

# USING A WEB-BASED GIS FOR ENVIRONMENTAL MANAGEMENT OF A CRUCIAL WINTER TRANSPORTATION ROUTE IN NORTHERN CANADA

R.A. Sims<sup>a\*</sup>, K. Warrendorf<sup>a</sup>, J. Matheson<sup>a</sup>, and E. Madsen<sup>b</sup>

<sup>a</sup>EBA Engineering Consultants Ltd., Oceanic Plaza, 1066 West Hastings Street, Vancouver, BC, V6E 3X2 Canada –  
(rsims, kwarrendorf, jmatheson)@eba.ca

<sup>b</sup>Joint Venture Management Committee, PO Box 2498 Stn Main, Yellowknife, NT, X1A 2P8 Canada –  
erik.madsen@riotinto.com

## Commission IV, WGIV/5

**KEY WORDS:** Transportation Planning, Northern Canada, Ice Roads, Environmental Management Systems, Emergency Response

### ABSTRACT:

A seasonal snow and ice road – the Tibbitt to Contwoyto Winter Road (TCWR) – is constructed each winter to provide a reliable transportation route to and from the operating diamond mines and various other exploration projects in northern mainland Canada. The TCWR is an approximately 600 km long route northeast of the community of Yellowknife, Northwest Territories, that supplies critical goods and materials, including fuel, cement, ammonium nitrate (prill), building materials and mining equipment, to these northern destinations each winter. The TCWR Joint Venture currently consists of BHP Billiton Diamonds Inc. and Diavik Diamond Mines Inc., and has managed the TCWR for the past eight years; before that, from 1982 to 1999, it was managed by Echo Bay Mines. Each year, the TCWR is constructed from the end of the Ingraham Trail about 70 kilometres east of Yellowknife at Tibbitt Lake, across 495 km of frozen lakes and streams and 64 land portages, to Contwoyto Lake in Nunavut. Since 2001, the Joint Venture has carried out an integrated environmental management program that includes extensive baseline inventories and a GIS-based Winter Road Environmental Management System (WREMS). WREMS includes environmental baseline mapping based on high resolution aerial imagery, LIDAR, Landsat TM, and detailed ground-based data on ecosystems, wildlife habitat and wildlife movements, aquatic resources, and heritage resources. WREMS provides a means to organize, manage, disseminate and regularly update spatial information. One of the core components of the WREMS is live, interactive mapping that provides access to the various spatial data layers available for each of the 64 terrestrial portages. Users can select layers, zoom, pan, overlay and query data. Other components of the system include a document catalogue, a searchable photo archive, and access to print-on-demand mapping and biophysical summaries for each portage. The goal of WREMS is one of continuous improvement in terms of content and performance. WREMS has been developed to serve as a portal for the Joint Venture and its consultant teams to access information for the many project components involved in the ongoing environmental management of the TCWR.

## 1. INTRODUCTION

The Tibbitt to Contwoyto Winter Road (TCWR) is a 600 km long ice road that is constructed and used each winter to supply mines and exploration camps in the Slave Geological Province to the northeast of Yellowknife, northern mainland Canada (Figure 1). The TCWR has successfully operated since 1982, and there have been continuous improvements year by year in terms of operational and environmental management.

The TCWR is one of the world's longest high-volume ice roads (Katz 2007), and in a given winter's operation, it currently transports greater than 250,000+ tonnes carried on greater than 7,500 truckloads. The transportation network supplies three operating diamond mines in the NWT, one diamond mine in Nunavut, and several other exploration sites.

In 2007, the road set a record with 10,922 loads northbound hauling 330,000 tonnes. Some 87% of the TCWR travels on frozen lakes, and the remaining 13% consists of 64 overland portages. About 20% of the on-portage TCWR has been upgraded with gravel/sand pads.

To address the need to comprehensively manage and disseminate spatial and non-spatial environmental information about the road, a web-based information management system

was developed. The Winter Road Environmental Management System (WREMS) provides a means to catalogue and spatially organize a wide range of TCWR-related data and information.

The password-protected WREMS website provides access to documents and photograph/image catalogues, key contacts, and various other supporting materials. WREMS also supports an interactive mapping tool allowing viewers to define sub-areas, select thematic overlays and other data, and examine detailed environmental information pertaining to the TCWR.

