WEB BASED MAPPING THE PUBLIC DEMAND FOR DATA ACCESSIBILITY AND VISUALIZATION

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1. INTRODUCTION

Many Canadian government agencies collect, analyze, and report on groundwater. There is an increasing need for government agencies to work together to provide improved access, distribution, and viewing of data holdings. Advances in web based mapping and data standards is making this progressively more possible (e.g. Peterson, 2003). Using Canadian Geospatial Data Infrastructure (CGDI) technologies a start is being made to deliver a national scale web mapping portal with enhanced analytical tools to the Canadian public. This will enable user groups to improve the management of their water resources and contribute to enhanced decision support capabilities. It will also permit access to online data by non GIS specialists or in settings where expensive GIS software is not available. This is seen as the first step in developing a more complete web mapping portal to the National Groundwater Database at the Geological Survey of Canada.

The current development is in partnership with various provincial and watershed authorities. The project has four principal thrusts

i. **Data exposure** - data providers expose their information using CGDI services;
ii. **Content standards** - registering these services against the data content standards of the National Groundwater Database (NGD);
iii. **CGDI standards** - modifying existing NGD translation mechanisms to expose the data in standard GML-based data format called Groundwater Markup Language (GWML);
iv. **Web application** - a web application (with a commercial partner) will provide tools to cache, display, and analyze water well data and watershed information using the standard GWML format.

2. DATA EXPOSURE AND CONTENT STANDARDS

The National Groundwater Database (NGD) is a national information system designed to coordinate groundwater information holdings in Canada. The NGD objective is to implement data management architecture and standards, to store and exchange groundwater information through internal channels and national initiatives, and to deliver information in a usable form to governments, educators, practitioners, and the general public. This work will be completed within the broader framework of the CGDI.

CGDI provides two principal services to users of online geospatial data. Individuals with an internet connection can access location-registered databases throughout Canada, thus serving as a one-stop catalogue of geographic data. Second, CGDI standardizes the way information in many of these databases is stored, accessed, and presented online. These standards often comply with international standards and hence much of CGDI services are compatible with non Canadian sources.

By applying CGDI standards, a consistent view of the data will be provided by the NGD through organization of the data into standard themes, layers, and features at three scales: national, provincial, and watershed. The themes will consist of broad categories such as “groundwater quantity”. Contributing agencies will then register layers and features, from their web services, into a particular theme at a specific scale; for example, a possible layer in the “groundwater quantity” theme might be “water well” which might contain features such as “monitoring well” and “production well”. Layers will be served as WMS layers, and features will be served as WFS features. The web application will consist of a suite of online-web tools for a range of national users, provincial agencies and groups of watershed organizations (Conservation Authorities).

The CGDI toolbox (data, standards, specifications, policies) is the foundation upon which the project is built. Data will be served by data providers using CGDI web service standards and specifications (WMS, WFS, GML). These data will be registered with NGD against national content standards, so that NGD can dynamically translate the served data into standard themes, layers and features. Standard themes will be represented as Web Map Contexts in conjunction with WMS services in NGD. The themes will consist of standard layers, exposed via WMS. Each layer will be composed of standard features, described in GWML (Groundwater Markup Language) and served via WFS from NGD in response to filter queries. GWML is being developed formally as a GML application, indeed as an extension to the international GeoSciML standard, following Open Geospatial Consortium (OGC) guidelines for development of such community profiles.

