along the eastern shore region of Nova Scotia has led to several EAs for proposed gold mines. Nova Scotia has a long history of mining for precious metals, coal, and other resources, but the industry has waxed and waned over time due to shifting prices and technology (Nova Scotia Department of Mines 1976, Parsons *et al.* 2012). The toxic legacy of historical mining operations (Sivarajah *et al.* 2024, Walker *et al.* 2015, Bowes and Walker 2024) and potential CC impacts of these resource-intensive projects have, understandably, led to renewed criticism in the public domain (Jones 2023). Consequently, the analysis presented here is both timely and important for public discourse and improving sustainable development practices in the province.

The long lifespan and high investment requirements of mining projects probably contributed to their high scores in CC basics and adaptation, because such considerations are important to the economic viability of the project, resulting in a high standard of coverage. On the other hand, mine projects were scored lower than most other project types on their GHG accounting and mitigation, due to the self-serving significance determination and lack of mitigations. While the context of the province's GHG reduction goals is important to consider, it would be extremely unlikely for any single project to cause an annual increase of 1-8% in provincial GHG emissions. Such provincial or national thresholds are inappropriately high for significance determination (Hetmanchuk 2020). Given the current and predicted future availability of sustainable electricity sources in Nova Scotia (Department of Natural Resources and Renewables 2020), both concrete actions (e.g., rooftop solar generation over structures) and aspirational targets (e.g., future shifts to green hydrogen-powered haul vehicles; Figueiredo *et al.* 2023) could reasonably be included in mining EA reports. For those emissions that cannot be eliminated through behavioural or technological improvements, carbon offsets should be required, such as investments in restoration of local peatlands, salt marshes, or forests on degraded lands. Any such offsets must, however, be accompanied by locally-calibrated carbon accounting and monitoring to ensure unbiased estimation of carbon stocks or flux (Haya *et al.* 2023), and consider the time-scales associated with expected emissions, expected offsets, and provincial GHG-reduction goals to avoid problems such as "multi-gas transactions" (Allen *et al.* 2021).

Quarries

Quarry projects have considerable room for improvement when it comes to their EA reports. This low level of CC consideration was surprising given the almost unanimous consideration of it in other project types, and the fact that several EA consulting firms contributed to both quarry EAs and other project types that scored well on this category. On the other hand, the relatively small size of quarry expansion projects may bias such EA reports towards minimalist coverage of anything that is not strictly required by law, as the cost of expansive coverage for such impacts may threaten the financial viability of a small project itself.

Going forward, consultants and proponents should look for additional guidance from publications released by the province of Nova Scotia as to how to properly quantify and report GHG emissions expected to be released by a project (Province of Nova Scotia 2020). When multiple aggregate sources are available near an intended building project, planners should consult published resources to determine which types of materials have the smallest impact on the environment, and preferentially develop those over others. Quarry developers could then cite these decisions as evidence of GHG mitigation. For example, Qamhia *et al.* (2023) found that different types of aggregate, and the efficiency with which quarry by-products could be used, impacted the GHG footprint of the cement it was used to create. At a minimum, proponents of quarries should be able to estimate GHGs from the lifetime of the project and annual vehicular activity and the emissions that were produced from off-road construction vehicles, which appear to be the main source of emissions for these projects (Jassim *et al.* 2018). Like mines, plans for reducing emissions from fossil fuels via technological and behavioural changes to operations should be expected within the EAs for quarries, with both near-term plans and aspirational targets for clean power use.

Quarry proponents are also missing opportunities to contextualize their projects as an essential part of the province's Climate Action Plan (Province of Nova Scotia 2022), or as part of larger projects. Quarries typically are accessed for aggregate for most construction projects and therefore contribute to the Climate Action Plan by improving the efficiency of transportation infrastructure through improved road networks (concerns mitigation; Zhang *et al.* 2023), by enhancing protections against sea-level rise and severe storms through provision of locally sourced construction and stabilization materials (concerns adaptation; Anfuso *et al.* 2021), and more. Such values may be difficult to quantify on a quarry-by-quarry basis; a consortium- or province-led effort to quantify these values in broader terms would assist quarry developers with improving their

EA reports in the future, as would integration of quarry EAs into the projects for which they will be the primary source of aggregate material.

Waste treatment and disposal facilities

The lack of consistency on CC basics for waste treatment facilities is likely due, in part, to the diverse nature of the projects within this category; proposed projects ranged from waste oil or tire recycling to asbestos disposal to a dangerous waste storage facility, all of which have very different land- and water-use requirements and very different goals. Nevertheless, it will be important for such projects to improve on this category going forward, as it ensures that CC is at least being considered during project design phases. In addition, these projects were very closely aligned on scores for GHG accounting and mitigation and likely share much in common with respect to climate adaptation, suggesting that the group designation remained reasonable.

Concerning GHG accounting and mitigation, proponents may have neglected to consider the potential impacts and improvements their work could have on GHGs because the projects are primarily concerned with limiting environmental damage from waste products. As such, most are likely necessary to human health and the operation of other industries in the province, and likely to be approved regardless of their impact on GHGs. Nevertheless, as with mining and quarrying, many choices must be made in the design and operation of waste management facilities that can impact GHG emissions, and as such a full accounting of the anticipated impacts of a waste management facility on GHGs is a useful decision aid when considering opportunities to mitigate environmental harms.