## 2. ENVIRONMENTAL STUDIES AND MAPPING

High-resolution airborne digital imagery and LIDAR (xyz relief) data were acquired across all portages, as part of an integrated environmental and engineering baseline investigation that was undertaken for the TCWR. Detailed ground studies and mapping activities were conducted to document ecosystems, wildlife habitat, fisheries/aquatic conditions, and archaeological resources. Several integrated mapping activities were completed for terrestrial portions of the TCWR corridor, including ecological land classification (ELC), wildlife habitat mapping, spatial delineation of localized contaminated sites, and mapping of various engineering parameters.

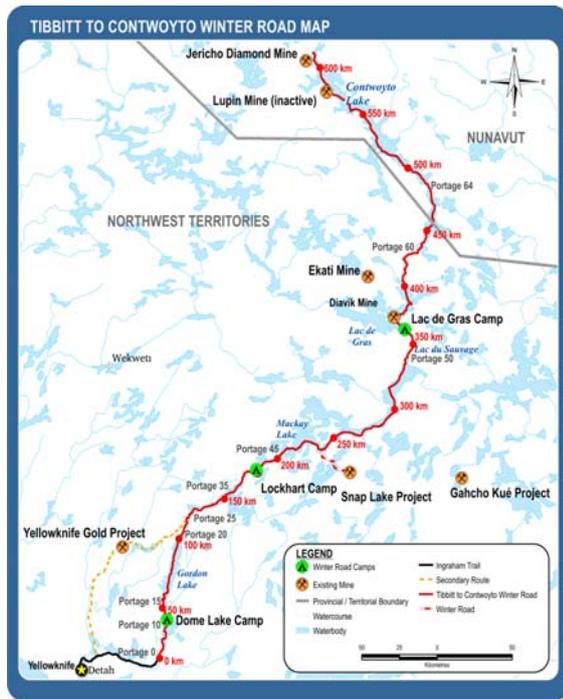


Figure 1. Map of the Tibbitt to Contwoyto Winter Road.

The ELC and wildlife habitat mapping was completed by biologists using on-screen digitizing and photo interpretation of the airborne digital imagery overlaid with the detailed elevational contours, as derived from LIDAR data. Thematic wildlife habitat mapping was completed using GIS models based on wildlife species-habitat relationships. Habitat mapping was completed for 13 wildlife species or groups of species which have special conservation values within the region.

For field use by TCWR operators, a mapbook was created for all of the TCWR's 65 portages. The mapbook includes summary descriptions of the environmental characteristics associated with each portage. It also provides various mapped data, including sampling locations, elevation contours, landmarks, ELC polygon linework and other thematic mapped features, overlain on positionally-corrected high-resolution imagery. An example of TCWR mapping from the mapbook is shown in Figure 2.

Mapping within the mapbook was also accompanied by narrative summaries, ground and oblique aerial photographs, and area calculations for various environmental features including ecosystems, expected use by wildlife, fish and aquatic resource and the characteristics of the road surface.

### 3. WEB-BASED MAPPING

While the mapbook has been a useful tool for TCWR planning and management, conventional hard-copy map products are limited in terms of the types and amounts of cartographic detail, data, labels or themes that can be presented. Given the large size of the mapbook, considerable effort and cost is involved in updating, re-rendering and redistributing updated versions. Progress in other aspects of information handling and map presentation has also occurred since the mapbook was produced; for example, better data processing techniques were developed to extract additional information content from the TCWR digital imagery (Pierce and Law 2008).

Web-based mapping was identified as the appropriate manner in which to maintain the TCWR corridor mapping over time. In this manner, all information is maintained as current, and there is the additional ability to construct "on-demand" customized maps for specific purposes. Because it is accessible over the web, TCWR mapping is easily accessible to TCWR planners, operators, and scientists and engineers conducting work along the road.

ESRI's ArcIMS© was selected as the spatial data server to deliver the web-mapping service. Javascript was used to program the client-side interactive display. Server-side functions were programmed with VB Script and linked to ArcIMS using the ActiveX connector.

All data layers used in the production of the hard-copy mapbook were loaded onto the web server plus those data layers that could not be displayed on the hard copy mapbook, including some 39 wildlife habitat themes (Figures 3 to 5).



Figure 2. Example of biophysical mapping within a terrestrial portage along the Tibbitt to Contwoyto Winter Road.



Figure 3. Winter Road Environmental Management System (WREMS) main page.

