Implementation and Transition of Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS v2.0)

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16. Abstract

Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS) is an XML-based system developed under a Federal Highway Administration (FHWA) State Pooled Funding Study led by the Ohio Department of Transportation (ODOT) from 2005 to 2012. This system was developed to become an industry-standard protocol for transmitting and storing geotechnical and geoenvironmental information serving a wide range of public-sector institution and private-sector industry organizations. A standard geotechnical data transfer format allows data providers, be it field data collectors, testing laboratories, or managers of data stored in a proprietary software, to efficiently serve stakeholders, including owners, regulators, engineering consultants, and the broader geotechnical community. Data files are produced in an open and consistent format that can then be readily imported, managed, and analyzed by stakeholders who require the data for preparing geotechnical boring logs, laboratory test summaries, performance monitoring instrumentation reports, and in situ testing profiles and reports. A standardized open and consistent format, developed and managed by the geotechnical and geoenvironmental community, lessens the burden on software developers and vendors who can now write code to perform translations to and from a single data exchange format instead of providing support for multiple proprietary and often closed formats. The objectives of this project were to complete the Beta testing of DIGGS Version 2.0, create training and development tools for users, and develop a sustainable business plan.

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FINAL

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Prepared in cooperation with the Ohio Department of Transportation
and the U.S. Department of Transportation, Federal Highway Administration

Acknowledgements

The following individuals comprise the Leadership Team and were the principal members of the project team:

Bradley Keelor – Geo-Institute of ASCE (Project Manager)

Allen Cadden, P.E. – Schnabel Engineering (Assistant Project Manager)

Robert Bachus, Ph.D., P.E. – Geosyntec Consultants (G-I DIGGS Committee Chair)

Paul Daisey – Image Matters, LLC (retired)

Roger Chandler – Keynetix

Peter Narsavage, P.E. – E.L. Robinson Engineering

Daniel Ponti – U.S. Geological Survey (retired)

Loren Turner, P.E. – Caltrans

The following participants from the previous DIGGS efforts assisted in providing valuable strategic direction throughout the duration of the project:

Marc Hoit – North Carolina State University

Khalid Mohamed – FHWA

We would also like to recognize the significant effort and support of Christopher Merklin and Stephen Taliaferro of ODOT, as well as the support of many other members of the Geo-Institute and the geoprofessional community who assisted in this development effort.

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EXECUTIVE SUMMARY**:** Data Interchange for Geotechnical and Geoenvironmental Specialists (DIGGS) is an XML-based system developed under a Federal Highway Administration (FHWA) State Pooled Fund Study project led by the Ohio Department of Transportation (ODOT) from 2005 to 2012. This system was developed to become an industry-standard protocol for transmitting and storing geotechnical and geoenvironmental information serving a wide range of public-sector institution and private-sector industry organizations. A standard geotechnical and geoenvironmental data transfer format allows data providers, be it field data collectors, testing laboratories, or managers of data stored in a proprietary software, to efficiently serve stakeholders, including owners, regulators, engineering consultants, and the broader geotechnical community. This efficiency is gained because the data files are produced in an open and consistent format that can then be readily imported, managed, and analyzed by stakeholders who require the data for preparing geotechnical boring logs, laboratory test summaries, performance monitoring instrumentation reports, and in situ testing profiles and reports. A standardized open and consistent format, developed and managed by the geotechnical and geoenvironmental community, lessens the burden on software developers and vendors who can now write code to perform translations to and from a single data exchange format instead of providing support for multiple proprietary and often closed formats. The objectives of this project were to complete the Beta testing of DIGGS Version 2.0, create training and development tools for users, and develop a business plan for continued and sustainable protocol implementation. This report was prepared to provide a summary of the efforts performed in support of the ODOT initiative.

1. Introduction

Departments of Transportation (DOTs) throughout the United States struggle with the storage, management, and recovery of geotechnical information. Further, these DOTs

are challenged to receive and share data internally within departments of their own organization or externally with consultants and/other stakeholders as each data set is collected and recorded using varying non-standard systems and in dissimilar formats. Until the DIGGS project there has not been a robust standard data transfer protocol for these important data sets. This generally required that agency personnel had to manually re-enter data if they wanted to electronically use the information on their projects. With the successful delivery of DIGGS 2.0α that concluded the State Pooled Fund Study, a protocol basis has been established and is currently available through the DIGGS website. Adoption of DIGGS by a State DOT would represent a significant step in eliminating the wasting of time and resources devoted to searching for historic data in warehouses and/or expense that results from duplicative investigations and testing due to lack of readily available knowledge regarding the historic investigation programs.

DIGGS provides a standard data transfer structure (Schema) that uses the Extensible Markup Language (XML), which has been extended to include Geographic Markup Language (GML) components to facilitate data exchange (e.g., readings and results) between hardware and software tools. DIGGS also provides a standardized format for summarizing geotechnical information and sharing this information between individuals and organizations. DIGGS establishes a format allowing data to be transferred and archived in an open format, which was developed through a consensus of industry participants. The ODOT project was initiated to test the Schema and to ensure that the Schema was compatible with current testing standards and protocols. Therefore, DIGGS is structured to facilitate data interchange between users while meeting challenges associated with current and future data collection, transfer, and management.

This history of the development of DIGGS is discussed in detail in the final report of the 2012 State Pooled Fund Study titled *"Development of Geotechnical Data Schema in Transportation."* DIGGS Version 1.0 was completed in the fall of 2006. After release, it

was determined that some of the expected capabilities were not realized, and a consultant was retained to correct the Schema and to assure that the structure was GML-compliant. DIGGS Version 1.1 was released in April 2010 and it corrected many technical issues identified in Version 1.0. The State Pooled Fund Study effort completed in 2012 represented an extended effort to finalize the Schema and meet the scope and goals for the original project. The version of DIGGS released in 2012 (i.e., DIGGS Version 2) was not easily understood by the industry and lacked the support of software vendors. It was recognized and recommended that as part of future developments, user-friendly tools be developed for use by the industry to facilitate development of mapping tools and to demonstrate usability for several of the most common geotechnical tests. Therefore, for the ODOT project, significant effort was devoted to improving the Schema and to developing tools to facilitate DIGGS implementation. The DIGGS Feedback Tool was specifically developed to allow programmers to convert data files created in Microsoft Excel, HoleBASE, gINT, or following the AGS format into a DIGGS format. The DIGGS Feedback Tool uses an Excel macro conversion to translate spreadsheet-entered data into a complete DIGGS file. In addition, the ODOT project included development of a web-based XML Validator to check DIGGS files for compatibility with the DIGGS standard. Finally, future implementation strategies of the standard protocol were considered and a DIGGS Business Plan was developed as part of this project.

2. Project Objectives

This project had two goals:

1. Oversee the finalization of the 2012 State Pooled Fund Study results by advancing DIGGS through Beta (β) testing and then into the final public release of DIGGS Version 2.0.

2. Transition DIGGS from the transportation pooled fund project to the Geo-Institute of ASCE (Geo-Institute), where the Geo-Institute intends to permanently manage, oversee, and maintain the DIGGS Data Schema and Data Dictionary.

2.1 Report Organization

This report is organized as follows:

- Section 2 – Project Team and Process: This section introduces the project team and explains each team member's role and responsibility in this project. The process followed for testing, revising, and releasing DIGGS Version 2.0 is outlined in this section as well.

- Section 3 – Testing, Revisions, and Release of DIGGS Version 2.0: This section explains the DIGGS Schema and introduces the Data Dictionary. It also introduces and explains the various tools that were developed as part of this project to support DIGGS.

- Section 4 – Transition of DIGGS to the Geo-Institute: This section identifies the goals of the Geo-Institute and the future developments that are needed for DIGGS to be an industry-adopted data transfer standard.

2.2 Project Team and Process

The project was completed by a team led by representatives of the Geo-Institute and a DIGGS Advisory Board, which included industry representatives and a software consultant. A list of the Leadership Team and the DIGGS Advisory Board is presented in the Acknowledgements.

Key roles and contributions of these Team members include:

Bradley Keelor – Served as the Project Manager for this contract and represented the Geo-Institute's interests in current and future DIGGS efforts.

Allen Cadden, P.E. – Provided coordination and liaison with the Board of Governors of the Geo-Institute.

Robert Bachus, Ph.D., P.E. – Chairman of the G-I DIGGS Committee, which was established to begin the American National Standards Institute (ANSI) standard process. Supported development, quality control, and application development.

Paul Daisey – Technical contact representative with Image Matters (subcontracted consultant firm). Led creation of web tools and validators for XML and GML schema.

Roger Chandler – Keynetix was instrumental in the evaluation of the schema and development of the DIGGS Feedback Tool.

Peter Narsavage, P.E. – Provided webmaster services to maintain the DIGGS website and support development and testing efforts.

Daniel Ponti – Instrumental in all efforts to revise and implement the DIGGS Schema and Data Dictionary and verified consistency of the DIGGS Feedback Tool.

Loren Turner, P.E. – Provided a link to past history of the DIGGS development and ongoing advancement of the Schema and participated in the Caltrans efforts to implement a similar schema for materials testing.

The Leadership Team utilized online meetings, face-to-face meetings, and workshops to develop and complete this project.

An industry survey was prepared to identify the community needs. The survey was developed by the Leadership Team. It was distributed to agencies and interested users, including all of the State DOTs, and consisted of approximately 25 questions designed to gauge the community understanding and interest in DIGGS. The results of the Community Survey were also used to help guide the development of the DIGGS Business Plan. The results of this survey are included as Appendix A. In general, the results confirmed the need and desire for a standard system such as DIGGS to facilitate the management of geotechnical data. Recommendations were also provided by the respondents regarding implementation development and training; however, the respondents had a low interest in contributing to the financial support of such an effort. The financial challenge to the development and implementation of DIGGS is addressed in the subsequent business plan development.

Building on the survey results, the Leadership Team focused its efforts on: (1) ensuring key tests within the Schema met applicable procedure requirements for documentation; (2) developing tools to ensure that this information was captured within the DIGGS files; (3) development of the necessary tools for developers to make data file conversions, and (4) validation of file formats to open standards.

3. Testing, Revisions, and Release of DIGGS Version 2.0

The heart of this project was the further development of the DIGGS schema itself and preparation of applications and/or tools to create and validate DIGGS-compatible files. A significant amount of the project's effort was spent to develop tools, features, and examples to facilitate the understanding, training, and use of the DIGGS format. This section provides a description of the various tools and features developed as part of the DIGGS project, including: (i) DIGGS Schema, (ii) Data Dictionary; (iii) Feedback Tool; (v)

Data Validator; (v) Utilization Tools; (vi) GeoServer/GVDC; (vii) Web Deployment; and (viii) Education and Training.

DIGGS Schema

The DIGGS Schema for Version 2.0 was advanced from earlier versions to incorporate strict compliance with XML and GML standards. The Schema identifies the specific structure of a valid DIGGS file. A narrative summary of the components and rules that are incorporated into the schema is located at http://diggsml.org/sites/default/files/attachments/DIGGS-Final-Report.pdf and is attached as Appendix B.

Modifications implemented during this study included:

(1) Corrected an issue that violated GML's object-property rule by allowing more than one schema object to be contained within a property element. Ran tests using ImageMatters' Team Engine to validate DIGGS as a GML compliant application schema.

(2) Modified several element names to be more descriptive.

(3) Added documentation to many schema elements.

(4) Updated test procedure objects in the geotechnical namespace for the following tests in response to subject expert review:

- Atterberg Limits Test (lab)
    - now includes both Fall Cone and Casagrande test for liquid limits
- Driven Penetration Tests
    - includes SPT and other hammer-based penetration tests in situ
- Particle Size (lab)
    - includes both sieve and hydrometer tests
- Chemical Tests (lab)

- Compaction Test (lab)
    - includes Proctor, Modified Proctor, Porter Static, California Test 216
- Density test (lab)
- PhotoIonization Detector test (lab)
- Specific Gravity test (lab)
- Shrinkage Limit (lab)
- Static Cone Penetration tests (in situ) – e.g., CPT
- Water Content (lab)
- Wireline logs (in-situ)
    - includes any kind of downhole sensors, including suspension velocity logs

The following test's test procedure objects were removed from the geotechnical namespace pending subject expert review:

Aggregate Abrasion Value Test	In Situ Penetrometer Test
Aggregate Crushing Value Test	In Situ Permeability Test
Aggregate Elongation Index Test	In Situ Redox Test
Aggregate Flakiness Index Test	In Situ Resistivity Test
Aggregate Impact Value Test	In Situ Vane Test
Aggregate Polished Stone Value Test	Lab CBR Test
Aggregate Slake Durability Test	Lab Penetrometer Test
Aggregate Soundness Test	Lab Permeability Test
Aggregate Ten Percent Fines Test	Lab Redox Test
Aggregate Water Absorption Test	Lab Velocity Test
Cation Exchange Test	Los Angeles Abrasion Test
Chalk Crushing Value Test	MCV Test
Compressive Strength Test	Micro Deval Test
Consolidation Test	Point Load Test
Direct Shear Test	Pressuremeter Test
Flame Ionization Detector Test	Pumping Test
Flat Dilatometer Test	Relative Density Test
Frost Susceptibility Test	Rock Porosity-Density Test
Hand Vane Test	Schmidt Rebound Hardness Test
In Situ CBR Test	Shore Scleroscope Hardness Test
In Situ Density Test	Suction Test
	Triaxial Test

These procedures are stored in a temporary schema file and will be added back to the schemas once they undergo subject expert review.

The current schema can be found at http://diggsml.org/diggs-schema-version-20b.

Data Dictionary

Once the basic structure of a DIGGS Data Schema (Schema) was developed, it was necessary to identify the required and optional fields for each considered test/activity. These fields and their associated formats (i.e., integer, text string, etc.) are identified as the Data Dictionary. The Data Dictionary is a "living document" and is expected to grow as new tests are added to the Schema or as protocols for existing tests evolve. During this study, several new test result definitions were added to the test properties dictionary. The Data Dictionary for the DIGGS Version 2.0 is located at http://diggsml.org/schemas/2.0.b/documentation//DiggsDocumentation.html and a sample section is attached in Appendix C. The Data Dictionary has been designed to always be "backward compatible." As new tests and functionalities are released, previously developed DIGGS files (from Version 2.0 forward) will be operable.

Feedback Tool

The Feedback Tool is a DIGGS data creation add-in written to enable users and developers to quickly create DIGGS structured files using an Excel spreadsheet. Test files were created as part of this project for a limited number of tests. Instructions have also been prepared to allow users to set up their own templates to use the Excel-as-input strategy when developing DIGGS files. This strategy was adopted to encourage developers, software vendors, and users to work with DIGGS and contribute comments that lead to the implementation and advancement of the DIGGS Schema. Specifically, the Feedback Tool uses a simple Excel spreadsheet to input data in cells or it can be

used to automatically read input files from conventional geotechnical software tools/structures (e.g., HoleBASE SI, gINT, or AGS structured files) and then prepare the appropriate DIGGS file.

The Feedback Tool is intended to assist users and developers to understand the schema structure and is not intended to be a complete conversion tool for all DIGGS file development. As vendors implement DIGGS conversion into their software, this Feedback Tool will no longer be required.

The initial versions of the Feedback Tool used the Excel spreadsheet and macro functions to translate these data into a comma-separated values (CSV) file that served as an input file using a web-based translation tool to produce a DIGGS-formatted file. Once a few of the tests were developed, there were significant challenges with ensuring that the online tool was always functional and would successfully (and consistently) convert the csv to DIGGS.

Near the end of the project, Keynetix modified the Feedback Tool to use "snippets" of .xml code for direct development of DIGGS files from the Excel spreadsheet. The updated DIGGS Feedback Tool is currently available via the DIGGS web site at http://diggsml.org/tools. The Feedback Tool is owned by Keynetix and continues to be expanded. It will be maintained online for developer reference and use by Keynetix.

A video is also provided at http://diggsml.org/presentations that demonstrates the use and general development process for expanding the functionality of the original Excel conversion tool which provides a good explanation and visualization of the conversion process.

DIGGS Validator

The DIGGS Validator is a web-based tool that was created to check DIGGS files for conformance with the XML language structure and the Schema definition. This tool can be found at http://diggsml.org/teamengine. Specifically, the DIGGS Validator checks DIGGS Version 2.0 files against DIGGS and Geography Markup Language (GML) Version 3.2.1 and 3.3 requirements, Extensible Markup Language (XML) rules, and the DIGGS Schema. It also validates instance document files (DIGGS data files including references to the schema design) against Schematron business rules. It is implemented as a Java Servlet web application hosted in an Apache Tomcat web server based on the Open Geospatial Consortium (OGC) Conformance and Interoperability Test and Evaluation (CITE), TEAM Engine and GML 3.2.1 Executable Test Suite (ETS). The DIGGS Validator TEAM Engine is also provided with XSL Transformations (XSLT) that transforms DIGGS instance document files using XSLT Stylesheets. The DIGGS Validator will require maintenance and updating as the Schema evolves and will be maintained on the DIGGS web site to help users as they build individual DIGGS files in accordance with the Schema, as needed.

The DIGGS Data Validator is a "high-end" tool that will primarily be used by developers and not the general user. Specifically, the intended audience for the DIGGS Data Validator includes:

1. Geotechnical and Geoenvironmental specialists who develop and update the ASCE Geo-Institute standard DIGGS Schemas, code lists, and dictionaries.
2. Software engineers working for vendors of Geotechnical and Geoenvironmental data collection, storage, analysis, and presentation tools, instruments, databases, and applications who are enhancing them to support use of DIGGS instance document files for data input and output.

3. Geotechnical and Geoenvironmental specialists who want to "look under the hood" to see how DIGGS works and how it can be expanded. Once vendors have implemented DIGGS support in their products, there will be no need for practitioners to investigate these technical details.

An overview document describing the DIGGS Validator is included as Appendix E.

Utilization Tools

To facilitate the use of DIGGS, a series of utilization tools is continuing to be developed as an extension of this project. These tools are specifically being developed to allow the user to visualize and use the information included in the DIGGS file. The utilization tools are being developed as .php applications and will be posted on the web site. Currently utilization tools are being created for: (i) general summary of DIGGS file content; (ii) moisture content tests; (iii) Atterberg limit test; (iv) particle size distribution test; (v) compaction test; and (vi) density test. As additional tools are developed by users, it is anticipated that the utilization tools will be deployed to the web site and available to all users. Like the Feedback Tool, it is envisioned that the utilization tools represent interim steps in the evolution and adoption of DIGGS. As software developers begin to incorporate the DIGGS format in their products, the need for the Feedback tool and the utilization tools will diminish.

GeoServer/GVDC

A geotechnical virtual data center (GVDC) was built for the COSMOS/PEER project using DIGGS Version 1.0 and remains essentially functional today as an example tool of what is possible with XML/GML based data files. This package is available as a zip file from the Geo-Institute upon request. Video clips of installation and using this tool are stored on the DIGGS web site at http://diggsml.org/cosmos-geotechnical-virtual-data-center-

demo-part-1 and http://diggsml.org/cosmos-geotechnical-virtual-data-center-demo-part-2.

More recent demonstrations of a VDC have been developed for testing of DIGGS Version 2.0 utilizing GeoServer built on GeoTools, which is an open source Java GIS toolkit. Open Geospatial Consortium (OGC) data standards supported by GeoServer include:

- Geography Markup Language (GML)
- KML (formerly Keyhole Markup Language)
- Web Map Service (WMS)
- Web Feature Service (WFS)
- Web Processing Service (WPS)

Because GeoServer is based on open standards, it may be hosted by and combined with other software based on open standards. GeoServer is implemented as a Java Servlet web application hosted by an Apache Tomcat web server similar to the Validator tool discussed above. Leveraging online services such as mapping, the VDC can build a reference map then incorporate the DIGGS instance document to reference the georeferenced test data for geotechnical and geoenvironmental professionals. An example of this powerful capability of the VDC is shown in Figure 1 using Google Earth maps as a base map. Detailed installation instructions and an overview are included as Appendix F.

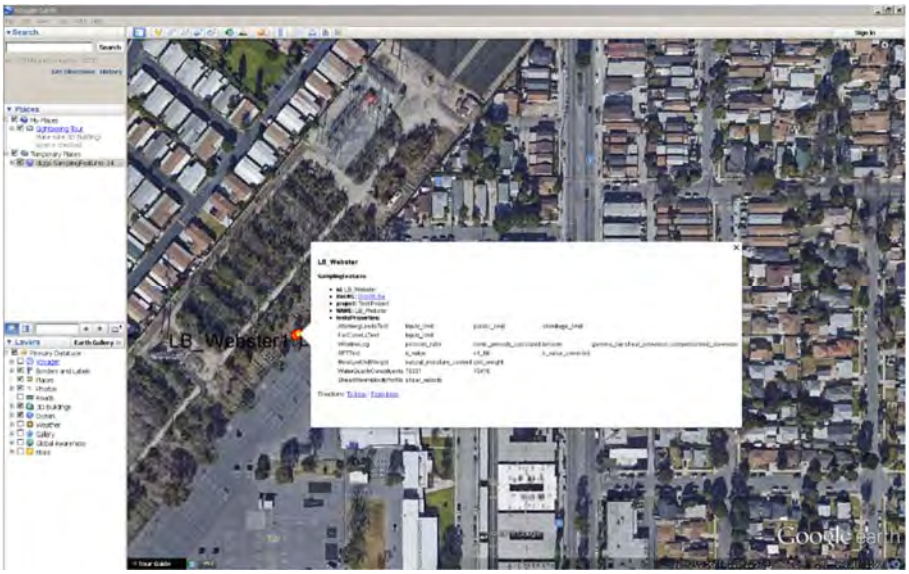


Figure 1: Map of Output of GeoServer utilizing the VDC

Web Deployment

It is intended that the DIGGS website (http://diggsml.org) will be maintained as part of the activities of the Geo-Institute of ASCE (GI). As such, the GI will not only host DIGGS, but will also provide technical support for the ongoing development and maintenance of the DIGGS website until such time that DIGGS becomes self-supporting (see subsequent discussion in Section 4). The remainder of this section is organized to guide the reader through the DIGGS web site and briefly describe the various links that are incorporated for the benefit of the user and developer communities.

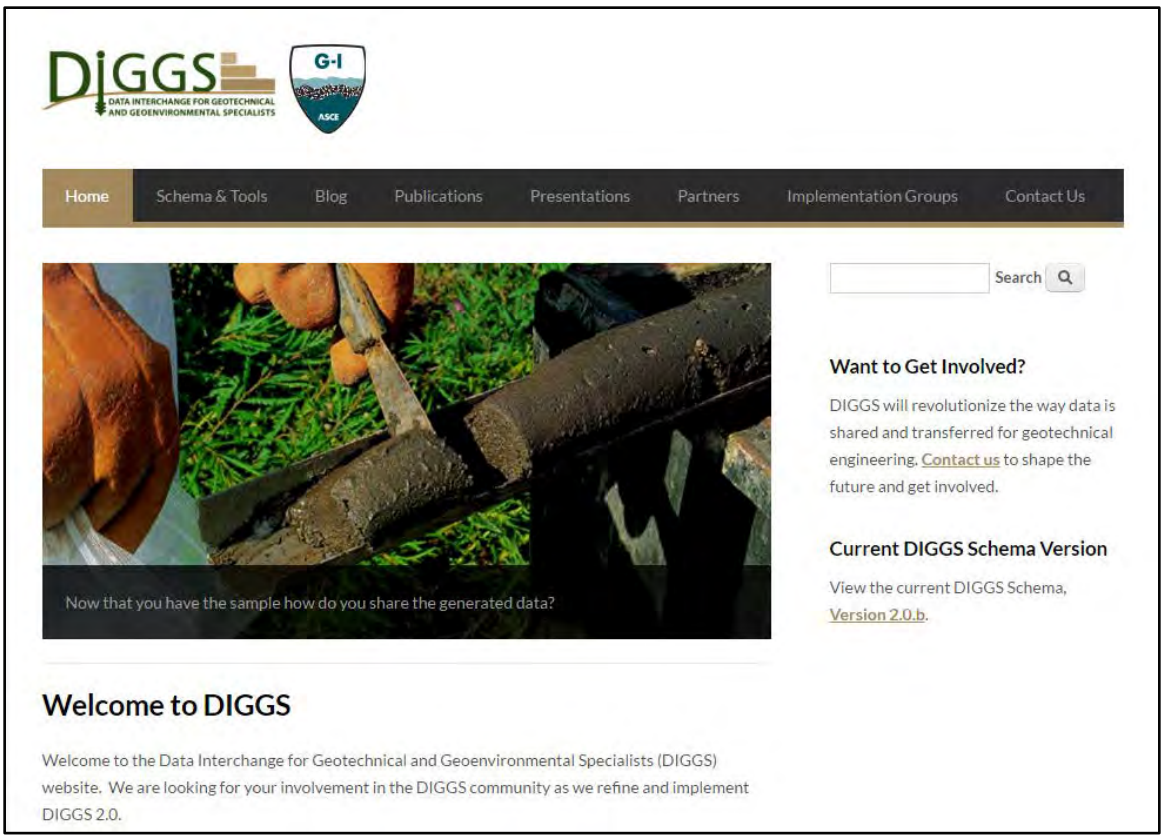


Figure 2: Front page of diggsml.org

The front page of the website provides quick menu links to the latest schema, contact information regarding the DIGGS Committee, and links to various blogs regarding DIGGS. Further, the menus provide access to publications describing the DIGGS effort, and presentations from various conferences.

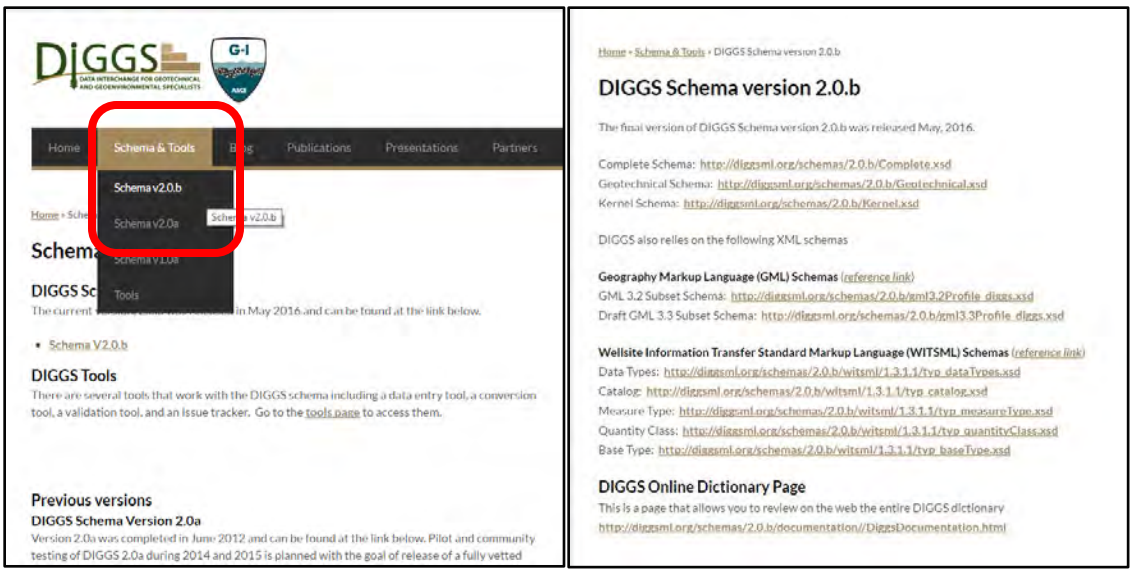


Figure 3: Menu link (left) to the DIGGS schema page (right)

The DIGGS schema page has links to the different XML schema files, also shown below. Together these three schema files define the DIGGS schema. Developers would link to these schema files in their application to implement the DIGGS format and instance documents.

Complete Schema: **http://diggsml.org/schemas/2.0.b/Complete.xsd**

Geotechnical Schema: **http://diggsml.org/schemas/2.0.b/Geotechnical.xsd**

Kernel Schema: **http://diggsml.org/schemas/2.0.b/Kernel.xsd**

At the bottom of the schema website page is a link to the DIGGS online Data Dictionary. This is an exhaustive list of every element that is defined within the DIGGS schema.

DIGGS Online Dictionary Page:

http://diggsml.org/schemas/2.0.b/documentation//DiggsDocumentation.html

This is a page that allows you to review on the web the entire DIGGS dictionary.

Also on the Schema & Tools menu (http://diggsml.org/schema-tools) is a link to the Tools that are helpful in testing and implementing DIGGS. These tools include: (i) the Feedback tool hosted by Keynetix to convert several commonly used industry formats to an XML formatted DIGGS file; (ii) an online service that will convert CSV files to XML-formatted DIGGS files and vice versa; (iii) a validator tool (described earlier); and (iv) links to conversion tools to convert from the AGS Data Transfer Standard utilized by the United Kingdom (UK) to DIGGS.

