ENGINEERING

Sustainability Assessment Tool for the Selection of Optimal Site Remediation Technologies for Contaminated Gasoline Sites

Connor Dunlop (Presenter - PhD student - University of Guelph)

Dr. Bassim Abbassi (Professor - University of Guelph)

Dr. Richard G. Zytner (Professor - University of Guelph)

Presentation for the International Bioremediation Symposium

Thank you and I hope you enjoy the presentation!

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UNIVERSITY of GUELPH

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Figure 1: Removal of contaminated soil at a gasoline station by excavation.
(Image obtained from: https://www.thetimesherald.com/story/news/local/port-huron/2016/10/17/gas-station-cleaning-up-contamination/92297398/)

1. Previous Education

- B.Eng. at the University of Guelph in 2015-2020.
  - Environmental Engineering Co-op Program.
  - Co-op at Agriculture and Agri-Food Canada.

- MASc. at the University of Guelph in 2020-2022.
  - Improving Ontario's regulatory framework for the land application of food-processing wastes.
  - Additionally, utilized life cycle assessment (LCA) to understand the cradle-to-grave impacts.

Figure 2: Location of University of Guelph, Ontario and Austin, Texas.

- Led to the selection of my topic for my PhD project and this presentation.

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2. Introduction to Site Remediation in Ontario

- The Federal Contaminated Sites Inventory (FCSI) is a database that can be used to search for contaminated locations in Canada. (Government of Canada, 2023).

- More than 8000 sites have documented elevated concentrations of various gasoline constituents.
  - Petroleum hydrocarbons (PHCs).
  - Polycyclic aromatic hydrocarbons (PAHs).
  - Benzene, toluene, ethylbenzene and xylene (BTEX).

- Therefore, it is important to ensure the successful remediation of these sites.

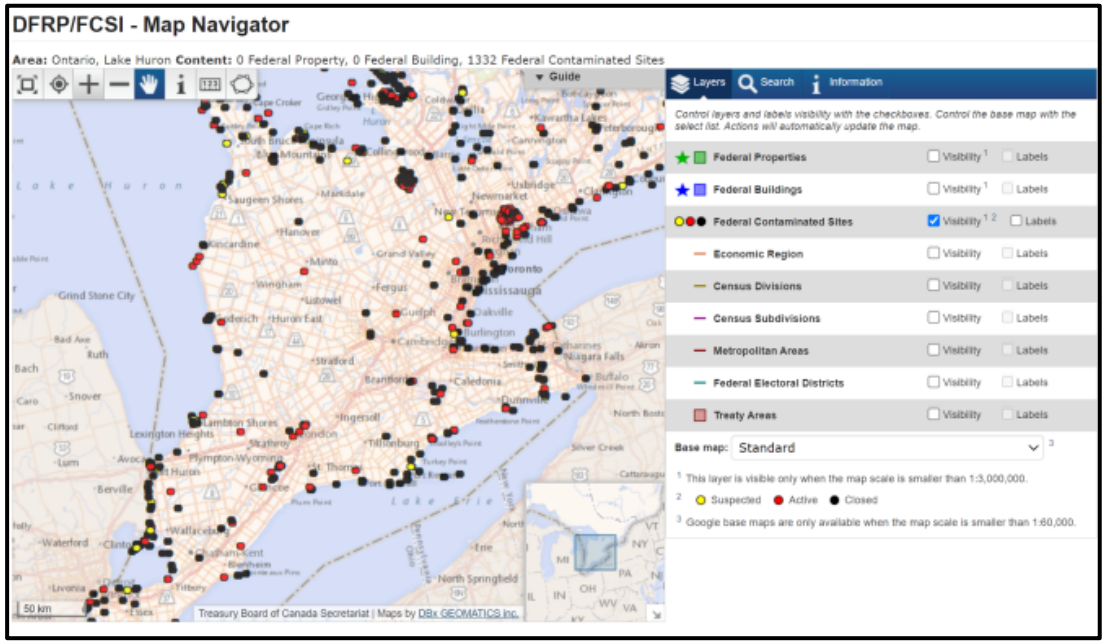


Figure 3: FCSI map navigator
(Image obtained from: https://map-carte.tbs-sct.gc.ca/map-carte/fcsi-rscf/map-carte.aspx?Language=EN&backto=www.tbs-sct.gc.ca/fcsi-rscf/cm-eng.aspx)

2. Introduction to Site Remediation in Ontario

- To help, the Ministry of the Environment, Conservation and Parks (MECP) has created a guideline to help qualified personnel navigate Ontario's legislative framework (MECP, 2021).