Waste management facilities performed poorly on CC adaptation, a category which is arguably more important for such facilities than most. Facilities that store or dispose of hazardous waste could cause considerable harm if they are not built to a sufficient standard to endure the expected increases in frequency or severity of severe weather events. In this context, climate projections and tools, as well as technological and behavioural adaptations, are critical to protecting both infrastructure and human health.

General guidance for future EAs

The process of establishing a baseline for greenhouse gases (GHGs) in a study area can be challenging but may be approached in several ways. In the broad sense, baseline conditions are what exists in the absence of the project on the landscape, quantified in such a way that the potential impacts of the project can be predicted, and any subsequent changes resulting from the project can be measured (Hirsch 1980). In the context of CC, these include the GHGs stored by soil, vegetation, ice, water, or geological formations, and the greenhouse gases that are sequestered or emitted on an annual basis by those features. Many forms of land use change can reduce carbon storage and sequestration, particularly when deforestation is part of the change. Direct measurement of such features is possible but would likely be cost-prohibitive in many cases for an EA study. Nevertheless, several metrics can be inferred using pre-existing data that are freely available via government sources (e.g., GIS data on forest inventory and soil or ecosystem classification) in combination with empirical studies of greenhouse gases in similar landscapes. The forest industry has produced hundreds of studies on carbon storage and dynamics associated with forests of different compositions, ages, and sizes (Smyth *et al.* 2024). Studies of carbon storage and dynamics in wetlands and other habitats are fewer, but likely sufficient for the purpose of estimating baseline conditions within a reasonable range (Gallant *et al.* 2020, Kendall *et al.* 2021). For rare ecosystems or those not well represented by studies of greenhouse gas dynamics in the literature, industry should be encouraged to initiate and publish such a study as a form of compensation for expected damages, or governments could fund such work proactively to ensure industry has the required tools to produce high quality baseline studies in the future.

GHG accounting is, from an EA standpoint, relatively straightforward, given the plethora of published information that is now available. Depending on the intended operational life of the project, it may be most appropriate to account for GHGs in two or three phases: construction, operation, and, for projects of limited duration, decommissioning (Wu *et al.* 2014). GHG emissions during construction and decommissioning phases are dominated by emissions from manufacturing and transportation of building materials (Sizirici *et al.* 2021), and from generators or heavy equipment used during on-site activities (Province of Nova Scotia 2020). International standards for estimated greenhouse gas footprints of many classes of building materials are now supplied with the materials themselves on an emissions per kg or per tonne basis (I.S.O. 2006, 2013) or have been published in academic literature (Sizirici *et al.* 2021). These values can easily be extrapolated based on the combination of materials that will be used in a project. Emissions from transportation and construction equipment can be estimated based on the GHG footprint of the equipment or materials being used, the fraction of the equipment's lifetime that it will be used for, and the fuel required to operate the equipment (Province of Nova Scotia 2020). The operations phase GHGs stem primarily from power or fuel requirements for running equipment or heating buildings on an ongoing basis, and from the building materials used during the construction phase, as well as the proportion of the lifespan of the equipment for which it will be used.

Significance determination for the impacts of a project on greenhouse gases should be based on clear, legally binding standards, because without such standards proponents may apply variable standards of their own design to make projects appear less detrimental (Murray *et al.* 2018), or portray limited consultation with community stakeholders, who lack the expertise to fully represent their interests to the same extent as proponents, as tacit designation of nonsignificance (Singh *et al.* 2020). Many aspects of EAs (e.g., air and water-borne pollutants) are assessed relative to thresholds at which negative impacts become detectable on human or environmental health, referred to by some as "technical" thresholds (Murray *et al.* 2018). With the changes made to the Nova Scotia Environmental Assessment Act in 2018, projects with GHG emissions above 50,000 t CO_2 equivalents per year are required to report emissions to the government; the size at which this requirement is activated may constitute an appropriate threshold for "significance" in the case of certain large projects. Nevertheless, this standard would not apply to many small and mid-sized projects and therefore leaves far too much leeway for proponents to misrepresent GHG impacts as negligible in comparison to a reference point of their choosing (Murray *et al.* 2018). Some scholars have proposed their own strategies for significance determination with GHGs that hold some promise (Murphy and Gillam 2013). Nova Scotia Department of Environment itself suggested that, given the importance and urgency of reducing global GHGs, any emissions that result from development are significant, and should be reported and mitigated to as high a degree as possible (Nova Scotia Environment 2011).

As currently practiced, the EIA process in many jurisdictions is biased against finding significant negative impacts, or towards assumed effectiveness of poorly supported mitigation measures (Singh *et al.* 2020). However, as with determination of significance for impacts on human health from air or water-borne pollutants, an effective significance determination system should be set proactively by the government with the advice of scientists and CC experts and should be considered relative to the pre-existing baseline conditions on the landscape (Murray *et al.* 2018, Singh *et al.* 2020). Failure to adequately consider baseline conditions in determining the significance of projected changes in GHG emissions post development is equivalent to assuming a "zero baseline" (Soimakallio *et al.* 2015), which both implicitly undervalues ecosystem services and reduces projected impacts relative to a landscape with significant carbon sequestration potential.