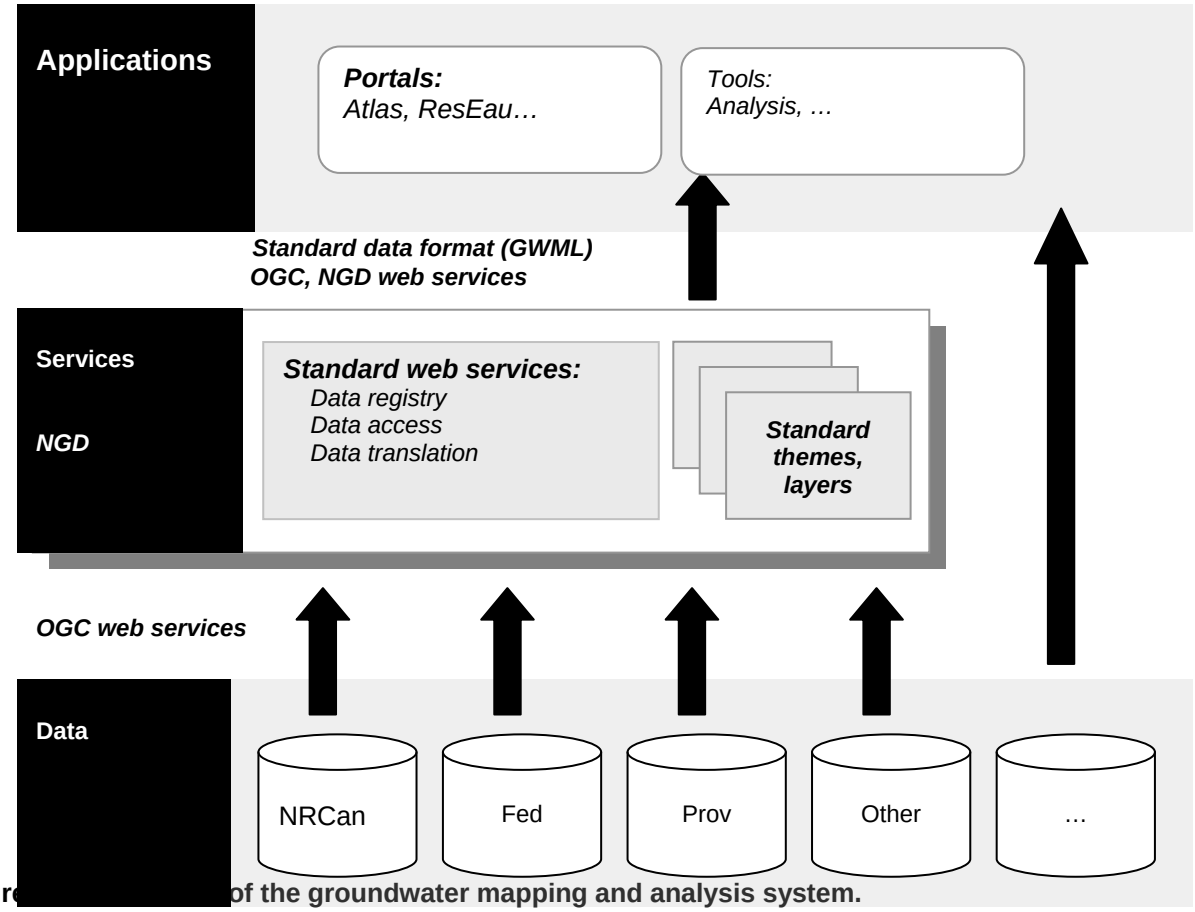

Figure [illegible] of the groundwater mapping and analysis system.

The system being developed aligns strongly with the three tiered CGDI architecture of data, services and applications, as shown in Figure 1:

- Data: data will be held at source, where possible, by the original data providers.
- Services: the geographically distributed data providers will serve data to NGD using CGDI-compliant web services, in local data formats; NGD will use CGDI-compliant web services to serve the data in standard themes, layers, and features, where the features will be represented in the GWML data format standard; NGD will also act as a central registry for the data.
- Applications: the data will be registered with the GeoConnections Discovery Portal and other portals such as the National Atlas of Canada; the analysis tools that will be developed represent web applications that access the data directly via the content standards from NGD, or as an exception directly from the data providers.