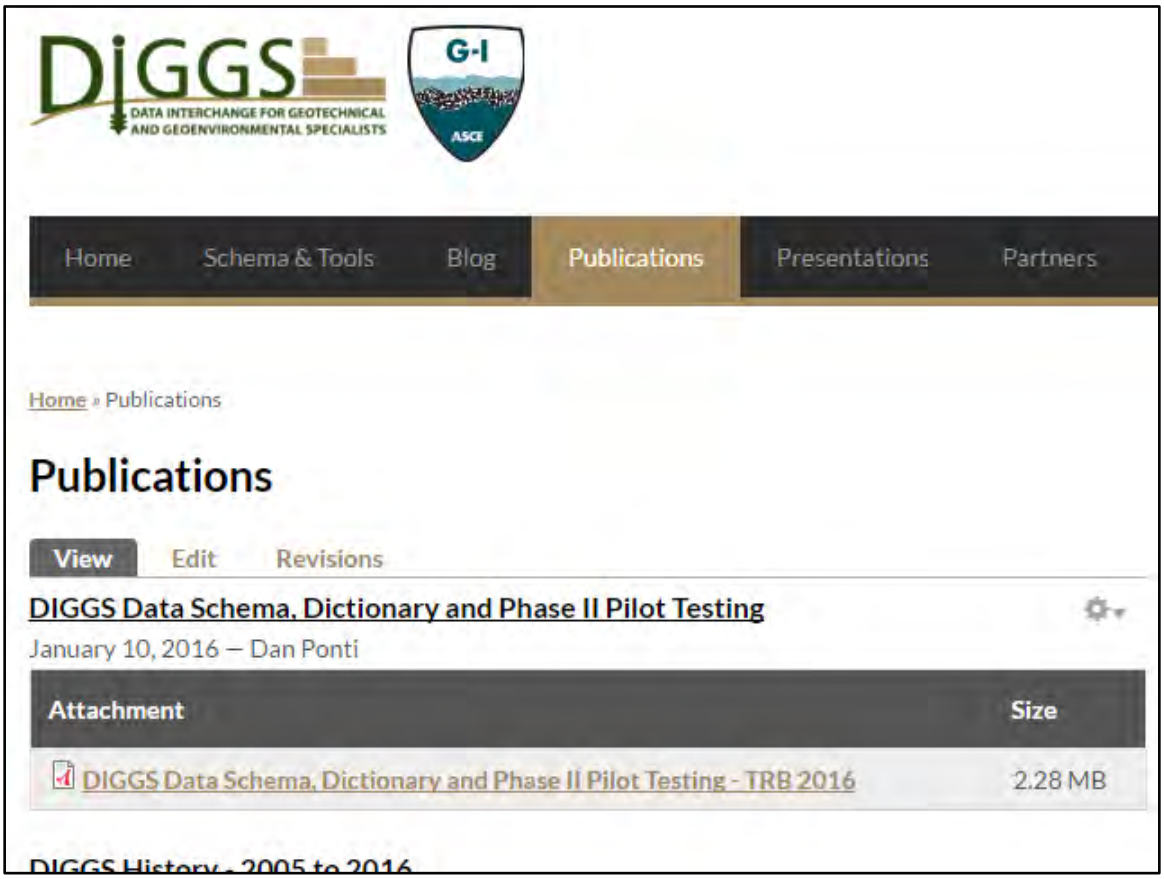


Figure 4: Menu link to DIGGS publications

The website also presents publications (http://diggsml.org/publications) that describe the DIGGS development effort from 2008 to the present, as well as links to video

presentations that various DIGGS team members have been giving at conferences or over the web (http://diggsml.org/presentations). Additionally, the website lists all the different partners in the DIGGS development process and the implementation groups (http://diggsml.org/partners).

Education and Training

Advancement of this project and the implementation of the DIGGS protocol require training on the fundamentals of data collection, storage, and value of a transfer protocol. In an effort to initiate this and gather feedback to help advance the development and beta testing of the schema, several presentations were made during this project. Of note was the Workshop presented at the 2016 Transportation Research Board (TRB) conference in Washington, DC. The presentations from this event are available at http://diggsml.org/publications.

To further document some of the tools that have been developed and their use, a working group meeting was held at the 2016 Geo-Institute of ASCE GeoCongress event in Phoenix, AZ. At this meeting, several tool presentations were made over a WebEx type platform and recorded. These recordings are also located on the website for reference and provide a detailed explanation of the validator and translator tools. (http://diggsml.org/presentations).

To further advance the training and ultimate implementation of DIGGS, the Leadership Team is planning on a series of presentations, training webinars, and workshops. A schedule of these sessions will be updated and announced on the home page of the DIGGS web site.

Beta Testing

Given the evolution of this project and the tools within, beta testing took on a more informal process. Tool development required users to apply the schema and in doing so identified areas of clarification needed. Further, detailed expert review of key test objects was completed to compare the data dictionary to the requirements of current industry standards and procedures. These efforts confirmed the functionality of the schema and defined methods for verification of future test elements within the schema or new elements to be added. A summary of the tests reviewed and Schema changes was provided above.

4. Transition of DIGGS to the Geo-Institute

Business Plan

The ongoing maintenance and development of a standardized open source protocol require a home and sponsoring organization. The Geo-Institute of ASCE (GI) will serve in this role. Ongoing management of this protocol will be by the DIGGS Consortium, comprised of an Advisory Board representing the user market including owners, vendors, consultants, contractors, etc., as appropriate; and Sponsors. A business plan for the ongoing support of DIGGS is attached as Appendix G. This document explains the management, operation, and financial business structure for the DIGGS Consortium that will manage this protocol. As the implementation of this protocol advances, it is likely that this business plan will evolve.

Standard Development

Recognition of a protocol as a "standard" requires a consensus review process. ASCE regularly produces such standards in accordance with American National Standards Institute (ANSI) protocols. Initial efforts were made during this project to establish the

GI DIGGS committee consisting of balanced representation to initiate the ANSI process for DIGGS. While DIGGS Version 2.0 was undergoing beta testing, it was premature to establish this committee. Once completed and implementation is underway with vendors and users, this consensus body can be reestablished. Dialogue has also been initiated with AASHTO materials testing subcommittees to consider inclusion of the DIGGS transfer protocol into highway standards. Having DIGGS become a recognized standard will facilitate the open development process and document evolutionary changes in the protocol.

Research Needs

The DIGGS open standard protocol is intended to be the subject of ongoing development and support. One of the keys to full implementation will be the adoption of this standard into user software and agency contractual requirements. Enhancements will further the value of DIGGS and can include the growth of the tests or objects that can be represented by this protocol and the tools available to implement transfer of information using DIGGS.

Research into additional objects that can be represented and integrated into DIGGS will be a long-term mission. It is intended to have DIGGS evolve to include testing procedures and standards defined within ASTM, ISO, AASHTO and other standards-based organizations, as well as demands requested by the geotechnical industry regarding data collection, presentation, and transmission. Industry trends that are visible today might include Monitoring While Drilling (MWD), grouting and ground improvement technologies, and construction data management where the U.S. Army Corps of Engineers (USACE) is leading the way in real-time data collection and communication. In addition, there are significant FHWA and DOT efforts towards asset management and performance measures that can be accommodated by a standard data

schema. Specifically, it is envisioned that earthwork and foundation installation quality control where compaction equipment and drill rigs are becoming data collection tools can be readily adapted to a DIGGS standard. The managing body for DIGGS will need to maintain vigilance to identify these trends and take a lead in the data transfer protocol development processes so that alternative methods do not develop competing standards.

Although this protocol was developed for the geotechnical and geoenvironmental community, long-term vision to integrate other large datasets of information, such as pavement and bridge inspection or structural health monitoring, should be investigated to allow more information to be readily exchanged and integrated into decision processes.

Conclusion

This study completed the ODOT goals to: (1) Oversee the finalization of the current DIGGS α version through β version and into the final public release of DIGGS 2.0, and (2) Transition DIGGS from the transportation pooled fund study to the Geo-Institute of ASCE. The Geo-Institute intends to permanently manage, oversee, and "own" the DIGGS international data schema (based on XML and GML format) and data dictionary. The system has been validated and is operational to begin implementation through vendors, owners, and users. Future development, maintenance, and management will be provided by the Geo-Institute of ASCE.

5. References

Development of Geotechnical Data Schema in Transportation, State Pooled Fund Study Final Report, June 30, 2012.

Appendices

Appendix A: Community Survey Results

Appendix B: DIGGS 2.0 Schema Structure

Appendix C: Data Dictionary

Appendix D: Feedback Tool

Appendix E: Validator Instructions

Appendix F: GeoServer Overview

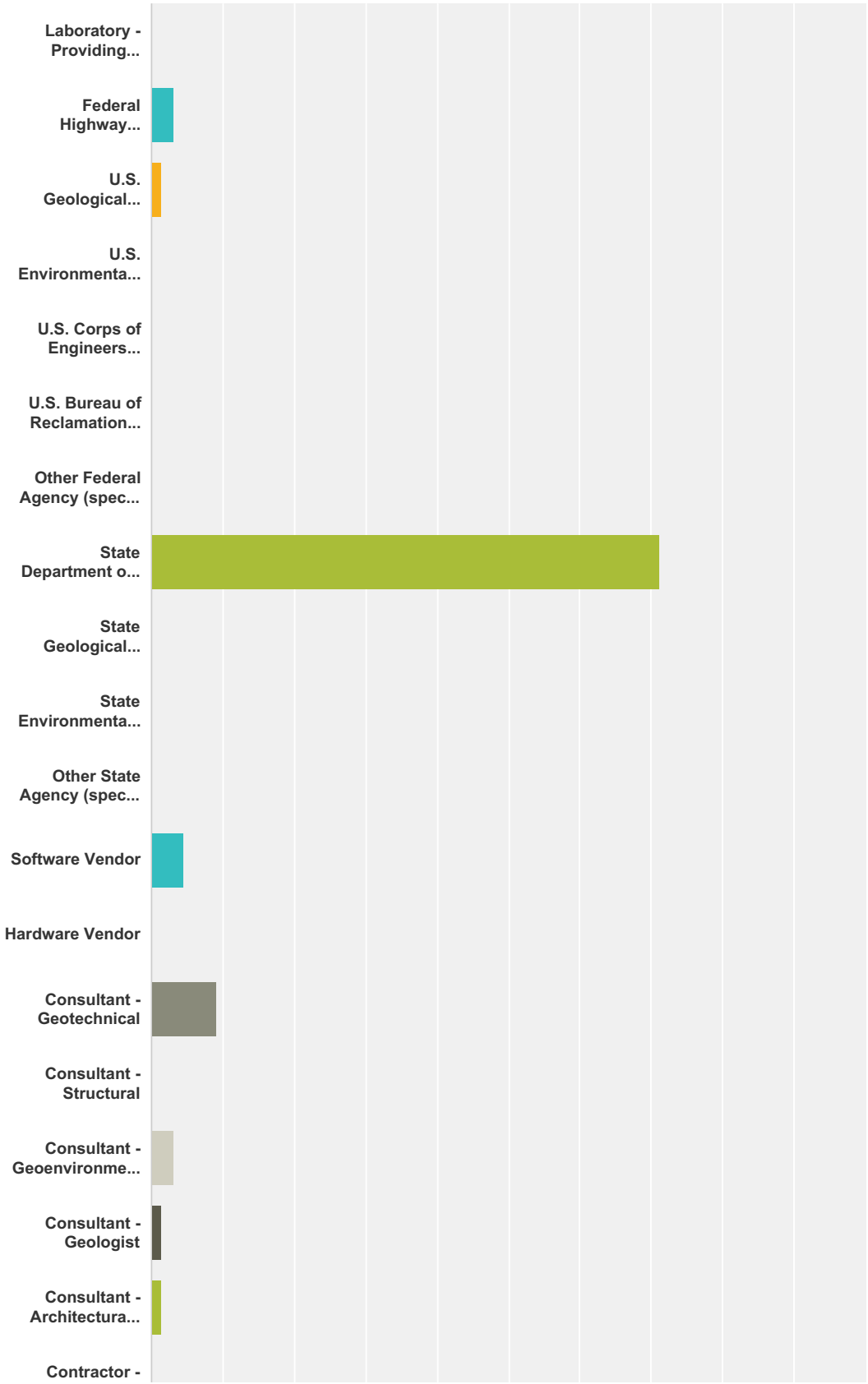
Appendix G: GeoServer Instructions

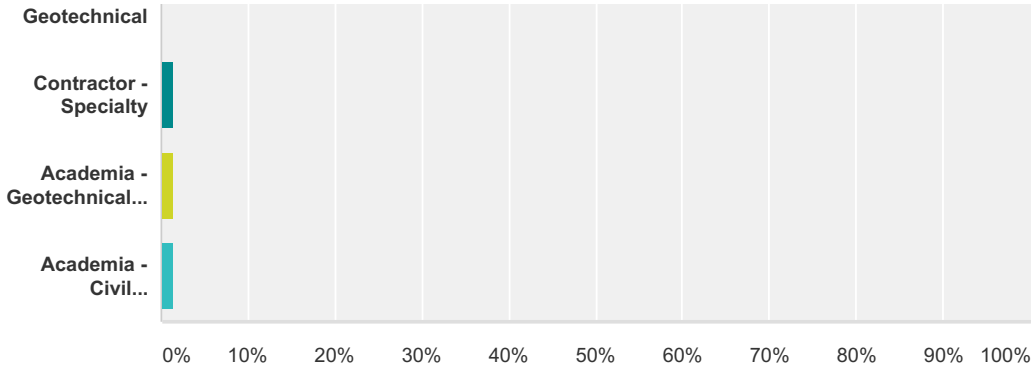
Appendix H: Business Plan

Appendix A: Community Survey Results

Q1 What category best describes your employer/organization?

Answered: 66 Skipped: 0



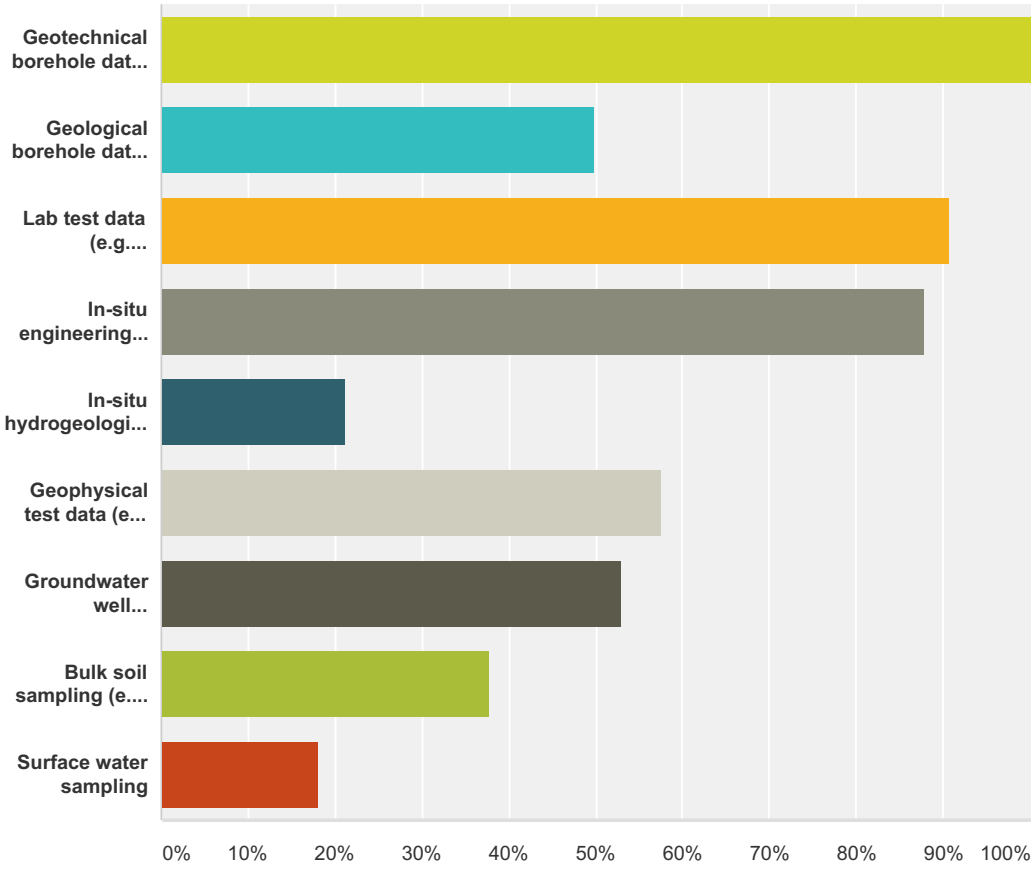


Answer Choices	Responses	
Laboratory - Providing Analysis of Geotechnical and/or Geoenvironmental Samples	**0.00%**	0
Federal Highway Administration (FHWA)	**3.03%**	2
U.S. Geological Survey (USGS)	**1.52%**	1
U.S. Environmental Protection Agency (USEPA)	**0.00%**	0
U.S. Corps of Engineers (USACE)	**0.00%**	0
U.S. Bureau of Reclamation (USBR)	**0.00%**	0
Other Federal Agency (specify below)	**0.00%**	0
State Department of Transportation (State DOT)	**71.21%**	47
State Geological Survey	**0.00%**	0
State Environmental Protection Agency (State EPA)	**0.00%**	0
Other State Agency (specify below)	**0.00%**	0
Software Vendor	**4.55%**	3
Hardware Vendor	**0.00%**	0
Consultant - Geotechnical	**9.09%**	6
Consultant - Structural	**0.00%**	0
Consultant - Geoenvironmental	**3.03%**	2
Consultant - Geologist	**1.52%**	1
Consultant - Architectural Engineering	**1.52%**	1
Contractor - Geotechnical	**0.00%**	0
Contractor - Specialty	**1.52%**	1
Academia - Geotechnical Engineering	**1.52%**	1
Academia - Civil Engineering	**1.52%**	1
Total		**66**

#	Other (please specify)	Date
1	EPC	4/9/2015 10:57 AM

Q2 What type of geotechnical or geoenvironmental data does your organization routinely generate or use in your work. (Please check all that apply)

Answered: 66 Skipped: 0



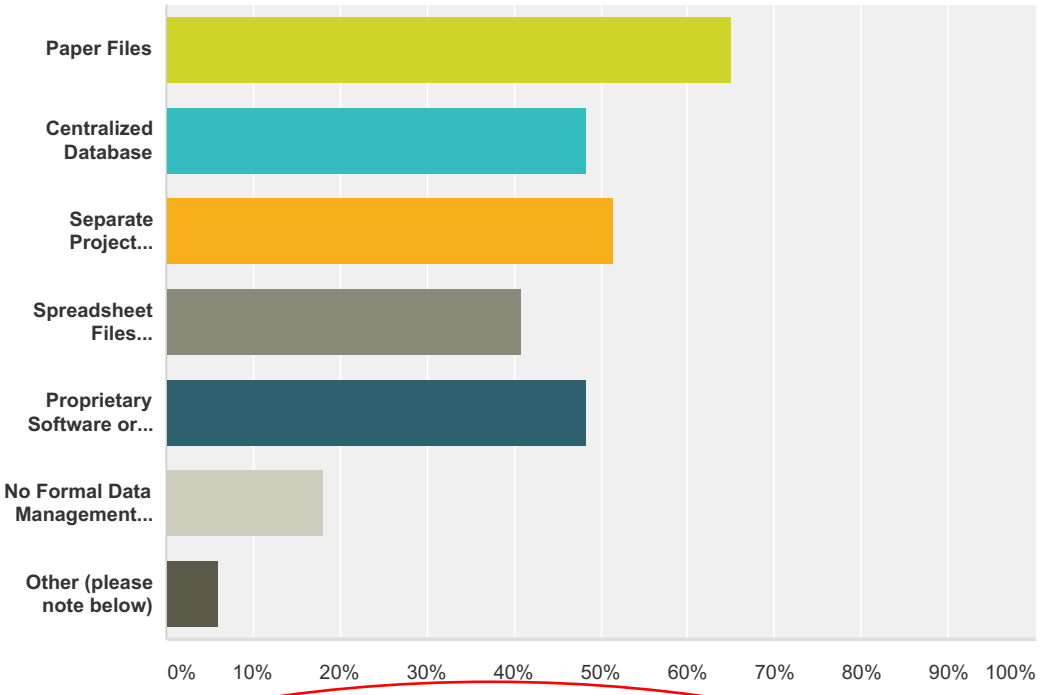
Answer Choices	Responses	
Geotechnical borehole data (e.g. soil classification, visual description, groundwater level, etc.)	**100.00%**	66
Geological borehole data (e.g. dating, bedding orientation, etc.)	**50.00%**	33
Lab test data (e.g. consolidation, gradation, strength, environmental etc.)	**90.91%**	60
In-situ engineering test data (e.g. SPT, CPT, vane shear, pressuremeter, etc.)	**87.88%**	58
In-situ hydrogeologic test data (e.g. pumping tests, dye tests, fluid penetration, etc.)	**21.21%**	14
Geophysical test data (e.g. shear wave velocity, etc.)	**57.58%**	38
Groundwater well Installation and monitoring	**53.03%**	35
Bulk soil sampling (e.g. environmental assessment, composite samples, leachate)	**37.88%**	25
Surface water sampling	**18.18%**	12

Total Respondents: 66	

#	Other (please specify)	Date
1	Information related to field construction testing- PDA/CAPWAP, Static Load Tests	4/21/2015 9:02 AM
2	FHWA has two main organizational program areas: Federal Lands and Federal-Aid. Federal Lands operates similar to a state highway agency - producing roadway design services to federally owned lands, and generates practically all the above data. I represent the Federal-Aid side of FHWA, which works with state highway agencies, but do not generate these data; the states with which I work do.	4/20/2015 10:45 AM
3	All of it for clients	4/16/2015 1:25 PM
4	lidar	4/6/2015 12:26 PM
5	All other borehole data from public records in an urban area (e.g. water well records, 1950's-1960's geotechnical investigations, water supply studies, oil and gas agency records, etc.)	1/15/2015 12:39 PM

Q3 For the data routinely generated or used by your organization, the data are typically stored using: (please check all that apply)

Answered: 66 Skipped: 0



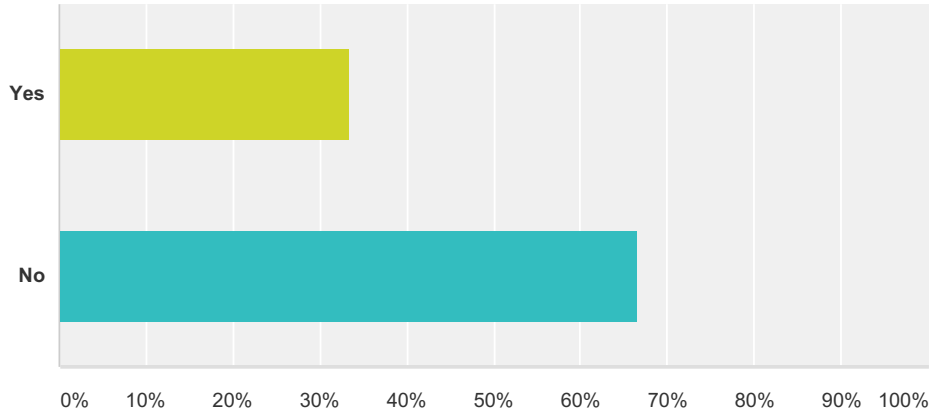
Answer Choices	Responses	
Paper Files	**65.15%**	43
Centralized Database	**48.48%**	32
Separate Project Databases	**51.52%**	34
Spreadsheet Files Maintained by Individual Staff Members	**40.91%**	27
Proprietary Software or Hardware	**48.48%**	32
No Formal Data Management Storage System Exists	**18.18%**	12
Other (please note below)	**6.06%**	4
Total Respondents: 66		

#	Answer Clarification	Date
1	Typically, project files are generated containig plans/profiles and MSWord recommendation documents. Borehole data is stored by project but metadata is exported to a centralized searchable database.	4/21/2015 9:02 AM
2	9 separate gint data bases and consultants by paper	4/20/2015 11:29 AM
3	No formal data repository or management system exists at the national level. However, several individual states with which I work do maintain systems. Those which come to mind are Ohio, Kentucky, Louisiana (developing).	4/20/2015 10:45 AM
4	pdf document	4/14/2015 11:53 AM

5	The soils lab uses excel spreadsheets that are then forwarded to the geotechnical section where boring logs are generated again in a different excel file. The data is not shared between excel files, it is manually entered. We are considering using gINT to replace our current excel based lab data reporting and boring log generation.	4/9/2015 10:14 AM
6	Caltrans uses a web-based document management system called "GeoDOG." All geotechnical reports generated by the Department are stored in PDF format in this system. Supporting design files and other digital content (e.g. Excel, photos, etc.) can also be stored on GeoDOG.	4/8/2015 12:26 PM
7	gINT.	4/3/2015 11:45 AM
8	borings are stored in gINT. location information and a pdf is stored in an ARCIMS application. we also maintain a paper copy of our boring logs and geophysical surveys.	4/3/2015 11:35 AM
9	Report copies stored on thumb drives in Adobe Acrobat (pdf) format	1/15/2015 12:39 PM

Q4 Does your organization utilize data transfer protocols (i.e. standardized systems for sharing data among offices or users) and if so what formats are utilized?

Answered: 66 Skipped: 0



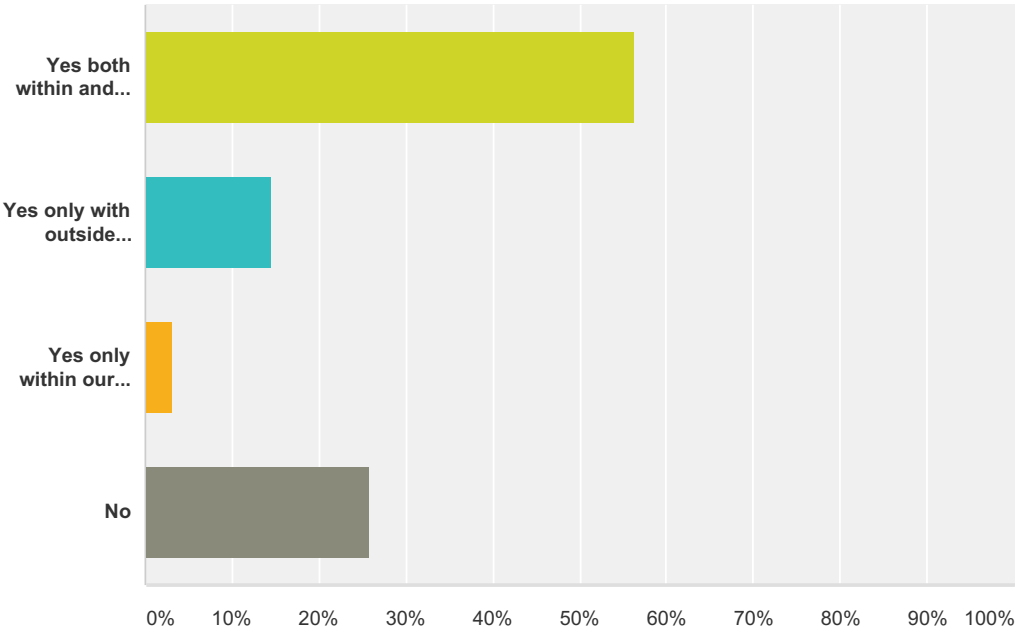
Answer Choices	Responses	
Yes	**33.33%**	22
No	**66.67%**	44
Total		**66**

#	Type of Data Transfer Protocols Used	Date
1	Some data is moved from one file type to another, typically by .csv or other text/Excel file system when needed.	4/21/2015 9:02 AM
2	Gint	4/20/2015 8:53 PM
3	Note: FHWA Federal-Aid (includes Resource Center, HQ Office of Infrastructure, and Research and Development) do not generate or maintain a data management system for geotechnical data. Federal lands has three semi-autonomous branches: Western, Central and Eastern. Each may or may not maintain a geotechnical data repository/system, and each may or may not use data transfer protocols.	4/20/2015 10:45 AM
4	We are trying to organize the data transfer	4/17/2015 5:32 PM
5	ProjectWise, Falcon, Ipswitch	4/13/2015 1:10 PM
6	gINT Geocomp	4/9/2015 1:03 PM
7	Since we are a public agency anyone can request our information. We receive a request either through email or phone and we send a pdf or paper copy.	4/9/2015 12:36 PM
8	AGS	4/9/2015 10:57 AM
9	EDD formats	4/9/2015 10:43 AM
10	Data exchange is primarily carried out through the use of the centralized GeoDOG system, or via file servers. Data format most commonly used include Excel, text, and gINT project files. No single data interchange format is used.	4/8/2015 12:26 PM
11	PDF, DGN, FTP site	4/7/2015 2:39 PM
12	AGS, custom protocols developed internally	4/6/2015 9:58 AM

13	Not typically enforced, but data must be sent either in the proprietary software format, or match schema of our database.	4/6/2015 8:51 AM
14	Mainly gINT software for subsurface exploration data	4/6/2015 6:59 AM
15	Ags	4/3/2015 12:20 PM
16	gint, Sharepoint	4/3/2015 11:42 AM
17	inhouse drilling by gINT. consultant drilling by paper/pdf	4/3/2015 11:41 AM
18	we have software for generating boring logs that can be shared amongst users	4/3/2015 11:38 AM
19	FTP, SharePoint, and ProjectWise	4/3/2015 11:16 AM
20	We have separate Oracle databases for boring and certain lab data that were developed in-house in the early '90s.	9/29/2014 11:13 AM

Q5 Does your organization have difficulty sharing or accessing geotechnical and/or geoenvironmental data that is newly generated or historically archived? Is the problem limited to internal sharing (i.e. within departments or among individuals/offices/districts) or external sharing (i.e. contractors, vendors, other DOTs or FHWA etc.)?