Mitigation of GHG emissions is also relatively straightforward, albeit still limited in scope when it comes to heavy industry. Limiting the footprint of the project to the smallest area necessary, and progressively reclaiming sections of the footprint that are no longer used, should be a starting point. By preserving or restoring woody plants and active soils to the project area, the developer maintains more carbon sequestration and storage potential than would otherwise be the case. Behavioural adjustments are also relatively easy to implement and can have significant impacts on resulting emissions. All staff should be required to adhere to energy-conserving actions such as turning off vehicles rather than idling them (to the extent that engine maintenance practices permit) when not in transit, coordinating across sites to increase two-way hauling instead of moving empty trucks, using high-efficiency fuels, and maintaining equipment to the manufacturer's specifications for optimal efficiency (Lewis *et al.* 2009, 2011). Renewable energy sources should be used to power equipment, buildings, and vehicles whenever possible. Although replacements for heavy diesel-powered vehicles and equipment are not yet commercially available, more sustainable options are available for many other applications. For example, office, residential, and commercial buildings could have rooftop photovoltaic power generation incorporated into designs from the start, and smaller classes of vehicles used by the proponent could be powered by electric or hybrid electric engines. Finally, all companies taking on projects large enough to require an EA should be required to have long-term plans for replacing outdated and inefficient equipment with more sustainable versions at the equipment's end of life.

A final component of the EA process in Nova Scotia is to consider the impacts of the environment on the project. In the broad sense, this consideration is to ensure that proponents plan and carry out development activities with a clear sense of what building standards may be necessary to ensure the safety of staff, the soundness of critical infrastructure, and the health of nearby communities in case of extreme weather or natural disasters. Proponents typically evaluate such impacts by having engineers and planners consult maps, data, and risk assessments on the probability of floods, seismic activity, forest fires, coastal storm surge, and other potentially catastrophic disturbances for the study area, and by adjusting plans to ensure that infrastructure can withstand them. In recent years, the compounding impacts of CC on the frequency and severity of such events has been brought into sharp focus for many parts of Canada (Insurance Bureau of Canada 2024), emphasizing the need to consider large-scale events that would have been too unlikely to warrant consideration even 20 years ago. The simplest approach for adapting to a changing climate is to choose a more robust standard to build towards. For example, instead of ensuring that roads can withstand a 1 in 20-year flood, proponents could ensure that roads can withstand a 1 in 100-year flood. On the other hand, this approach may be more costly than is necessary and could make decommissioning more difficult. A more nuanced approach, where climate projections are explicitly incorporated into the planning process, is likely to yield a more realistic and efficient set of scenarios to which the plans can be adapted. Although incorporating climate projections into the planning process may seem intimidating to those who have not used them, there are many simple and accessible tools that are now available through government and nonprofit organizations to examine such expected effects as increased temperatures and fire activity, increased rainfall and flood risk, and expected sea level rise (Canadian Centre for Climate Services 2024, The Prairie Climate Centre 2019, Wang *et al.* 2016).

Finally, for larger or longer-lived projects, there may be considerable value in cumulative effects analysis, wherein the effects of both

CC and the project, as well as any interactions between them, on valued environmental components within the study area are simultaneously considered (Sinclair *et al.* 2017). No EA reports that we read had such analyses included, despite the potential value in doing so. For example, for projects that are expected to alter wetlands and watercourses, thereby impacting water temperatures and sediment loads, they would additionally need to consider the additive effects of CC-driven increases in water temperatures while the effects of the project persist, when determining whether their proposed alterations could negatively impact fish. Although such analyses may seem complex, the suite of modeling tools that are now available to consulting firms should simplify the process, particularly where such models are already regularly used to predict project impacts. Moreover, guidance on cumulative effects assessment is readily available for Canadian practitioners (IAAC 2018). This lack of cumulative effects assessment in Nova Scotian EAs appears to be primarily a legal and policy gap that could be addressed through regulatory changes (Northrup 2022).

To avoid damaging increases in global temperatures, massive reductions in carbon emissions are needed over the coming decades (IPCC 2018). As such, Nova Scotia has committed to 53% lower GHG emissions than levels in 2005 by 2030 and net zero GHG emissions by 2050 (Province of Nova Scotia 2022). Achieving these reductions will require significant actions by large industrial emitters, and likely significant changes to the legal frameworks within which these emitters operate. The EA process is well positioned to become a standardized planning tool for developers to transparently consider and plan reductions in their GHG emissions, as well as to plan for and adapt to emerging risks associated with CC. We hope that the data, analysis, and perspectives shared in this report have improved awareness of the many tools, resources, and approaches that planners can use to immediately improve their EA reports. Moreover, we hope that we have clarified some of the regulatory and research gaps that currently inhibit more effective consideration of CC in the EA process, such that these gaps can be appropriately addressed in the coming years.

Acknowledgements We wish to thank Dr. Peter Duinker for several helpful discussions, reviews of draft manuscripts, and recommendations on study design. We also thank Tony Walker, Ian Stewart, and an anonymous referee for their constructive and insightful reviews, which greatly improved the manuscript. We thank Dalhousie University and the Nova Scotia Museum for supporting this work via course credit for LF and salaried time for SRH, respectively.

