LANDSLIDE DATABASE MANAGEMENT PHILOSOPHY IN THE GEOLOGICAL SURVEY OF CANADA

Grignon, A. G., Geological Survey of Canada, Canada
Bobrowsky, P. T., Geological Survey of Canada, Canada
Coultish, T., Geological Survey of Canada, Canada

ABSTRACT

In Canada, landslides have been studied since the 1800s and their accompanying descriptions remain a valuable source of information in modern day slope stability research. Until now, many of these studies were conducted in isolation from each other especially in regards to the parameters which best describe the characteristics of landslides. Although considerable work is still required before seamless sharing of this type of information can be achieved, efforts are now underway in the Geological Survey of Canada to arrive at information harmony within the professional landslide community in the country. In particular, the goal of data sharing and dissemination represents one of the key objectives of the landslide database management project. Recognizing the unique needs of the various partners (Provincial government agencies, municipalities, academia and the private sector), the GSC has started a national inventory of landslides in Canada. As this inventory evolves, it is expected to comprise a database that can be used as the foundation for more sophisticated analytical and predictive modelling efforts. In this paper, we discuss the current issues surrounding development of the landslide inventory and the interest of creating a practical repository useful to all Canadians.

RÉSUMÉ

Des études sur les glissements de terrain sont réalisées au Canada depuis les années 1800, et les descriptions qui les accompagnent demeurent une importante source d'information pour les recherches actuelles sur la stabilité des pentes. Jusqu'à maintenant, un grand nombre de ces études ont été réalisées en vase clos, surtout en ce qui a trait aux paramètres qui caractérisent le mieux les glissements. Il reste encore énormément de travail à faire pour que le partage de ce type d'information devienne transparent, mais à la Commission géologique du Canada (CGC) de grands efforts sont déployés pour harmoniser l'information au sein de la collectivité canadienne des spécialistes des glissements. En particulier, un des objectifs clés du projet de gestion des bases de données sur les glissements consiste à partager et à diffuser les données. Compte tenu des besoins uniques des différents partenaires (organismes gouvernementaux provinciaux, municipalités, universités et secteur privé), la CGC a entrepris d'établir un répertoire national des glissements de terrain au Canada. Au fur et à mesure que le répertoire progresse, on prévoit inclure une base de données qui pourrait servir d'outil de base pour les activités plus poussées de modélisation analytique et prédictive. Dans cet article, nous abordons les questions d'actualité liées à l'élaboration du répertoire sur les glissements et examinons l'intérêt associé à la création d'un dépôt d'information pratique et utile pour tous les canadiens et canadiennes.

1. INTRODUCTION

Many current landslide databases focus on finding information that will fit into a predetermined database structure. This paper describes a different philosophy in landslide database implementation and management. Working with multiple partners with disparate data needs and requirements, poses a number of challenges. In response, the Geological Survey of Canada (GSC) proposes a database structure based on partner input with a collaborative effort aimed at maintaining this database on the longer term. Herein the characteristics, issues and benefits are described along with the adopted approach and anticipated future developments.

2. BACKGROUND

In Canada, landslides have been studied since the 1800s (Evans 1999) and their accompanying descriptions remain a valuable source of information in modern day slope stability research. Much of the existing work on inventories can be classified into two types. The first type includes work on researching historical landslide events using existing reports, publications or newspaper clippings (e.g., Ibsen and Brunsden 1996; Liverman et al. 2003). The second type identifies a study area where aerial photography or imagery interpretation is used to map landslides (e.g., Agostoni et al. 1998; Aylsworth and Duk-Rodkin 1999; Yamagishi et al. 2002). Both styles of inventory research assume an initial database structure prior to conducting their implementation.

The GSC conducted a national workshop and a series of provincial workshops across Canada in order to learn more regarding the status of various existing landslide inventories that reside with multiple stakeholders (e.g., Couture 2002). Such inventories contain varying degrees of information. In order to provide an online database structure that best represents the information to be shared

by partners, an initial analysis of what was available from all partners was necessary. Through this initial analysis, a limited list of fields was identified, though links to more detailed information, where available, will be added in future phases.