Answered: 62 Skipped: 4



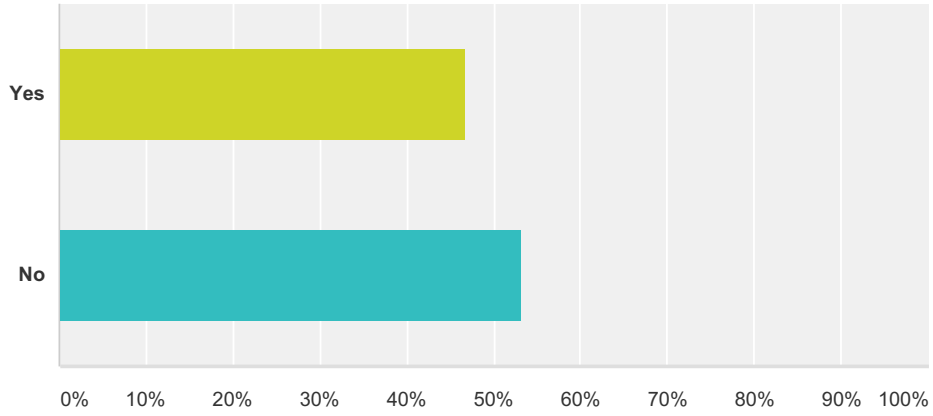
Answer Choices	Responses	
Yes both within and outside organization	**56.45%**	35
Yes only with outside organizations	**14.52%**	9
Yes only within our organization	**3.23%**	2
No	**25.81%**	16
Total		**62**

#	Answer Clarification	Date
1	Not in general- most platforms allow data transfer among needed formats. Exporting/Importing lab and sensor data to other forms has been difficult- and providing lab and boring log data in useful electronic format to 3rd parties (usually when the 3rd party doesn't have the software to load electronic files in the proprietary format).	4/21/2015 9:14 AM
2	This answer is from the FHWA Federal-Aid perspective. We have restrictions, both internally and externally, on accessing systems, and must go through involved approval processes to 1) establish data portals behind our firewall; and 2) access external systems requiring and executable system or plug-in that would be required to run/access the system.	4/20/2015 5:00 PM

3	Some data files and software became obsolete and was not possible to open for reuse.	4/9/2015 3:01 PM
4	Much of our data is on local servers that are not accessible to offices at other locations, and there is no access for external clients. Data can be put on an FTP site, but there is no standardized format for doing so.	4/9/2015 11:26 AM
5	The GeoDOG system is only accessible to Caltrans users through the internal network. Those outside the department need to submit requests for individual project documents. Document access within the department is facilitated by GeoDOG, common file servers, and email. However, there is room for significant improvement to make all geotechnical-related data sets more accessible and in formats more readily useable (e.g. store data files rather than pdf files).	4/8/2015 12:36 PM
6	Historical documents are in paper storage. Newer documents are put into PDF format, stored electronically but not accessible outside the local work unit.	4/6/2015 7:21 AM
7	It is a challenge to find old information and reports.	4/3/2015 11:46 AM
8	Historical data can be difficult to obtain.	4/3/2015 11:41 AM
9	Boring data from the 90's on are fairly accessible. Older paper logs are stored at our various regional offices. Lab testing -- particularly undisturbed testing -- has no real storage solution.	9/29/2014 11:21 AM

Q6 Do the existing storage formats used for your geotechnical data restrict or hinder you or your organization's ability to select/consider specific software packages that may meet your needs? If so please indicate what problems you have encountered.

Answered: 62 Skipped: 4



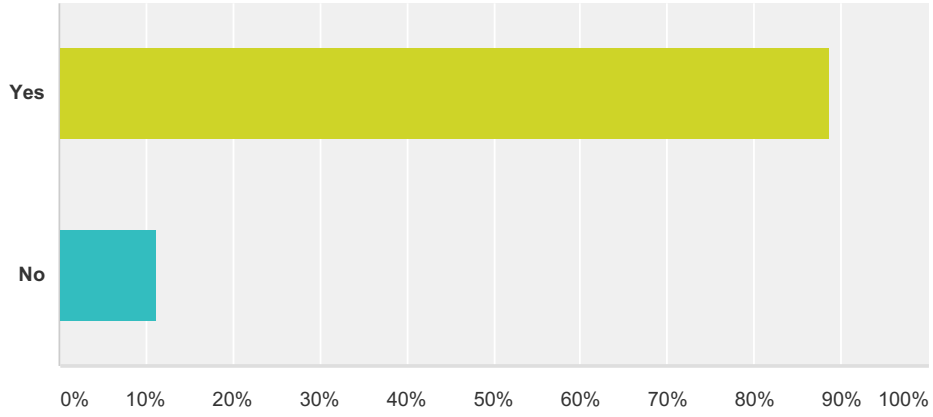
Answer Choices	Responses	
Yes	**46.77%**	29
No	**53.23%**	33
Total		**62**

#	Problems Encountered	Date
1	At the moment, it isn't the hardware so much as the software and a lack of internal IT knowledge on how to "push" the data from one system to another. As an example- we are having a difficult time developing systems that take data from our Trimble hand-held data collectors into gINT databases for management and plotting and then to another database format compatible with Microstaiton inport. These are all MS Access databases, but the table structures are different and doing the mapping and writing the correspondance files is not a familiar activity to either the engineers or the IT staff.	4/21/2015 9:14 AM
2	inhouse in 9 different data bases (all gINT) and consultant on paper and pdf	4/20/2015 11:33 AM
3	Multiple formats and non-standardized software inhibit the transfer of data between offices and between our clients and us. The easiet data to share is excel spreadsheets	4/19/2015 9:06 AM
4	We are using gINT Enterprise	4/17/2015 5:36 PM
5	Data transfer between dfiierent applications	4/14/2015 3:03 PM
6	Data management in a GIS accessible format	4/14/2015 11:59 AM
7	Not sure	4/13/2015 1:13 PM
8	This happens occasionally depending on software type and upgrades.	4/9/2015 3:01 PM
9	We previously had an in-house database that became out-dated and just moved to gINT which we can upload to a central server. It will also work better with our microstation applications.	4/9/2015 12:38 PM

10	Boring logs are completed in gINT which make it difficult to edit, and other data is placed on spreadsheets with no specified format, so transferring data from one software to another is difficult and cumbersome.	4/9/2015 11:26 AM
11	Interoperability between software is limiting. Lab test, field test, and other types of test equipment generate data files in various proprietary formats. This makes it difficult to synthesize and move data between software packages.	4/8/2015 12:36 PM
12	We integrate with HoleBASE, gINT, LogPlot so we can transmit data to each system. We also integrate with various LIMS through standard and custom data transfer protocols.	4/6/2015 9:59 AM
13	We currently use gINT for boring logs and are moving towards gINT Enterprise. Even though gINT Enterprise uses Microsoft SQL Server for its database, the database structure is still strongly tied to how the data is entered in gINT.	4/6/2015 9:07 AM
14	file may not be compatible to the system we have	4/6/2015 8:59 AM
15	Would like to be able to work with in-situ (e.g. CPT and DMT) data seamlessly.	4/6/2015 7:05 AM
16	Historical data exists in tiff files from scanned microfilm. New data in pdf and dgn formats	4/3/2015 2:48 PM
17	Have large existing paper filing system with data dating back to the 50s. Will take a very large effort to scan into pdf format and place into a database. Would prefer the data base to link with GIS.	4/3/2015 11:46 AM
18	We haven't encountered any yet, but we are looking to update our systems and I'm sure we're going to have some problems.	4/3/2015 11:18 AM
19	Project location mapping problems	1/15/2015 12:45 PM
20	Some would like to transition over to gINT for drafting and other purposes, however it would take some effort to move all of the data (~25000 holes plus testing data) and get the drillers/regions familiar with the new process.	9/29/2014 11:21 AM

Q7 Would your organization benefit and see value in being able to more easily access and share geotechnical and geoenvironmental data that are routinely generated and/or used for your projects? If so, please indicate what benefits you foresee. If not, please indicate why do you not see benefit/value.

Answered: 62 Skipped: 4



Answer Choices	Responses	
Yes	**88.71%**	55
No	**11.29%**	7
Total		**62**

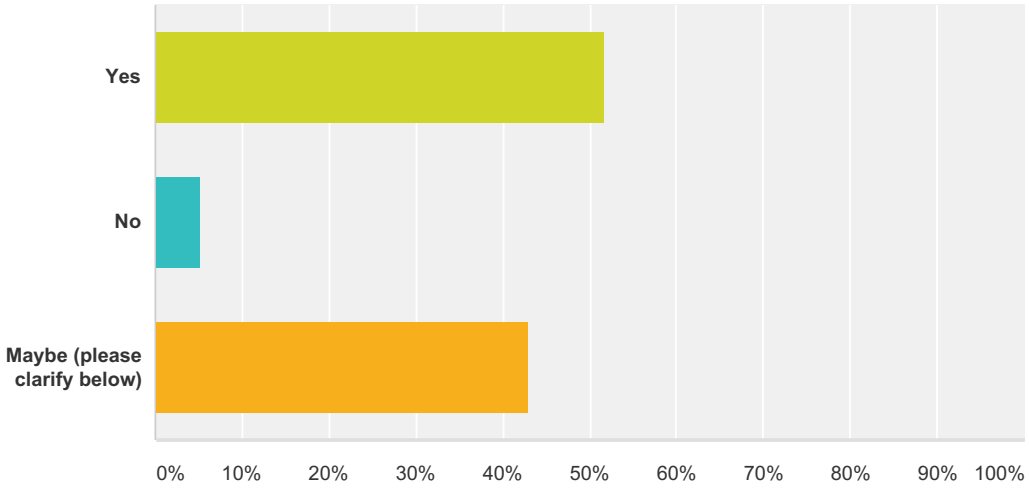
#	Clarify Value or Lack of Value Foreseen	Date
1	Specifically, we are finding a large amount of "lost" data when we have consulting engineers perform soil borings under contract for municipally led or county-state aid projects. We hope that when we upgrade an online system later this summer we can begin to require them to submit boring log information into the system. Currently, DOT administered projects put geotechnical informaiton online to share internally/externally. It would also be useful to more effectively share data with universities for their educational and research use (capstone projects, thesis work). We are having success providing our boring log templates to consultants for our projects such that work for us is captured. Tools such as plotting metadata using Google Earth (and similar) for visualization of boring locations has been a tremendous development.	4/21/2015 9:14 AM
2	From the FHWA Federal-Aid perspective, access to and easy display of data when reviewing projects would be very helpful. Easy access to historical data within the vicinity of planned projects would also be valuable.	4/20/2015 5:00 PM
3	Easily access data from other projects. It may lighten the amount of exploration required for new projects. Save time when looking for old data.	4/20/2015 12:05 PM
4	reduced number of borings by easy access to existing data (to reuse). Also knowledge of what may be uncounted provides savings of time and money by being properly prepared.	4/20/2015 11:33 AM
5	Yes it would be a benefit, but due to the lack of interest/concern about this from the larger portion of the organization this would recieve low priority,	4/19/2015 9:06 AM
6	It would make the geotechnical analysis more efficient.	4/17/2015 10:15 PM

7	Difficult to keep up with technology. Data systems and programs are often obsolete before even being implimented and are often not compatable with outside agencies.	4/17/2015 5:25 PM
8	The benefit would be for data exchange across various software, much like the LandXML	4/16/2015 1:26 PM
9	Efficient storage, easy access whenever you are, easy transfer between different applications, reduction of redundant data entry (it may be useful to cathc errors, tough expensive)	4/14/2015 3:03 PM
10	Information will be of great value in preliminary engineering concepts Data may not meet the chain of custody requirements for professionally sealed work	4/14/2015 11:59 AM
11	Would minimize duplication of work. Would help establish databases for studies and correlattions.	4/13/2015 1:13 PM
12	Having the ablitiy of access historical data would greatly enhance our ability to structure subsequent geotechnical investigations and field and laboratory programs to reflect past experience and data gaps.	4/10/2015 8:11 AM
13	This is expected to make data easily accessible for future use and has the potential for saving cost and time. It will also make it easier for internal and external use and sharing of data. Some of our offices started digitizing old geotechnical data and preparing new collected data in digital form since early 2000s in anticipation of expansion of such technologies.	4/9/2015 3:01 PM
14	It would be useful to share data with other agencys and consultants.	4/9/2015 2:00 PM
15	Look to remove the need to reformat information for use each time information is transferred or shared	4/9/2015 12:58 PM
16	Anything outside our state isn't really applicable due to differing geological conditions.	4/9/2015 12:38 PM
17	Having a standardized system for storing data across offices and groups within offices would make sharing of data more accessible.	4/9/2015 11:26 AM
18	Allowing data to more easily transcend projects	4/9/2015 11:23 AM
19	greater use of existing data for new projects resulting in project savings	4/9/2015 10:52 AM
20	We have a lot of geotechnical information from around the state but in its current format we are unable to access this information or use it to assist with future explorations.	4/9/2015 10:15 AM
21	If test equipment vendors and geotechnical analysis software vendors supported a single data standard (either as their native format or as an optional export/import format), there would be great benefit -- better integration of data throughout business processes.	4/8/2015 12:36 PM
22	Sharing information would keep from spending money to gather data that may already be available from another source.	4/7/2015 2:40 PM
23	We think that a completion of easy sharing of data will allow all parties on our projects to more appropriately evaluate subsurface conditions. Ultimately leading to a better product and lower bid prices.	4/7/2015 11:49 AM
24	We are both the generators and the prime users of the data. We have no real difficulties handling the data. Others that use the data tend to do so at a very low level. We have no complaints from them, except that we do not generate enough of it to meet all of their needs, which is not a data management problem.	4/6/2015 1:52 PM
25	If data is readily available then the engineers may not need to conduct duplicate site investigations.	4/6/2015 1:24 PM
26	Have been collecting in electronic format for quite some time and do not have difficulty in generating/reusing data	4/6/2015 8:54 AM
27	Better and more efficient decision making.	4/6/2015 7:48 AM
28	Exploration logs and reports could be available as soon as finalized if stored in an publically accessible and secure location instead of a local network.	4/6/2015 7:21 AM
29	To optimize review, project scope development, and subsurface exploration program	4/6/2015 7:05 AM
30	We have access internally, but could be improved. Access to external data would be helpful.	4/3/2015 3:34 PM
31	Ability to quickly share, import and display data from various sources would aid in planning, and in some cases reduce number of borings necessary on some projects.	4/3/2015 2:48 PM
32	Ease of finding old historical information. Elimination of having different versions of the same data.	4/3/2015 11:46 AM
33	easily sharing our geotechnical data with other users and being able to easily obtain other users data would provide a multitude of benefits	4/3/2015 11:41 AM

34	compatability with software packages. more easily shared with other organizations.	4/3/2015 11:38 AM
35	Faster data gathering and interpretation.	4/3/2015 11:18 AM
36	Access to shared geotech data is crucial for regional subsurface mapping for engineering geology projects (e.g. Green infrastructure planning in combined sewer areas; preliminary studies for large diameter sewer projects; general mapping projects)	1/15/2015 12:45 PM
37	Internal customers and Consultants will benefit from accessing our shared data for design and analysis.	11/19/2014 11:27 AM
38	Somewhat. We have managed to feed most of the drill holes into ArcGIS and that allows us to run useful queries. Streamlining the process would be a benefit though.	9/29/2014 11:21 AM
39	Increased efficiency, able to share more easily with DOTs and other government agencies	9/26/2014 11:50 PM

Q8 One of the goals of DIGGS is to provide a system that saves time/money by making data management easier and more reliable, improving the efficiency of geotechnical and geoenvironmental evaluations, and creating opportunities for enhanced data analysis. If it was demonstrated to your organization that DIGGS provides such a system, would your organization be inclined to use it or require that DIGGS be used on your projects?

Answered: 58 Skipped: 8



Answer Choices	Responses	
Yes	**51.72%**	30
No	**5.17%**	3
Maybe (please clarify below)	**43.10%**	25
Total		**58**

#	Answer Clarification	Date
1	1) If we had instrumentation projects, we would require a DIGGS compatible export of data from "the cloud" or wherever the data was stored such that it would be useable in other programs that could "understand" and present DIGGS data- such as sensor information. 2) we would require electronic reporting of data from lab tests and provide DIGGS as an option (with a correspondence file) to using the gINT data template.	4/21/2015 9:17 AM
2	We are always looking for new ways to make our operation more efficient.	4/20/2015 12:06 PM
3	We would work on this for our clients	4/16/2015 1:27 PM
4	My organization, specifically my group 'Information Management and Advanced Technology (IMAT) Services" is developing Web map applications for geotechnical database management systems. We are currently using AGS format. When AGS is not adequate we develop our own standards.	4/14/2015 3:07 PM

5	I would have to see specific examples and learn more about the cost of implementation.	4/10/2015 8:13 AM
6	Our agency contributed significantly to DIGGS and provided support to DIGGS development in collaboration with other organizations.	4/9/2015 3:03 PM
7	if our current software allows that option	4/9/2015 2:02 PM
8	There is no centralized data management for all types of information at my agency, but certain sections of my agency would likely adopt such a standard	4/9/2015 12:59 PM
9	I hope we would, but older folks (e.g. those in charge) might be resistant to the idea.	4/9/2015 11:24 AM
10	It would have to be affordable in order to get buy-in from upper management.	4/9/2015 10:17 AM
11	Internally, we'd need the tools to take in, process, and make DIGGS data useable in our practice. Externally, contractors and others need tools to generate DIGGS data files. With these in place, it would then be possible to establish requirements for use of DIGGS.	4/8/2015 12:40 PM
12	We have a significant investment in our GeoGIS system so we would have to be able to integrate this platform into that system in order to see the benefit.	4/7/2015 2:42 PM
13	Our system is adequate for our primary and secondary purposes, but to make our information more accessible to tertiary users like researchers or the public, we might consider DIGGS.	4/6/2015 1:54 PM
14	It depends on the efforts requried to switch or make changes	4/6/2015 10:22 AM
15	funding is the issue	4/6/2015 9:00 AM
16	I see it as a software vendor development issue. If not standardized/incorporated by all geotech software, we would just maintain current data acquisition practices....which results in us getting data in a standardized format and no problems for re-use.	4/6/2015 8:57 AM
17	Depends upon effort, cost and resources needed to adopt system.	4/6/2015 7:23 AM
18	this question is not really appropriate. We would require DIGGS to be used in our hardware and software purchases to effectively exchange info. in cases where we subcontract field work (insitu testing most likely) we could require this on projects	4/5/2015 8:38 PM
19	It is tough for our organization to embrace anything different or new. We struggle with having the time to research and implement new ideas.	4/3/2015 11:47 AM
20	We would likely use it, but of course it depends on cost. State DOT's have many software needs and limited funding. Also, if the costs are high, it may not be reasonable to force our consultants to use the software	4/3/2015 11:42 AM
21	I see a benefit to it, but as a State agency getting a policy or procedure approved can be challenging. We recently started a mandatory soil sampling and reporting procedure so putting on a new layer or changing things again may be rejected.	4/3/2015 11:21 AM
22	Would likely be phased in over 3-5 year period	11/4/2014 2:33 PM
23	The likely path forward for us would be to adopt the full capabilities of gINT. We already use a very small piece of it for printing logs and we have a full licence now that it's been bought out by Bentley.	9/29/2014 11:24 AM

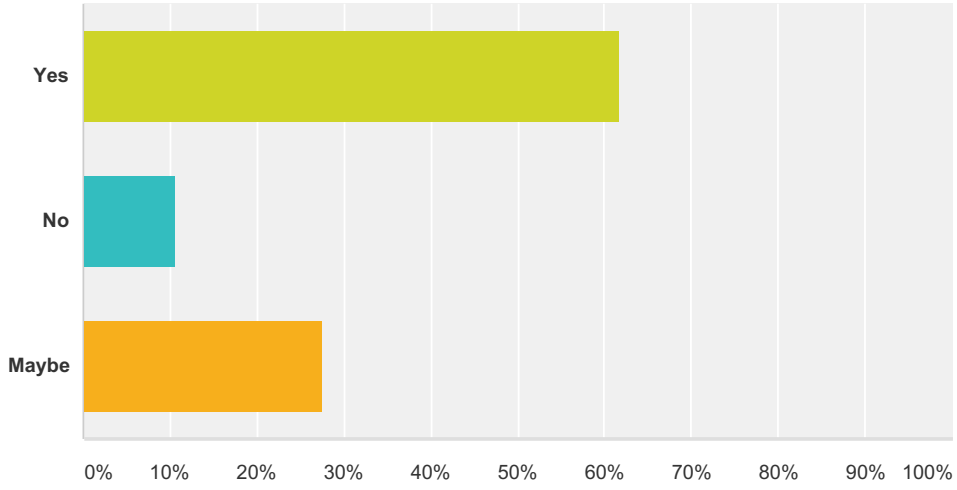
Q9 You answered "No" to the above question. Why would you not utilize the DIGGS data transfer standard?

Answered: 3 Skipped: 63

#	Responses	Date
1	Already have a database in place	4/20/2015 8:55 PM
2	We already have a data management system in place,	4/9/2015 12:41 PM
3	Additional requirements placed on geotechnical firms and contractors are not necessary. Typically the project report contains all the information for a project and if in the unlikely event that data would be used for the next design, the small amount of manual data reentry is relatively inexpensive compared to everyone entering all data into a common format.	4/7/2015 2:31 PM

Q10 For FHWA and DOT respondents, do you envision that DIGGS could help your organization meet goals for information management, data asset management, and/or future guidance and requirements of Moving Ahead for Progress in the 21st Century Act (MAP-21)?

Answered: 47 Skipped: 19

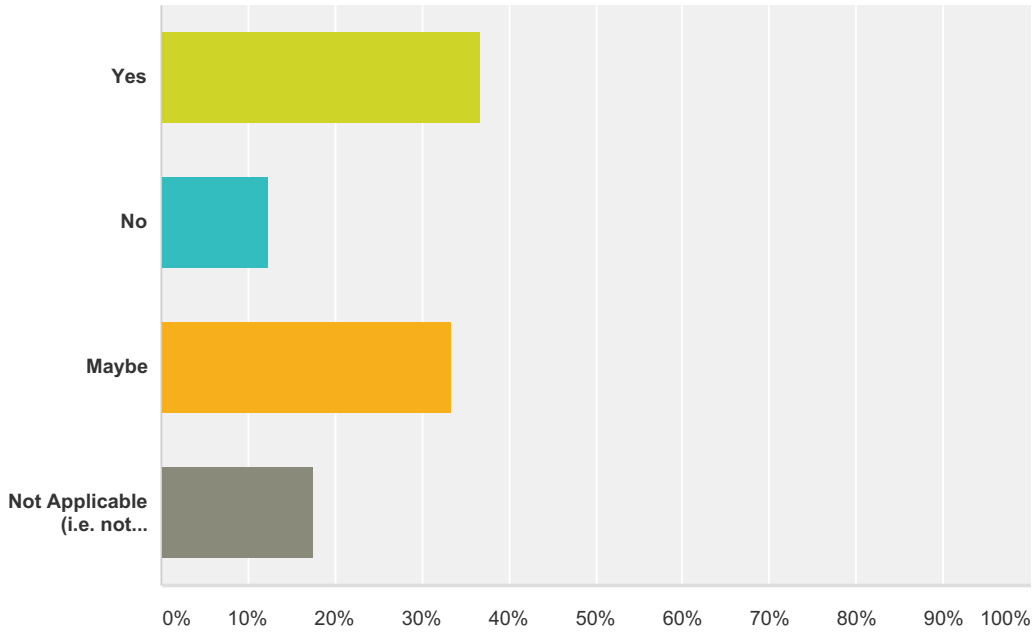


Answer Choices	Responses	
Yes	**61.70%**	29
No	**10.64%**	5
Maybe	**27.66%**	13
Total		**47**

#	Answer Clarification	Date
1	DIGGS strongest asset would be its ability to facilitate informaiton sharing and data warehousing for large scale projects and data mining initiatives. At the very least, the metadata could be exceptionally useful for statitstical purposes.	4/21/2015 9:21 AM
2	Not sure	4/13/2015 1:18 PM
3	We have a number of programs and initiatives that would benefit from DIGGS.	4/9/2015 3:07 PM
4	DIGGS is merely a transfer format....we have a standard transfer format currently so thus it does not provide any enhancement for our agency.	4/6/2015 9:01 AM
5	could help for all of these factors	4/3/2015 11:44 AM

Q11 If you work for a state DOT, another public agency, or if you are an owner (or work as an owners representative), would you be inclined to require use of the DIGGS standard for the delivery and exchange of data for projects under your control?

Answered: 57 Skipped: 9



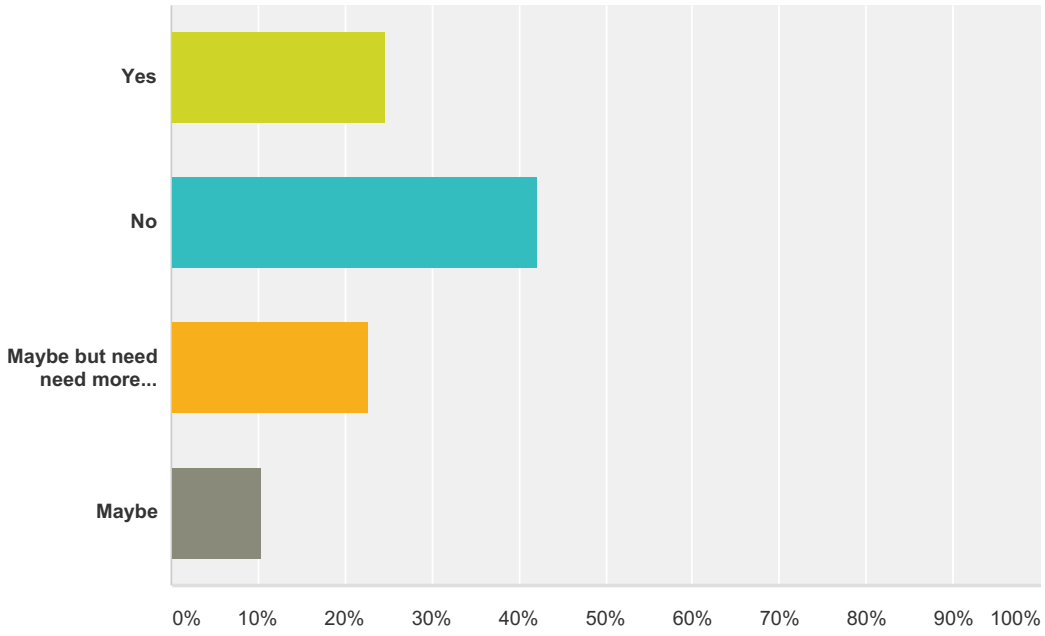
Answer Choices	Responses	
Yes	**36.84%**	21
No	**12.28%**	7
Maybe	**33.33%**	19
Not Applicable (i.e. not agency, owner, or owners representative)	**17.54%**	10
Total		**57**

#	Answer Clarification	Date
1	It may depend on the nature of the project and the type of information. We may start with lab and sensor data to import/export/exchange. We have a boring data requirement that works well for us- but although we may require input with our existing templates, we may make the data available as DIGGS output for others' to use.	4/21/2015 9:21 AM
2	Would look into initial flexibility in requiring DIGGS until a reasonable level of adoption is achieved in the industry and public sectors.	4/9/2015 3:07 PM
3	Not at this point	4/6/2015 10:23 AM
4	If it were universally adopted by all software developers.....not something I would try to concern myself over as an end user of the data. As mentioned before we have no problems receiving data....it would	4/6/2015 9:01 AM
5	I would be inclined to require it, but cost would need to be considered.	4/3/2015 11:44 AM

6	sometimes "requiring" something doesn't always end up the way you might want it to.	10/29/2014 2:11 PM
7	Ironically, our Design-Build contracts require supplemental geotech data to be delivered in "gINT or similar" standard format.	9/29/2014 11:28 AM

Q12 Would you be interested in being a pilot tester for DIGGS 2.0 alpha? Pilot testing of DIGGS 2.0 alpha is beginning now with this survey and will run for approximately four months. Pilot testers are asked to provide feedback on geotechnical data tests contained in DIGGS and on tools to create DIGGS files and plot data.