REFERENCES

Allen, M., Tanaka, K., Macey, A., Cain, M., Jenkins, S., Lynch, J. & Smith, M. (2021). Ensuring that offsets and other internationally transferred mitigation outcomes contribute effectively to limiting global warming. *Environmental Research Letters* 16(7): 1-9. 074009. doi.org/10.1088/1748-9326/abfcf9

Anfuso, G., Postacchini, M., di Luccio, D. & Benassai, G. (2021). Coastal sensitivity/vulnerability characterization and adaptation strategies: A review. In *Journal of Marine Science and Engineering* 9(1): 1-29. doi.org/10.3390/jmse9010072

Anthonissen, J., Van den bergh, W. & Braet, J. (2016). Review and environmental impact assessment of green technologies for base courses in bituminous pavements. *Environmental Impact Assessment Review* 60: 139-147. doi.org/10.1016/j.eiar.2016.04.005

Avetisyan, H.G., Miller-Hooks, E. & Melanta, S. (2012). Decision Models to Support Greenhouse Gas Emissions Reduction from Transportation Construction Projects. *Journal of Construction Engineering and Management* 138(5): 631-641. doi.org/10.1061/(asce)co.1943-7862.0000477

Barrow, C.J. (1997). Introduction. In: Environmental and Social Impact Assessment: An Introduction. Oxford University Press, New York, NY, USA. p. 1-14.

Bowes, B.L. & Walker, T.R. (2024). Effective management of endangered Blanding's Turtle (*Emydoidea blandingii*) populations in Nova Scotia, Canada, requires consideration of threats posed by legacy gold mine contamination. *Proceedings of the Nova Scotian Institute of Science* 53(2): 289-304.

Canadian Centre for Climate Services. (2024). ClimateData.ca: Climate Data for a Resilient Canada. Available from: climatedata.ca/ (Accessed 3 December 2024)

Department of Natural Resources and Renewables. (2020). Nova Scotia's 2030 Clean Power Plan Nova Scotia. Halifax, NS.

East Coast Aquatics Inc. (2017). Arlington Heights Waste Disposal Facility. Bridgetown, NS.

Figueiredo, R.L., da Silva, J.M. & Ortiz, C.E.A. (2023). Green hydrogen: Decarbonization in mining – Review. *Cleaner Energy Systems* 5: 100075. doi.org/10.1016/j.cles.2023.100075

Gallant, K., Withey, P., Risk, D., van Kooten, G.C. & Spafford, L. (2020). Measurement and economic valuation of carbon sequestration in Nova Scotian wetlands. *Ecological Economics* 171 (February): 106619. doi.org/10.1016/j.ecolecon.2020.106619

Garbary, D.J. & Hill, N.M. (2021). Climate change in Nova Scotia: temperature increases from 1961 to 2020. *Proceedings of the Nova Scotian Institute of Science* 51(2): 411-442.

Gilbert, L. (2021). The Impacts of Climate Change on Ticks and Tick-Borne Disease Risk. *Annual Review of Entomology* 66(1): 373-388. doi.org/10.1146/annurev-ento-052720-094533

Haya, B.K., Evans, S., Brown, L., Bukoski, J., Butsic, V., Cabiyo, B., Jacobson, R., Kerr, A., Potts, M. & Sanchez, D.L. (2023). Comprehensive review of carbon quantification by improved forest management offset protocols. *Frontiers in Forests and Global Change* 6: 958879. doi.org/10.3389/ffgc.2023.958879

Hetmanchuk, K. (2020). Consideration of climate change mitigation in Canadian environmental assessment: intention and implementation. *Impact Assessment and Project Appraisal* 38(3): 181-193. doi.org/10.1080/14615517.2019.1625252

Hirsch, A. (1980). The baseline study as a tool in environmental impact assessment. In: Speth, G. (Ed). Biological evaluation of environmental impacts: Proceedings of a symposium at the 1976 meeting of the Ecological Society of America. Council on Environmental Quality and the U.S. Fish and Wildlife Service, Washington, D.C., USA. p. 84.

Northrup, T. (2022). Cumulative Effects FAQ Materials for the Website of the Confederacy of Mainland Mi'kmaq. Confederacy of Mainland Mi'kmaq, Millbrook, NS. cmmns.com/wp-content/uploads/2023/06/Cumulative-Effects-FAQ-Materials-for-CMM-Website_Draft-2_24-March-2022-003.pdf

Rizi, H.A.Y. & Shin, D. (2022). Green Hydrogen Production Technologies from Ammonia Cracking. *Energies* 15(21).

IAAC. (2018). Technical Guidance for Assessing Cumulative Environmental Effects under the *Canadian Environmental Assessment Act, 2012*, Version 2. Impact Assessment Agency of Canada, Environment and Climate Change Canada, Ottawa, ON. www.canada.ca/en/impact-assessment-agency/services/policy-guidance/assessing-cumulative-environmental-effects-ceaa2012.html

Insurance Bureau of Canada. (2024). One-Year Update Following 2023 Nova Scotia Wildfires and Flooding. Halifax, NS.

