3D Sub-surface Visualization of Water Quality Data and Geological Layers for Coal Seam Gas Fields

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ABSTRACT/INTRODUCTION

Understanding the impact of coal seam gas extraction on ground water aquifers is a critical aspect of coal seam gas extraction, undertaken by government agencies working together with geoscientists, gas companies and community groups. Periodic monitoring and analysis of ground water quality through well sampling is essential to ensure that the environmental impact of CSG extraction is minimized. Subsequently, a critical tool that both government agencies and mining companies are demanding is a 3D visualization and analysis tool that enables them to explore and interpret trends in water quality over space and time, in relation to both ground water aquifers and geological layers. This presentation will describe the Web-based system we have developed through the 3D CSG Water Atlas project - a collaboration between the Centre for Coal Seam Gas (CCSG), Centre for Water in the Minerals Industry (CWIMI) and the eResearch Lab at the University of Queensland. We will describe and demonstrate the open source tools that we've developed including the QA/QC, data ingest, backend database, Cesium-based visualization and reporting services. Finally we will present the feedback from government, research and industry users and our plans for future work.

RELATED WORK

One of our first tasks involved identifying and evaluating a short-list of existing platforms for 3D sub-surface visualization. Potential candidates included: Cesium [1]; NASA World Wind [2], including the Geoscience Australia World Wind Suite [3] and EarthSci [4]; Google Earth [5] and the Qld Government's Coal Seam Gas Globe [9]; ParaViewGeo [6]; and QUT's Groundwater Visualisation System (GVS) [7-8]. Criteria for evaluation included: speed/efficiency; scalability; open source, free; easy to install; cross-platform; customizable; supports common data formats; rich visualizations; works in Chrome, Firefox, Internet Explorer. Our evaluation indicated that Cesium was the optimum platform, being free and open-source, Web-browser based, cross-platform, fast and scalable; readily customisable/extensible and supported by an active international community of developers. It supports parsing of GOCAD models and other GIS standards, subsurface 3-D data display and interactivity and is based on WebGL – a JavaScript API which has been adopted by most modern browsers for rendering 3D graphics on the Web.

SYSTEM ARCHITECTURE

Figure 1 provides a high-level view of the 3D Water Atlas system architecture[1], developed using Cesium.

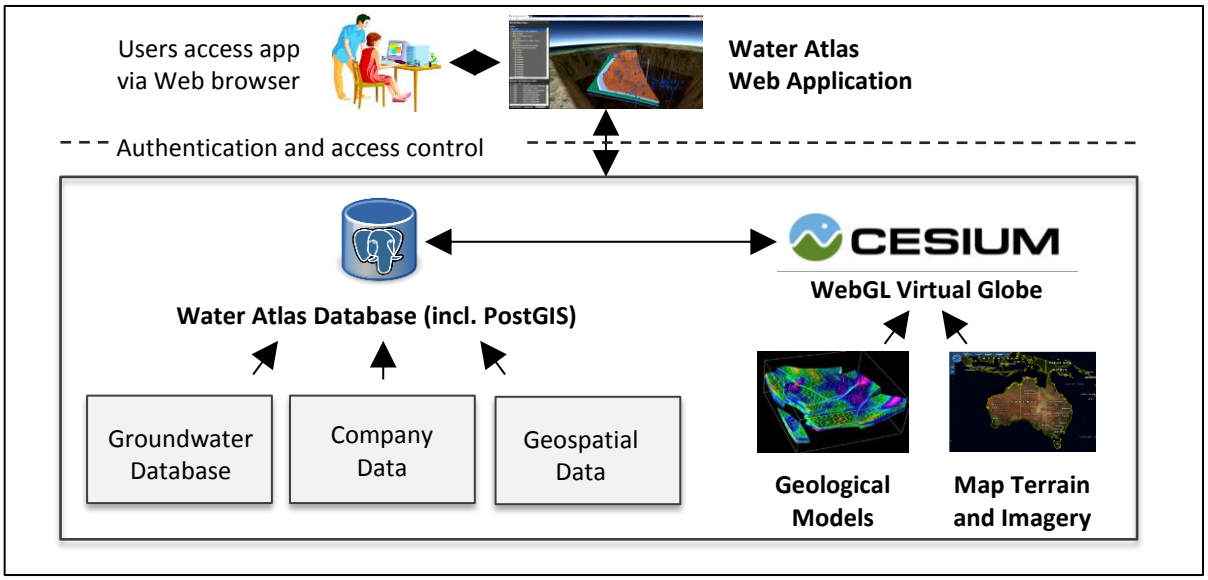

Figure 1: System architecture for the 3D Water Atlas

[1] http://3dwa.metadata.net/3dwa

The 3D CSG Water Atlas comprises three key components:

- A **PostgreSQL database with PostGIS extensions** [3] for storing bore registration, aquifer, casing, stratigraphy, water analysis, and additional geospatial data required to support Atlas functionality;
- **Cesium** [1], a JavaScript library for creating 3D globes and 2D maps in a standard Web browser. Cesium is open-source software, available under an Apache 2.0 license, that comprises a WebGL-based Virtual Globe and Map Engine. The 3D Water Atlas runs on WebGL compatible browsers, including current versions of Chrome and Firefox.
- The **Geological Framework Model** (or "Surat Supermodel") and **Map Terrain and Imagery layers** (e.g. Bing Maps) that are loaded into the Cesium 3D scene.