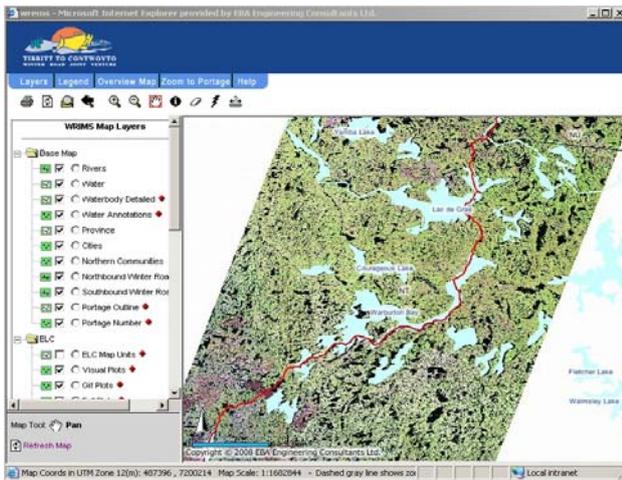


Figure 4. Winter Road Environmental Management System web-mapping showing a portion of the route overlain on Landsat TM imagery.

Key customizations include “zoom to portage tool” where users can zoom directly to pre-selected areas of interest, themed wildlife habitat layers and a group layers folder structure to help organize related types of data layers in the map. Raster layers (Landsat TM and the aerial photography) were programmed to be visible only at appropriate scales, to optimize the map refresh rate. The customized group layers folder structure helps organize the data into discipline groups making it easier for the user to turn on or off specific layers.

The web-mapping is made available to authorized users as a link within the WREMS web portal (Figure 3). WREMS then provides, through a series of menus and sub-pages, access to various catalogued data and documents, as well as a searchable photo catalogue (with photo positions included as a spatial data layer that can be overlaid on any base or thematic mapping).

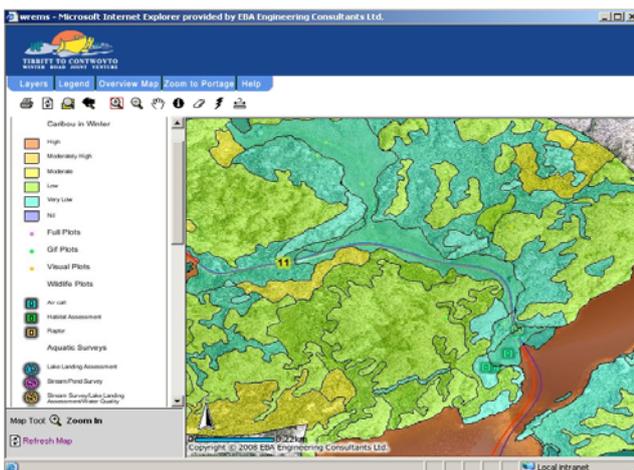


Figure 5. Web-mapping of a section of one of the terrestrial portages showing rated caribou habitat quality in winter.

As existing data layers are updated or revised and new spatial data becomes available, WREMS provides up-to-date mapping without the need for costly and time-consuming production of hard-copy mapbooks. Furthermore, non-technical users are able to access digital map data without the need for proprietary software and training.

GIS and web-based environmental management systems provide the tools to help companies such as the TCWR Joint Venture manage and effectively access spatial data and reference documents for planning and environmental management purposes. WREMS is a suitable model for other northern transportation corridors where it is important to organize and access spatially-based environmental management data.

## REFERENCES

Katz, H. 2007. Diamond alley – the worlds longest ice road is a winter supply route for four Northwest Territories mines and a marvel of engineering. *Can. Geogr. Journal* (Nov-Dec, 2007).

Pierce, B.G., and Y. Law. 2008. High resolution lake edge extraction from colour orthophotography. Proceedings of the 10th Circumpolar Remote Sensing Symposium / 29th Canadian Symposium on Remote Sensing, Whitehorse, Yukon, Canada (in press).

## ACKNOWLEDGEMENTS

WREMS was developed and is maintained for the TCWR Joint Venture, which is currently composed of BHP-Billiton Diamonds Inc. and Diavik Diamond Mines Inc.

EBA staff contributing to the development and maintenance of WREMS are Karen Warrendorf, Richard Sims, Jeff Matheson, York Law, Morgan Zondervan and Barry Pierce. Digital imagery and LIDAR data were acquired by Terra Remote Sensing Inc.