IPCC. (2018). Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. Masson-Delmotte, V., Zhai, P., Pörtner, H.-O., Roberts, D., Skea, J., Shukla, P.R., Pirani, A., Moufouma-Okia, W., Péan, C., Pidcock, R., Connors, S., Matthews, J.B.R., Chen, Y., Zhou, X., Gomis, M.I., Lonnoy, E., Maycock, T., Tignor, M. & Waterfield, T. (Eds). Intergovernmental Panel on Climate Change, World Meteorological Organization, Geneva, Switzerland. 616 p.

I.S.O. (2006). I.S.O. 14044, Environmental Management – Life Cycle Assessment – Requirements and Guidelines. Geneva, Switzerland.

I.S.O. (2013). I.S.O. 14067, Greenhouse Gases – Carbon footprint of products – Requirements and Guidelines for Quantification and Communication. Geneva, Switzerland.

Jain, P., Barber, Q.E., Taylor, S.W., Whitman, E., Castellanos Acuna, D., Boulanger, Y., Chavardès, R.D., Chen, J., Englefield, P., Flannigan, M., Girardin, M.P., Hanes, C.C., Little, J., Morrison, K., Skakun, R.S., Thompson, D.K., Wang, X. & Parisien, M.A. (2024). Drivers and Impacts of the Record-Breaking 2023 Wildfire Season in Canada. *Nature Communications* 15(1): 6764. doi.org/10.1038/s41467-024-51154-7

Jassim, H.S.H., Lu, W. & Olofsson, T. (2018). Assessing energy consumption and carbon dioxide emissions of off-highway trucks in earthwork operations: An artificial neural network model. *Journal of Cleaner Production* 198: 364-380. doi.org/10.1016/j.jclepro.2018.07.002

Jiricka, A., Formayer, H., Schmidt, A., Völler, S., Leitner, M., Fischer, T.B. & Wachter, T.F. (2016). Consideration of climate change impacts and adaptation in EIA practice - Perspectives of actors in Austria and Germany. *Environmental Impact Assessment Review* 57: 78-88. doi.org/10.1016/j.eiar.2015.11.010

Jones, A.M. (2023). Nova Scotia's modern 'gold rush' poses huge risk to climate, expert warns. *CTV News (website)*. www.ctvnews.ca/

Kendall, R.A., Harper, K.A., Burton, D. & Hamdan, K. (2021). The role of temperate treed swamps as a carbon sink in southwestern Nova Scotia. *Canadian Journal of Forest Research* 51(1): 78-88. doi.org/10.1139/cjfr-2019-0311

Lewis, P., Frey, H.C. & Rasdorf, W. (2009). Development and use of emissions inventories for construction vehicles. *Transportation Research Record* 2123: 46-53. doi.org/10.3141/2123-06

Lewis, P., Leming, M. & Rasdorf, W. (2011). Impact of Engine Idling on Fuel Use and CO_2 Emissions of Nonroad Diesel Construction Equipment. *Journal of Management in Engineering* 28(1): 31-38.

Ma, F., Sha, A., Lin, R., Huang, Y. & Wang, C. (2016). Greenhouse gas emissions from asphalt pavement construction: A case study in China. *International Journal of Environmental Research and Public Health* 13(3): 351-365. doi.org/10.3390/ijerph13030351

MacKinnon, A.J., Duinker, P.N. & Walker, T.R. (2018). Emerging Concepts for Science in EIA. Chapter 6 from The Application of Science in Environmental Impact Assessment. MacKinnon, A.J., Duinker, P.N., & Walker, T.R., eds. Routledge Focus, London, UK. doi.org/10.4324/9781351173445

Mekis, É., Vincent, L.A., Shephard, M.W. & Zhang, X. (2015). Observed Trends in Severe Weather Conditions Based on Humidex, Wind Chill, and Heavy Rainfall Events in Canada for 1953-2012. *Atmosphere - Ocean* 53(4): 383-397. doi.org/10.1080/07055900.2015.1086970

Murphy, M.R. & Gillam, K.M. (2013). Greenhouse Gases and Climate in Environmental Impact Assessment – Practical Guidance. In: 33rd Annual Conference of the International Association for Impact Assessment. International Association for Impact Assessment, Calgary, AB.

Murray, C.C., Wong, J., Singh, G.G., Mach, M., Lerner, J., Ranieri, B., Peterson St-Laurent, G., Guimaraes, A. & Chan, K.M.A. (2018). The Insignificance of Thresholds in Environmental Impact Assessment: An Illustrative Case Study in Canada. *Environmental Management* 61(6): 1062-1071. doi.org/10.1007/s00267-018-1025-6

Nova Scotia Environmental Assessment Branch. (2001). A Proponents Guide to Environmental Assessment. Nova Scotia Department of the Environment, Halifax, NS.

Nova Scotia Department of Environment and Climate Change. (2024). Environmental Assessment: Projects. Available from: novascotia.ca/nse/ea/projects.asp (Accessed 25 February 2024)

Nova Scotia Department of Mines. (1976). A brief history of mining and geology in Nova Scotia, Halifax, NS.

Nova Scotia Environment. (2011). Guide to Considering Climate Change in Environmental Assessments in Nova Scotia. Nova Scotia Department of Environment, Halifax, NS.