- Within the guideline, three main approaches are listed for treating contaminated sites:
  - In-situ treatment.
  - On-site containment.
  - Removal off-site for treatment.

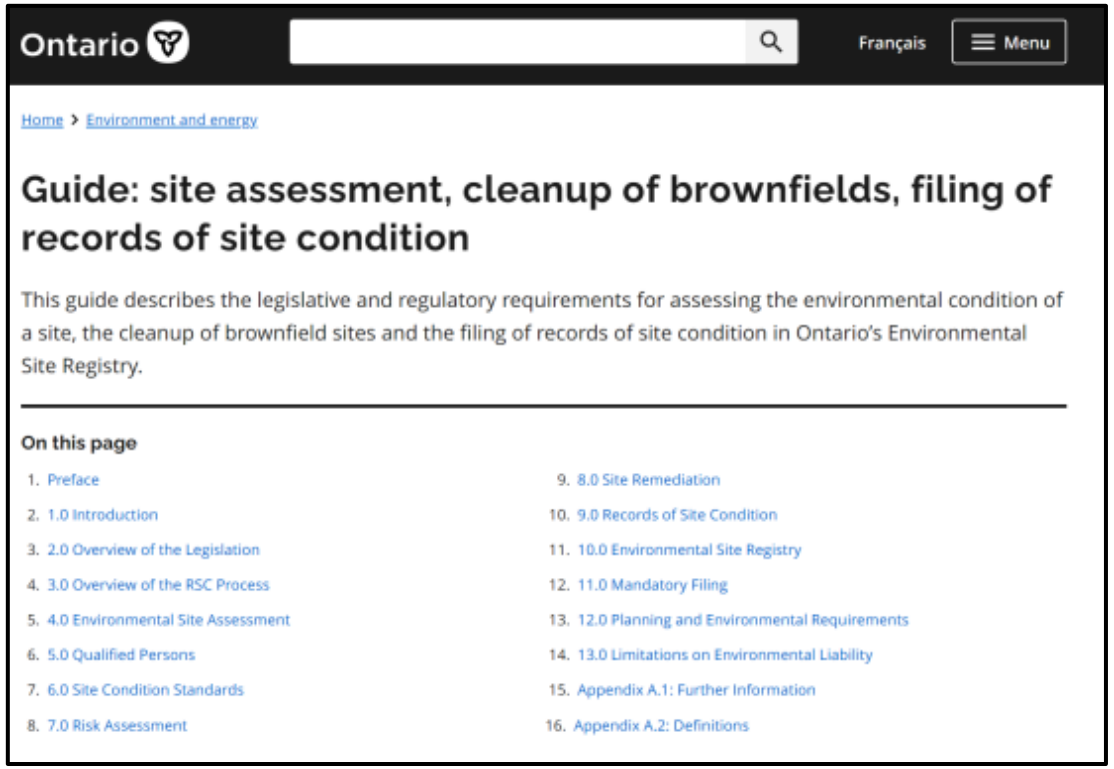


Figure 4: Ontario guidelines for site assessment, cleanup, and documentation.
(Image obtained from: Guide: site assessment, cleanup of brownfields, filing of records of site condition | ontario.ca)

2. Introduction to Site Remediation in Ontario

- Different factors are then discussed within the guideline when selecting the optimal treatment technology:
  - Media to be cleaned at the site.
  - Time to clean the site.
  - Cost.

- As such, one of the most frequently selected solutions is simply excavation followed by landfill disposal.
  - However, there is little discussion on the overall impact of the technology when used for remediation.