Answered: 57 Skipped: 9



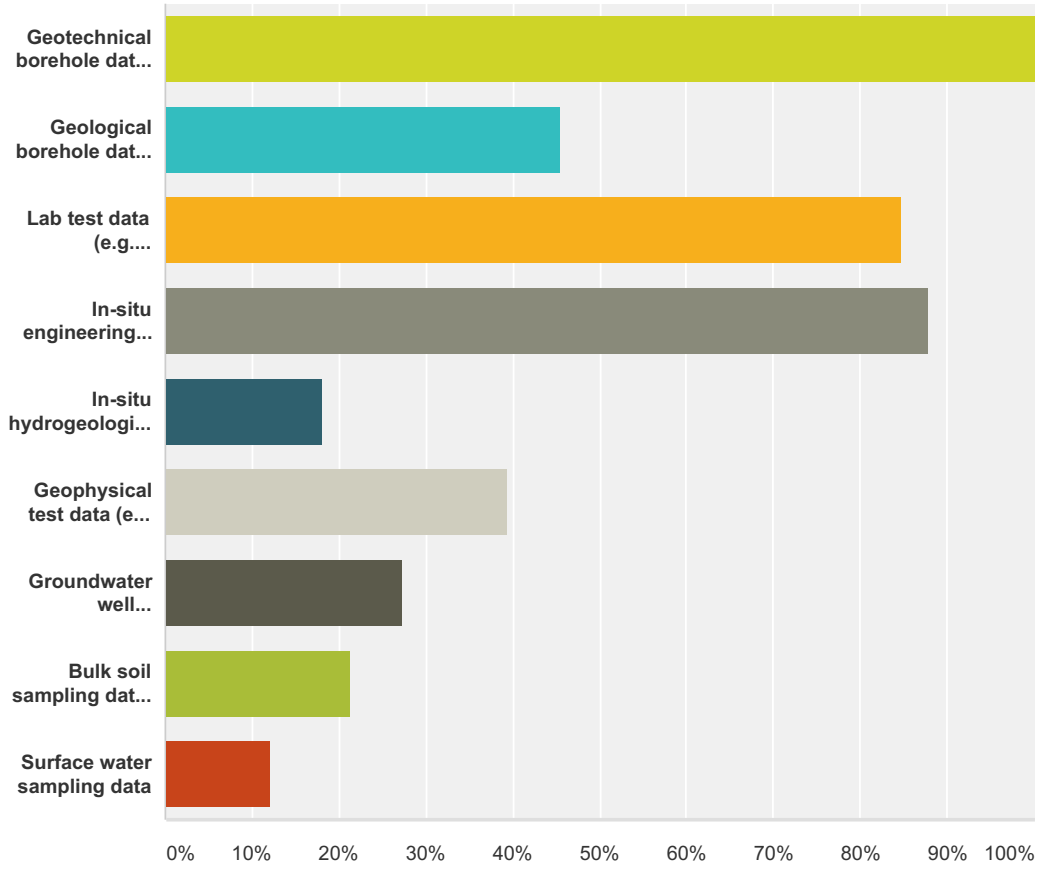
Answer Choices	Responses	
Yes	**24.56%**	14
No	**42.11%**	24
Maybe but need need more information, please contact me.	**22.81%**	13
Maybe	**10.53%**	6
Total		**57**

#	Answer Clarification	Date
1	if it doesn't take too much time and cause disruption to current processes.	4/20/2015 11:37 AM
2	Yes please include me in the test program. I would like to test it with our WMA.	4/14/2015 3:09 PM
3	Can't do during construction season	4/3/2015 2:51 PM
4	We have some other ongoing projects that will be coming up, I don't think I will have time to provide a fair assessment	4/3/2015 11:44 AM
5	david.thomas@state.co.us	4/3/2015 11:22 AM

6	too late	1/15/2015 12:48 PM
7	I need to check with our IOT folks before answering	9/23/2014 4:16 PM

Q13 You indicated that were interested or possibly interested in being a pilot tester. Please indicate the type of geotechnical or geoenvironmental data you would like to test using DIGGS.

Answered: 33 Skipped: 33



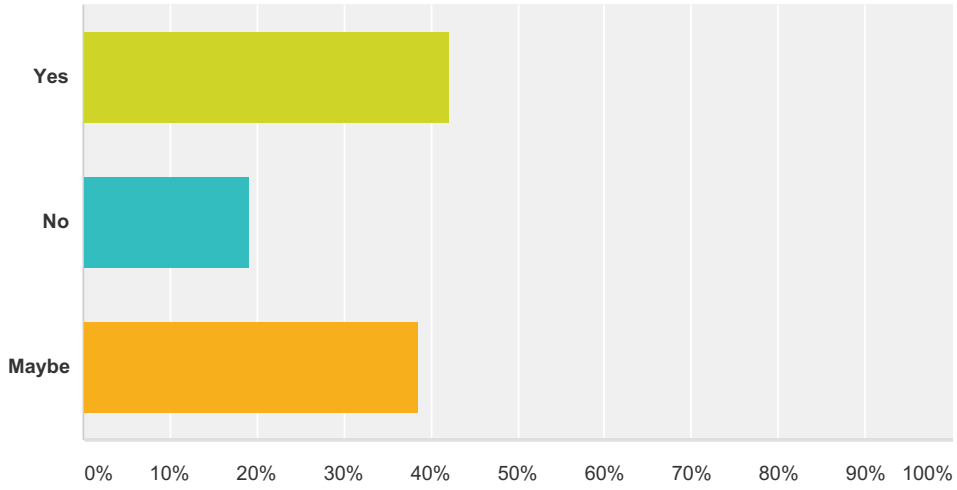
Answer Choices	Responses	
Geotechnical borehole data (e.g. soil classification, visual description, groundwater level, etc.)	**100.00%**	33
Geological borehole data (e.g. dating, bedding orientation, etc.)	**45.45%**	15
Lab test data (e.g. consolidation, gradation, strength, environmental etc.)	**84.85%**	28
In-situ engineering test data (e.g. SPT, CPT, vane shear, pressuremeter, etc.)	**87.88%**	29
In-situ hydrogeologic test data (e.g. pumping tests, dye tests, fluid penetration, etc.)	**18.18%**	6
Geophysical test data (e.g. shear wave velocity, etc.)	**39.39%**	13
Groundwater well Installation and monitoring data	**27.27%**	9
Bulk soil sampling data (e.g. environmental assessment, composite samples, leachate)	**21.21%**	7
Surface water sampling data	**12.12%**	4

Total Respondents: 33	

#	Other (please specify)	Date
1	We may need some assistance with input/output tools and viewers and such	4/21/2015 9:23 AM

Q14 Once DIGGS 2.0 beta is created, would you be interested in being a community reviewer?

Answered: 57 Skipped: 9

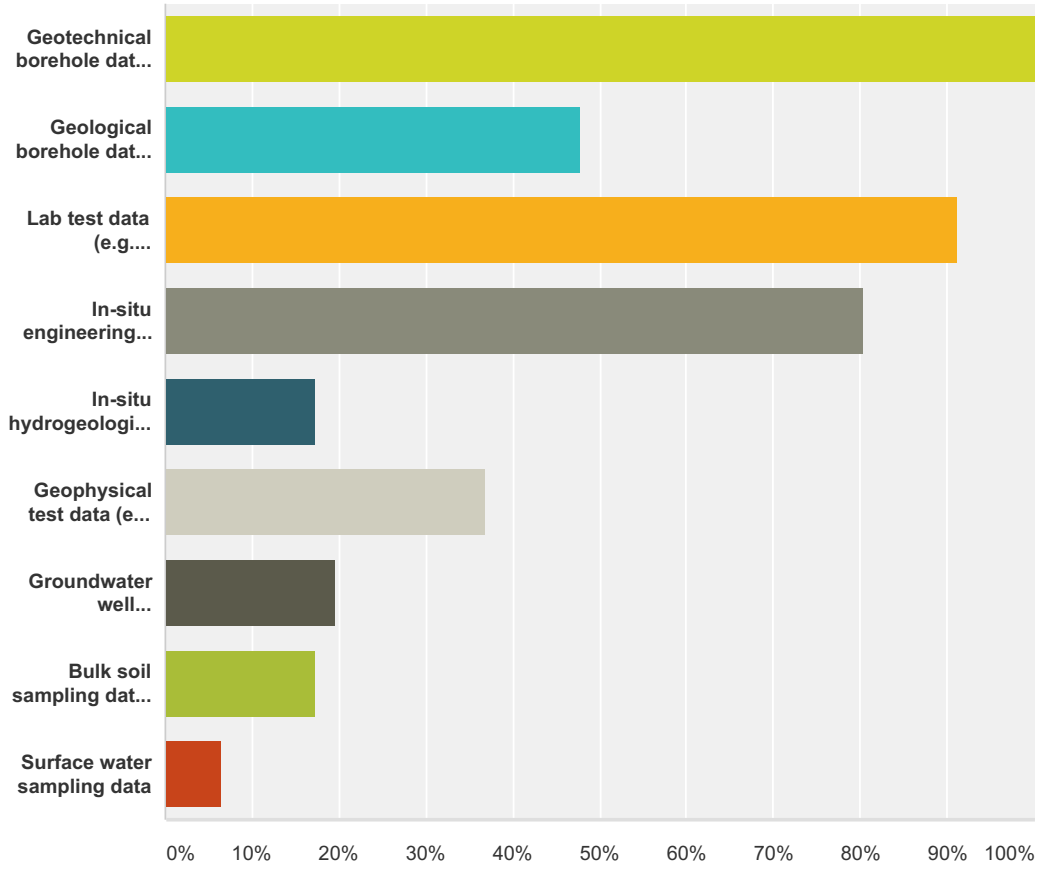


Answer Choices	Responses	
Yes	**42.11%**	24
No	**19.30%**	11
Maybe	**38.60%**	22
Total		**57**

#	Answer Clarification	Date
1	It would depend on the committmenet level and expectations. It woudl be an unqualified yes, except we are exceptionally busy with several time consuming program delivery efforts.	4/21/2015 9:23 AM
2	Depends on resources we have available.	4/13/2015 1:19 PM
3	I would need to know more specifics...	4/6/2015 1:26 PM
4	It depends on the requirements of DIGGS 2.0	4/6/2015 10:24 AM
5	Not sure what this is.	4/6/2015 10:01 AM
6	Depends on the demands and my schedule.	4/3/2015 11:22 AM
7	mbarendse@dot.ny.gov	9/29/2014 11:28 AM

Q15 You indicated that were interested or possibly interested in being a community reviewer of DIGGS. Please indicate the type of geotechnical or geoenvironmental data you would like to review using DIGGS.

Answered: 46 Skipped: 20



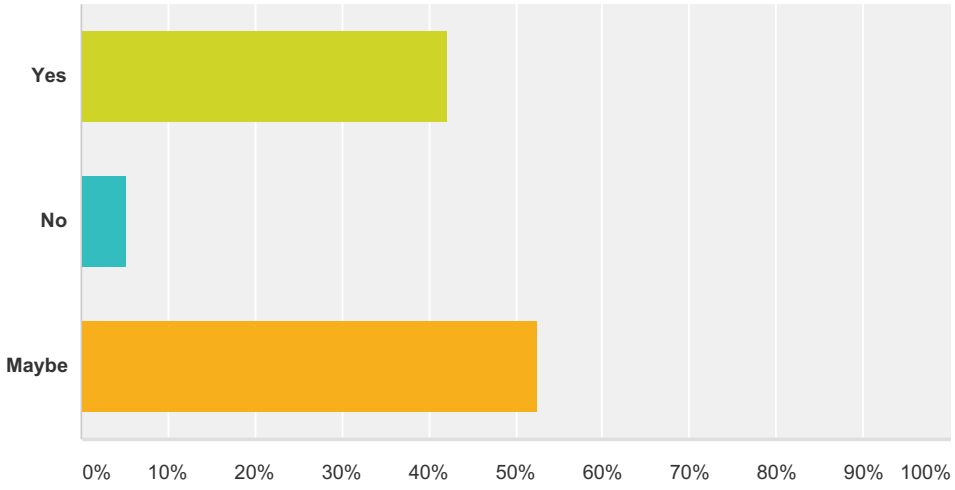
Answer Choices	Responses	
Geotechnical borehole data (e.g. soil classification, visual description, groundwater level, etc.)	**100.00%**	46
Geological borehole data (e.g. dating, bedding orientation, etc.)	**47.83%**	22
Lab test data (e.g. consolidation, gradation, strength, environmental etc.)	**91.30%**	42
In-situ engineering test data (e.g. SPT, CPT, vane shear, pressuremeter, etc.)	**80.43%**	37
In-situ hydrogeologic test data (e.g. pumping tests, dye tests, fluid penetration, etc.)	**17.39%**	8
Geophysical test data (e.g. shear wave velocity, etc.)	**36.96%**	17
Groundwater well Installation and monitoring data	**19.57%**	9
Bulk soil sampling data (e.g. environmental assessment, composite samples, leachate)	**17.39%**	8
Surface water sampling data	**6.52%**	3

Total Respondents: 46	

#	Other (please specify)	Date
1	Geotechnical Instrumentation Data	4/20/2015 5:07 PM

Q16 When DIGGS 2.0 is released to the public for use, would your organization consider using the data standard and adopting it across your organization?

Answered: 57 Skipped: 9

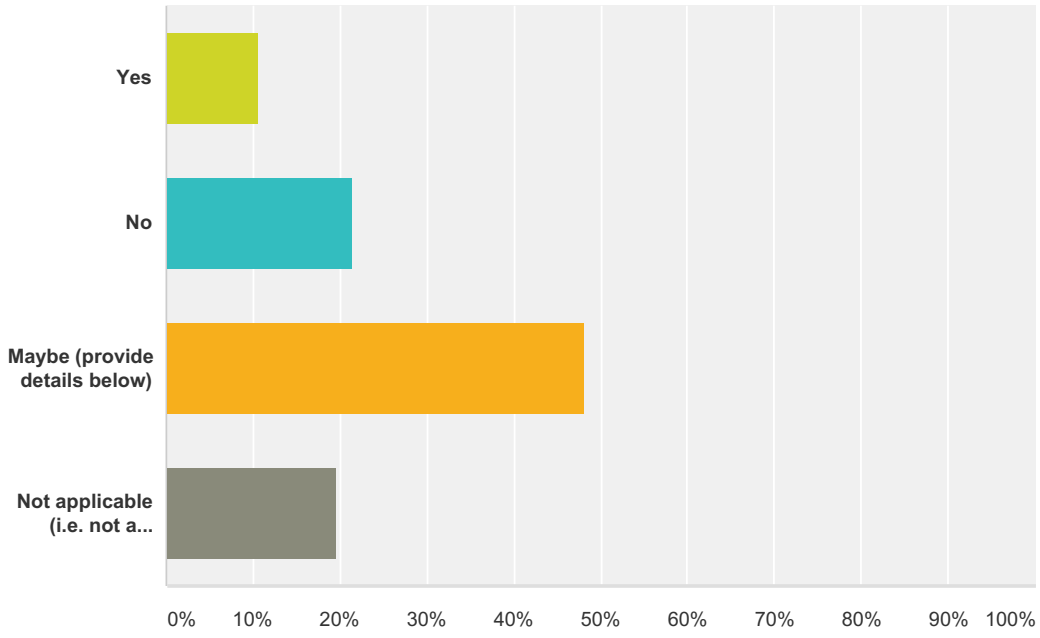


Answer Choices	Responses	
Yes	**42.11%**	24
No	**5.26%**	3
Maybe	**52.63%**	30
Total		**57**

#	Response Clarification	Date
1	We would need to evaluate how to integrate it with our District soils/material practices, counsultants, and other internal/external users. As	4/21/2015 9:25 AM
2	I would help you work with AASHTO to make it a standard	4/20/2015 5:07 PM
3	Have to be careful here as this would indicate setting a policy for transportation agencies. The goal is to reach a point for DIGGS adoption but will have to go through careful planning for our agency and meet a number of requirements before adoption.	4/9/2015 3:11 PM
4	I do not have the authority to implement this. ◦Tamara P. Haas, P.E. ◦Strategic Planning/Asset Management Director Email: TamaraP.Haas@state.nm.us would be able to provide more direction.	4/9/2015 10:31 AM
5	As stated, we will need to see how it interfaces with the project we now have to archive data in GeoGIS.	4/7/2015 2:45 PM
6	If the software package we currently uses adopts the standard for import and export of data, we would. But it is not something we would be looking to support or develop software tools to use.	4/6/2015 9:04 AM
7	We woudl have to test it to see how well it interfaces with our current practice.	4/6/2015 7:51 AM
8	Need more information.	4/3/2015 11:23 AM
9	Change like that takes significant time and effort in organizations like ours.	9/29/2014 11:30 AM

Q17 If you are a federal or state agency, would you consider funding DIGGS out of your annual or project budgets if you knew it would ultimately mean more efficient and less costly projects?

Answered: 56 Skipped: 10



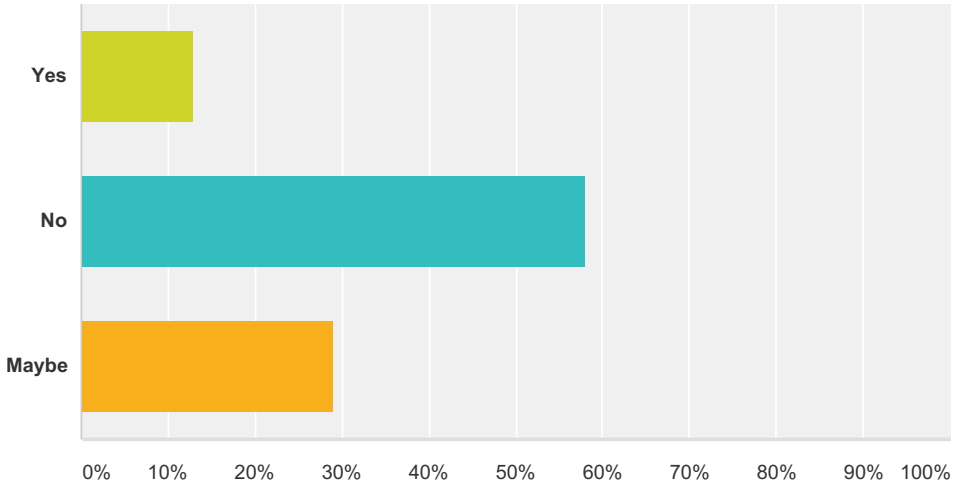
Answer Choices	Responses	
Yes	**10.71%**	6
No	**21.43%**	12
Maybe (provide details below)	**48.21%**	27
Not applicable (i.e. not a public organization)	**19.64%**	11
Total		**56**

#	Answer Clarification	Date
1	I'm not exactly sure how this could be funded either annually or by other means. We contribute somehow to AASHTO/ASTM/TRB, but I don't know how those funding mecanisms work. In principle supporting the data interchange standard would have value. The business case would need to be that it had "internal" value to the Department; unfortunately at this time the strongest selling point is the "external" improvement in data exchange to others.	4/21/2015 9:34 AM
2	Working with other states, AASHTO and FHWA, we could see if there was some type of funding source that could be dedicated.	4/20/2015 5:09 PM
3	Depends on cost.	4/13/2015 1:20 PM
4	I would need to know more about the cost.	4/10/2015 8:18 AM
5	This would require some planning and consideration of several factors before making such a decision.	4/9/2015 3:12 PM

6	Funding would likely come from programs within the agency that would see a value in the use of DIGGS, depending on budget	4/9/2015 1:02 PM
7	management would be making that decision	4/9/2015 10:55 AM
8	I do not have the authority to make this decision	4/9/2015 10:32 AM
9	Although, I am not in a position of authority to make future funding commitments on behalf of the Department about ongoing DIGGS maintenance, through our research program we have provided funding and resources over the past 10 years towards DIGGS development. I anticipate that level of interest and support will continue as this is an important development effort.	4/8/2015 12:47 PM
10	This would likely have to come from our research dollars which I am not authorized to obligate.	4/7/2015 2:46 PM
11	Can't say for sure as I do not control the money....	4/6/2015 1:27 PM
12	Need more details	4/6/2015 10:25 AM
13	Our state participated in the pooled fund study for its development. I don't see DIGGS as something that makes our projects more efficient or less costly. We have a standard that works for us presently. If DIGGS is widely adopted and incorporated into software, we would migrate toward its use.	4/6/2015 9:07 AM
14	I don't handle funding	4/6/2015 9:02 AM
15	depends on cost and the benefit associated with that cost.	4/6/2015 7:52 AM
16	We may have to include that in out budget, but don't know if it will be approved or not.	4/6/2015 7:09 AM
17	If a funding source is available	4/3/2015 2:52 PM
18	would need to know more	4/3/2015 1:14 PM
19	If research money/funding available	4/3/2015 11:48 AM
20	Everyone in the organization would need to see and understand the value.	4/3/2015 11:48 AM
21	I don't have a budget. I'd have to get funding approved through other sources and that will take time and justification.	4/3/2015 11:24 AM
22	Willing to donate time.	1/15/2015 12:50 PM
23	It is highly unlikely this would gain any traction. If it came back up as a pooled-fund study, we would be supportive.	9/29/2014 11:32 AM
24	We have to go through our research division for such funding	9/23/2014 4:19 PM

Q18 Is there currently a mechanism in place for your organization to provide ongoing funding of DIGGS from annual or project budgets?

Answered: 31 Skipped: 35

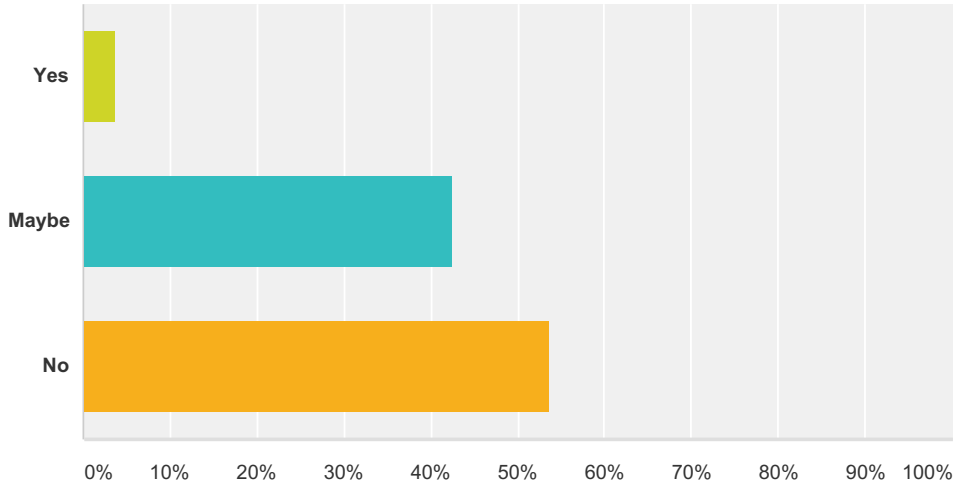


Answer Choices	Responses	
Yes	**12.90%**	4
No	**58.06%**	18
Maybe	**29.03%**	9
Total		**31**

#	Answer Clarification	Date
1	Not of which I am aware (not to say there isn't one)- although "operating" budgets are very constrained.	4/21/2015 9:40 AM
2	Funding to date has been through the research program through the Transportation Pooled Fund (TPF) program. Consistent annual funding through operational project funds is subject to many uncertainties -- up/down budget cycle years, competing priorities, etc. Multi-year funding agreements through the TPF or the National Cooperative Highway Research Program (NCHRP) are likely to be a more consistent source of DIGGS support funding for DOTs.	4/8/2015 12:53 PM
3	I am not familiar with the financial operations of the DOT I work for.	4/6/2015 9:22 AM
4	through research funds possibly	4/3/2015 11:51 AM
5	assuming that research funding can be used	4/3/2015 11:47 AM
6	See previous answer.	4/3/2015 11:26 AM

Q19 As an individual, would you consider paying a modest annual user fee to access and use the DIGGS schema and tools developed as part of this initiative?

Answered: 54 Skipped: 12

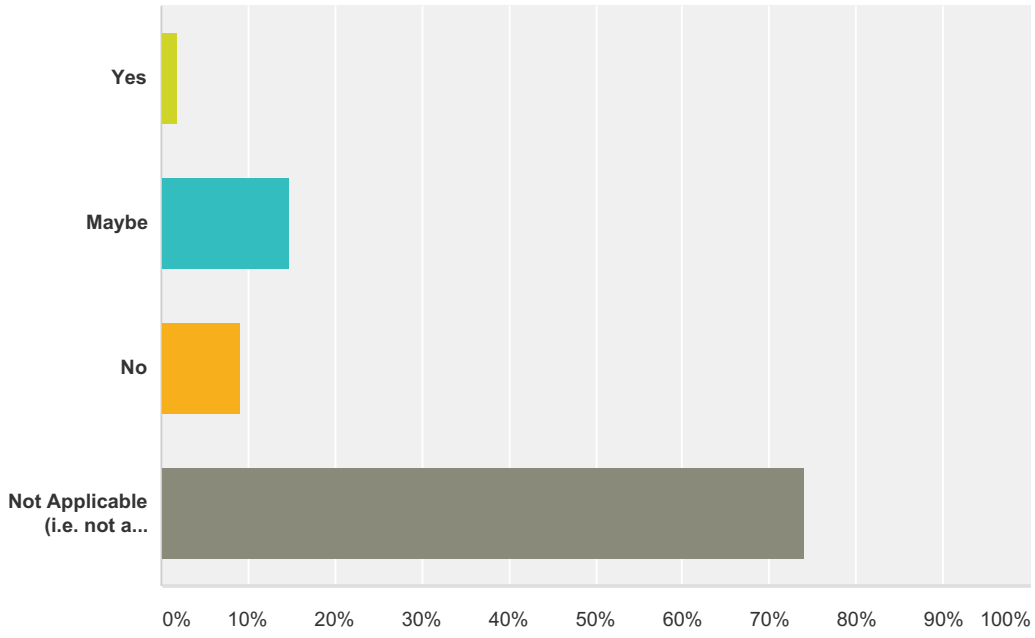


Answer Choices	Responses	
Yes	**3.70%**	2
Maybe	**42.59%**	23
No	**53.70%**	29
Total		**54**

#	Answer Clarification	Date
1	Perhaps as a check-box on the ASCE membership renewal?	4/21/2015 9:40 AM
2	This would require a decision of decision-makers above me; however, we could find out if some type of commitment could be made between AASHTO and FHWA and additional state contributions.	4/20/2015 5:13 PM
3	depends on the final value of the system developed	4/20/2015 11:42 AM
4	I don't think individuals need to pay.	4/14/2015 3:17 PM
5	Depends on costs.	4/13/2015 1:22 PM
6	This would need to be a Caltrans funded and supported activity to be effective in the department.	4/8/2015 12:53 PM
7	We are not the ones who benefit from using DIGGS. We are a software vendor and the amount of money we have and are investing in this standard should not then require the software vendors to pay an annual usage fee. We don't use DIGGS. We enable our users to use DIGGS in our software. The organizations who benefit from using DIGGS should pay for it (e.g. owners (DOTs, USACE	4/6/2015 10:08 AM
8	would need to quantify what "modest" means	4/3/2015 11:47 AM
9	Depends on it's usefulness and application.	4/3/2015 11:26 AM
10	Depends on the amount of the fee	1/15/2015 1:01 PM
11	One time licensing is actually better. Getting justifications re-approved and paying the bills on time is a challenge.	9/29/2014 11:36 AM

Q20 If you represent a private organization, would your organization consider paying an annual organizational fee to be able access and use the DIGGS schema and tools as developed through this initiative?

Answered: 54 Skipped: 12

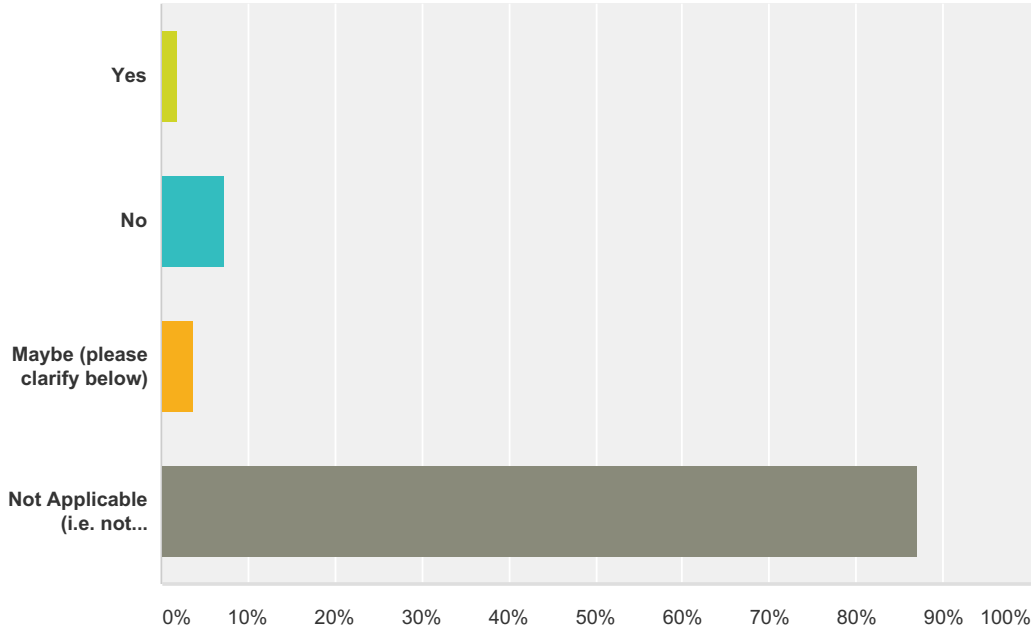


Answer Choices	Responses	
Yes	**1.85%**	1
Maybe	**14.81%**	8
No	**9.26%**	5
Not Applicable (i.e. not a private organization)	**74.07%**	40
Total		**54**

#	Answer Clarification	Date
1	If it benefits our software	4/16/2015 1:30 PM

Q21 If you are a software or hardware vendor, would you consider paying a licensing fee to be able to maintain up-to-date schema that could be used with your equipment or software.