Ollerhead, J. (2023). Climate change and the coasts of Maritime Canada: expect the previously unexpected. *Proceedings of the Nova Scotian Institute of Science* 53: 19-27. doi.org/doi.org/10.15273/pnsis.v53i1.11808

Padey, P., Blanc, I., Le Boulch, D. & Xiusheng, Z. (2012). A Simplified Life Cycle Approach for Assessing Greenhouse Gas Emissions of Wind Electricity. *Journal of Industrial Ecology* 16 (suppl.1). doi.org/10.1111/j.1530-9290.2012.00466.x

Parsons, M.B., LeBlanc, K.W.G., Hall, G.E.M., Sangster, A.L., Vaive, J.E. & Pelchat, P. (2012). Environmental geochemistry of tailings, sediments and surface waters collected from 14 historical gold mining districts in Nova Scotia; Geological Survey of Canada, Ottawa, ON. Open File 7150. doi:10.4095/291923.

Pecl, G.T., Araújo, M.B., Bell, J.D., Blanchard, J., Bonebrake, T.C., Chen, I.C., Clark, T.D., Colwell, R.K., Danielsen, F., Evengård, B., Falconi, L., Ferrier, S., Frusher, S., Garcia, R.A., Griffis, R.B., Hobday, A.J., Janion-Scheepers, C., Jarzyna, M.A., Jennings, S., Lenoir, J., Linnetved, H.I., Martin, V.Y., McCormack, P.C., McDonald, J., Mitchell, N.J., Mustonen, T., Pandolfi, J.M., Pettorelli, N., Popova, E., Robinson, S.A., Scheffers, B.R., Shaw, J.D., Sorte, C.J.B., Strugnell, J.M., Sunday, J.M., Tuanmu, M.N., Vergés, A., Villanueva, C., Wernberg, T., Wapstra, E. & Williams, S.E. (2017). Biodiversity redistribution under climate change: Impacts on ecosystems and human well-being. *Science* 355(6332): 1389. March 31, 2017.

Province of Nova Scotia. (1995). Nova Scotia Royal Gazette Part II Environmental Assessment Regulations made under Section 49 of the Environment Act. Canada.

Province of Nova Scotia. (2018). Quantification, Reporting and Verification Regulations made under Section 112Q of the Environment Act. Nova Scotia Provincial Legislature, Halifax, NS.

Province of Nova Scotia. (2020). Standards for Quantification, Reporting, and Verification of Greenhouse Gas Emissions. Nova Scotia Department of Environment, Halifax, NS.

Province of Nova Scotia. (2022). Our climate, our future: Nova Scotia's climate change plan for clean growth. Halifax, NS.

Qamhia, I.I.A., Tutumluer, E. & Ozer, H. (2023). Life Cycle Assessment of Aggregate Quarry By-Product Fines in Pavement Applications. *Sustainability (Switzerland)* 15(13): 10705. doi.org/10.3390/su151310705

Rubenstein, M.A., Weiskopf, S.R., Bertrand, R., Carter, S.L., Comte, L., Eaton, M.J., Johnson, C.G., Lenoir, J., Lynch, A.J., Miller, B.W., Morelli, T.L., Rodriguez, M.A., Terando, A. & Thompson, L.M. (2023). Climate change and the global redistribution of biodiversity: substantial variation in empirical support for expected range shifts. *Environmental Evidence* 12(1): 7. doi.org/10.1186/s13750-023-00296-0

Schumacher, E., Brown, A., Williams, M., Romero-Severson, J., Beardmore, T. & Hoban, S. (2022). Range shifts in butternut, a rare, endangered tree, in response to past climate and modern conditions. *Journal of Biogeography* 49(5): 866-878.

Sinclair, A.J., Doelle, M. & Duinker, P.N. (2017). Looking up, down, and sideways: Reconceiving cumulative effects assessment as a mindset. *Environmental Impact Assessment Review* 62: 183-194. doi.org/10.1016/j.eiar.2016.04.007

Singh, G.G., Lerner, J., Mach, M., Murray, C.C., Ranieri, B., St-Laurent, G.P., Wong, J., Guimaraes, A., Yunda-Guarin, G., Satterfield, T. & Chan, K.M.A. (2020). Scientific shortcomings in environmental impact statements internationally. *People and Nature* 2(2): 369-379. doi.org/10.1002/pan3.10081

Sivarajah, B., Campbell, L.M., Smol, J.P., Vermaire, J.C. & Kurek, J. (2024). Historical gold mining increased metal(loid) concentrations in lake sediments from Nova Scotia, Canada. *Facets* 9: 1-14. doi.org/10.1139/facets-2023-0063

Sizirici, B., Fseha, Y., Cho, C.S., Yildiz, I. & Byon, Y.J. (2021). A review of carbon footprint reduction in construction industry, from design to operation. *Materials* 14(20): 6094. doi.org/10.3390/ma14206094

Smyth, C., Metsaranta, J., Tompalski, P., Hararuk, O. & Le Noble, S. (2024). 10-year progress on Forest Carbon Research in Canada. *Environmental Reviews* 32: 611-637. doi.org/10.1139/er-2024-0001

Soimakallio, S., Cowie, A., Brandão, M., Finnveden, G., Ekvall, T., Erlandsson, M., Koponen, K. & Karlsson, P.E. (2015). Attributional life cycle assessment: is a land-use baseline necessary? *International Journal of Life Cycle Assessment* 20(10): 1364-1375.