Figure 5: Excavation of a diesel contaminated site and landfill disposal of contaminated soil
(Figures obtained from: https://www.ablecleanup.com/portfolio/excavation-of-gasoline-and-diesel/ and https://blog.soilutions.co.uk/2012/08/23/classification-and-disposal-of-contaminated-soil/)

3. Introduction to LCA

- LCA is a tool that was developed by the International Organization for Standardization (ISO) in 2006 that can be used to quantify the environmental impacts of a product, process or activity, from cradle-to-grave (ISO 2006).
  - Thus, LCA can be used to help further assess and compare the various site remediation alternatives.

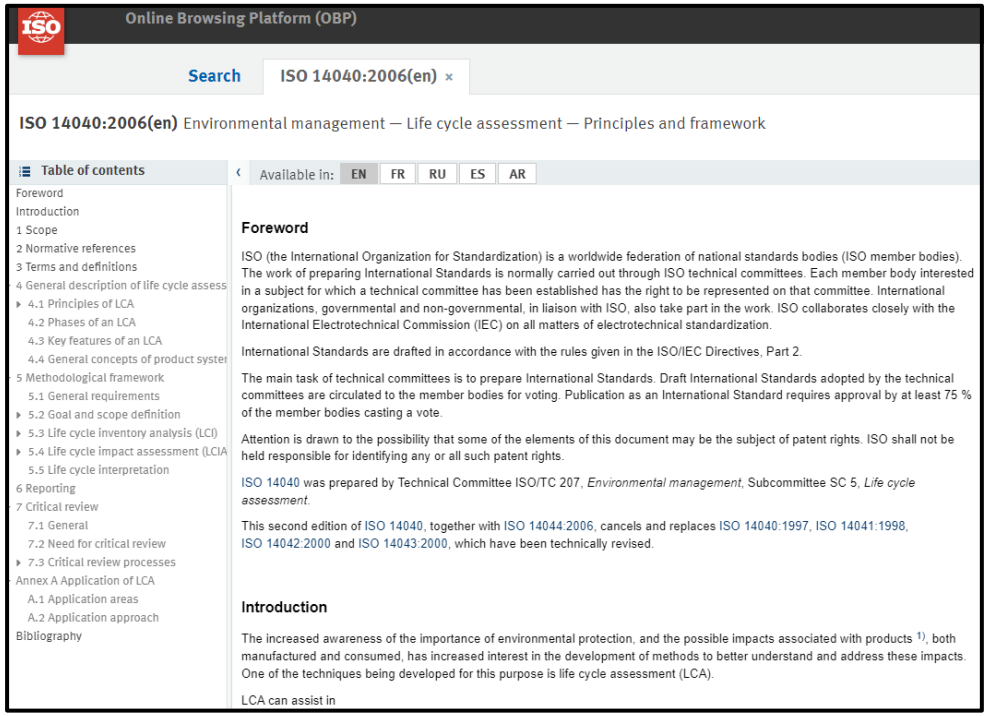


Figure 6: Overview of ISO 14040 – Life Cycle Assessment
(Figure obtained from: https://www.iso.org/obp/ui/#iso:std:iso:14040:ed-2:v1:en)

4. Scope of LCA Site Remediation Project

- To help qualified personnel further understand the impacts associated with each site remediation technology and to assist them with the selection of the optimal solution for the proposed site, the objectives for the research project are to:
  1. *Conduct an extensive literature review on LCA studies associated with site remediation technologies.*
  2. *Identify knowledge gaps and limitations of the available LCA data.*
  3. *Complete an LCA on a contaminated gasoline site to evaluate the environmental impacts associated with each technology (excavation and off-site treatment, bioremediation, no-treatment).*
  4. *Evaluate how the environmental impacts can fluctuate based on different site properties such as increased transportation distances or different energy mixes by utilizing sensitivity analysis.*
  5. *Develop a tool that can be used to rank the various treatment options that can be applicable to any site to determine the optimal sustainable solution.*
  6. *Additionally, determine the economic and social impacts of each technology.*

5. Literature Review Results

- Overall, a large amount of research was found that applied the LCA methodology within the site remediation area.

- Most papers completed comparative LCA studies to determine the overall optimal technology.
  - Additionally, some literature reviews were identified that summarized previous LCA research.