Answered: 54 Skipped: 12

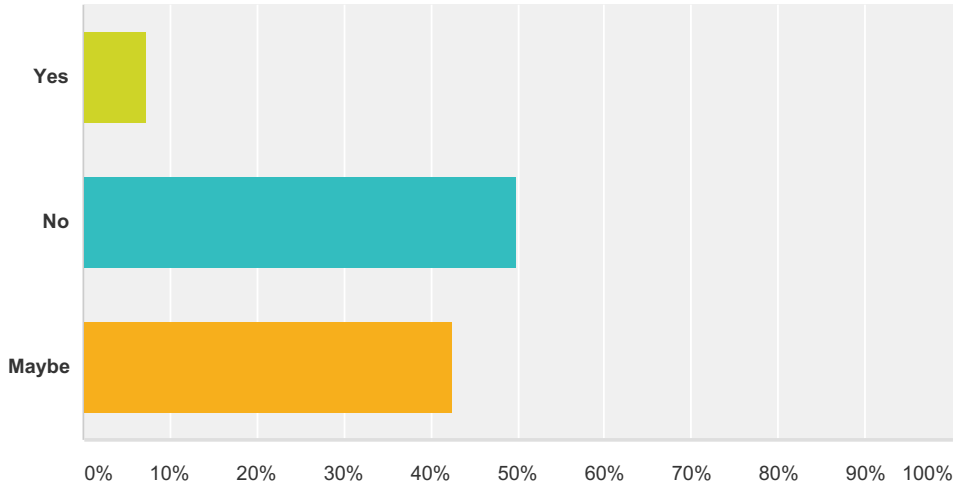


Answer Choices	Responses	
Yes	**1.85%**	1
No	**7.41%**	4
Maybe (please clarify below)	**3.70%**	2
Not Applicable (i.e. not hardware or software vendor)	**87.04%**	47
Total		**54**

#	Other (please specify)	Date
1	If it benefits our clients	4/16/2015 1:30 PM
2	Depend upon the profit that I will expect to get.	4/14/2015 3:17 PM
3	might support the format but don't see why we should pay as there is no direct benefit to us.	4/9/2015 1:09 PM

Q22 Would your organization be willing to be a "Sustaining Member" of DIGGS on an annual basis?

Answered: 54 Skipped: 12

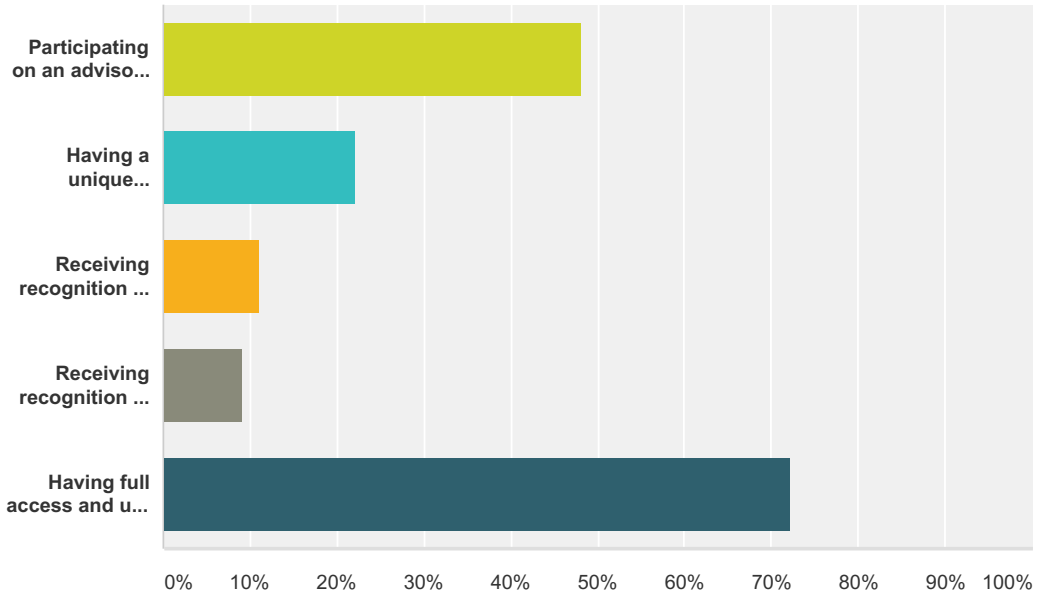


Answer Choices	Responses	
Yes	**7.41%**	4
No	**50.00%**	27
Maybe	**42.59%**	23
Total		**54**

#	Answer Clarification	Date
1	Unsure of how this would be agreed to/administered by the DOT. We do pay annual support licenses for IT services. Not sure if some sort of "service contract" model would be appropriate- perhaps something like a maintenance fee that would give us the latest updates or something else. As a practical matter- this may be the easiest to pay for- although the model isn't a good one as the interchange standard is presumably free. I see you may have thought about this in #22 below-	4/21/2015 9:40 AM
2	Probably not at this time but maybe in the future.	4/13/2015 1:22 PM
3	funding questions are ouside the area of my responsibility	4/13/2015 11:38 AM
4	If we could fund through the TPF of NCHRP mechanisms, this is possible.	4/8/2015 12:53 PM
5	Would need approval of upper management	4/7/2015 11:55 AM
6	It depends benefits and costs.	4/6/2015 10:26 AM
7	We're a State agency. I don't know the rules and regulations that might govern this.	4/3/2015 11:26 AM
8	We are too small.	1/15/2015 1:01 PM

Q23 If you were a "Sustaining Member" of DIGGS, what would add value to your membership?

Answered: 54 Skipped: 12



Answer Choices	Responses	
Participating on an advisory group for enhancements and upgrade ideas	**48.15%**	26
Having a unique identifier for your organization in the schema	**22.22%**	12
Receiving recognition on the DIGGS website	**11.11%**	6
Receiving recognition at DIGGS events and activities	**9.26%**	5
Having full access and use of the DIGGS schema and tools	**72.22%**	39
Total Respondents: 54		

#	Other Value	Date
1	not sure of the value	4/20/2015 11:42 AM
2	DIGGS Schema and tools will be use by some of our offices so they may need full access to justify cost.	4/9/2015 3:20 PM
3	I do not intend to become a sustaining member....none of the above are applicable.	4/6/2015 9:10 AM

Q24 Beyond what has been considered in the previous questions for funding, what other funding mechanisms do you suggest that could make DIGGS sustainable?

Answered: 8 Skipped: 58

#	Responses	Date
1	Not sure.	4/21/2015 9:40 AM
2	fhwa and AASHTO. need to be a widely used standard nationally.	4/20/2015 11:42 AM
3	Appears to me that the subscription model appears to be best suited, maybe with a reduced cost the first year to allow companies to test the use of the schema before making a larger committment. Also fee should be based, not on organization size but by size of geotechnical staff, or revenue from geotechnical projects. This would be suitable for larger firms that may not have a geotechnical staff that is proportionate to the overall size of the organization.	4/19/2015 9:16 AM
4	Need to find way for those who benefit from its use to pay for it. Why not charge a fee per use that users could pass on to their clients as a cost of doing business? Afterall they benefit from more transparency in data and greater efficiencies in it preparation	4/9/2015 1:09 PM
5	Part of ASCE dues	4/9/2015 11:26 AM
6	- licensing fee to include in software packages - mega Project tagging fee - similar to % art $$ in public projects, dedicate some amount of public projects to data management including DIGGS format support. - Data Portal access fee/subscription (a portal to access public information in DIGGS format that could be combined with my companies private information)	4/5/2015 8:47 PM
7	Expand to mining industry (e.g.industrial minerals); sell subscriptions; use Google Ad words scheme; use pro bono help (e.g. interns from university geo/environmental engineering departments; local geotechnical and geoenvironmental engineering companies, etc.); get ASFE involved.	1/15/2015 1:01 PM
8	If we were encouraged/pushed from the federal level, there's a a better chance that some funding could be freed up.	9/29/2014 11:36 AM

Q25 Please provide contact information for the primary decision maker regarding potential adoption of DIGGS within your organization.

Answered: 30 Skipped: 36

Answer Choices	Responses	
Name:	**100.00%**	30
Company:	**96.67%**	29
Address 1:	**96.67%**	29
Address 2:	**10.00%**	3
City/Town:	**93.33%**	28
State/Province:	**93.33%**	28
ZIP/Postal Code:	**93.33%**	28
Country:	**83.33%**	25
Email Address:	**86.67%**	26
Phone Number:	**83.33%**	25

#	Name:	Date
1	(unknown) depends on extent	4/21/2015 9:42 AM
2	Jeff Jirava	4/20/2015 12:10 PM
3	Bill Kramer	4/20/2015 11:47 AM
4	James Sheehan	4/19/2015 9:21 AM
5	Brandon Hee	4/17/2015 10:30 PM
6	Mohammed Mulla	4/17/2015 5:43 PM
7	Strah Antoljak	4/16/2015 1:30 PM
8	Bulent Hatipoglu	4/14/2015 3:19 PM
9	Jeff Sizemore	4/13/2015 1:25 PM
10	Marcus Galvan	4/13/2015 11:39 AM
11	Christopher Benda	4/10/2015 8:22 AM
12	W. Allen Marr	4/9/2015 1:11 PM
13	Mark Lindemann	4/9/2015 12:43 PM
14	Bob Arndorfer	4/9/2015 11:17 AM
15	Tamara Haas	4/9/2015 11:06 AM
16	Loren Turner	4/8/2015 12:54 PM
17	Kaye Chancellor Davis	4/7/2015 2:50 PM
18	Athar Khan	4/7/2015 11:58 AM

19	Bob Burnett	4/6/2015 1:57 PM
20	Mark Wolcott	4/6/2015 10:28 AM
21	Scott Deaton	4/6/2015 10:09 AM
22	Leo Fontaine	4/6/2015 9:11 AM
23	allen cadden	4/5/2015 8:48 PM
24	jim Coffin	4/3/2015 3:45 PM
25	Richard Endres	4/3/2015 2:57 PM
26	David Horhota	4/3/2015 1:56 PM
27	David Ahlvers	4/3/2015 12:08 PM
28	Jeff Jackson	4/3/2015 11:49 AM
29	Ty Ortiz	11/19/2014 11:36 AM
30	Rick Heckel, PE, D.GE	9/26/2014 11:57 PM
#	**Company:**	**Date**
1	NDDOT	4/20/2015 12:10 PM
2	IL-DOT	4/20/2015 11:47 AM
3	HDR Engineering	4/19/2015 9:21 AM
4	Hawaii DOT	4/17/2015 10:30 PM
5	NCDOT	4/17/2015 5:43 PM
6	Bentley Systems	4/16/2015 1:30 PM
7	RIZZO Associates	4/14/2015 3:19 PM
8	SCDOT	4/13/2015 1:25 PM
9	TxDOT	4/13/2015 11:39 AM
10	Vermont Agency of Transportation	4/10/2015 8:22 AM
11	Geocomp	4/9/2015 1:11 PM
12	Nebraska Dept. of Roads	4/9/2015 12:43 PM
13	Wisconsin DOT	4/9/2015 11:17 AM
14	NMDOT	4/9/2015 11:06 AM
15	Caltrans	4/8/2015 12:54 PM
16	ALDOT	4/7/2015 2:50 PM
17	Indiana Department of Transportation	4/7/2015 11:58 AM
18	NYSDOT	4/6/2015 1:57 PM
19	Maryland State Highway Administration	4/6/2015 10:28 AM
20	Dataforensics	4/6/2015 10:09 AM
21	ConnDOT	4/6/2015 9:11 AM
22	Schnabel Engineering	4/5/2015 8:48 PM
23	WYDOT	4/3/2015 3:45 PM
24	Michigan Dept. of Transporation	4/3/2015 2:57 PM
25	Florida DOT	4/3/2015 1:56 PM

26	Missouri Dept. of Trans.	4/3/2015 12:08 PM
27	Montana DOT	4/3/2015 11:49 AM
28	CDOT	11/19/2014 11:36 AM
29	Ardent Geotechnical Consultants	9/26/2014 11:57 PM
#	**Address 1:**	**Date**
1	300 Airport Road	4/20/2015 12:10 PM
2	2300 south dirksen parkway	4/20/2015 11:47 AM
3	11 Stanwix St. Suite 800	4/19/2015 9:21 AM
4	2530 Likelike Highway	4/17/2015 10:30 PM
5	1020 Birch Ridge Dr.	4/17/2015 5:43 PM
6	1160 North Dutton Ave	4/16/2015 1:30 PM
7	500 Penn Center Blvd	4/14/2015 3:19 PM
8	955 Park St	4/13/2015 1:25 PM
9	125 E. 11th Street	4/13/2015 11:39 AM
10	2178 Aiprort Road	4/10/2015 8:22 AM
11	125 Nagog Park	4/9/2015 1:11 PM
12	1400 Highway 2	4/9/2015 12:43 PM
13	3502 Kinsman Blvd	4/9/2015 11:17 AM
14	P.O. Box 1149	4/9/2015 11:06 AM
15	(see contact info)	4/8/2015 12:54 PM
16	3700 Fairground Road	4/7/2015 2:50 PM
17	120 S. Shortridge Rd	4/7/2015 11:58 AM
18	50 Wolf Road, MP42	4/6/2015 1:57 PM
19	7450 Traffic Dr	4/6/2015 10:28 AM
20	6825 Jimmy Carter Blvd #1210	4/6/2015 10:09 AM
21	2800 Berlin Turnpike	4/6/2015 9:11 AM
22	1380 Wilmington Pike, Suite 100	4/5/2015 8:48 PM
23	5300 Bishop Blvd.	4/3/2015 3:45 PM
24	P.O. Box 30049	4/3/2015 2:57 PM
25	5007 NE 39th Avenue	4/3/2015 1:56 PM
26	PO Box 270	4/3/2015 12:08 PM
27	2701 Prospect ave	4/3/2015 11:49 AM
28	4670 Holly St	11/19/2014 11:36 AM
29	151 Heritage Park Drive	9/26/2014 11:57 PM
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3	Suite 403	9/26/2014 11:57 PM

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9	Austin	4/13/2015 11:39 AM
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24	Gainesville	4/3/2015 1:56 PM
25	Jefferson City	4/3/2015 12:08 PM
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27	Denver	11/19/2014 11:36 AM
28	Murfreesboro	9/26/2014 11:57 PM

#	State/Province:	Date
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4	Hawaii	4/17/2015 10:30 PM
5	NC	4/17/2015 5:43 PM
6	CA	4/16/2015 1:30 PM
7	PA	4/14/2015 3:19 PM
8	SC	4/13/2015 1:25 PM

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10	VT	4/10/2015 8:22 AM
11	MA	4/9/2015 1:11 PM
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13	WI	4/9/2015 11:17 AM
14	NM	4/9/2015 11:06 AM
15	AL	4/7/2015 2:50 PM
16	IN	4/7/2015 11:58 AM
17	NY	4/6/2015 1:57 PM
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23	Mi	4/3/2015 2:57 PM
24	FL	4/3/2015 1:56 PM
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28	TN	9/26/2014 11:57 PM
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22	US	4/3/2015 1:56 PM
23	USA	4/3/2015 12:08 PM
24	USA	4/3/2015 11:49 AM
25	USA	9/26/2014 11:57 PM
#	**Email Address:**	**Date**

1	jjirava@nd.gov	4/20/2015 12:10 PM
2	william.kramer@illinois.gov	4/20/2015 11:47 AM
3	Jim.Sheahan@hdrinc.com	4/19/2015 9:21 AM
4	brandon.h.hee@hawaii.gov	4/17/2015 10:30 PM
5	mmulla@ncdot.gov	4/17/2015 5:43 PM
6	strah.antoljak@bentley.com	4/16/2015 1:30 PM
7	bulent.hatipoglu@rizzoassoc.com	4/14/2015 3:19 PM
8	marcus.galvan@txdot.gov	4/13/2015 11:39 AM
9	chris.benda@state.vt.us	4/10/2015 8:22 AM
10	wam@geocomp.com	4/9/2015 1:11 PM
11	mark.lindemann@nebraska.gov	4/9/2015 12:43 PM
12	robert.arndorfer@dot.wi.gov	4/9/2015 11:17 AM
13	TamaraP.Haas@state.nm.us	4/9/2015 11:06 AM
14	chancellork@dot.state.al.us	4/7/2015 2:50 PM
15	atkhan@indot.in.gov	4/7/2015 11:58 AM
16	Bob.Burnett@dot.ny.gov	4/6/2015 1:57 PM
17	MWolcott@SHA.STATE.MD.US	4/6/2015 10:28 AM
18	sdeaton@dataforensics.net	4/6/2015 10:09 AM
19	leo.fontaine@ct.gov	4/6/2015 9:11 AM
20	acadden@schnabel-eng.com	4/5/2015 8:48 PM
21	endresr@michigan.gov	4/3/2015 2:57 PM
22	david.horhota@dot.state.fl.us	4/3/2015 1:56 PM
23	David.Ahlvers@modot.mo.gov	4/3/2015 12:08 PM
24	jejackson@mt.gov	4/3/2015 11:49 AM
25	Ty.ortiz@state.co.us	11/19/2014 11:36 AM
26	Rheckel@ardent-geo.com	9/26/2014 11:57 PM
#	**Phone Number:**	**Date**
1	701-328-6908	4/20/2015 12:10 PM
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3	412.497.6039	4/19/2015 9:21 AM
4	808-832-3405x122	4/17/2015 10:30 PM
5	(919) 707-6866	4/17/2015 5:43 PM
6	415.248.6135	4/16/2015 1:30 PM
7	4128562183	4/14/2015 3:19 PM
8	512-416-2224	4/13/2015 11:39 AM
9	802-828-6910	4/10/2015 8:22 AM
10	978 635 0012	4/9/2015 1:11 PM
11	402-479-4752	4/9/2015 12:43 PM

12	608-246-7940	4/9/2015 11:17 AM
13	3342062277	4/7/2015 2:50 PM
14	(317) 610-7251 ext 219	4/7/2015 11:58 AM
15	518-457-4711	4/6/2015 1:57 PM
16	678-406-0106	4/6/2015 10:09 AM
17	8605943180	4/6/2015 9:11 AM
18	6106966066	4/5/2015 8:48 PM
19	3077774205	4/3/2015 3:45 PM
20	517-322-1207	4/3/2015 2:57 PM
21	352-955-2924	4/3/2015 1:56 PM
22	573 751-7455	4/3/2015 12:08 PM
23	406-444-3371	4/3/2015 11:49 AM
24	303 398 6601	11/19/2014 11:36 AM
25	615-962-5314	9/26/2014 11:57 PM

Q26 Please provide your contact information.

Answered: 34 Skipped: 32

Answer Choices	Responses	
Name:	**100.00%**	34
Company:	**88.24%**	30
Address 1:	**85.29%**	29
Address 2:	**8.82%**	3
City/Town:	**85.29%**	29
State/Province:	**85.29%**	29
ZIP/Postal Code:	**88.24%**	30
Country:	**76.47%**	26
Email Address:	**85.29%**	29
Phone Number:	**73.53%**	25

#	Name:	Date
1	Derrick Dasenbrock	4/21/2015 9:42 AM
2	Jeff Jirava	4/20/2015 12:10 PM
3	me	4/20/2015 11:47 AM
4	Scott T Anderson	4/19/2015 9:21 AM
5	Herbert Chu	4/17/2015 10:30 PM
6	Tri Buu	4/17/2015 4:28 PM
7	Bulent Hatipoglu	4/14/2015 3:19 PM
8	Brent Conner	4/14/2015 12:04 PM
9	Jeff Sizemore	4/13/2015 1:25 PM
10	same as above	4/13/2015 11:39 AM
11	Khalid Mohaed	4/9/2015 3:24 PM
12	W. Allen Marr	4/9/2015 1:11 PM
13	Dan Ponti	4/9/2015 1:05 PM
14	Same	4/9/2015 12:43 PM
15	Daniel Simpon	4/9/2015 11:27 AM
16	Bob Arndorfer	4/9/2015 11:17 AM
17	Michelle R. Mann	4/9/2015 11:06 AM
18	Matthew Waterman	4/9/2015 11:00 AM
19	Loren Turner	4/8/2015 12:54 PM

20	Kaye Chancellor Davis	4/7/2015 2:50 PM
21	Andrew Graettinger	4/7/2015 2:35 PM
22	Jon Paauwe	4/7/2015 11:58 AM
23	XIN CHEN	4/6/2015 10:28 AM
24	Scott Deaton	4/6/2015 10:09 AM
25	Leo Fontaine	4/6/2015 9:11 AM
26	Charles Dusseault	4/6/2015 7:30 AM
27	Kwame Adu-Gyamfi	4/6/2015 7:14 AM
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30	Jeff Jackson	4/3/2015 11:49 AM
31	David Thomas	4/3/2015 11:28 AM
32	Robert Gorman	1/15/2015 1:02 PM
33	Ilyess Ksouri	11/19/2014 11:36 AM
34	Matt Barendse	9/29/2014 11:39 AM
#	**Company:**	**Date**
1	Minnesota Dept. of Transportation	4/21/2015 9:42 AM
2	NDDOT	4/20/2015 12:10 PM
3	same	4/20/2015 11:47 AM
4	HDR Engineering	4/19/2015 9:21 AM
5	Hawaii DOT	4/17/2015 10:30 PM
6	Idaho Transportation Dept.	4/17/2015 4:28 PM
7	RIZZO Associates	4/14/2015 3:19 PM
8	Arizona Department of Transportation	4/14/2015 12:04 PM
9	SCDOT	4/13/2015 1:25 PM
10	FHWA	4/9/2015 3:24 PM
11	Geocomp	4/9/2015 1:11 PM
12	USGS	4/9/2015 1:05 PM
13	Geosyntec	4/9/2015 11:27 AM
14	Wisconin DOT	4/9/2015 11:17 AM
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16	Bechtel	4/9/2015 11:00 AM
17	Caltrans	4/8/2015 12:54 PM
18	ALDOT	4/7/2015 2:50 PM
19	The University of Alabama	4/7/2015 2:35 PM
20	Indiana Department of Transportation	4/7/2015 11:58 AM
21	Maryland State Highway Administration	4/6/2015 10:28 AM
22	Dataforensics	4/6/2015 10:09 AM

23	NH Dept. of Transportation	4/6/2015 7:30 AM
24	Virginia Department of Transportation	4/6/2015 7:14 AM
25	Schnabel Engineering	4/5/2015 8:48 PM
26	Missouri Dept. of Trans.	4/3/2015 12:08 PM
27	Montana DOT	4/3/2015 11:49 AM
28	Colorado DOT	4/3/2015 11:28 AM
29	CDOT	11/19/2014 11:36 AM
30	NYSDOT - Geotechnical Engr Bureau	9/29/2014 11:39 AM
#	**Address 1:**	**Date**
1	1400 Gervais Ave	4/21/2015 9:42 AM
2	300 Airport Road	4/20/2015 12:10 PM
3	1670 Broadway Suite 3400	4/19/2015 9:21 AM
4	2530 Likelike Highway	4/17/2015 10:30 PM
5	3311 W State st	4/17/2015 4:28 PM
6	500 Penn Center Blvd	4/14/2015 3:19 PM
7	1221 N. 21st Avenue	4/14/2015 12:04 PM
8	955 Park St.	4/13/2015 1:25 PM
9	1200 New Jersey Ave, SE	4/9/2015 3:24 PM
10	125 Nagog Park	4/9/2015 1:11 PM
11	345 Middlefield Road	4/9/2015 1:05 PM
12	2100 Main St	4/9/2015 11:27 AM
13	3502 Kinsman Blvd.	4/9/2015 11:17 AM
14	P.O. Box 1149	4/9/2015 11:06 AM
15	50 Beale Street	4/9/2015 11:00 AM
16	5900 Folsom Blvd	4/8/2015 12:54 PM
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19	120 S. Shortridge Rd	4/7/2015 11:58 AM
20	7450 Traffic Dr	4/6/2015 10:28 AM
21	6825 Jimmy Carter Blvd #1210	4/6/2015 10:09 AM
22	5 Hazen Dr	4/6/2015 7:30 AM
23	1401 East Main Street	4/6/2015 7:14 AM
24	1380 Wilmington Pike, Suite 100	4/5/2015 8:48 PM
25	PO Box 270	4/3/2015 12:08 PM
26	2701 Prospect Ave	4/3/2015 11:49 AM
27	4670 Holly St	4/3/2015 11:28 AM
28	4670 Holly St	11/19/2014 11:36 AM
29	50 Wolf Rd. (MP 4-2)	9/29/2014 11:39 AM

#	Address 2:	Date
1	PO Box 7129	4/17/2015 4:28 PM
2	Suite 150	4/9/2015 11:27 AM
3	Unit A	4/3/2015 11:28 AM
#	**City/Town:**	**Date**
1	Maplewood	4/21/2015 9:42 AM
2	Bismarck	4/20/2015 12:10 PM
3	Denver	4/19/2015 9:21 AM
4	Honolulu	4/17/2015 10:30 PM
5	Boise	4/17/2015 4:28 PM
6	Pittsburgh	4/14/2015 3:19 PM
7	Phoenix	4/14/2015 12:04 PM
8	Columbia	4/13/2015 1:25 PM
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14	Santa Fe	4/9/2015 11:06 AM
15	San Francisco	4/9/2015 11:00 AM
16	Sacramento	4/8/2015 12:54 PM
17	Montgomery	4/7/2015 2:50 PM
18	Tuscaloosa	4/7/2015 2:35 PM
19	Indianapolis	4/7/2015 11:58 AM
20	Hanover	4/6/2015 10:28 AM
21	Norcross	4/6/2015 10:09 AM
22	Concord	4/6/2015 7:30 AM
23	Richmond	4/6/2015 7:14 AM
24	West Chester	4/5/2015 8:48 PM
25	Jefferson City	4/3/2015 12:08 PM
26	Helena	4/3/2015 11:49 AM
27	Denver	4/3/2015 11:28 AM
28	Denver	11/19/2014 11:36 AM
29	Albany	9/29/2014 11:39 AM
#	**State/Province:**	**Date**
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2	ND	4/20/2015 12:10 PM
3	Colorado	4/19/2015 9:21 AM

4	HI	4/17/2015 10:30 PM
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6	PA	4/14/2015 3:19 PM
7	Arizona	4/14/2015 12:04 PM
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11	CA	4/9/2015 1:05 PM
12	California	4/9/2015 11:27 AM
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15	CA	4/9/2015 11:00 AM
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21	GA	4/6/2015 10:09 AM
22	NH	4/6/2015 7:30 AM
23	VA	4/6/2015 7:14 AM
24	PA	4/5/2015 8:48 PM
25	MO	4/3/2015 12:08 PM
26	Montana	4/3/2015 11:49 AM
27	CO	4/3/2015 11:28 AM
28	CO	11/19/2014 11:36 AM
29	NY	9/29/2014 11:39 AM

#	ZIP/Postal Code:	Date
1	55109	4/21/2015 9:42 AM
2	58504	4/20/2015 12:10 PM
3	80202	4/19/2015 9:21 AM
4	96819	4/17/2015 10:30 PM
5	83703	4/17/2015 4:28 PM
6	15235	4/14/2015 3:19 PM
7	85345	4/14/2015 12:04 PM
8	29201	4/13/2015 1:25 PM
9	20590	4/9/2015 3:24 PM
10	01720	4/9/2015 1:11 PM
11	94062	4/9/2015 1:05 PM

12	92648	4/9/2015 11:27 AM
13	53704	4/9/2015 11:17 AM
14	87504	4/9/2015 11:06 AM
15	94105	4/9/2015 11:00 AM
16	95819	4/8/2015 12:54 PM
17	36110	4/7/2015 2:50 PM
18	35487	4/7/2015 2:35 PM
19	46219	4/7/2015 11:58 AM
20	21076	4/6/2015 10:28 AM
21	30071	4/6/2015 10:09 AM
22	03302	4/6/2015 7:30 AM
23	23219	4/6/2015 7:14 AM
24	19382	4/5/2015 8:48 PM
25	65102	4/3/2015 12:08 PM
26	59620	4/3/2015 11:49 AM
27	80216	4/3/2015 11:28 AM
28	48170	1/15/2015 1:02 PM
29	80216	11/19/2014 11:36 AM
30	12232	9/29/2014 11:39 AM
#	**Country:**	**Date**
1	USA	4/21/2015 9:42 AM
2	US	4/20/2015 12:10 PM
3	USA	4/19/2015 9:21 AM
4	USA	4/17/2015 10:30 PM
5	USA	4/17/2015 4:28 PM
6	US	4/14/2015 3:19 PM
7	USA	4/14/2015 12:04 PM
8	USA	4/13/2015 1:25 PM
9	US	4/9/2015 3:24 PM
10	USA	4/9/2015 1:05 PM
11	United States	4/9/2015 11:27 AM
12	USA	4/9/2015 11:17 AM
13	USA	4/9/2015 11:00 AM
14	USA	4/8/2015 12:54 PM
15	USA	4/7/2015 2:50 PM
16	USA	4/7/2015 2:35 PM
17	United States	4/7/2015 11:58 AM
18	USA	4/6/2015 10:28 AM