Stantec Consulting Ltd. (2017). Highway 101 Digby to Marshalltown Corridor: environmental assessment registration. Dartmouth, NS.

Strum Consulting Ltd. (2023a). Ellershouse 3 Wind Project. Halifax, NS.

Strum Consulting Ltd. (2023b). Mersey River wind farm: environmental assessment registration. Bedford, NS.

The Federal-Provincial-Territorial Committee on Climate Change and Environmental Assessment. (2003). Incorporating Climate Change Considerations in Environmental Assessment: General Guidance for Practitioners. Ottawa, ON.

The Prairie Climate Centre. (2019). Climate Atlas of Canada, version 2 using BCCAQv2 climate model data. Available from: climateatlas.ca/ (Accessed 3 December 2024)

Vincent, L.A., Zhang, X., Mekis, É., Wan, H. & Bush, E.J. (2018). Changes in Canada's Climate: Trends in Indices Based on Daily Temperature and Precipitation Data. *Atmosphere - Ocean* 56(5): 332-349. doi.org/10.1080/07055900.2018.1514579

Walker, T.R. & Grant, J. (2015). Metal(loid)s in sediment, lobster and mussel tissues near historical gold mine sites. *Marine Pollution Bulletin* 101(1): 404-408. doi.org/10.1016/j.marpolbul.2015.10.010

Wang, T., Hamann, A., Spittlehouse, D. & Carroll., C. (2016). Locally downscaled and spatially customizable climate data for historical and future periods for North America. *PLoS ONE* 11(6): e0156720.

WSP Consulting. (2023). Highway 101 Cambridge Interchange and connector roads EA registration document. Dartmouth, NS.

Wu, P., Xia, B. & Zhao, X. (2014). The importance of use and end-of-life phases to the life cycle greenhouse gas (GHG) emissions of concrete - A review. *Renewable and Sustainable Energy Reviews* 37: 360-369.

Zhang, L., Chen, H., Li, S. & Liu, Y. (2023). How road network transformation may be associated with reduced carbon emissions: An exploratory analysis of 19 major Chinese cities. *Sustainable Cities and Society* 95: 104575. doi.org/10.1016/j.scs.2023.104575

APPENDIX A: MEAN SCORES WITHIN EACH CATEGORY ACROSS PROJECT TYPES

Appendix Table 1

Modal scores of 38 different EAs on five questions about Climate Change basics. For categories with no true mode, the median values are presented.

Project type	Mentioned?	Acknowledged as problem?	Obfuscating statements absent?	NS guides & reporting standards cited?	Other literature used?	All
Green Hydrogen	1	0	-0.5	0.5	1	2
Mine	1	1	1	1	0	4
Quarry	1	1	0	0	1	1
Roads & Corridors	1	1	1	1	1	5
Wind Farm	1	1	1	0	1	4
Waste Treatment	1	1	1	0	1	3
All	1	1	1	0	1	4

Appendix Table 2

Modal scores of 38 different EAs for five questions about GHG accounting. For categories with no true mode, the median values are presented.

Project type	Present?	Estimates reasonable?	Assumptions appropriate?	Sequestration considered?	Significance determination appropriate?	All
Green Hydrogen	1	0.5	0.5	0	0	2
Mine	1	1	1	0	-1	2
Quarry	0	0	0	0	0	0
Road / Corridor	1	1	1	1	1	5
Wind Farm	1	1	1	0	1	4
Waste Treatment	0	0	0	0	0	0
All	1	0	0	0	1	0

Appendix Table 3

Modal scores of 38 different EAs for five questions about GHG mitigation. For categories with no true mode, the median values are presented.

Project type	Present?	Behavioural reductions?	Tech-based reductions?	Offsets / compensation	Enforcement?	All
Green Hydrogen	1	1	1	0.5	0.5	4
Mine	1	1	0	0	0	2
Quarry	1	1	0	0	0	3
Road / Corridor	1	1	0	1	1	4
Wind Farm	1	1	1	0	0	3
Waste Treatment	1	0	0	0	0	2
All	1	1	0	0	0	3

Appendix Table 4

Modal scores of 38 different EAs for five questions about Climate Change adaptation. For categories with no true mode, the median values are presented.

Project type	Present?	Behavioural (incl. geospatial)	Technological	Projections/ tools used?	All
Green Hydrogen	1	1	0.5	0.5	3
Mine	1	0	1	0	2
Quarry	1	1	0	0	2
Roads & Corridors	1	1	0	1	3
Wind Farm	1	1	0	0	2
Waste Treatment	1	1	0	0	2
All	1	1	0	0	2

APPENDIX B: LIST OF EA PROJECTS REVIEWED FOR THIS REPORT

Project name	Proponent	Project type	Consulting firm	Year
Bear Head Energy Green Hydrogen and Ammonia Production, Storage and Loading Facility	Bear Head Energy Inc.	Green Hydrogen & Ammonia Production Plant	Stantec Consulting Ltd.	2023
EverWind Point Tupper Green Hydrogen/ Ammonia Project - Phase 1	EverWind Fuels Company	Green Hydrogen & Ammonia Production Plant	Strum	2023
Beaver Dam Mine	Atlantic Gold	Mine	GHD & McCallum	2019
Goldboro Gold Mine	Signal Gold Inc.	Mine	GHD & McCallum	2022
Fifteen Mile Stream Gold Project	Atlantic Gold	Mine	MER	2021
Walden Quarry Expansion Project	Municipal Enterprises Ltd	Quarry	McCallum Environmental Ltd.	2023
Middle River Pit Expansion Project, Victoria County	Municipal Enterprises Ltd	Quarry	Envirosphere	2023
Blair Road Pit Expansion Project	The Shaw Group Limited	Quarry	Englobe	2023
Granite Village Quarry Expansion Project	Municipal Enterprises Ltd	Quarry	Municipal Enterprises Ltd.	2023
Spicer North Mountain Quarry Expansion Project	B. Spicer Construction Ltd.	Quarry	East Cost Aquatics Inc.	2020