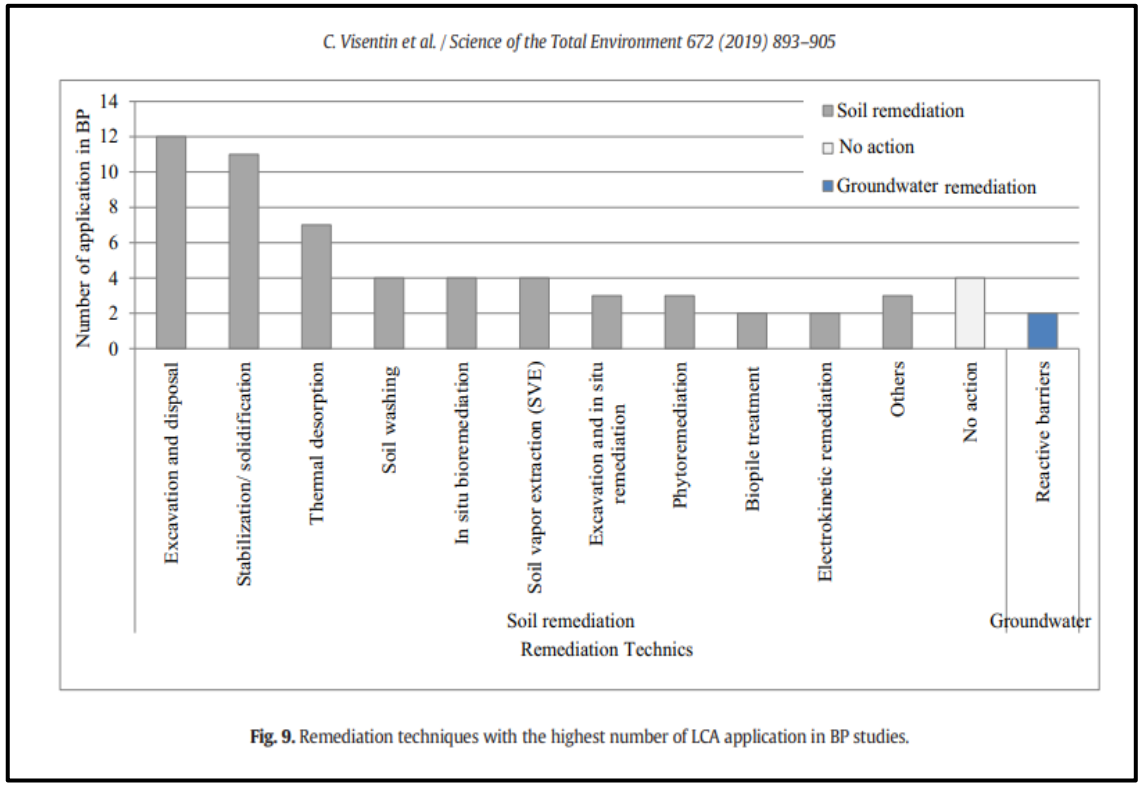


Figure 8: Remediation techniques from previous LCA studies
(Figure obtained from: Visentin et al., 2019)

5. Literature Review Results

- However, one study also incorporated fuzzy synthetic evaluation (FSE) with the LCA process to determine the best treatment scenario (Guangji et al., 2022).
  - FSE is a method that can help to model uncertainty in decision making scenarios.

- The integrated LCA-FSE results showed that ex-situ thermal desorption and in-situ containment could be the optimal plan.