The **3D Water Atlas server code**, implemented using PHP and Python: performs database queries to retrieve detailed bore, aquifer, casing, stratigraphy, and water analysis data; and performs processing to generate triangle meshes for geological model cross sections. The **3D Water Atlas client code**, based on Cesium, provides interactive features such as clicking on bores to view detailed data, searching bore registrations by any property in the data model, generating pie charts and Piper diagrams based on ion concentrations from imported water analysis records, showing/hiding geological model layers, and computing and rendering geological model cross sections.

SYSTEM FUNCTIONALITY AND USER INTERFACE

The system functionality includes the ability to:

- Upload/import groundwater datasets (from the Qld Govt) and geological models (GOCAD TSurf format);
- Search/filter across datasets within the database;
- Present search results in a variety of formats;
- Export subsets of the data for analysis and re-use within proprietary analysis tools.

Users can execute search and retrieval of wells based on well properties that include: Company ID/Company Name (Arrow, QGC, Santos); Sample type (Baseline, CSG well, GWDB); Record source ("GWDB", "Clean"); Facility type (Office, Shire, etc.). Search results are presented via the Cesium prototype (see Figure 2). When the user clicks on an individual well – either in the search results pane or in the 3D scene – the data associated with that well is extracted on-demand from the server and displayed in a pop-up table that shows: access to the Aquifer, Casing, Facility Role, Strata Log, Stratigraphy and Water Analysis data. Users can also generate piper diagrams for the major ions ("Ca", "Mg", etc.) - rendering analysis data as charts. Users are also able to interactively specify cross-sections (by drawing a line between two points) to dynamically generate geological cross-sections and relate these to the well data.

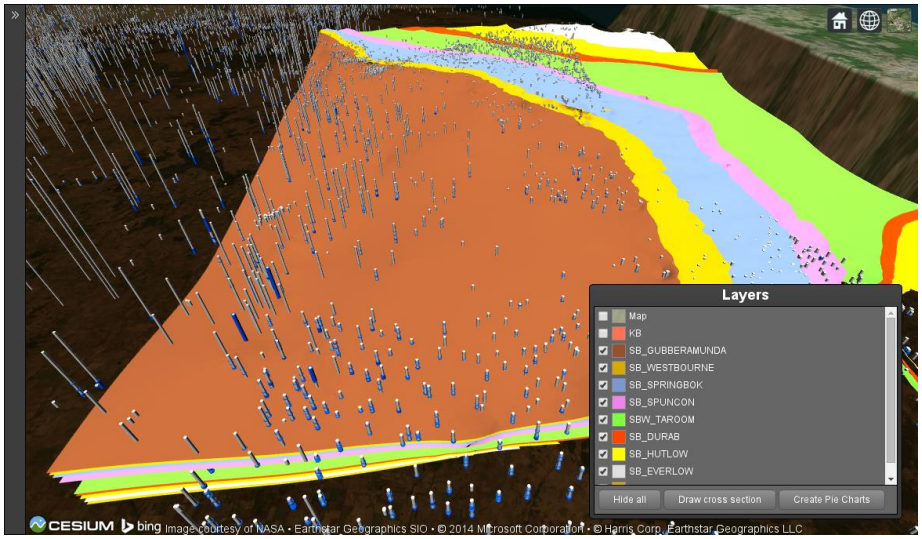

Figure 2: The Surat Basin Supermodel and Water Quality Bores rendered using Cesium

FEEDBACK AND CONCLUSION

Feedback from industry partners generated from demos and user evaluations has included: the ability to upload confidential company data into the system but restrict access to it via authentication and role-based access controls; the ability to display contours for particular water quality parameters and selected regions or geological formations; highlighting of wells that show values outside of 80 percentile range; the ability to interactively generate scatter plots and stiff diagrams for a given time/region, to show correlations between water chemistry and other factors.

ACKNOWLEDGEMENTS

Funding for this project has been provided by the UQ Centre for Coal Seam Gas (CCSG). We also acknowledge the valuable contributions made to this work from our collaborators: Sue Vink and Lucy Reading (CWIMI), Joan Esterle (School of Earth Sciences), Jim Underschulz and Alex Wolhuter (CCSG).

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ABOUT THE AUTHOR(S)

Charles Brooking is a Senior Software Developer in the eResearch Lab at the School of ITEE, UQ. He has over 10 years experience in developing software services for eResearch applications in the environmental domain. He has extensive experience in spatial data management and analysis and has been the principle developer of the Health-e-Waterways, OzTrack and now the 3D Coal Seam Gas Water Atlas systems.

Chih-hao Yu recently submitted his PhD thesis in Semantic Annotation Services for 3D Cultural Heritage. He was a PhD student in the eResearch Lab from 2010-2014 and is currently a developer on the 3D CSG Water Atlas project. He has a B.Multimedia from UQ and his area of expertise is in 3D modelling and multimedia applications.

Jane Hunter is Director of the eResearch Lab in the School of ITEE at the University of Queensland. She has a PhD in Computer Science from the University of Cambridge and has published over 120 peer-reviewed papers in the fields of eResearch, Semantic Web and scientific data management – in a wide range of disciplines including materials, environmental, biomedical and social sciences, as well as digital humanities. She is currently Chair of the Academy of Sciences Committee for Data in Science and also Vice-President of the Australasian Association for Digital Humanities.