In addition to the landslide inventory, a number of thematic layers of information have been included in the online Geographic Information Systems (GIS). Albeit at a small scale, these are meant to help provide contextual information that may be helpful for small scale modelling.

3. CHARACTERISTICS

In order to reach the desired goal for this online database a phased implementation is being undertaken. The inventory implementation project is set over 3 years having started in March 2003. Over this time period the database will evolve as more data are added from the partners.

3.1 Current phase

Presently, the Web GIS component has been implemented using a rudimentary database. This is meant to present basic information on the events without describing each in great detail (Figure 1).

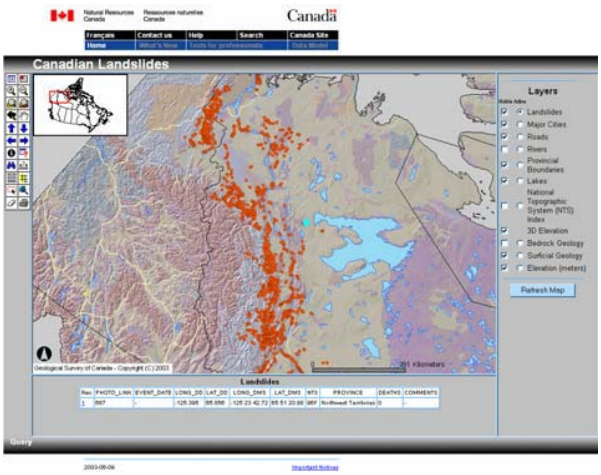

Figure 1. Screen shot of Web GIS environment for the Canada Landslide Project.

There are currently over 5000 landslide entries in the database compiled from a number of GSC data sources. To accompany the inventory, some small-scale thematic layers have been added to provide context. In order to provide more detailed spatial context to visitors, the National Topographic System (NTS) map sheet number was added to each database entry.

The online GIS environment also facilitates spatial and content queries.

3.2 Future phases

Although the current implementation lists landslide events, to date it only shows those identified by the GSC. The next phase will convert the current flat file approach to a relational database structure, linking the basic information set to its source information, contacts and metadata (e.g., Rose, B., Mauldon, M., Drumm, E.C., Moore, H., Oliver, L., and Trolinger B. (personal communication 2004) submitted to CE World: ASCE's First Virtual World Congress for Civil Engineering). The new structure will highlight these information sets in a more efficient relational structure as shown in Figure 2.

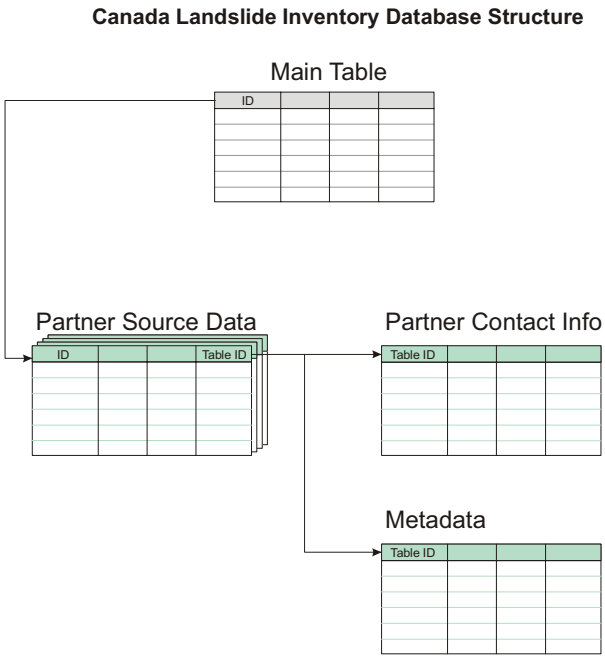

Figure 2. Canada landslide inventory database structure.