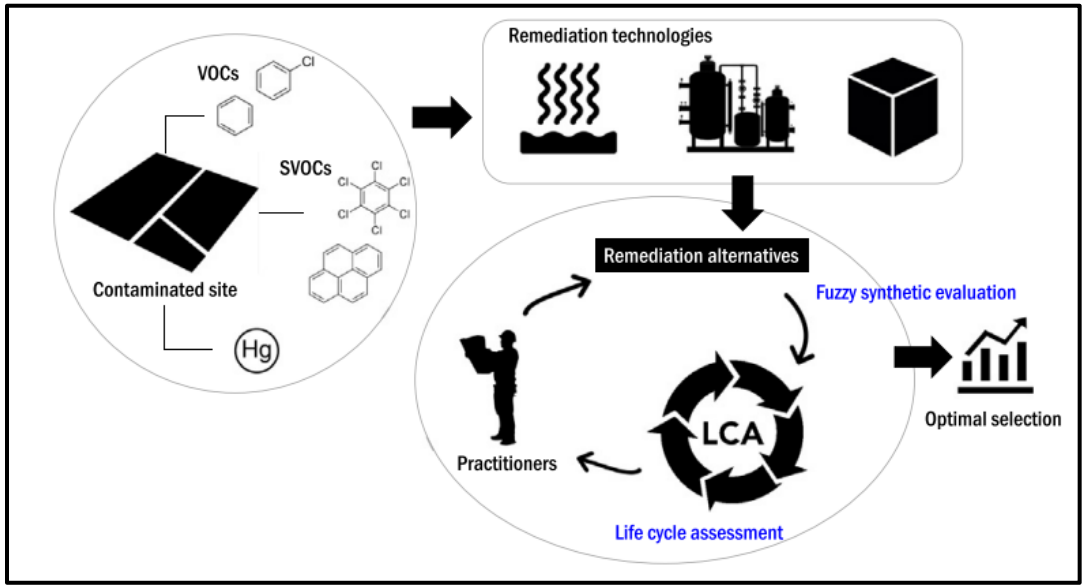


Figure 8: LCA and FSE approach for remediation selection.
(Figure obtained from: Guangji et al., 2022)

5. Literature Review Results

- Additionally, using a search of “LCA models Ontario” one study was found that used the methodology to assess building retrofits (Toufeili et al., 2022).

- The proposed method was then demonstrated using an institutional building in Windsor, Ontario.
  - Helps to ensure balance between energy savings and technical performance.

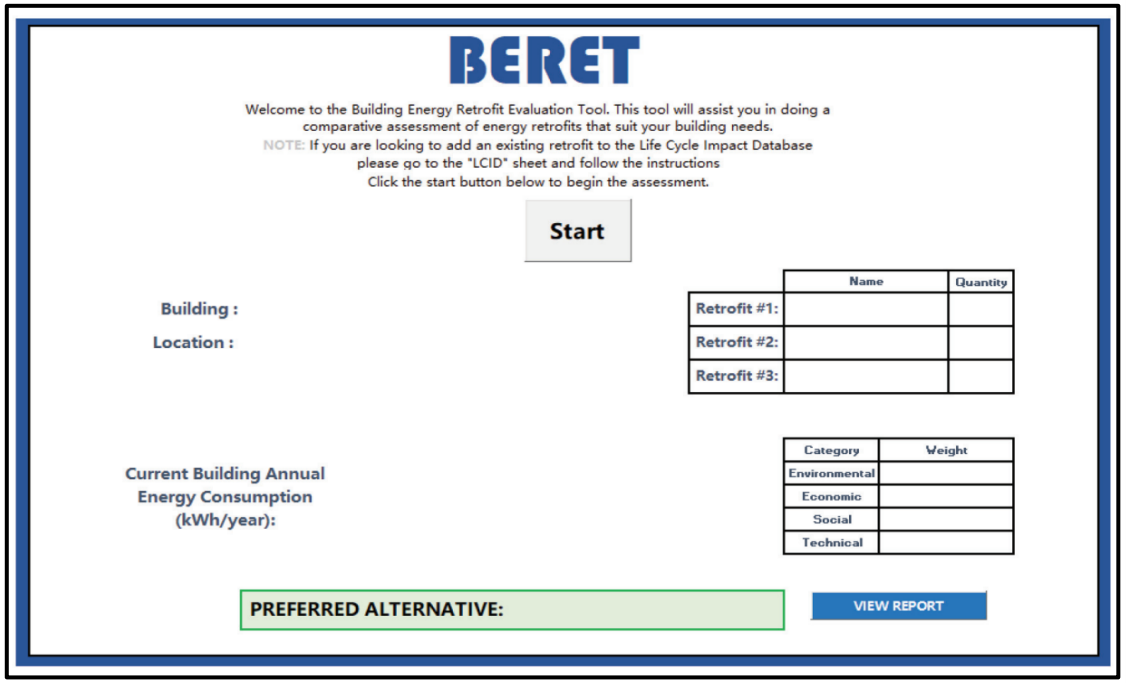


Figure 9: Interface for building energy retrofit evaluation tool (BERET)
(Figure obtained from: Toufeli et al., 2022)

5. Literature Review Results

- Overall, the literature review revealed an extensive amount of research has been conducted on applying the LCA methodology within the site remediation area.
  - Comparisons between different technologies.
  - Utilizing economic and social assessments in combination with LCA.

