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Report Partner Document

REMOTE SENSING TOOLS FOR ENVIRONMENTAL MONITORING AND CERTIFICATION OF WELL SITES

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This partner document has been created to provide a non-technical summary of information presented in Remote Sensing Tools for Environmental Monitoring and Certification of Well Sites (2024) referred to in this document as “The Report”, prepared by Michael Henley, Vanessa Caron, Parnian Rezania, Eduardo Loos, Kevin Renkema, and Dean MacKenzie, of Vertex Professional Services Ltd., for and with funding by Petroleum Technology Alliance Canada (PTAC), the Alberta Upstream Petroleum Research Fund (AUPRF), and the Clean Resource Innovation Network (CRIN). Additional background information is provided in this partner document to supplement the readers understanding of progress presented in The Report.

Introduction

The Report presents the results of an initiative conducted by Vertex Professional Services Ltd. The primary objective of The Report is to evaluate and develop advanced remote sensing tools for monitoring and certifying well sites, particularly padded sites, more efficiently and accurately than conventional methods. These tools are designed to reduce field disturbance, improve decision-making, and support reclamation certification.

Background Information

Well sites, particularly those built on pads in sensitive environments such as wetlands and peatlands, present monitoring challenges. Traditional in-person assessments are costly, time-consuming, and risk further environmental disturbance. Remote sensing, on the other hand, uses airborne and satellite-based sensors to collect environmental data over large areas without direct site contact. By integrating remote sensing with in situ data, the project aimed to monitor vegetation health and recovery, assess hydrological impacts on peatlands, differentiate wetland types for informed management decisions, and expand monitoring capabilities to both padded and non-padded sites. The project leveraged machine learning (ML) and artificial intelligence (AI) to process large datasets, using optical imagery, LiDAR, and Synthetic Aperture Radar (SAR) to identify environmental changes over time.

Ecological recovery refers to the process by which vegetation, soil, and hydrological conditions return to a stable, self-sustaining state after disturbance. Recovery rates vary widely depending on the ecosystem type, the extent of disturbance, and ongoing environmental pressures. In wetlands and forested areas, for example, recovery may take decades and require careful monitoring to ensure that desired plant communities, soil stability, and water dynamics are re-established.

Padded sites are well sites constructed with a large gravel or soil based to provide stable ground for drilling equipment, especially in areas with soft or saturated soils such as peatlands. The pad elevates the work area, protecting equipment from sinking and reducing the immediate need for heavy road construction. However, pads can cause long-term ecological impacts by altering natural drainage patters, compacting soils, and preventing vegetation regrowth.

Non-padded sites, by contrast, are built without such a base and often involve minimal ground disturbance, especially in drier or more stable soil conditions. These sites may allow for quicker vegetation recovery recovery but can be more challenging for equipment access in wet or unstable environments. The decision to use a padded or non-padded site depends on factors such as soil type, expected weather conditions, equipment requirements, and long-term land use goals.

Project Summary

TASK ONE: INTEGRATION OF REMOTE SENSING DATA IN SITU DATA

Field measurements of vegetation, hydrology, and soil conditions are accurate but limited in scale, while remote sensing offers broader coverage but requires validation. In this task, historical vegetation and wetland classification datasets from previous PTAC and Pathways Alliance projects, along with high-resolution imagery, were used to create 113 tamarack forest training polygons based on field data. These polygons were then integrated into ML classification models, improving the accuracy of tamarack forest mapping. The integration of in situ data with remote sensing imagery reduced uncertainty in classification results and provided a stronger foundation for subsequent environmental monitoring.