In order to enhance the usability of the data, multiple access options will be explored such as downloading the raw data and connecting to a map feature server from GIS software.

In addition to the existing list of thematic layers available online, other small and large scale information will be delivered through the same web GIS environment. Some of these include an NTS map sheet grid to help visitors identify possible datasets available for purchase and the extent covered. The Web GIS may also connect directly to the NTS online database of maps and display the maps at the appropriate scales down to 1:50 000 map scales. For those visitors interested in aerial photographs available within a landslide study area, a link to the National Air Photo Library will also be made available.

When querying the landslide database, full contact information from the data provider as well as metadata will be made available. Such information will be accessible as part of the linked databases. Within the metadata, an accuracy statement will be included to allow visitors to better gauge the spatial precision and accuracy of the data displayed.

Although implementing this landslide inventory presents some challenges, maintenance is an ongoing effort that requires much consideration. Because of the distributed nature of the original data sets, ongoing access to the online database for updating purposes will be implemented in subsequent phases. There will be single and multiple event input capabilities directly online. These will be made available to registered authorized users and all input information will go through an internal vetting process before appearing in the database.

4. BENEFITS

There are a number of benefits the project will achieve with this landslide inventory. This will be the only consolidated landslide inventory for all of Canada and it will be available online to anyone at no cost. Along with the tools provided in the Web GIS environment, this database will provide a quick reference to historical landslide information. Government impartiality also ensures the information provided is non-partisan and unbiased.

The inventory will provide valuable data to professionals working with landslide information, however, it will also act as a means to enhance public awareness regarding landslide hazards. Additionally, centralized access to this landslide database in conjunction with the available thematic layers provides a convenient environment for analysis (cf., Dikau et al. 1996). The suite of tools made available through the online interface may also increase interest from other interested users such as municipal planners and emergency response planners (Davis 2000).

Above all, the database is meant to be a collaborative project for sharing landslide information amongst an interested professional landslide community.

5. CHALLENGES

With any project that requires data from disparate sources, the challenges start with the acquisition process. Once the data are obtained, it is important to disseminate the information as effectively as possible, however, some issues can slow this process.

As with all collaborative projects, partnerships are key in the successful delivery of the primary objective. Initiating and fostering these relationships are an ongoing effort with their own set of difficulties.

5.1 Acquisition

Since there is no single accepted standard methodology to describe landslide events, ontologies become an important hurdle as implied by Vaugeois (2002). This ultimately affects the amount of data collected as well as the database structure.

With information provided by multiple sources, data are often delivered without much of the metadata required to establish spatial precision and accuracy. Even projection information can be difficult to establish without metadata. UTM zones are often not available in databases where the initial collection assumed the zone as constant. In such cases, the importance of contact information for the data source is crucial in identifying the spatial accuracy of the data.

Beyond the issue of spatial accuracy, the accuracy of the actual landslide data can only be assumed based on the individual submitting the data. It would be impossible to verify this information without revisiting each site for confirmation; therefore a data disclaimer to this effect will be required.

5.2 Dissemination

Given the variability observed amongst datasets, it has been difficult to provide much detail in the initial data table of the database. To ensure data would be present for all fields in this initial table, the number of fields was limited to the following:

- ID number
- NTS map sheet number
- Province
- Landslide Type
- Date

This list of fields was determined by evaluating each data set provided and finding the lowest usable common denominator to supply information for the initial table.

The added details available from some partner inventories will still be made available as linked tables in the relational database structure. Contact information for each data provider will also be accessible through the database for further inquiries on the data presented.

In order to maintain the relevancy of the inventory a maintenance schedule will be required, however, it is difficult to judge what time period will be adequate as this will mostly be based on how often partners contribute information. It is hoped that by allowing registered users (partners) to input their own landslide data to the database directly, it will lessen the ongoing maintenance workload.