- However, it was identified that currently no model has been developed that can be applied at any generic contaminated gasoline site.
  - Although, evaluation tools have been used to decrease uncertainties (Guanji et al., 2022).
  - Additionally, LCA models have been created for applications such as building retrofits (Toufeili et al., 2016).

6. Goal of the LCA Study

- Thus, the goal for this LCA study was to first quantify the impacts of remediation technologies at generic sites.
- Next the site parameters will be varied to understand which technologies are the most sensitive to the changes.
- Finally, a model will then be created that can be used to select the optimal site remediation technology at any contaminated site.
  - The results will then look to be validated by applying the model at real world contaminated sites.

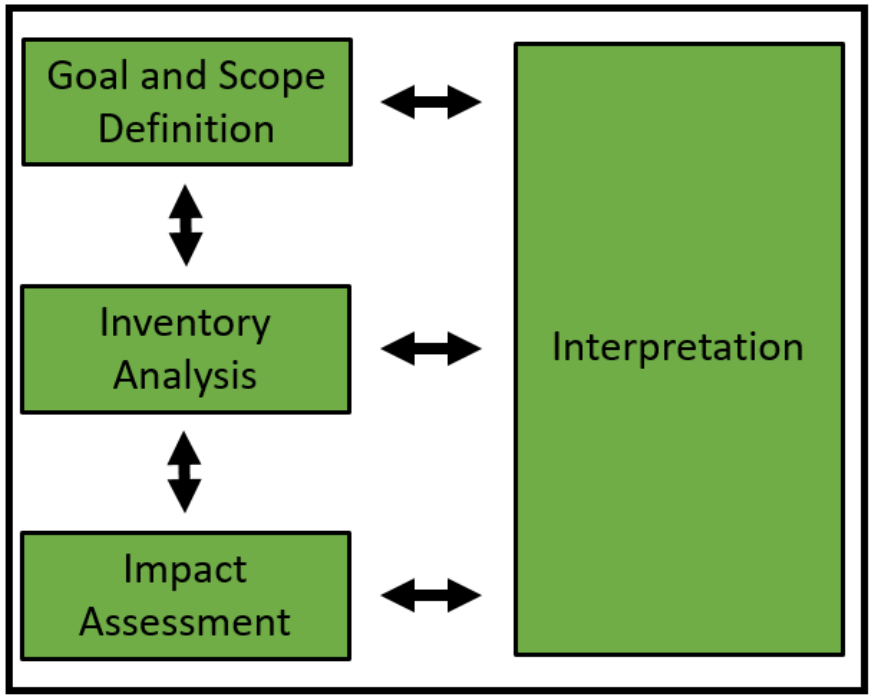
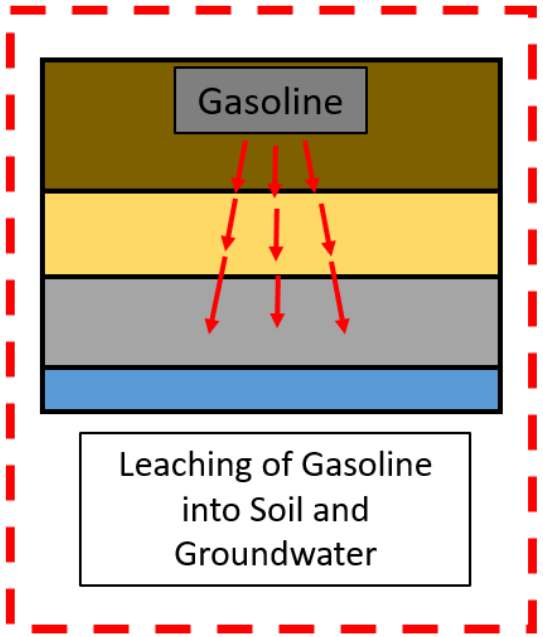
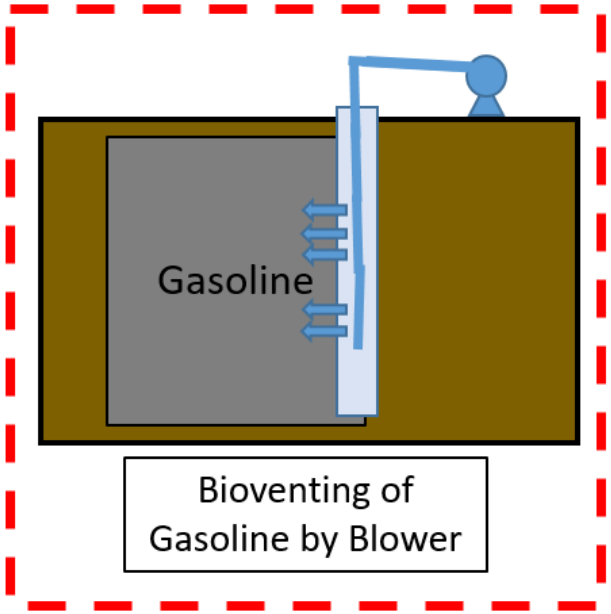