19	USA	4/6/2015 10:09 AM
20	USA	4/6/2015 7:30 AM
21	USA	4/6/2015 7:14 AM
22	United States	4/5/2015 8:48 PM
23	USA	4/3/2015 12:08 PM
24	USA	4/3/2015 11:49 AM
25	USA	4/3/2015 11:28 AM
26	US	9/29/2014 11:39 AM
#	**Email Address:**	**Date**
1	derrick.dasenbrock@state.mn.us	4/21/2015 9:42 AM
2	jjirava@nd.gov	4/20/2015 12:10 PM
3	scott.t.anderson@hdrinc.com	4/19/2015 9:21 AM
4	herbert.chu@hawaii.gov	4/17/2015 10:30 PM
5	tri.buu@itd.idaho.gov	4/17/2015 4:28 PM
6	bulent.hatipoglu@rizzoassoc.com	4/14/2015 3:19 PM
7	bconner@azdot.gov	4/14/2015 12:04 PM
8	sizemorejc@scdot.org	4/13/2015 1:25 PM
9	khalid.mohamed@dot.gov	4/9/2015 3:24 PM
10	wam@geocomp.com	4/9/2015 1:11 PM
11	ponti@astound.net	4/9/2015 1:05 PM
12	dsimpson@geosyntec.com	4/9/2015 11:27 AM
13	robert.arndorfer@dot.wi.gov	4/9/2015 11:17 AM
14	michelle.mann@state.nm.us	4/9/2015 11:06 AM
15	mkwaterm@bechtel.com	4/9/2015 11:00 AM
16	loren.turner@dot.ca.gov	4/8/2015 12:54 PM
17	chancellork@dot.state.al.us	4/7/2015 2:50 PM
18	Andrewg@eng.ua.edu	4/7/2015 2:35 PM
19	jpaauwe@indot.in.gov	4/7/2015 11:58 AM
20	XCHEN@SHA.STATE.MD.US	4/6/2015 10:28 AM
21	sdeaton@dataforensics.net	4/6/2015 10:09 AM
22	kwame.adu-gyamfi@vdot.virginia.gov	4/6/2015 7:14 AM
23	acadden@schnabel-eng.com	4/5/2015 8:48 PM
24	kevin.mclain@modot.mo.gov	4/3/2015 12:08 PM
25	jejackson@mt.gov	4/3/2015 11:49 AM
26	david.thomas@state.co.us	4/3/2015 11:28 AM
27	rfranklingorman@gmail.com	1/15/2015 1:02 PM
28	ilyess.ksouri@state.co.us	11/19/2014 11:36 AM
29	Matt.Barendse@dot.ny.gov	9/29/2014 11:39 AM

#	Phone Number:	Date
1	651.366.5597	4/21/2015 9:42 AM
2	701-328-6908	4/20/2015 12:10 PM
3	303.318.6283	4/19/2015 9:21 AM
4	808-832-3405x121	4/17/2015 10:30 PM
5	208 334 8448	4/17/2015 4:28 PM
6	4126062192	4/14/2015 3:19 PM
7	62-712-8206	4/14/2015 12:04 PM
8	803-737-1571	4/13/2015 1:25 PM
9	202 366 0886	4/9/2015 3:24 PM
10	978 635 0012	4/9/2015 1:11 PM
11	650-329-5679	4/9/2015 1:05 PM
12	7149690800	4/9/2015 11:27 AM
13	608-246-7940	4/9/2015 11:17 AM
14	415.768.3920	4/9/2015 11:00 AM
15	916-227-7174	4/8/2015 12:54 PM
16	3342062277	4/7/2015 2:50 PM
17	205-348-1707	4/7/2015 2:35 PM
18	(317) 610-7251 ext226	4/7/2015 11:58 AM
19	678-406-0106	4/6/2015 10:09 AM
20	804-328-3144	4/6/2015 7:14 AM
21	6106966066	4/5/2015 8:48 PM
22	573 751-1044	4/3/2015 12:08 PM
23	406-444-3371	4/3/2015 11:49 AM
24	303 398 6606	11/19/2014 11:36 AM
25	518-457-4796	9/29/2014 11:39 AM

Q27 Please list the name and email address of others within your organization that would be interested in learning about DIGGS.

Answered: 7 Skipped: 59

#	Responses	Date
1	Shoup, Heather Z Graeff, Robert N ; Laningham, Brian K ; Miller, Dave K ; Olson, Joseph ; Pearman-Green, Veniecy ; Short, Michael A ; Stewart, James M ; Twardowski, Jan R ; Wagoner, Ronald R Thompson, Dave C	4/20/2015 11:47 AM
2	callie.ewald@state.vt.us tom.eliassen@state.vt.us marcy.meyers@state.vt.us	4/10/2015 8:22 AM
3	Silas Nichols, Naser AbuHejla, Ben Rivers, Barry Siel,	4/9/2015 3:24 PM
4	Matt Chartier Martin Hawkes	4/9/2015 1:11 PM
5	Michael Land - mtland@usgs.gov Thomas Holzer - tholzer@usgs.gov	4/9/2015 1:05 PM
6	William Adzimahe WAdzimahe@SHA.STATE.MD.US	4/6/2015 10:28 AM
7	Ty Ortiz ty.ortiz@state.co.us	4/3/2015 11:28 AM

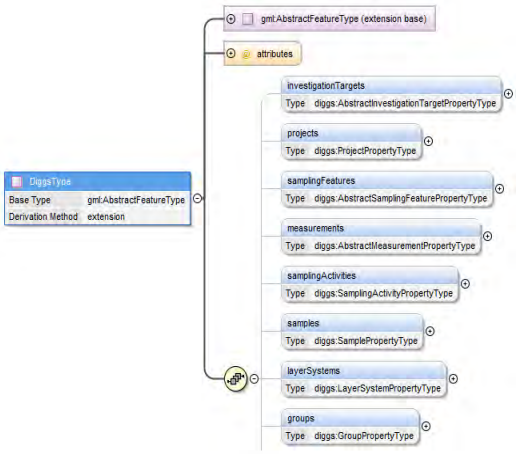
Appendix B: DIGGS 2.0 Schema Structure

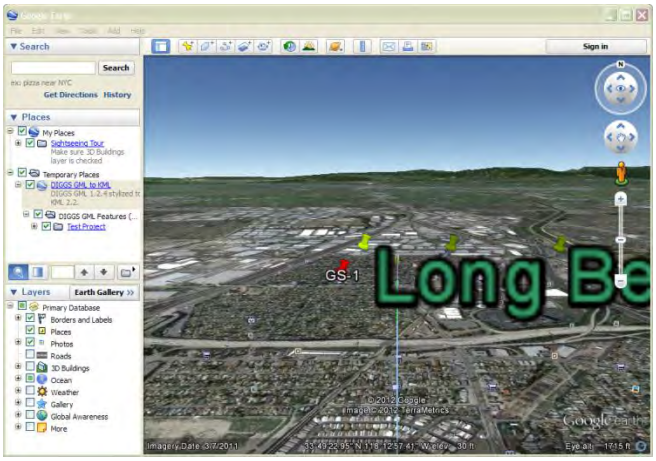
EXCERPT FROM:

Development of Geotechnical Data Schema in Transportation

for the
Ohio Department of Transportation
Office of Research and Development

and the
Federal Highway Administration





State Job Number 134254

June 30, 2012

DIGGS2.0.a standard includes supporting dictionaries, codelists and identifier names all encoded in machine readable XML that make use of IANA[1] registered DIGGS identifiers:

1) Coordinate Reference System (CRS) dictionaries containing Compound 3D CRSs that support DIGGS 3D data worldwide.

2) Units of Measurement (UoM) dictionaries that support typical measurements recorded by equipment used to capture DIGGS data.

3) Codelists that specify controlled vocabularies for test parameters and results, measurement phenomena, and other classifications typically recorded in DIGGS data

4) Uniform Resource Identifier (URI) Name Register and Governance Policies

DIGGSML Schema Overview

The DIGGS schemas are Open Geospatial Consortium (OGC) *Geography Markup Language (GML) application schemas* meaning that all schema constructs must derive from GML elements and types and follow GML's Object/property model, which govern how schema elements and XML instance documents are constructed. GML is an XML application that provides a grammar and base vocabulary for describing geographic data. GML was developed in order to provide a standard means of representing information about geospatial features – their properties, interrelationships, and so on. Features describe real world entities and are the fundamental objects in GML. Features can be concrete and tangible, such as boreholes and trench walls, or abstract and conceptual, such as projects and jurisdictional boundaries. GML features are described in terms of their properties, which can represent spatial and temporal characteristics or associations with other features. For instance, GML can describe the location, shape, and extent of geographic objects as well as properties such as color, speed, and density, some of which may depend on time. As it is impossible to describe all features for all application domains and predict their usage a priori, the GML core schemas do not fix definitions of specific implementation of feature types such as a trial pits or layer systems. Rather, specific features and properties are defined in GML Application Schemas, which are created by user communities such as DIGGS. So, DIGGS defines the appropriate GML elements and applications used in the delivered schema as applied to Geotechnical and Geoenvironmental engineering.

GML provides a base of common geographic and geometric constructs (e.g. the Abstract Feature model, Points, Line Strings, and Polygons) that can be shared and reused by GML Application Schemas. In turn, the GML constructs are built upon XML constructs such as elements, attributes, types, data types (e.g. integers, strings, dates), international language support, etc. By building on upon successful existing web technologies, the DIGGS GML Application Schemas can leverage a whole world of GML and XML Tools.

DIGGS Objects

[1] The Internet Assigned Numbers Authority (IANA) is responsible for the global coordination of the DNS Root, IP addressing, and other Internet protocol resources

The DIGGS schema contains elements in the form of Objects and Properties. An Object represents a feature (e.g. Borehole, sample, etc) and then properties about that object (e.g. diameter, height, density, etc).

Features are the primary *0bjects* in DIGGS. They are named entities comprised of descriptive properties. Non-feature objects also exist and are structurally the same as features; but, typically are not shared out of context with the features they are associated with. In DIGGS, objects appear as nested complex property values of features (a complex property element is one that contains child elements), e.g. a polygon representation of a trench wall's surface extent. A layer system defining soil descriptions is an example of a DIGGS feature, whereas the individual layers contained within a layer system are just objects that wouldn't be shared outside of the context of the layer system. *Metadata objects* are specially typed objects in GML, which describe contextual information about features or other objects.

DIGGS Properties

Properties are simply child elements of a feature or object. For example, a numeric result of a test is a property of the test feature. Figure illustrates properties as direct children of a Borehole feature.

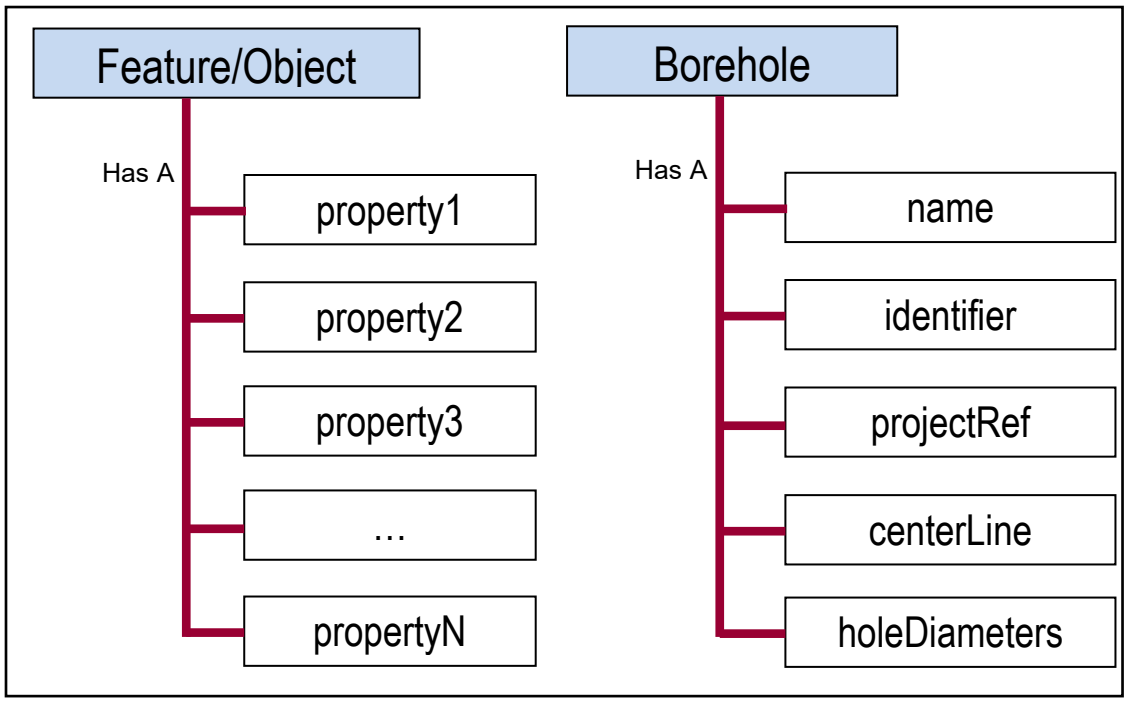


Figure 1: A DIGGS Feature or Object is described by its property children

Figure 1 also reveals a GML syntactic convention used to distinguish between Objects and properties; element and type names representing *Objects* are written in *UpperCamelCase* and the *property* names are written in *lowerCamelCase*.

DIGGS Applications

Both Custom-Off-The-Shelf (COTS) software (e.g. Saxon, GeoTools, Oxygen, Altova, Galdos GML SDK, Snowflake GML Viewer, and OGC Web Feature, Map/Portrayal, Registry, and Coverage Service

implementations) and specialized DIGGS software (e.g. DIGGS KML and Excel tools) can process DIGGS data structures for various purposes in varying degrees. For example, some GML aware COTS applications can detect and extract metadata or geometry types from GML instances and are designed to handle such typed information for specific purposes. Visualization applications (e.g. OGC Feature Portrayal Service) will detect and extract geometry properties to display on a map or earth browser. Registry applications (e.g. OGC Web Registry Service) can harvest metdata for discovery and archival purposes. Appendix B - Section **Error! Reference source not found.** (**Error! Reference source not found.**) and Appendix B - Section 0 (Specialized DIGGS Tools) describe the software support for DIGGS in the market place at the time of writing.

DIGGSML Repository Location

The official DIGGS2.0.a standard is available to the public from the DIGGSML web home page managed at http://www.diggsml.org/ . In particular the schemas can be accessed at http://diggsml.org/2.0a/schemas/.

DIGGS Repository Organization

The DIGGS2.0.a online repository includes the DIGGSML Schemas and the supporting Codelists, Dictionaries, Documentation and Sample Instance directories as shown in Figure 2.

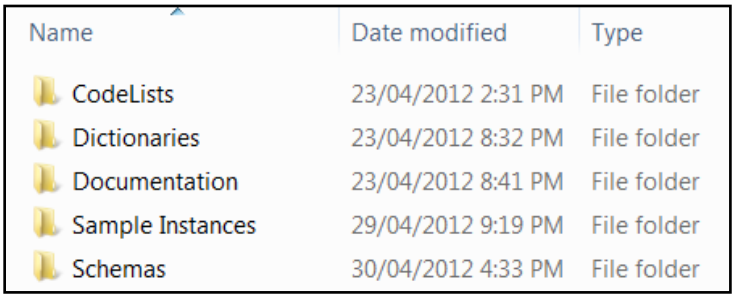
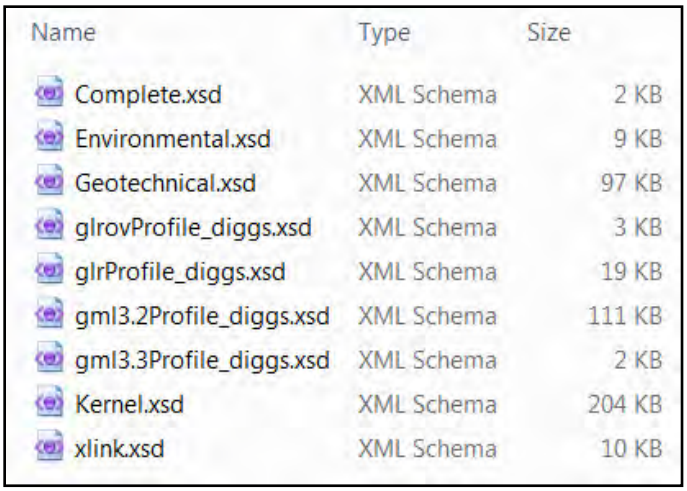


Figure 2: DIGGS 2.0.a Root Level Directory Structure

DIGGS Official Schemas

The online DIGGSML Schema repository contains 9 XML Schema Definition (XSD) files as shown in Figure 3.



Name	Type	Size
Complete.xsd	XML Schema	2 KB
Environmental.xsd	XML Schema	9 KB
Geotechnical.xsd	XML Schema	97 KB
glrovProfile_diggs.xsd	XML Schema	3 KB
glrProfile_diggs.xsd	XML Schema	19 KB
gml3.2Profile_diggs.xsd	XML Schema	111 KB
gml3.3Profile_diggs.xsd	XML Schema	2 KB
Kernel.xsd	XML Schema	204 KB
xlink.xsd	XML Schema	10 KB

Figure 3: DIGGS 2.0.a Schema File Directory

DIGGS Data

Instances of the schema that contain actual data can be created and stored anywhere, online or offline, but were designed for sharing over the web. Data repositories are maintained by DIGGS users and can be read by applications on mobile devices, desktop workstations, or computer servers from various data stores:

- File directories – accessible online as public or private web pages or offline in local file directories (e.g. for field work without internet access).

- Spatial Databases – accessible online through public or secure web interfaces or offline using a standalone client interface

Data instances can be validated against the official DIGGS schemas online or can be validated by a locally saved/cached copy of the DIGGS schemas.

DIGGS Dictionaries

DIGGS has the ability to transmit data using many different units (length in inches, feet, meters, etc). GML provides an XML encoding to define both CRS and Units dictionaries specifically designed to conform to the international standard models for CRS (ISO TC211 19111 Spatial Referencing by Coordinates) and Units (SI), respectively. Such GML CRS and Units dictionaries can be defined and extended for custom use in specific application domains and was done for DIGGS.

DIGGS Code Lists

Code lists are controlled vocabularies used by DIGGS property values. These are the structures that provide “pick lists” for data use. For example, soil color may be selected from the code list (e.g. grey, brown, etc). Such controlled vocabularies are used to avoid errors and ambiguities often found in data that make use free text values. An example of such a code list would be all the types of chemical determinands that can be observed from sample test readings.

The code lists were generated as an XML encoding automatically from a summary spreadsheet maintained in Excel (*DIGGSCodeTypes.xlsx*).

Name of List	List URN	Code	Description	Authority
Chemical Determinand	urn:x-diggs:def:code-list:AGS:chemical_determinand	246TCP	2,4,6 -	AGS
Chemical Determinand	urn:x-diggs:def:code-list:AGS:chemical_determinand	AG	Silver	AGS
Chemical Determinand	urn:x-diggs:def:code-list:AGS:chemical_determinand	DST	Disulfoton	AGS
Chemical Determinand	urn:x-diggs:def:code-list:AGS:chemical_determinand	2MNAP	2 -	AGS
Chemical Determinand	urn:x-diggs:def:code-list:AGS:chemical_determinand	AL	Aluminium	AGS
Chemical Determinand	urn:x-diggs:def:code-list:AGS:chemical_determinand	AS	Arsenic	AGS

Figure 4: Sample Codes in Spreadsheet Used as Input to XML Encoding

The truncated spreadsheet shown in Figure 4 contains all codes from the DIGGS1.0.a code lists plus additional enumerations and codes added in v2.0.a, which are categorized into three types A, B, and C as summarized in the following table.

Type	Description	Proposed DIGGS Implementation
A	Codes to describe in more detail a specific data element, where the data element cannot be controlled or validated by the schema alone (e.g. table data and CPT parameter names).	If the code is absolutely necessary for DIGGS to function and be unambiguous for source and target data interchange, then these codes should be implemented into enumerated lists. Enumerated lists are part of the schema and are validated by schema alone.
B	Codes created, maintained, and published by recognized standards organizations, used in practice, and commonly referenced with or without software (e.g. USCS Group Symbols for soil classification, Munsell color codes, EPSG spatial reference codes).	For codes that are commonly referenced, nomenclature and abbreviations well documented, and maintained by a standards body, these should be implemented in DIGGS using codetype and codespace attributes. DIGGS might require that some codetype and codespace attributes be mandatory. Although the codespace would reference the standards organization (e.g. USCS, AASHTO), the full list of codes (e.g. SP, SW) would not be in the codelist, since the standards organization maintains this list, and it would be left to the users to comply with the standards published by that standards organization.
C	Codes created by an organization, government agency, trade group, or company to standardize nomenclature and terms across a specific user base (e.g. roles, titles, equipment names, test names).	Codes that are used in localized practice should be made available for integration into DIGGS as needed. Codespace and codetype attributes would be optional. This would be applicable, for example, for codes such as "roles" where the value itself likely carries meaning without other external references. However, specific user groups may want to standardize the possible values being used. Three possibilities: • DIGGS file authors could simply use codes (uncontrolled) without any reference to a codetype or codespace. However, the recipient of the DIGGS file would not know what standards are being referenced. • The DIGGS author could populate the codetype and codespace attributes. Since these are optional and the format uncontrolled, the recipient may still be unable to resolve the references in a systematic manner. • The DIGGS author could reference a published codespace that can be validated with schematron.

In DIGGS2.0.a a new XML encoding was used. The DIGGS1.0.a code lists (e.g. *agsCodeList_V1.xml*) were converted from a GML Dictionary encoding to the international language supported XML encoding called ebRIM, which was standardized by the international OASIS standards body and adopted by the OGC as a Registry Information Model (RIM). The ebRIM encoding is a machine readable XML encoding that was designed for publishing and sharing common information resources such as code lists and dictionaries over the web. The advantages of using ebRIM are that it includes support for international languages, discovery and life cycle management of the information. Such ebRIM codelists can easily be viewed in human readable HTML.

DIGGS 2.0.a Feature Model

DIGGS2.0.a defines 8 base classes of features (as shown in Figure 5 below) that can be contained as a child under the root DIGGS element. This classification is formalized so that all existing features in DIGGS are categorized by derivation from these base classes. The existing features in DIGGS2.0.are the commonly used and requested features by the DIGGS community, e.g. Project, Borehole, Sample, etc. (the complete list appears in Appendix B - Section).

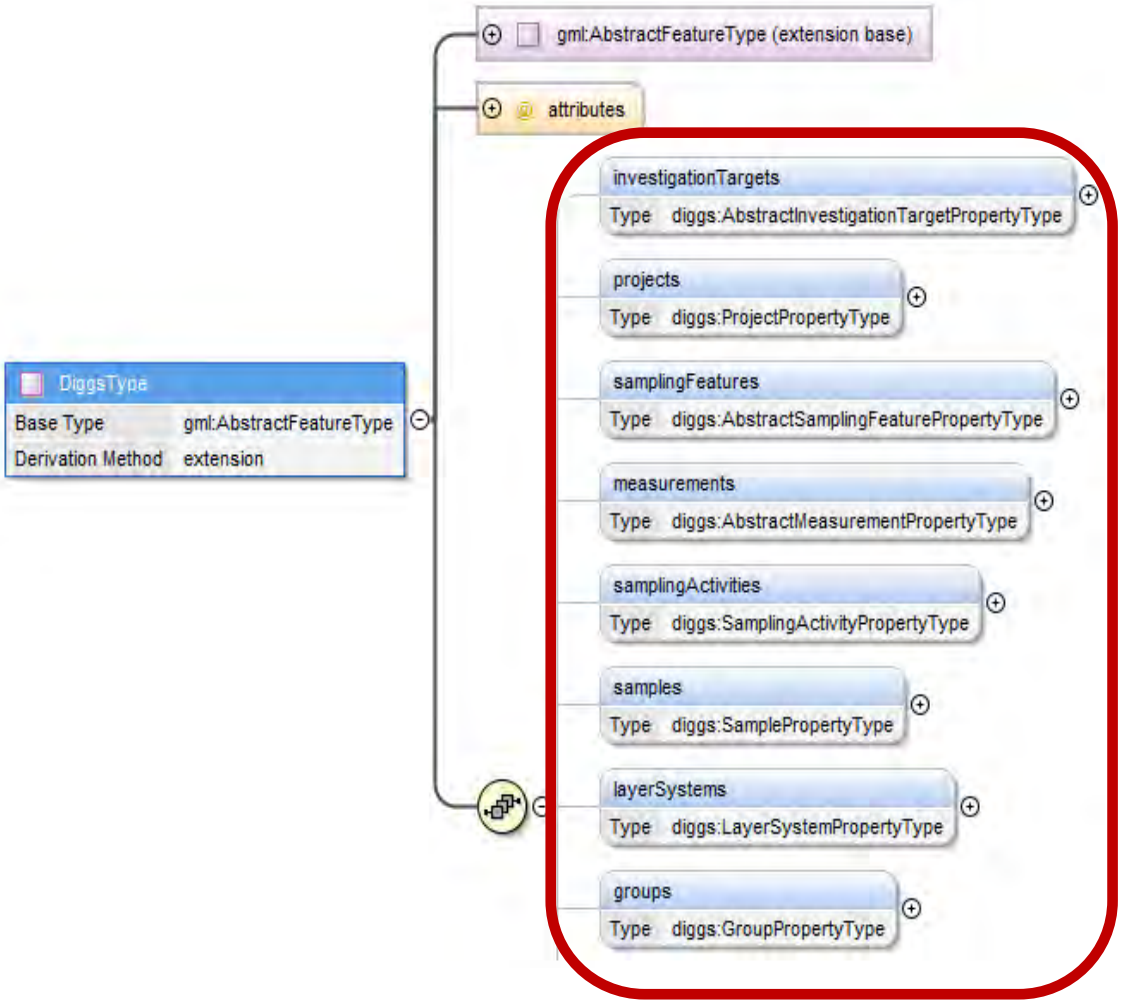


Figure 5: Base Feature Classes in DIGGS 2.0.a

The 8 base feature classes are classified by Processes, Entities, and Groups as follows:

1) **InvestigationTarget** –target features of interest being sampled/measured [Entity]
2) **Project** - business activities that collect, compile, and process information from locations [Process]
3) **SamplingFeature** - real world places and constructions (e.g. Boreholes) from which observations are made, samples are collected, or tests are run. [Entity]

4) **Measurement** – test readings (in-situ or not) taken from samples collected from sampling features, or created via a sampling activity [Process]
5) **SamplingActivity** - the process of sample creation or collection [Process]
6) **Sample** - earth material, fluids, or gases collected or created for observation and testing [Entity]
7) **LayerSystem** - ordered interval observations or interpretations of earth materials, properties or features at a location [Entity]
8) **Group** - collections of projects, locations, samples or groups of these, for the purpose of providing meaningful context to observations and measurements.

DIGGS Feature Properties and Attributes

DIGGS objects have a number of properties including mandatory and optional. Optional properties of all objects include status, description, and remarks metadata; and all features include additional optional properties including associated file and role metadata objects. Projects, Sampling Features, Samples, Layer Systems, Sensors, and Groups are "named" features. In addition to the identifiers and other properties, they also carry a mandatory name property. Some DIGGS objects are named (i.e. carry a mandatory name property) including some of the layers and all of the Metadata objects.

Objects that need to be referenced within the schema need to have a name. For example, a borehole must have a name, so it can be referred in the schema as to where a sample came from. A sample must have a name so a test can be assigned to the sample. Properties that stay within the hierarchy of the object and need no external reference do not have a mandatory name.

Specialized DIGGS Tools

The current project developed two specialized tools: 1) An Microsoft Excel converter that can read DIGGSML schema files and put the data into more familiar excel spreadsheet formats and tables. 2) A KML converter that converts the DIGGSML schema files into the Google mapping KML format to allow the data to be displayed on a Google map. These tools can only read and view data contained in DIGGSML compliant files. They cannot be used to enter or create DIGGSML files.

A detailed explanation of these tools is contained in the Appendix B.

Some possible uses for these tools are:

- Programmers might use Excel to gain an understanding of data structure for mapping toor from DIGGS.
- It might be easier for some to read Excel compared to XML. Its an alternative way to understand data structure.
- These tools may be used as a first step to map to a database table structure .

Other examples of custom applications might emerge from future projects sponsored by ASCE, DOTs, USGS through Projects like DIGGSML, COSMOS. Future examples might include DIGGS Validator, DIGGS Data and Map Server, DIGGS Registry, DIGGS Processing/Analysis, etc.

DIGGS Data Hierarchy, Schema and Data Dictonary

Appendix C: Data Dictionary

Partial printout.