5.3 Partnerships

One of the initial problems encountered with collecting the information was identifying with whom and where the information sources reside. A number of workshops

across Canada were organized during the first year of the project to meet with potential data providers. These have also been useful in identifying diverse client needs. Each workshop also identified certain private sector data providers with access restrictions on their client's data. In these cases, data can only be shared with the permission of the client.

Now that this series of workshops has been completed, the names collected during this exercise will form the basis for a landslide community of practice. These individuals will be the first registered users of the online database and will hopefully continue to share information in a timely manner to maintain the inventory.

6. APPROACH

The most important part of the proposed strategy is to keep things as simple as possible. Using a phased approach to developing the online inventory allows for incremental development stages based on realistic deliverables. The strategy is meant to expand and extend each subsequent phase to incorporate elements required for a continued progression towards a useful and helpful solution. One of the more important needs identified through the workshops was to have a central repository of landslide data that can be used by the professionals who require this information.

In the initial phases of the project, significant emphasis was placed on identifying data providers and helping those providers supply their data in a usable format for the online inventory. This was achieved through the help of numerous local contacts made available for data compilation and aggregation.

In order to address the issue of standardized landslide ontology, the GSC adopted the popular Varnes classification (Cruden and Varnes 1996). Many partners have expressed an interest in adopting a single classification scheme and therefore knowing that the GSC is working with the Varnes classification helps in their decision making process. In the online inventory however, the data provided is not required to follow this classification model. The classification scheme used will figure in the metadata and therefore help in classifying the landslide information correctly.

All data received from the data providers will be verified for spatial accuracy. All records with an invalid spatial reference will be omitted from the database until its reference has been corrected. Initially, access to external tools and data will be provided through the Landslides website (http://www.landslides.nrcan.gc.ca) although integration may be available in subsequent phases.

7. NEXT STEPS

The next steps in the Web GIS evolution focus on implementing a relational database driven inventory and on adding new data and tools. There are currently over 5000 landslides listed in the current version of the Web GIS tool. These will be transferred to the new relational database along with over 10 000 additional records from multiple partners across Canada. In order to add more value and context to the inventory, the NTS map sheet grid of 1:50 000 scale will be added to the supplemental thematic maps. In future phases these topographic maps may be made available directly within the online solution. As larger scale thematic layers become available, they will be accessible through the online GIS. Links to the National Air Photo Library will also enable access to more context data relative to landslides. As the Canada Landslide Project is part of Natural Resources Canada's Natural Hazards and Emergency Response Program, links to maps for other related natural hazards such as earthquake data, will also be made available.

Once the relational database model is implemented and functional, additional tools and access options will be developed to allow professionals from the landslide community of practice to add new landslide records to the online database similarly to what is shown in Figure 3. Given this added functionality it is important to note, "as distribution maps are increasingly being made available online, good quality information protection needs to be established" (De et al. 2002 [online]). To allay this issue, the GSC plans to implement a simple vetting process before making the information available online.

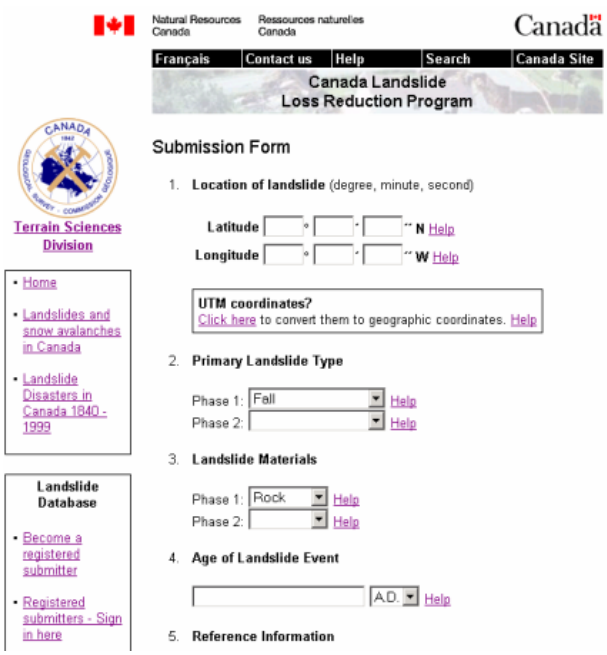

Figure 3. Early prototype of online landslide input form.