Appendix B cont'd

Project Name	**Proponent**	**Project Type**	**Consulting firm**	**Year**
Sheet Harbour Aggregate Quarry Project	Dexter Construction Company Limited	Quarry	GHD	2019
Money Point Quarry Expansion Project	Dexter Construction Company Limited	Quarry	Dexter Construction Company Limited	2018
Highway 101 Digby to Marshalltown Corridor Project	Nova Scotia Department of Transportation and Infrastructure Renewal	Roads & Corridors	Stantec Consulting Ltd.	2017
Highway 101 Twinning Three Mile Plains to Falmouth Project	Nova Scotia Department of Transportation and Infrastructure Renewal	Roads & Corridors	Stantec Consulting Ltd.	2017
Highway 107 Burnside to Bedford Project	Nova Scotia Department of Transportation and Infrastructure Renewal	Roads & Corridors	Dillon	2018
Highway 102 Aerotech Connector Road project	Nova Scotia Department of Transportation and Infrastructure Renewal	Roads & Corridors	Wood	2021
Highway 104 Twinning Sutherlands River to Antigonish Project	Nova Scotia Department of Transportation and Infrastructure Renewal	Roads & Corridors	CBCL	2019
Highway 101 Cambridge Interchange and Connector Road Project	Department of Public Works	Roads & Corridors	WSP Canada Inc.	2023
NS-NB Reliability Inertie Project	Nova Scotia Power Inc	Roads & Corridors	Nova Scotia Power Inc	2023

Kmtnuk Wind Power Project	Kmtnuk Wind Ltd.	Wind Farm	Strum	2023
Weavers Mountain Wind Energy Project	WEB Weavers Mountain Wind Limited Partnership	Wind Farm	Strum	2023
Ellershouse 3 Wind Project	Ellershouse 3 GP Inc, Annapolis Valley First Nation and Potentia Renewables Canada Holdings LP (i.e., Ellershouse 3 Wind Limited Partnership)	Wind Farm	Strum	2023
Wedgeport Wind Farm Project	Wedgeport Wind Farm GP Inc, Elemental Energy Renewables Inc, Stevens Wind Ltd and Sipekne'katik First Nation, (i.e., Wedgeport Wind Farm Limited Partnership)	Wind Farm	McCallum Environmental Ltd.	2023
Higgins Mountain Wind Farm Project	Higgins Mountain Wind Farm General Partner Inc, Sipekne'katik First Nation, Elemental Energy Renewables Inc and Stevens Wind Ltd (i.e., Higgins Mountain Wind Farm Limited Partnership)	Wind Farm	Strum	2023
Mersey River Wind Farm	Mersey River Wind Inc.	Wind Farm	Strum	2023
Goose Harbour Lake Wind Farm Project	PHP Wind GP Inc and PHP Wind LP Inc, (i.e., Port Hawkesbury Paper Wind Ltd Partnership)	Wind Farm	Strum	2023
Westchester Wind Project	Natural Forces Developments LP	Wind Farm	Natural Forces Developments LP	2023

Appendix B cont'd

Project Name	Proponent	Project Type	Consulting firm	Year
Goose Harbour Lake Wind Farm	Port Hawkesbury Paper Wind	Wind Farm	Strum	2023
Bear Lake Wind Power Project	Bear Lake Wind Ltd	Wind Farm	Strum	2023
Ellershouse Windfarm Expansion Project	Alternative Resource Energy Authority	Wind Farm	Strum	2017
New Victoria Community Wind Power Project	Celtic Current Limited Partnership	Wind Farm	Celctic Current LP.	2016
Envirosoil Limited - Waste Oil Recycling and Water Treatment Facility Project	Envirosoil Limited	Waste Treatment	Wind Farm+D22+D34+ D34:D40	2023
Waste Dangerous and Non-Dangerous Goods Temporary Storage Facility	Envirosystems Incorporated	Waste Treatment	GHD	2020
Asbestos Waste Disposal Cell Project	Colchester Containers Limited	Waste Treatment	Englobe	2019
Pyrolysis Plant Project	Sustane Chester Incorporated	Waste Treatment	Strum	2018
Asbestos Disposal Facility	Yarmouth County Solid Waste Management Authority	Waste Treatment	Fracflow Consultants Inc.	2019
Asbestos Waste Disposal Facility Project	Arlington Heights C&D Limited	Waste Treatment	East Cost Aquatics Inc.	2017
Lower Carbon Fuel: Tire Derived Fuel (TDF) System	Lafarge Canada Inc.	Waste Treatment	Lafarge	2017