Full Dictionary can be found at
http://diggsml.org/schemas/2.0.b/documentation//DiggsDocumentation.html#CylindricalSampleDetailType_diameter

Table of Contents

Group by: Namespace

http://www.opengis.net/gml/3.2

http://www.opengis.net/gml/3.3/ce

http://www.opengis.net/gml/3.3/lr

http://diggsml.org/schemas/2.0.b

Elements

Complex Types

diggs:BoreholeEventType/diggs:holeStability
diggs:BoreholeEventType/diggs:waterDepth
diggs:BoreholeType/diggs:backfill
diggs:BoreholeType/diggs:boreholePurpose
diggs:BoreholeType/diggs:casing
diggs:BoreholeType/diggs:chiseling
diggs:BoreholeType/diggs:constructionEvent
diggs:BoreholeType/diggs:constructionMethod
diggs:BoreholeType/diggs:flush
diggs:BoreholeType/diggs:holeDiameter
diggs:BoreholeType/diggs:totalMeasuredDepth
diggs:BoreholeType/diggs:waterStrike
diggs:BoreholeType/diggs:whenConstructed
diggs:Boundary
diggs:BoundaryType/diggs:dipAngle
diggs:BoundaryType/diggs:dipDirection
diggs:BoundaryType/diggs:distinctness
diggs:BoundaryType/diggs:origin
diggs:BoundaryType/diggs:topography
diggs:BusinessAssociate
diggs:BusinessAssociateType/diggs:address
diggs:BusinessAssociateType/diggs:associatedWith
diggs:BusinessAssociateType/diggs:emailAddress
diggs:BusinessAssociateType/diggs:phoneNumber
diggs:Calibration
diggs:CalibrationType/diggs:date
diggs:Casing
diggs:CasingType/diggs:casingInsideDiameter
diggs:CasingType/diggs:casingLocation
diggs:CasingType/diggs:casingMaterial
diggs:CasingType/diggs:casingOutsideDiameter
diggs:CasingType/diggs:casingWallThickness
diggs:ChainOfCustodyEvent
diggs:ChainOfCustodyEventType/diggs:containerType
diggs:ChainOfCustodyEventType/diggs:dateReceived
diggs:ChainOfCustodyEventType/diggs:dateSent
diggs:ChainOfCustodyEventType/diggs:destinationCustodian
diggs:ChainOfCustodyEventType/diggs:destinationCustodianRef
diggs:ChainOfCustodyEventType/diggs:preservativeAdded
diggs:ChainOfCustodyEventType/diggs:shippingContainerId
diggs:ChainOfCustodyEventType/diggs:sourceCustodian
diggs:ChainOfCustodyEventType/diggs:sourceCustodianRef
diggs:Chiseling
diggs:ChiselingType/diggs:chiselingLocation
diggs:ChiselingType/diggs:chiselingToolUsed
diggs:ChiselingType/diggs:timeTaken
diggs:CodeOrPercentType/diggs:description
diggs:CodeOrPercentType/diggs:percentage
diggs:Color
diggs:ColorDescription
diggs:ColorDescriptionType/diggs:baseBoundary
diggs:ColorDescriptionType/diggs:color
diggs:ColorSystem
diggs:ColorSystemType/diggs:colorType
diggs:ColorSystemType/diggs:description
diggs:ColorType/diggs:abundanceCode
diggs:ColorType/diggs:abundancePercent
diggs:ColorType/diggs:colorCode
diggs:ComponentLithology
diggs:ComponentLithologyType/diggs:abundanceCode
diggs:ComponentLithologyType/diggs:abundancePercent
diggs:ComponentLithologyType/diggs:lithology
diggs:Constituent
diggs:ConstituentDescription
diggs:ConstituentDescriptionType/diggs:constituent
diggs:ConstituentSystem
diggs:ConstituentSystemType/diggs:constituentType
diggs:ConstituentSystemType/diggs:description
diggs:ConstituentType/diggs:abundanceCode
diggs:ConstituentType/diggs:abundancePercent
diggs:ConstituentType/diggs:codeValue
diggs:ConstituentType/diggs:distribution
diggs:ConstructionMethod
diggs:ConstructionMethodType/diggs:equipmentUsed
diggs:ConstructionMethodType/diggs:equipmentUsedRef
diggs:ConstructionMethodType/diggs:methodLocation
diggs:ConstructionMethodType/diggs:procedure
diggs:ConstructionMethodType/diggs:procedureRef
diggs:Contract
diggs:ContractType/diggs:associatedFile
diggs:ContractType/diggs:client
diggs:ContractType/diggs:clientRef
diggs:ContractType/diggs:contractor
diggs:ContractType/diggs:contratorRef
diggs:ContractType/diggs:type
diggs:CylindricalSampleDetail
diggs:CylindricalSampleDetailType/diggs:diameter
diggs:CylindricalSampleDetailType/diggs:length
diggs:CylindricalSampleDetailType/diggs:rockQualityDesignation
diggs:CylindricalSampleDetailType/diggs:solidCoreRecovery
diggs:CylindricalSampleDetailType/diggs:totalCoreRecovery
diggs:DelayEvent
diggs:DelayEventType/diggs:delayType
diggs:DelayEventType/diggs:timeOfDelay
diggs:Detector
diggs:DetectorType/diggs:detectorLocation
diggs:DetectorType/diggs:measurand
diggs:DetectorType/diggs:measurementAxisBearing
diggs:DetectorType/diggs:measurementAxisInclination
diggs:DetectorType/diggs:type
diggs:Diggs
diggs:DiggsType/diggs:associatedFile
diggs:DiggsType/diggs:businessAssociate
diggs:DiggsType/diggs:documentInformation
diggs:DiggsType/diggs:equipment
diggs:DiggsType/diggs:fieldDescription
diggs:DiggsType/diggs:group
diggs:DiggsType/diggs:measurement
diggs:DiggsType/diggs:project
diggs:DiggsType/diggs:sample
diggs:DiggsType/diggs:samplingActivity
diggs:DiggsType/diggs:samplingFeature
diggs:EnvironmentType
diggs:EquipmentPropertyType
diggs:EquipmentType
diggs:EventPropertyType
diggs:FeatureReferenceType
diggs:FieldPropertiesPropertyType
diggs:FieldPropertyType
diggs:FlushPropertyType
diggs:FlushType
diggs:FractionalReferenceType
diggs:FractureDescriptionPropertyType
diggs:FractureDescriptionType
diggs:FractureSpacingPropertyType
diggs:FractureSpacingType
diggs:GroupGroupType
diggs:GroupPropertyType
diggs:IndexedParameterType
diggs:LimitPropertyType
diggs:LimitType
diggs:LineStringType
diggs:LinearExtentPropertyType
diggs:LinearSpatialReferenceSystemPropertyType
diggs:LinearSpatialReferenceSystemType
diggs:LithologyDescriptionPropertyType
diggs:LithologyDescriptionType
diggs:LithologyPropertyType
diggs:LithologySystemType
diggs:LithologyType
diggs:LocationAccuracyPropertyType
diggs:LocationAccuracyType
diggs:LocationPropertyType
diggs:MeasureOrStringType
diggs:MetadataReferenceType
diggs:MonitorResultPropertyType
diggs:MonitorResultType
diggs:MonitorType
diggs:MultiCurvePropertyType
diggs:MultiCurveType
diggs:MultiTimeInstantType
diggs:NullDataType
diggs:OrientationDescriptionPropertyType
diggs:OrientationDescriptionType
diggs:OrientationPropertyType
diggs:OrientationSystemType
diggs:OrientationType
diggs:OtherDescriptionPropertyType
diggs:OtherDescriptionSystemType
diggs:OtherDescriptionType
diggs:ParameterPropertyType
diggs:ParameterType
diggs:ParticleDensityPropertyType
diggs:ParticleDensityType
diggs:ParticleSizeDistributionPropertyType
diggs:ParticleSizeDistributionType
diggs:ParticleSizePropertyType
diggs:ParticleSizeType
diggs:ParticleSizeValueType
diggs:PercentDoubleType
diggs:PercentMeasureType
diggs:PhoneType
diggs:PlanarObservationRepresentationPropertyType
diggs:PlanarObservationRepresentationType
diggs:PointLocationPropertyType
diggs:PointType
diggs:PolygonType
diggs:PostStrikeReadingPropertyType
diggs:PostStrikeReadingType
diggs:ProcedurePropertyType
diggs:ProjectGroupType
diggs:ProjectPropertyType
diggs:ProjectType
diggs:PropertyInfoPropertyType
diggs:PropertyParametersType
diggs:PropertyPropertyType
diggs:PropertyType
diggs:QualifierPropertyType
diggs:ReadingGroupPropertyType
diggs:ReadingType
diggs:RemarkPropertyType
diggs:RemarkType
diggs:ResultSetType
diggs:ResultsPropertyType
diggs:RolePropertyType
diggs:RoleType
diggs:SampleGroupType
diggs:SampleProducedPropertyType
diggs:SampleProducedType
diggs:SamplePropertyType
diggs:SampleType
diggs:SamplingActivityPropertyType
diggs:SamplingActivityType
diggs:SamplingFeatureGroupType
diggs:SensorPropertyType
diggs:SensorType
diggs:SimpleMultiPointType
diggs:SizeFractionPropertyType
diggs:SizeFractionType
diggs:SoftwareApplicationPropertyType
diggs:SoftwareApplicationType
diggs:SoundingEventPropertyType
diggs:SoundingEventType
diggs:SpecificationPropertyType
diggs:SpecificationType
diggs:SpecimenConditionsPropertyType
diggs:SpecimenConditionsType
diggs:StationType
diggs:StrainPerTimeMeasureType
diggs:StratigraphyDescriptionPropertyType
diggs:StratigraphyDescriptionType
diggs:StratigraphySystemType
diggs:SurfacePropertyType
diggs:TestLocationPropertyType

diggs:DiggsType/diggs:specification
diggs:DiscontinuityDescription
diggs:DiscontinuityDescriptionType/diggs:fractureDescription
diggs:DiscontinuityDescriptionType/diggs:fractureSpacing
diggs:DiscontinuitySystem
diggs:DiscontinuitySystemType/diggs:description
diggs:DiscontinuitySystemType/diggs:discontinuityType
diggs:DocumentInformation
diggs:DocumentInformationType/diggs:auditTrail
diggs:DocumentInformationType/diggs:author
diggs:DocumentInformationType/diggs:authorRef
diggs:DocumentInformationType/diggs:creationDate
diggs:DocumentInformationType/diggs:destination
diggs:DocumentInformationType/diggs:destinationSoftware
diggs:DocumentInformationType/diggs:disclaimer
diggs:DocumentInformationType/diggs:effectiveDate
diggs:DocumentInformationType/diggs:language
diggs:DocumentInformationType/diggs:protocol
diggs:DocumentInformationType/diggs:sourceSoftware
diggs:Environment
diggs:EnvironmentType/diggs:barometricPressure
diggs:EnvironmentType/diggs:gasFlow
diggs:EnvironmentType/diggs:gasPressure
diggs:EnvironmentType/diggs:otherEnvironmentalParameter
diggs:EnvironmentType/diggs:temperature
diggs:Equipment
diggs:FeatureMetadataProperties/diggs:associatedFile
diggs:FeatureMetadataProperties/diggs:remark
diggs:FeatureMetadataProperties/diggs:role
diggs:FeatureReference
diggs:FieldProperties
diggs:FieldPropertyType/diggs:apparentDensity
diggs:FieldPropertyType/diggs:beddingOrientation
diggs:FieldPropertyType/diggs:beddingSpacing
diggs:FieldPropertyType/diggs:cementation
diggs:FieldPropertyType/diggs:consistency
diggs:FieldPropertyType/diggs:dilatancy
diggs:FieldPropertyType/diggs:dryStrength
diggs:FieldPropertyType/diggs:moistureCondition
diggs:FieldPropertyType/diggs:odor
diggs:FieldPropertyType/diggs:otherFieldProperty
diggs:FieldPropertyType/diggs:particleAngularity
diggs:FieldPropertyType/diggs:particleShape
diggs:FieldPropertyType/diggs:particleSize
diggs:FieldPropertyType/diggs:particleSorting
diggs:FieldPropertyType/diggs:plasticity
diggs:FieldPropertyType/diggs:reactionToHCl
diggs:FieldPropertyType/diggs:rockHardness
diggs:FieldPropertyType/diggs:rockSlakingRate
diggs:FieldPropertyType/diggs:rockWeathering
diggs:FieldPropertyType/diggs:soilStructure
diggs:FieldPropertyType/diggs:toughness
diggs:Flush
diggs:FlushType/diggs:fluidType
diggs:FlushType/diggs:flushColor
diggs:FlushType/diggs:flushZoneLocation
diggs:FlushType/diggs:maxflushReturn
diggs:FlushType/diggs:minFlushReturn
diggs:FractureDescription
diggs:FractureDescriptionType/diggs:aperatureMeasurement
diggs:FractureDescriptionType/diggs:aperatureObservation
diggs:FractureDescriptionType/diggs:dipAngle
diggs:FractureDescriptionType/diggs:dipDirection
diggs:FractureDescriptionType/diggs:discontinuityNumber
diggs:FractureDescriptionType/diggs:fractureHealing
diggs:FractureDescriptionType/diggs:fractureSetNumber
diggs:FractureDescriptionType/diggs:infillHardness
diggs:FractureDescriptionType/diggs:infillMaterial
diggs:FractureDescriptionType/diggs:jointRoughnessCoefficient
diggs:FractureDescriptionType/diggs:persistence
diggs:FractureDescriptionType/diggs:planarity
diggs:FractureDescriptionType/diggs:roughness
diggs:FractureDescriptionType/diggs:seepageRating
diggs:FractureDescriptionType/diggs:surfaceAppearance
diggs:FractureDescriptionType/diggs:termination
diggs:FractureDescriptionType/diggs:type
diggs:FractureDescriptionType/diggs:wallStrength
diggs:FractureDescriptionType/diggs:wallWeathering
diggs:FractureDescriptionType/diggs:waterFlow
diggs:FractureDescriptionType/diggs:wavinessAmplitude
diggs:FractureDescriptionType/diggs:wavinessWavelength
diggs:FractureSpacing
diggs:FractureSpacingType/diggs:averageSpacing
diggs:FractureSpacingType/diggs:fracturesPerUnitLength
diggs:FractureSpacingType/diggs:maxSpacing
diggs:FractureSpacingType/diggs:minSpacing
diggs:GroupGroup
diggs:Limit
diggs:LimitType/diggs:constraint
diggs:LimitType/diggs:limitType
diggs:LimitType/diggs:value
diggs:LinearExtent
diggs:LinearSpatialReferenceSystem
diggs:LinearSpatialReferenceSystemType/diggs:linearElementAccuracy
diggs:LinearSpatialReferenceSystemType/diggs:linearReferencingMethodAccuracy
diggs:Lithology
diggs:LithologyDescription
diggs:LithologyDescriptionType/diggs:baseBoundary
diggs:LithologyDescriptionType/diggs:componentLithology
diggs:LithologyDescriptionType/diggs:primaryLithology
diggs:LithologySystem
diggs:LithologySystemType/diggs:description
diggs:LithologySystemType/diggs:lithologyClassificationType
diggs:LithologyType/diggs:alternateCode
diggs:LithologyType/diggs:classificationCode
diggs:LithologyType/diggs:color
diggs:LithologyType/diggs:constituent
diggs:LithologyType/diggs:fieldProperties
diggs:LithologyType/diggs:grainSizeDistribution
diggs:LithologyType/diggs:lithDescription
diggs:LocationAccuracy
diggs:LocationAccuracyType/diggs:measurementMethod
diggs:TestResultPropertyType
diggs:TestResultType
diggs:TestType
diggs:TimeArrayPropertyType
diggs:TimeDomainType
diggs:TimeInstantType
diggs:TimeIntervalPropertyType
diggs:TimeIntervalType
diggs:TrialPitEventPropertyType
diggs:TrialPitEventType
diggs:TrialPitType
diggs:Val0-100MeasureType
diggs:ValueAtTimeType
diggs:VectorLinearSpatialReferenceSystemPropertyType
diggs:VectorLinearSpatialReferenceSystemType
diggs:WaterStrikePropertyType
diggs:WaterStrikeType
diggs:areaPerTimeMeasure
diggs:forcePerTimeMeasure

Simple Types

diggs:AllUnits
diggs:ColorCharacterEnumType
diggs:ConstituentCategoryEnumType
diggs:DescriptivePropertiesEnumType
diggs:DescriptorTechniqueEnumType
diggs:EmailEnumType
diggs:EmailStringType
diggs:ExtEmailEnumType
diggs:ExtPhoneEnumType
diggs:ExtQualifierEnumType
diggs:FractionEnumType
diggs:IdentifierReferenceType
diggs:IntegerEnumType
diggs:LimitEnumType
diggs:LithologyCharacterEnumType
diggs:MediumEnumType
diggs:OrientationObsPropertyEnumType
diggs:OtherNameType
diggs:PercentEnumType
diggs:PermilEnumType
diggs:PhoneEnumType
diggs:PhoneNumberStringType
diggs:PropertyDataTypeEnumType
diggs:QualifierEnumType
diggs:SampleFractionEnumType
diggs:SpecimenEnumType
diggs:SpecimenShapeEnumType
diggs:SpecimenShapeType
diggs:SpecimenType
diggs:StratigraphyObservationEnumType
diggs:UnifiedDateTimeType
diggs:Val0-100Type
diggs:areaPerTimeUom
diggs:diggsDensityOrUnitWeightUom
diggs:forcePerTimeUom
diggs:geotechnicalDensityUom
diggs:investigationTargetEnumType
diggs:particleSizeUom
diggs:strainPerTimeUom

Attributes

@diggs:technique

Element Groups

diggs:FeatureMetadataProperties
diggs:TestMetadataProperties

diggs:LocationAccuracyType/diggs:result
diggs:MeasureOrString
diggs:MeasureOrStringType/diggs:numeric
diggs:MeasureOrStringType/diggs:textual
diggs:Monitor
diggs:MonitorResult
diggs:MonitorType/diggs:reading
diggs:MultiCurve
diggs:MultiPointLocation
diggs:MultiTimeInstant
diggs:MultiTimeInstantType/diggs:timeMember
diggs:Orientation
diggs:OrientationDescription
diggs:OrientationDescriptionType/diggs:orientation
diggs:OrientationSystem
diggs:OrientationSystemType/diggs:description
diggs:OrientationSystemType/diggs:orientationFeatureType
diggs:OrientationType/diggs:dipOrPlunge
diggs:OrientationType/diggs:strikeOrBearing
diggs:OtherDescription
diggs:OtherDescriptionSystem
diggs:OtherDescriptionSystemType/diggs:description
diggs:OtherDescriptionSystemType/diggs:otherSystemType
diggs:OtherDescriptionType/diggs:parameter
diggs:Parameter
diggs:ParameterType/diggs:index
diggs:ParameterType/diggs:parameterName
diggs:ParameterType/diggs:parameterUnits
diggs:ParameterType/diggs:parameterValue
diggs:ParticleDensity
diggs:ParticleDensityType/diggs:assumedDensity
diggs:ParticleDensityType/diggs:measuredDensity
diggs:ParticleSize
diggs:ParticleSizeDistribution
diggs:ParticleSizeDistributionType/diggs:d10
diggs:ParticleSizeDistributionType/diggs:d30
diggs:ParticleSizeDistributionType/diggs:d50
diggs:ParticleSizeDistributionType/diggs:d60
diggs:ParticleSizeDistributionType/diggs:equivalentDiameter
diggs:ParticleSizeDistributionType/diggs:maximumDiameter
diggs:ParticleSizeDistributionType/diggs:meanGrainsize
diggs:ParticleSizeDistributionType/diggs:minimumDiameter
diggs:ParticleSizeDistributionType/diggs:modalGrainsize
diggs:ParticleSizeDistributionType/diggs:otherParticleSizeProperty
diggs:ParticleSizeType/diggs:descriptor
diggs:ParticleSizeType/diggs:value
diggs:PlanarObservationRepresentation
diggs:PlanarObservationRepresentationType/diggs:layerBaseIntersection
diggs:PlanarObservationRepresentationType/diggs:layerTopIntersection
diggs:PlanarObservationRepresentationType/diggs:representativeSurface
diggs:PlanarSurface
diggs:PointLocation
diggs:PostStrikeReading
diggs:PostStrikeReadingType/diggs:timeFollowingStrike
diggs:PostStrikeReadingType/diggs:waterDepth
diggs:Project
diggs:ProjectGroup
diggs:ProjectType/diggs:arealExtent
diggs:ProjectType/diggs:contract
diggs:ProjectType/diggs:linearExtent
diggs:ProjectType/diggs:location
diggs:ProjectType/diggs:projectDateTimeSpan
diggs:ProjectType/diggs:purpose
diggs:ProjectType/diggs:referencePoint
diggs:Property
diggs:PropertyParameters
diggs:PropertyType/diggs:atTemperature
diggs:PropertyType/diggs:context
diggs:PropertyType/diggs:correctionUsed
diggs:PropertyType/diggs:curveState
diggs:PropertyType/diggs:detectionLimits
diggs:PropertyType/diggs:detectorRef
diggs:PropertyType/diggs:measurementAxisBearing
diggs:PropertyType/diggs:measurementAxisInclination
diggs:PropertyType/diggs:measurementTechnique
diggs:PropertyType/diggs:nullValue
diggs:PropertyType/diggs:propertyClass
diggs:PropertyType/diggs:propertyName
diggs:PropertyType/diggs:qualifier
diggs:PropertyType/diggs:reportable
diggs:PropertyType/diggs:sampleFraction
diggs:PropertyType/diggs:typeData
diggs:PropertyType/diggs:uom
diggs:Qualifier
diggs:Reading
diggs:ReadingType/diggs:outcome
diggs:ReadingType/diggs:responseZoneLocation
diggs:ReadingType/diggs:sensor
diggs:Remark
diggs:RemarkType/diggs:author
diggs:RemarkType/diggs:authorRef
diggs:RemarkType/diggs:content
diggs:RemarkType/diggs:remarkDateTime
diggs:ResultSet
diggs:Role
diggs:RoleType/diggs:businessAssociate
diggs:RoleType/diggs:businessAssociateRef
diggs:RoleType/diggs:remark
diggs:RoleType/diggs:rolePerformed
diggs:RoleType/diggs:timePerformed
diggs:Sample
diggs:SampleGroup
diggs:SampleProduced
diggs:SampleProducedType/diggs:sampleLocation
diggs:SampleType/diggs:blockSampleDetails
diggs:SampleType/diggs:chainOfCustodyEvent
diggs:SampleType/diggs:classification
diggs:SampleType/diggs:componentLithology
diggs:SampleType/diggs:condition
diggs:SampleType/diggs:cylindricalSampleDetails
diggs:SampleType/diggs:initialContainerType
diggs:SampleType/diggs:matrix

diggs:SampleType/diggs:medium
diggs:SampleType/diggs:primaryLithology
diggs:SampleType/diggs:purpose
diggs:SamplingActivity
diggs:SamplingActivityType/diggs:activityLocation
diggs:SamplingActivityType/diggs:activityType
diggs:SamplingActivityType/diggs:samplesProduced
diggs:SamplingActivityType/diggs:samplingDate
diggs:SamplingActivityType/diggs:samplingEnvironment
diggs:SamplingActivityType/diggs:samplingEquipment
diggs:SamplingActivityType/diggs:samplingEquipmentRef
diggs:SamplingActivityType/diggs:samplingProcedure
diggs:SamplingActivityType/diggs:samplingProcedureRef
diggs:SamplingActivityType/diggs:sourceSample
diggs:SamplingFeatureGroup
diggs:Sensor
diggs:SensorType/diggs:dateInstalled
diggs:SensorType/diggs:detector
diggs:SensorType/diggs:referencePoint
diggs:SizeFraction
diggs:SizeFractionType/diggs:maximumGrainSize
diggs:SizeFractionType/diggs:minimumGrainSize
diggs:SizeFractionType/diggs:percentOfTotalSample
diggs:SoftwareApplication
diggs:SoftwareApplicationType/diggs:name
diggs:SoftwareApplicationType/diggs:version
diggs:SoundingEvent
diggs:SoundingEventType/diggs:casingBottom
diggs:SoundingEventType/diggs:soundingBottom
diggs:Specification
diggs:SpecificationType/diggs:associatedFile
diggs:SpecificationType/diggs:fullMethodName
diggs:SpecificationType/diggs:methodDescription
diggs:SpecificationType/diggs:shortMethodName
diggs:SpecificationType/diggs:standardClause
diggs:SpecificationType/diggs:standardPart
diggs:SpecificationType/diggs:standardReferenceNumber
diggs:SpecificationType/diggs:standardTitle
diggs:SpecificationType/diggs:standardVersion
diggs:SpecimenConditions
diggs:SpecimenConditionsType/diggs:crossSectionalArea
diggs:SpecimenConditionsType/diggs:dilutionFactor
diggs:SpecimenConditionsType/diggs:drySpecimenWeight
diggs:SpecimenConditionsType/diggs:leachatePreparationDateTime
diggs:SpecimenConditionsType/diggs:leachatePreparationMethod
diggs:SpecimenConditionsType/diggs:otherSpecimenProperty
diggs:SpecimenConditionsType/diggs:sizeFraction
diggs:SpecimenConditionsType/diggs:specimenDescription
diggs:SpecimenConditionsType/diggs:specimenDiameter
diggs:SpecimenConditionsType/diggs:specimenHeight
diggs:SpecimenConditionsType/diggs:specimenLength
diggs:SpecimenConditionsType/diggs:specimenShape
diggs:SpecimenConditionsType/diggs:specimenType
diggs:SpecimenConditionsType/diggs:specimenVolume
diggs:SpecimenConditionsType/diggs:specimenWidth
diggs:SpecimenConditionsType/diggs:wetSpecimenWeight
diggs:Station
diggs:StationType/diggs:type
diggs:StratigraphyDescription
diggs:StratigraphyDescriptionType/diggs:name
diggs:StratigraphySystem
diggs:StratigraphySystemType/diggs:description
diggs:StratigraphySystemType/diggs:stratigraphyType
diggs:Test
diggs:TestMetadataProperties/diggs:equipment
diggs:TestMetadataProperties/diggs:equipmentRef
diggs:TestMetadataProperties/diggs:specification
diggs:TestMetadataProperties/diggs:specificationRef
diggs:TestResult
diggs:TestType/diggs:outcome
diggs:TestType/diggs:procedure
diggs:TestType/diggs:resultTime
diggs:TestType/diggs:samplingTime
diggs:TestType/diggs:validTime
diggs:TimeInstant
diggs:TimeInstantType/diggs:remarks
diggs:TimeInstantType/diggs:role
diggs:TimeInstantType/diggs:status
diggs:TimeInterval
diggs:TimeIntervalType/diggs:duration
diggs:TimeIntervalType/diggs:end
diggs:TimeIntervalType/diggs:start
diggs:TrialPit
diggs:TrialPitEvent
diggs:TrialPitEventType/diggs:depth
diggs:TrialPitEventType/diggs:length
diggs:TrialPitEventType/diggs:stability
diggs:TrialPitEventType/diggs:width
diggs:TrialPitType/diggs:backfill
diggs:TrialPitType/diggs:constructionEvent
diggs:TrialPitType/diggs:constructionMethod
diggs:TrialPitType/diggs:pitLength
diggs:TrialPitType/diggs:pitWidth
diggs:TrialPitType/diggs:shoring
diggs:TrialPitType/diggs:totalMeasuredDepth
diggs:TrialPitType/diggs:trialPitPurpose
diggs:ValueAtTimeType/diggs:elapsedTime
diggs:ValueAtTimeType/diggs:value
diggs:VectorLinearSpatialReferenceSystem
diggs:VectorLinearSpatialReferenceSystemType/diggs:linearElementAccuracy
diggs:VectorLinearSpatialReferenceSystemType/diggs:linearReferencingMethodAccuracy
diggs:VectorLinearSpatialReferenceSystemType/diggs:offsetVector
diggs:WaterStrike
diggs:WaterStrikeType/diggs:bottomCasing
diggs:WaterStrikeType/diggs:dateTime
diggs:WaterStrikeType/diggs:postStrikeReading
diggs:WaterStrikeType/diggs:sealDepth
diggs:WaterStrikeType/diggs:waterStrikeDepth
diggs:associatedProjectRef
diggs:dataValues
diggs:groupRef
diggs:investigationTarget

diggs:laboratoryTestRef
diggs:location
diggs:measurementRef
diggs:originalProjectRef
diggs:originalSamplingFeatureRef
diggs:parameters
diggs:projectRef
diggs:properties
diggs:results
diggs:sampleProducedRef
diggs:sampleRef
diggs:samplingActivityRef
diggs:samplingFeatureRef
diggs:sensorRef
diggs:timeDomain