As the inventory grows and the benefits are demonstrated, interest in sharing this information is also expected to grow. This will hopefully result in more

partners and sharing of more landslide information through a central impartial access point. With time, the existing partnerships will also serve to help identify areas for improvement to better suit the evolving needs of the professional community.

8. CONCLUSION

In this paper we have discussed a different philosophy for establishing and using landslide inventories. By collating inventories from multiple sources ranging from private sector companies to academia, a central repository of landslide information that can be accessed freely and shared by all Canadians might help accelerate research in this topical area. Although there are many challenges associated with such a task, a phased implementation will ensure these are addressed incrementally. The benefits to the landslide community of practice are obvious, however, it is hoped this information might also be of use to a greater audience and provide a broader awareness and appreciation of the dangers that landslides impose on our population and infrastructure.

9. REFERENCES

Agostoni, S., Laffi, R., Mazzoccola, D., Sciesa E., and Presbitero, M. 1998. Landslide Inventory data base for an Alpine Area, Lombardia, Itally. *In* Proceedings of the 8th Congress of the International Association for Engineering Geology and the Environment, Vancouver, British Columbia, 21-25 September 1998. A.A. Balkema, Rotterdam. pp. 919 –924.

Aylsworth, J.M., and Duk-Rodkin A. 1999. Landslides in the Yukon and western District of Mackenzie, North West Territories. Poster at Cordilleran Roundup, Vancouver, British Columbia, 26-29 January 1999. 1 poster.

Couture, R. 2002. Workshop on Landslide Hazards and Risk Management in Canada. Available from the Geological Survey of Canada, Ottawa, Ontario. Open File 4316.

Cruden, D., and Varnes D.J. 1996. Landslide Types and Processes. *In* Landslides Investigation and Mitigation. *Edited by* A.K. Turner and R.L. Schuster. National Academy Press, Washington, D.C. pp. 36-75.

Davis, J.F. 2000. Landslides, the pervasive but overlooked hazard. Abstracts with Programs – Geological Society of America, 32: 57-58.

De, S., Eastman, C.M., and Farkas C. 2002. Secure Access Control in a Multi-user Geodatabase [online]. Available from http://gis.esri.com/library/userconf/proc02/pap0355/p0355.htm [cited 26 August 2002].

Dikau, R., Cavallin, A., and Jäger S. 1996. Databases and GIS for landslide research in Europe. Geomorphology, 15: 227-239.

Evans, S.G. 1999. Landslide disasters in Canada, 1840-1998. Available from the Geological Survey of Canada, Ottawa, Ontario. Open File 3712.

Ibsen, M.-L., and Brunsden D. 1996. The nature, use and problems of historical archives for the temporal occurrence of landslides, with specific reference to the south coast of Britain, Ventnor, Isle of Wight. Geomorphology, 15: 241-258.

Liverman, D.G., Batterson, M.J., and Taylor D.M. 2003. Geological Hazards and Disasters in Newfoundland – Recent Discoveries. Available from Government of Newfoundland and Labrador, Department of Mines and Energy, Geological Survey, St. John's, Newfoundland. Report 03-01

Vaugeois, L.M. 2002. Creating a statewide landslide hazard database. Abstracts with Programs – Geological Society of America, 34: 23.

Yamagishi, H., Ito, Y., and Kawamura M. 2002. Characteristics of Deep-Seated Landslides of Hokkaido: Analyses of Database of Landslides of Hokkaido, Japan. Environmental & Engineering Geoscience, 8: 35-46.