TASK TWO: VERIFICATION AND ASSESSMENT OF SUSTAINABILITY IN FORESTS DEVELOPING ON PADS

Forest patches developing on well pads can indicate ecological recovery, but their sustainability needs verification over time. For this task, LiDAR canopy height models and Sentinel-2 normalized difference vegetation index (NDVI) time-series data from 2017 to 2023 were used to extract polygons of forest cover greater than two meters in height and assess annual vegetation greenness trends. These trends were then compared to reference values from undisturbed forest sites. The analysis found that most sites exhibited stable or slightly improving vegetation conditions, though some areas showed signs of decline. This approach allows for rapid, repeatable assessment of forest sustainability that are far faster and less disruptive than traditional field methods.

TASK THREE: DEVELOPMENT OF DIGITAL REMOTE SENSING TOOLS TO DETECT IMPACTS CAUSED BY PADS ON PEATLAND

Well pads and their associated access roads can disrupt peatland hydrology, leading to vegetation stress and water pooling. In this task, Sentinel-2 NDVI and NDWI metrics were applied to 106 padded sites near Lesser Slave Lake, Alberta, with mapped access roads. Automated sampling was performed at regular intervals and offsets along these roads, and vegetation and wetness values on either side were compared to detect anomalies. This process identified multiple areas of potential impact that warrant targeted field investigation. The methodology enables large-scale and efficient screening of peatland impacts across extensive networks of linear features.

TASK FOUR: DIFFERENTIATION OF BOGS AND FENS AND ASSOCIATED WELL SITES

Wetland type plays an important role in reclamation decision-making, as fens typically support denser tamarack stands than bogs. This task used Sentinel-2 summer and fall imagery, Sentinel-1 SAR data, and the Alberta Biodiversity Monitoring Institute wetland inventory to train a machine learning classification model that mapped tamarack forest cover. The classification achieved an accuracy of 85% and revealed that 3.5 square kilometers of tamarack forest fell within areas classified as bogs. These findings suggest potential misclassification of some wetlands and indicate the value of this method for improving bog-fen differentiation, pending further field validation.

TASK FIVE: DEVELOPMENT AND IMPROVEMENT OF REMOTE SENSING TOOLS FOR NON-PADDED WELL SITES IN THE GREEN ZONE

Many well sites do not have pads but still require environmental monitoring. In this task, padded-site LiDAR processing tools were adapted to extract forest polygons for non-padded sites, and a dense time-series NDVI analysis method was developed to identify short-term disturbances. The NDVI data were processed with smoothing algorithms to reduce atmospheric and sensor noise, producing cleaner vegetation trend data.

While disturbance detection algorithms were only partially developed due to time constraints, the work successfully demonstrated the adaptability of the tools to a wider range of site conditions.

Conclusion

The project presented in The Report achieved its primary objective of advancing the application of remote sensing technologies to monitor the impacts of both padded and non-padded well sites in wetland and upland areas. Through the development of new analytical tools and the enhancement of existing ones, the research team demonstrated that large areas can be assessed for vegetation health, hydrological impacts, and wetland classification with greater speed and accuracy than traditional field-based methods.

The work resulted in several important outcomes. The integration of in situ data with remote sensing imagery improved the accuracy of vegetation classification, particularly for tamarack forests. New forest sustainability assessment tools allowed for the rapid evaluation of vegetation recovery trends on well pads. Automated peatland impact detection methods made it possible to identify potential hydrological disturbances caused by pads and access roads across extensive landscapes. The development of classification techniques for differentiating bogs and fens provided valuable insights that could improve wetland mapping and management decisions. In addition, existing remote sensing tools were successfully adapted for use on non-padded sites, expanding their applicability across a broader range of environments.

These tools can be applied to hundreds of sites in a matter of days, enabling faster reclamation assessments, more targeted field investigations, and better-informed remediation planning. By reducing the need for extensive on-the-ground monitoring, they also minimize disturbance to recovering ecosystems and lower overall project costs. The flexible, modular design of the tools ensures they can be adapted to other environmental monitoring applications beyond oil and gas reclamation. Collectively, the results demonstrate that remote sensing technologies may improve the efficiency, accuracy, and scope of environmental monitoring and certification practices.