Figure 9: LCA methodology from ISO 14040

7. System Boundaries for LCA Study

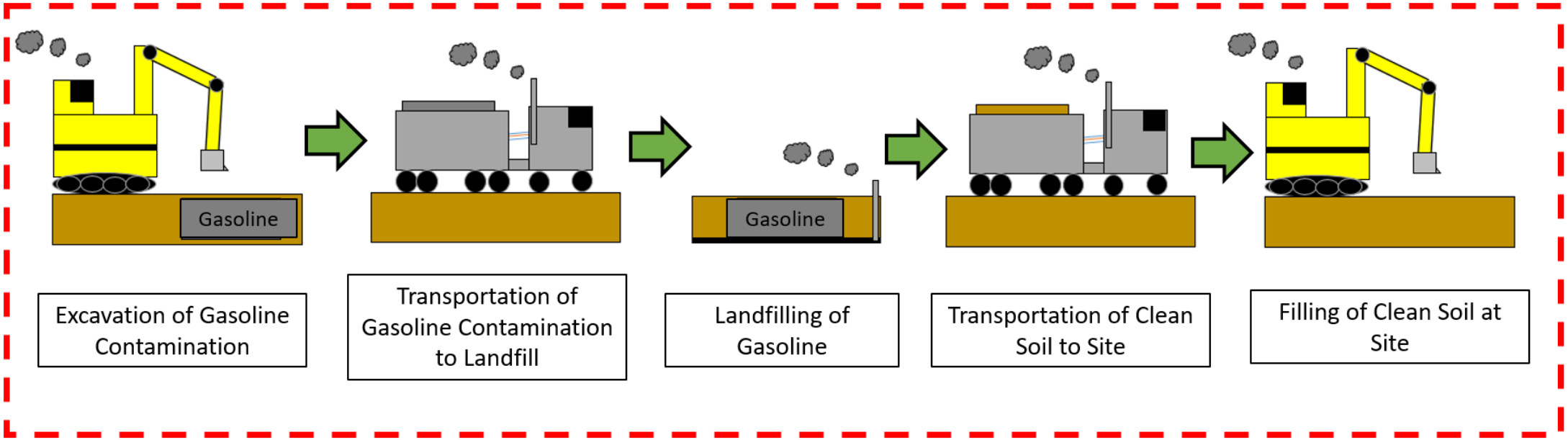


No-Treatment System Boundary



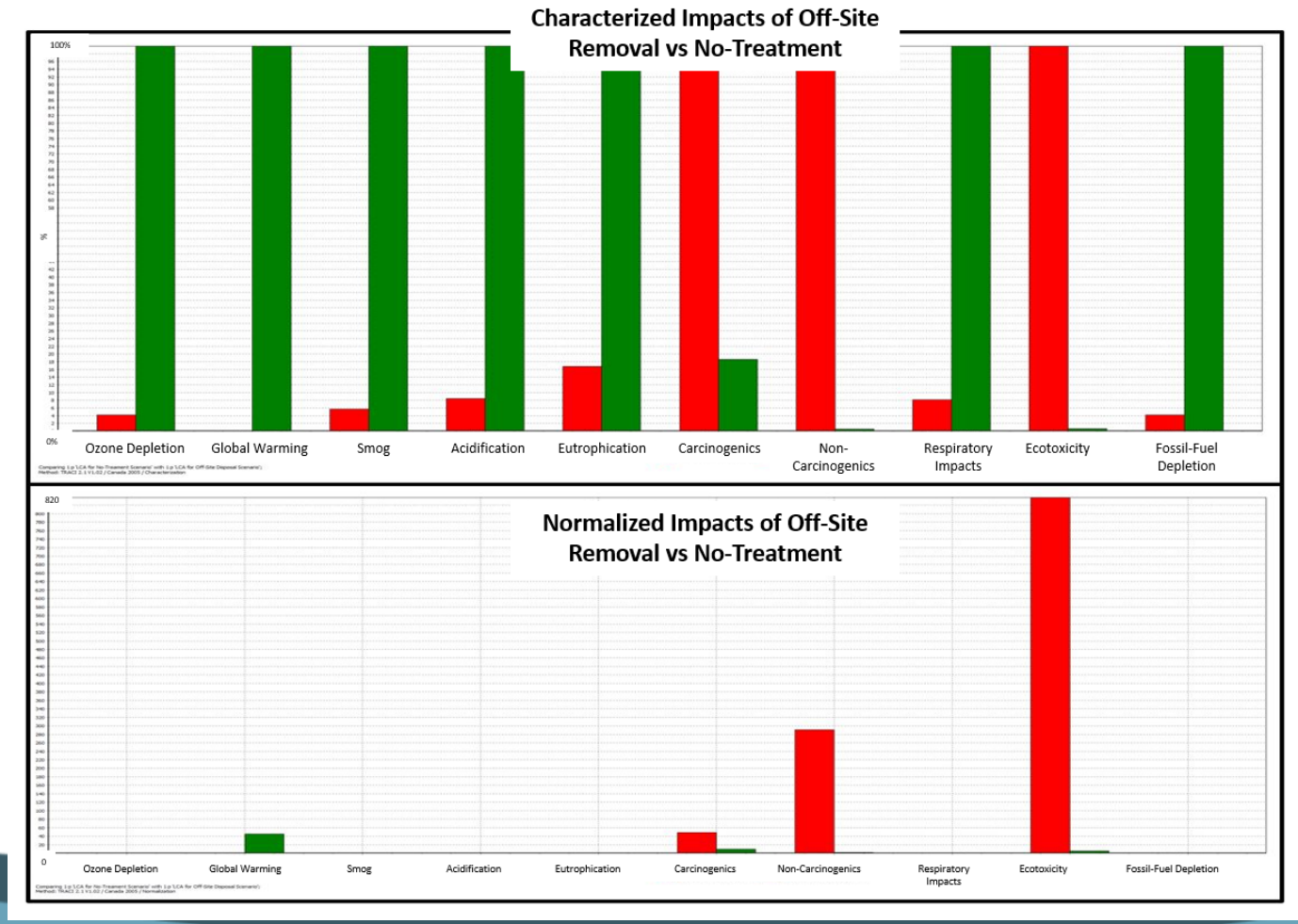
Bioremediation System Boundary

7. System Boundaries for LCA Study



8. Preliminary LCA Results

- As shown in the normalized results, the most significant impact will be:
  - Ecotoxicity.
  - Carcinogenics.
- Thus, this comparison shows that there are benefits to the remediation process if utilized.
- Additionally, there are benefits post remediation such as:
  - Decreased human health risks.
  - Increased social/economic opportunities.



9. Next Steps for Project and Timeline

- The next steps for the project will be to:
  - Obtain data to complete the LCA site remediation comparisons.
  - Understand how the LCA results can fluctuate with different site parameters.
  - Create a model that can be used to select the optimal technology at any contaminated site.

10. References

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Thanks for listening, any questions?

Email: cdunlop@uoguelph.ca

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