3. WEB APPLICATION

The Web Portal is an OGC compliant system that provides the core administration tools required to build and manage a discovery/analysis portal accessed concurrently by "private" contributors and public users. The site runs on a redundant cluster of servers with individual pairs of nodes for load balancing, map rendering, spatial database operations, and network attached data storage (Figure. 2). Database synchronization is enabled through sophisticated pooling techniques. The portal allows OGC compliant WMS / WFS calls to serve data from its internal libraries to the client application – similarly it can be called to deliver rendered map images to other WMS compliant viewers. Styled Layer Descriptors are supported for serving maps or when fetching information from other WMS servers. Metadata is supported and viewable for each layer. Results can be delivered to or from the client through GML/XML with filter encoding. Although it has been significantly enhanced, much of the core platform utilizes OGC compliant open source components for rendering, database storage, administration, transactional queries and concurrency, spatial GIS operators, etc.

The web browser application will provide a fast, full screen, GIS style web map service, allowing data to be displayed on standardized base data layers, including geo-codable street information. Tools will permit dynamic map based queries and viewing of geographic data and document data. Data analysis will include layered data simulating three-dimensional geological models, watershed characterization, monitoring, and time series data. Queries will be able to analyze watershed thematic maps, construct subsurface cross-sections, boreholes graphs, and view historic time-series data. Users will be able to navigate and analyze map-based groundwater information using interactive flash layers, multiple levels of control, wizards, animation, and tutorials.

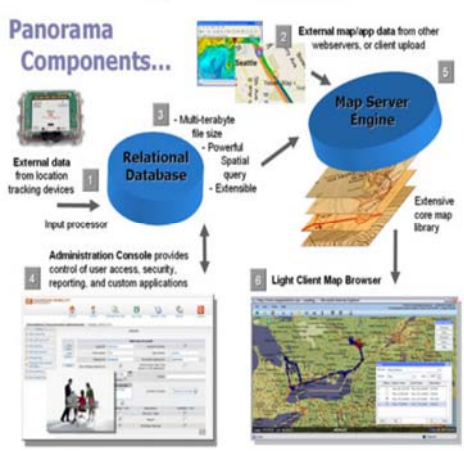

Figure 2. Example web mapping components.

4. USERS

Three types of GIServices can be identified in terms of different end users (Jiang, 2003): i) general public or novice users; ii) the domain specialists, i.e. professionals who collect, maintain and use geographic data in their professional work; iii) both novice and specialist users, for instance, in planning support systems. It is anticipated that users will be drawn from each of the three groups. To-date the Canadian groundwater community has enunciated a number of user priorities within a national report on the state of groundwater resources in Canada (see section 7.3 in Riveria et al., 2003), that include:

- Increased web-based access to water well data and related information
- Coordination of the accessible data within a national information network
- Analysis and modeling tools to operate over the data to aid decision-making
- Increased education, outreach and assistance to regional groups

Of the three groups indicated above, project elements pertaining to data exposure, standards, and CGDI standards directly address interests of the GIS professional or groundwater researcher. The visualization and analysis tools of the web mapping application will permit the public, the groundwater manager, and the researcher to view, query, and complete basic data exploration. The immediate value for the ground water manager and researcher is the ability to

view and interrogate data beyond the confines of expensive GIS software and without the aid of specialized GIS staff.

Ontario Source Water Protection Example: A key example illustrates the collective user needs. Ontario Ministry of Environment's Clean Water Act directs local agencies (e.g. Conservation Authorities) to characterize land and water resources of all watersheds in Ontario. They need to develop tools to access information for analysis and regulation under their Source Water Protection responsibilities. The ability to store, access, display, analyze and update a 600,000 well-water-record database is required in order to delineate the extent and vulnerability of all municipal wellhead areas, as well as sensitive and/or highly vulnerable recharge zones. The generic business case of all users is to prevent another contaminated-well scenario like Walkerton. This project will enhance the access, display and analysis functions required by the users in support of decision-making.

It is anticipated that the system will evolve and will incorporate interactive map editing functions with on-map annotation and collaboration tools. This will then allow project collaborators to send notifications attached to spatial objects so that multiple users can review and "discuss" geographic objects in map-space.

5. ACKNOWLEDGEMENTS

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