http://diggsml.org/schemas/2.0.b/geotechnical

Elements

diggs_geo:AtterbergLimitsTest
diggs_geo:AtterbergLimitsTestType/diggs_geo:casagrandeTrial
diggs_geo:AtterbergLimitsTestType/diggs_geo:fallConeTrial
diggs_geo:AtterbergLimitsTestType/diggs_geo:handRemoved
diggs_geo:AtterbergLimitsTestType/diggs_geo:multiPointLLmethod
diggs_geo:AtterbergLimitsTestType/diggs_geo:ovenDriedBeforeTest
diggs_geo:AtterbergLimitsTestType/diggs_geo:percentRetainedNo40
diggs_geo:AtterbergLimitsTestType/diggs_geo:plasticLimitTrial
diggs_geo:AtterbergLimitsTestType/diggs_geo:shrinkageLimitTrial
diggs_geo:AtterbergLimitsTestType/diggs_geo:sieveProcedure
diggs_geo:AtterbergLimitsTestType/diggs_geo:specimenInitialState
diggs_geo:CasagrandeTrial
diggs_geo:CasagrandeTrialType/diggs_geo:blowCount
diggs_geo:CasagrandeTrialType/diggs_geo:isManual
diggs_geo:CasagrandeTrialType/diggs_geo:trialNo
diggs_geo:CasagrandeTrialType/diggs_geo:waterContent
diggs_geo:DriveSet
diggs_geo:DriveSetType/diggs_geo:blowCount
diggs_geo:DriveSetType/diggs_geo:delay
diggs_geo:DriveSetType/diggs_geo:index
diggs_geo:DriveSetType/diggs_geo:penetration
diggs_geo:DriveSetType/diggs_geo:torque
diggs_geo:DrivenPenetrationTest
diggs_geo:DrivenPenetrationTestType/diggs_geo:depthCasing
diggs_geo:DrivenPenetrationTestType/diggs_geo:driveSet
diggs_geo:DrivenPenetrationTestType/diggs_geo:hammerDropHeight
diggs_geo:DrivenPenetrationTestType/diggs_geo:hammerEfficiency
diggs_geo:DrivenPenetrationTestType/diggs_geo:hammerMass
diggs_geo:DrivenPenetrationTestType/diggs_geo:hammerType
diggs_geo:DrivenPenetrationTestType/diggs_geo:penetrationTestType
diggs_geo:DrivenPenetrationTestType/diggs_geo:rodExternalDiameter
diggs_geo:DrivenPenetrationTestType/diggs_geo:rodType
diggs_geo:DrivenPenetrationTestType/diggs_geo:rodWeight
diggs_geo:DrivenPenetrationTestType/diggs_geo:samplerInternalDiameter
diggs_geo:DrivenPenetrationTestType/diggs_geo:samplerLength
diggs_geo:DrivenPenetrationTestType/diggs_geo:samplerLinerDescription
diggs_geo:DrivenPenetrationTestType/diggs_geo:samplerRetainerDescription
diggs_geo:DrivenPenetrationTestType/diggs_geo:selfWeightPenetration
diggs_geo:DrivenPenetrationTestType/diggs_geo:totalPenetration
diggs_geo:DrivenPenetrationTestType/diggs_geo:waterDepth
diggs_geo:FallConeTrial
diggs_geo:FallConeTrialType/diggs_geo:penetration
diggs_geo:FallConeTrialType/diggs_geo:trialNo
diggs_geo:FallConeTrialType/diggs_geo:waterContent
diggs_geo:Grading
diggs_geo:GradingType/diggs_geo:otherGradingProperty
diggs_geo:GradingType/diggs_geo:particleSize
diggs_geo:GradingType/diggs_geo:percentPassing
diggs_geo:GradingType/diggs_geo:percentRetained
diggs_geo:GradingType/diggs_geo:sieveNumber
diggs_geo:GradingType/diggs_geo:weightRetained
diggs_geo:Hydrometer
diggs_geo:HydrometerType/diggs_geo:dispersionDevice
diggs_geo:HydrometerType/diggs_geo:dispersionDuration
diggs_geo:HydrometerType/diggs_geo:drySoilWeight
diggs_geo:HydrometerType/diggs_geo:hydrometerType
diggs_geo:HydrometerType/diggs_geo:otherHydrometerProperty
diggs_geo:HydrometerType/diggs_geo:sedimentationData
diggs_geo:HydrometerType/diggs_geo:sizeFractionUsed
diggs_geo:HydrometerType/diggs_geo:soakingPeriod
diggs_geo:HydrometerType/diggs_geo:specificGravityUsed
diggs_geo:LabCompactionTest
diggs_geo:LabCompactionTestTrial
diggs_geo:LabCompactionTestTrialType/diggs_geo:dryDensity
diggs_geo:LabCompactionTestTrialType/diggs_geo:moistureAdjustment
diggs_geo:LabCompactionTestTrialType/diggs_geo:otherTrialProperty
diggs_geo:LabCompactionTestTrialType/diggs_geo:tamperReading
diggs_geo:LabCompactionTestTrialType/diggs_geo:trialNo
diggs_geo:LabCompactionTestTrialType/diggs_geo:waterContent
diggs_geo:LabCompactionTestType/diggs_geo:blowsPerLayer
diggs_geo:LabCompactionTestType/diggs_geo:compactionTestType
diggs_geo:LabCompactionTestType/diggs_geo:mouldDiameter
diggs_geo:LabCompactionTestType/diggs_geo:mouldVolume
diggs_geo:LabCompactionTestType/diggs_geo:numberOfLayers
diggs_geo:LabCompactionTestType/diggs_geo:rammerDiameter
diggs_geo:LabCompactionTestType/diggs_geo:rammerDrop
diggs_geo:LabCompactionTestType/diggs_geo:rammerIsManual
diggs_geo:LabCompactionTestType/diggs_geo:rammerMass
diggs_geo:LabCompactionTestType/diggs_geo:trial
diggs_geo:LabDensityTest
diggs_geo:PanData
diggs_geo:PanDataType/diggs_geo:otherGradingProperty
diggs_geo:PanDataType/diggs_geo:percentLoss
diggs_geo:PanDataType/diggs_geo:percentRetained
diggs_geo:PanDataType/diggs_geo:weightRetained
diggs_geo:ParticleSizeTest
diggs_geo:ParticleSizeTestType/diggs_geo:hydrometer
diggs_geo:ParticleSizeTestType/diggs_geo:sieveAnalysis
diggs_geo:PlasticLimitTrial
diggs_geo:PlasticLimitTrialType/diggs_geo:isManual

Complex Types

diggs_geo:AtterbergLimitsTestType
diggs_geo:CasagrandeTrialPropertyType
diggs_geo:CasagrandeTrialType
diggs_geo:DriveSetPropertyType
diggs_geo:DriveSetType
diggs_geo:DrivenPenetrationTestType
diggs_geo:FallConeTrialPropertyType
diggs_geo:FallConeTrialType
diggs_geo:GradingPropertyType
diggs_geo:GradingType
diggs_geo:HydrometerPropertyType
diggs_geo:HydrometerType
diggs_geo:LabCompactionTestTrialPropertyType
diggs_geo:LabCompactionTestTrialType
diggs_geo:LabCompactionTestType
diggs_geo:PanDataPropertyType
diggs_geo:PanDataType
diggs_geo:ParticleSizeTestType
diggs_geo:PlasticLimitTrialPropertyType
diggs_geo:PlasticLimitTrialType
diggs_geo:SedimentationPropertyType
diggs_geo:SedimentationType
diggs_geo:ShrinkageLimitTrialPropertyType
diggs_geo:ShrinkageLimitTrialType
diggs_geo:SieveAnalysisPropertyType
diggs_geo:SieveAnalysisType
diggs_geo:SpecifiGravityTestType
diggs_geo:WaterContentTestType

Simple Types

diggs_geo:AtterbergInitialConditionEnumType
diggs_geo:CompactionTestEnumType

diggs_geo:PlasticLimitTrialType/diggs_geo:trialNo
diggs_geo:PlasticLimitTrialType/diggs_geo:waterContent
diggs_geo:Sedimentation
diggs_geo:SedimentationType/diggs_geo:clockTime
diggs_geo:SedimentationType/diggs_geo:compositeCorrection
diggs_geo:SedimentationType/diggs_geo:correctedReading
diggs_geo:SedimentationType/diggs_geo:effectiveLength
diggs_geo:SedimentationType/diggs_geo:elapsedTime
diggs_geo:SedimentationType/diggs_geo:hydrometerReading
diggs_geo:SedimentationType/diggs_geo:particleDiameter
diggs_geo:SedimentationType/diggs_geo:percentPassing
diggs_geo:SedimentationType/diggs_geo:temperature
diggs_geo:ShrinkageLimitTrial
diggs_geo:ShrinkageLimitTrialType/diggs_geo:massDrySoil
diggs_geo:ShrinkageLimitTrialType/diggs_geo:trialNo
diggs_geo:ShrinkageLimitTrialType/diggs_geo:volumeDrySoil
diggs_geo:ShrinkageLimitTrialType/diggs_geo:volumeWetSoil
diggs_geo:ShrinkageLimitTrialType/diggs_geo:waterContentWetSoil
diggs_geo:SieveAnalysis
diggs_geo:SieveAnalysisType/diggs_geo:gradingData
diggs_geo:SieveAnalysisType/diggs_geo:otherSieveAnalysisProperty
diggs_geo:SieveAnalysisType/diggs_geo:panData
diggs_geo:SieveAnalysisType/diggs_geo:sandGravelConsistency
diggs_geo:SieveAnalysisType/diggs_geo:wetSieved
diggs_geo:SpecifiGravityTestType/diggs_geo:correctionFactorForWaterTemperature
diggs_geo:SpecifiGravityTestType/diggs_geo:temperatureWaterAndSoil
diggs_geo:SpecifiGravityTestType/diggs_geo:waterTemperature
diggs_geo:SpecificGravityTest
diggs_geo:WaterContentTest
diggs_geo:WaterContentTestType/diggs_geo:dryingTemperature
diggs_geo:WaterContentTestType/diggs_geo:dryingTime
diggs_geo:WaterContentTestType/diggs_geo:waterContentFromTrimmings

http://www.opengis.net/gml/3.3/lrov

Complex Types

glrov:VectorType

http://www.witsml.org/schemas/131

Complex Types

witsml:abstractMeasure
witsml:accelerationLinearMeasure
witsml:anglePerLengthMeasure
witsml:anglePerTimeMeasure
witsml:areaMeasure
witsml:areaPerAreaMeasure
witsml:cost
witsml:densityMeasure
witsml:dimensionlessMeasure
witsml:dynamicViscosityMeasure
witsml:electricCurrentMeasure
witsml:electricPotentialMeasure
witsml:encodedArrayString
witsml:energyPerAreaMeasure
witsml:equivalentPerMassMeasure
witsml:forceMeasure
witsml:forcePerLengthMeasure
witsml:forcePerVolumeMeasure
witsml:frequencyMeasure
witsml:generalMeasureType
witsml:genericMeasure
witsml:illuminanceMeasure
witsml:indexCurve
witsml:indexedObject
witsml:lengthMeasure
witsml:lengthPerLengthMeasure
witsml:magneticFieldStrengthMeasure
witsml:magneticInductionMeasure
witsml:massConcentrationMeasure
witsml:massMeasure
witsml:massPerLengthMeasure
witsml:measuredDepthCoord
witsml:momentOfForceMeasure
witsml:nameStruct
witsml:perLengthMeasure
witsml:planeAngleMeasure
witsml:powerMeasure
witsml:pressureMeasure
witsml:ratioGenericMeasure
witsml:refNameString
witsml:refObjectString
witsml:refPositiveCount
witsml:relativePowerMeasure
witsml:specificVolumeMeasure
witsml:temperatureSlopeMeasure
witsml:thermodynamicTemperatureMeasure
witsml:timeMeasure
witsml:typeOptionalClassString
witsml:velocityMeasure
witsml:volumeFlowRateMeasure
witsml:volumeMeasure
witsml:volumePerVolumeMeasure
witsml:volumePerVolumeMeasurePercent
witsml:wellElevationCoord
witsml:wellKnownNameStruct
witsml:wellVerticalDepthCoord
witsml:yAxisAzimuth

Simple Types

witsml:ActivityClassType
witsml:ActivityCode
witsml:ArrayElementDataType
witsml:AziRef
witsml:BearingType
witsml:BhaStatus
witsml:BitDullCode
witsml:BitReasonPulled
witsml:BitType
witsml:BladeShapeType
witsml:BladeType
witsml:BopType
witsml:BoxPinConfig
witsml:CementJobType
witsml:ConnectionPosition
witsml:DeflectionMethod
witsml:DerrickType
witsml:DrawWorksType
witsml:DriveType
witsml:ElevCodeEnum
witsml:Ellipsoid
witsml:FiberMode
witsml:GasPeakType
witsml:GeodeticDatum
witsml:Hemispheres
witsml:HoleCasingType
witsml:HoleOpenerType
witsml:InstalledFiberPoint
witsml:IntervalMethod
witsml:IntervalType
witsml:ItemState
witsml:JarAction
witsml:JarType
witsml:LithologySource
witsml:LithologyType
witsml:LogDataType
witsml:LogIndexDirection
witsml:LogIndexType
witsml:LogTraceOrigin
witsml:LogTraceState
witsml:MaterialType
witsml:MeasuredDepthUom
witsml:MeasurementType
witsml:MessageProbability
witsml:MessageSeverity
witsml:MessageType
witsml:MudLogParameterType
witsml:NADTypes
witsml:NameTagLocation
witsml:NameTagNumberingScheme
witsml:NameTagTechnology
witsml:NozzleType
witsml:OTDRReason
witsml:PercentUom
witsml:PitType
witsml:Projection
witsml:ProjectionVariantsObliqueMercator
witsml:PumpOpType
witsml:PumpType
witsml:QualifierType
witsml:RealtimeData
witsml:RigType
witsml:RiskAffectedPersonnel
witsml:RiskCategory
witsml:RiskSubCategory

witsml:RiskType
witsml:ScrType
witsml:ShowFluorescence
witsml:ShowLevel
witsml:ShowRating
witsml:ShowSpeed
witsml:SupportCraft
witsml:SurfEquipType
witsml:TargetCategory
witsml:TargetScope
witsml:TargetSectionScope
witsml:TrajStationStatus
witsml:TrajStationType
witsml:TubularAssembly
witsml:TubularComponent
witsml:TypeSurveyTool
witsml:WellDirection
witsml:WellFluid
witsml:WellPurpose
witsml:WellStatus
witsml:WellVerticalCoordinateUom
witsml:WellboreShape
witsml:WellboreType
witsml:abstractBoolean
witsml:abstractCommentString
witsml:abstractDate
witsml:abstractDateTime
witsml:abstractDouble
witsml:abstractInt
witsml:abstractMaximumLengthString
witsml:abstractNameString
witsml:abstractPositiveCount
witsml:abstractShort
witsml:abstractString
witsml:abstractTypeEnum
witsml:abstractUidString
witsml:abstractUncollapsedString
witsml:abstractUomEnum
witsml:abstractYear
witsml:accelerationLinearUom
witsml:anglePerLengthUom
witsml:anglePerTimeUom
witsml:anyDate
witsml:areaPerAreaUom
witsml:areaUom
witsml:beaufortScaleIntegerCode
witsml:calendarYear
witsml:commentString
witsml:date
witsml:densityUom
witsml:descriptionString
witsml:dimensionlessUom
witsml:dynamicViscosityUom
witsml:electricCurrentUom
witsml:electricPotentialUom
witsml:encodedValueString
witsml:energyPerAreaUom
witsml:equivalentPerMassUom
witsml:forcePerLengthUom
witsml:forcePerVolumeUom
witsml:forceUom
witsml:frequencyUom
witsml:geodeticZoneString
witsml:iadcBearingWearCode
witsml:iadcIntegerCode
witsml:illuminanceUom
witsml:integerCount
witsml:kindString
witsml:lengthPerLengthUom
witsml:lengthUom
witsml:levelIntegerCode
witsml:listOfDouble
witsml:listOfString
witsml:logicalBoolean
witsml:magneticFieldStrengthUom
witsml:magneticInductionUom
witsml:massConcentrationUom
witsml:massPerLengthUom
witsml:massUom
witsml:momentOfForceUom
witsml:nameString
witsml:nonNegativeCount
witsml:perLengthUom
witsml:planeAngleUom
witsml:positiveBigCount
witsml:positiveCount
witsml:powerUom
witsml:pressureUom
witsml:pumpActionIntegerCode
witsml:refString
witsml:refWellDatum
witsml:relativePowerUom
witsml:schemaVersionString
witsml:shortDescriptionString
witsml:specificVolumeUom
witsml:str16
witsml:str2
witsml:str32
witsml:thermodynamicTemperatureUom
witsml:timeUom
witsml:timeZone
witsml:timestamp
witsml:uidString
witsml:uncollapsedString
witsml:unitlessQuantity
witsml:uomString
witsml:velocityUom
witsml:volumeFlowRateUom
witsml:volumePerVolumeUom
witsml:volumeUom

http://www.w3.org/1999/xlink

Attributes	Attribute Groups
@xlink:actuate	xlink:arcLink
@xlink:arcrole	xlink:emptyLink
@xlink:from	xlink:extendedLink
@xlink:href	xlink:locatorLink
@xlink:label	xlink:resourceLink
@xlink:role	xlink:simpleLink
@xlink:show	xlink:titleLink
@xlink:title	
@xlink:to	
xlink:arcLink/@xlink:type	
xlink:emptyLink/@xlink:type	
xlink:extendedLink/@xlink:type	
xlink:locatorLink/@xlink:type	
xlink:resourceLink/@xlink:type	
xlink:simpleLink/@xlink:type	
xlink:titleLink/@xlink:type	

No namespace

Attributes

diggs:CodeWithAuthorityType/@codeSpace
diggs:ColorPropertyType/@character
diggs:ComponentLithologyType/@association
diggs:DensityOrUnitWeightMeasureType/@uom
diggs:EmailType/@type
diggs:FeatureReferenceType/@identifierRef
diggs:FieldPropertyType/diggs:otherFieldProperty/@propertyName
diggs:FractionalReferenceType/@percentage
diggs:IndexedParameterType/@codeSpace
diggs:IndexedParameterType/@description
diggs:IndexedParameterType/@index
diggs:IndexedParameterType/@name
diggs:IndexedParameterType/@uom
diggs:NullDataType/@reason
diggs:ParticleSizeValueType/@uom
diggs:PercentDoubleType/@uom
diggs:PercentMeasureType/@uom
diggs:PhoneType/@type
diggs:PropertyType/@index
diggs:StrainPerTimeMeasureType/@uom
diggs:Val0-100MeasureType/@uom
diggs:areaPerTimeMeasure/@uom
diggs:forcePerTimeMeasure/@uom
glrov:VectorType/@offsetUom
gml:AbstractTimeGeometricPrimitiveType/@frame
gml:AggregationAttributeGroup/@aggregationType
gml:AssociationAttributeGroup/@nilReason
gml:CodeType/@codeSpace
gml:CodeWithAuthorityType/@codeSpace
gml:CoordinateSystemAxisType/@uom
gml:CoordinatesType/@cs
gml:CoordinatesType/@decimal
gml:CoordinatesType/@ts
gml:DirectPositionListType/@count
gml:GridType/@dimension
gml:MeasureType/@uom
gml:OrientableCurveType/@orientation
gml:OwnershipAttributeGroup/@owns
gml:RelatedTimeType/@relativePosition
gml:SRSInformationGroup/@axisLabels
gml:SRSInformationGroup/@uomLabels
gml:SRSReferenceGroup/@srsDimension
gml:SRSReferenceGroup/@srsName
gml:SequenceRuleType/@axisOrder
gml:TimePositionType/@calendarEraName
gml:TimePositionType/@frame
gml:TimePositionType/@indeterminatePosition
gml:UnitOfMeasureType/@uom
gml:referenceSystem/@codeSpace
gml:referenceSystem/@uom
witsml:accelerationLinearMeasure/@uom
witsml:anglePerLengthMeasure/@uom
witsml:anglePerTimeMeasure/@uom
witsml:areaMeasure/@uom
witsml:areaPerAreaMeasure/@uom
witsml:cost/@currency
witsml:densityMeasure/@uom
witsml:dimensionlessMeasure/@uom
witsml:dynamicViscosityMeasure/@uom
witsml:electricCurrentMeasure/@uom
witsml:electricPotentialMeasure/@uom
witsml:encodedArrayString/@uom
witsml:energyPerAreaMeasure/@uom
witsml:equivalentPerMassMeasure/@uom
witsml:forceMeasure/@uom
witsml:forcePerLengthMeasure/@uom
witsml:forcePerVolumeMeasure/@uom
witsml:frequencyMeasure/@uom
witsml:generalMeasureType/@uom
witsml:genericMeasure/@uom
witsml:illuminanceMeasure/@uom
witsml:indexCurve/@columnIndex
witsml:indexedObject/@description
witsml:indexedObject/@index
witsml:indexedObject/@name
witsml:indexedObject/@uom
witsml:lengthMeasure/@uom
witsml:lengthPerLengthMeasure/@uom
witsml:magneticFieldStrengthMeasure/@uom
witsml:magneticInductionMeasure/@uom
witsml:massConcentrationMeasure/@uom
witsml:massMeasure/@uom
witsml:massPerLengthMeasure/@uom
witsml:measuredDepthCoord/@datum

witsml:measuredDepthCoord/@uom
witsml:momentOfForceMeasure/@uom
witsml:nameStruct/@namingSystem
witsml:perLengthMeasure/@uom
witsml:planeAngleMeasure/@uom
witsml:powerMeasure/@uom
witsml:pressureMeasure/@uom
witsml:ratioGenericMeasure/@denominator
witsml:ratioGenericMeasure/@numerator
witsml:ratioGenericMeasure/@uom
witsml:refNameString/@uidRef
witsml:refObjectString/@object
witsml:refObjectString/@uidRef
witsml:refPositiveCount/@uidRef
witsml:relativePowerMeasure/@uom
witsml:specificVolumeMeasure/@uom
witsml:temperatureSlopeMeasure/@uom
witsml:thermodynamicTemperatureMeasure/@uom
witsml:timeMeasure/@uom
witsml:typeOptionalClassString/@classType
witsml:velocityMeasure/@uom
witsml:volumeFlowRateMeasure/@uom
witsml:volumeMeasure/@uom
witsml:volumePerVolumeMeasure/@uom
witsml:volumePerVolumeMeasurePercent/@uom
witsml:wellElevationCoord/@datum
witsml:wellElevationCoord/@uom
witsml:wellKnownNameStruct/@code
witsml:wellKnownNameStruct/@namingSystem
witsml:wellVerticalDepthCoord/@datum
witsml:wellVerticalDepthCoord/@uom
witsml:yAxisAzimuth/@northDirection
witsml:yAxisAzimuth/@uom

http://www.w3.org/XML/1998/namespace

Attributes	Attribute Groups
@xml:base	xml:specialAttrs
@xml:id	
@xml:lang	
@xml:space	

Main schema Complete.xsd

Namespace	http://diggsml.org/schemas/2.0.b
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **2.0.b**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/Complete.xsd

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Imported schema gml3.2Profile_diggs.xsd

Namespace	http://www.opengis.net/gml/3.2
Annotations	GML Subset schema for ,PointPropertyType,CodeType,EngineeringDatum,CoordinateSystemAxis,CurvePropertyType,AbstractGML,AbstractFeature,MultiGeometryPropertyType,MultiPointPropertyType ,AssociationAttributeGroup,ReferenceType,EngineeringDatumType,CoordinateSystemAxisType,AbstractGMLType,AbstractFeatureCollectionType,AbstractFeatureType, written by gmlSubset.xslt.
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **3.2.1**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/gml3.2Profile_diggs.xsd

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Imported schema xlinks.xsd

Namespace	http://www.w3.org/1999/xlink
Annotations	GML 3.0 candidate xlinks schema. Copyright (c) 2001 OGC, All Rights Reserved.
Properties	Attribute Form Default **unqualified** Element Form Default **unqualified** Version **2.0**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/xlinks.xsd

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Imported schema gml3.3Profile_diggs.xsd

Namespace	http://www.opengis.net/gml/3.3/ce
Annotations	Draft GML 3.3 subset for DIGGS including: LinearReferencing, Compact Geometry Encodings
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **3.3.0**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/gml3.3Profile_diggs.xsd

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Imported schema glrProfile_diggs.xsd

Namespace	http://www.opengis.net/gml/3.3/lr
Annotations	GML 3.3 profile for DIGGS including: Basic Linear Referencing
Properties	Attribute Form Default **unqualified** Element Form Default **qualified**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/glrProfile_diggs.xsd

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Imported schema glrovProfile_diggs.xsd

Namespace	http://www.opengis.net/gml/3.3/lrov
Annotations	GML 3.3 profile for DIGGS including: Vector Offset Linear Referencing
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **3.3.0**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/glrovProfile_diggs.xsd

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Included schema Kernel.xsd

Namespace	http://diggsml.org/schemas/2.0.b
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **2.0.b**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/Kernel.xsd

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Imported schema xml.xsd

Namespace	http://www.w3.org/XML/1998/namespace
Annotations	 About the XML namespace This schema document describes the XML namespace, in a form suitable for import by other schema documents. See http://www.w3.org/XML/1998/namespace.htmland http://www.w3.org/TR/REC-xmlfor information about this namespace. Note that local names in this namespace are intended to be defined only by the World Wide Web Consortium or its subgroups. The names currently defined in this namespace are listed below. They should not be used with conflicting semantics by any Working Group, specification, or document instance. See further below in this document for more information about how to refer to this schema document from your own XSD schema documentsand about the namespace-versioning policy governing this schema document. Father (in any context at all) denotes Jon Bosak, the chair of the original XML Working Group. This name is reserved by the following decision of the W3C XML Plenary and XML Coordination groups: <blockquote> In appreciation for his vision, leadership and dedication the W3C XML Plenary on this 10th day of February, 2000, reserves for Jon Bosak in perpetuity the XML name "xml:Father". </blockquote> About this schema document This schema defines attributes and an attribute group suitable for use by schemas wishing to allow <code>xml:base</code>, <code>xml:lang</code>, <code>xml:space</code>or <code>xml:id</code>attributes on elements they define. To enable this, such a schema must import this schema for the XML namespace, e.g. as follows: <pre><schema . . .> . . . <import namespace="http://www.w3.org/XML/1998/namespace" schemaLocation="http://www.w3.org/2001/xml.xsd"/></pre> or <pre><import namespace="http://www.w3.org/XML/1998/namespace" schemaLocation="http://www.w3.org/2009/01/xml.xsd"/></pre> Subsequently, qualified reference to any of the attributes or the group defined below will have the desired effect, e.g. <pre><type . . .> . . . <attributeGroup ref="xml:specialAttrs"/></pre> will define a type which will schema-validate an instance element with any of those attributes. Versioning policy for this schema document In keeping with the XML Schema WG's standard versioning policy, this schema document will persist at http://www.w3.org/2009/01/xml.xsd. At the date of issue it can also be found at http://www.w3.org/2001/xml.xsd. The schema document at that URI may however change in the future, in order to remain compatible with the latest version of XML Schema itself, or with the XML namespace itself. In other words, if the XML Schema or XML namespaces change, the version of this document at http://www.w3.org/2001/xml.xsdwill change accordingly; the version at http://www.w3.org/2009/01/xml.xsdwill not change.

```
<p>Previous dated (and unchanging) versions of this schema document are at:</p>
<ul>
<li>
<a href="http://www.w3.org/2009/01/xml.xsd">http://www.w3.org/2009/01/xml.xsd</a>
</li>
<li>
<a href="http://www.w3.org/2007/08/xml.xsd">http://www.w3.org/2007/08/xml.xsd</a>
</li>
<li>
<a href="http://www.w3.org/2004/10/xml.xsd">http://www.w3.org/2004/10/xml.xsd</a>
</li>
<li>
<a href="http://www.w3.org/2001/03/xml.xsd">http://www.w3.org/2001/03/xml.xsd</a>
</li>
</ul>
</div>
</div>
```

Properties	Attribute Form Default **unqualified** Element Form Default **unqualified**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/xml.xsd

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Imported schema Geotechnical.xsd

Namespace	http://diggsml.org/schemas/2.0.b/geotechnical
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **2.0.b**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/Geotechnical.xsd

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Imported schema typ_dataTypes.xsd

Namespace	http://www.witsml.org/schemas/131
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **1.3.1**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/witsml/1.3.1.1/typ_dataTypes.xsd

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Included schema typ_catalog.xsd

Namespace	http://www.witsml.org/schemas/131
Annotations	WITSML- Catalog of Value Constrainted Types.
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **1.3.1**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/witsml/1.3.1.1/typ_catalog.xsd

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Included schema typ_measureType.xsd

Namespace	http://www.witsml.org/schemas/131
Annotations	These types represent numeric quantities with a unit of measure implemented as a uom attribute. The units are gathered into single quantity class which represents a group of units. The unit symbols appropriate for the class are captured as enumerated lists. The implementation of this is to develop a type for each uom class that is a union of a standard list, the unknown value, and the Other: extension. Additional files will contain these structures.
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **1.3.1**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/witsml/1.3.1.1/typ_measureType.xsd

[top]

Included schema typ_quantityClass.xsd

Namespace	http://www.witsml.org/schemas/131
Annotations	This file defines a set of standard POSC units of measure for various quantity classes. This units list captures information contained in the POSC units dictionary at http://www.posc.org/refs/poscUnits20.xml. The enumerated lists do not contain any deprecated units.
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **1.3.1**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/witsml/1.3.1.1/typ_quantityClass.xsd

[top]

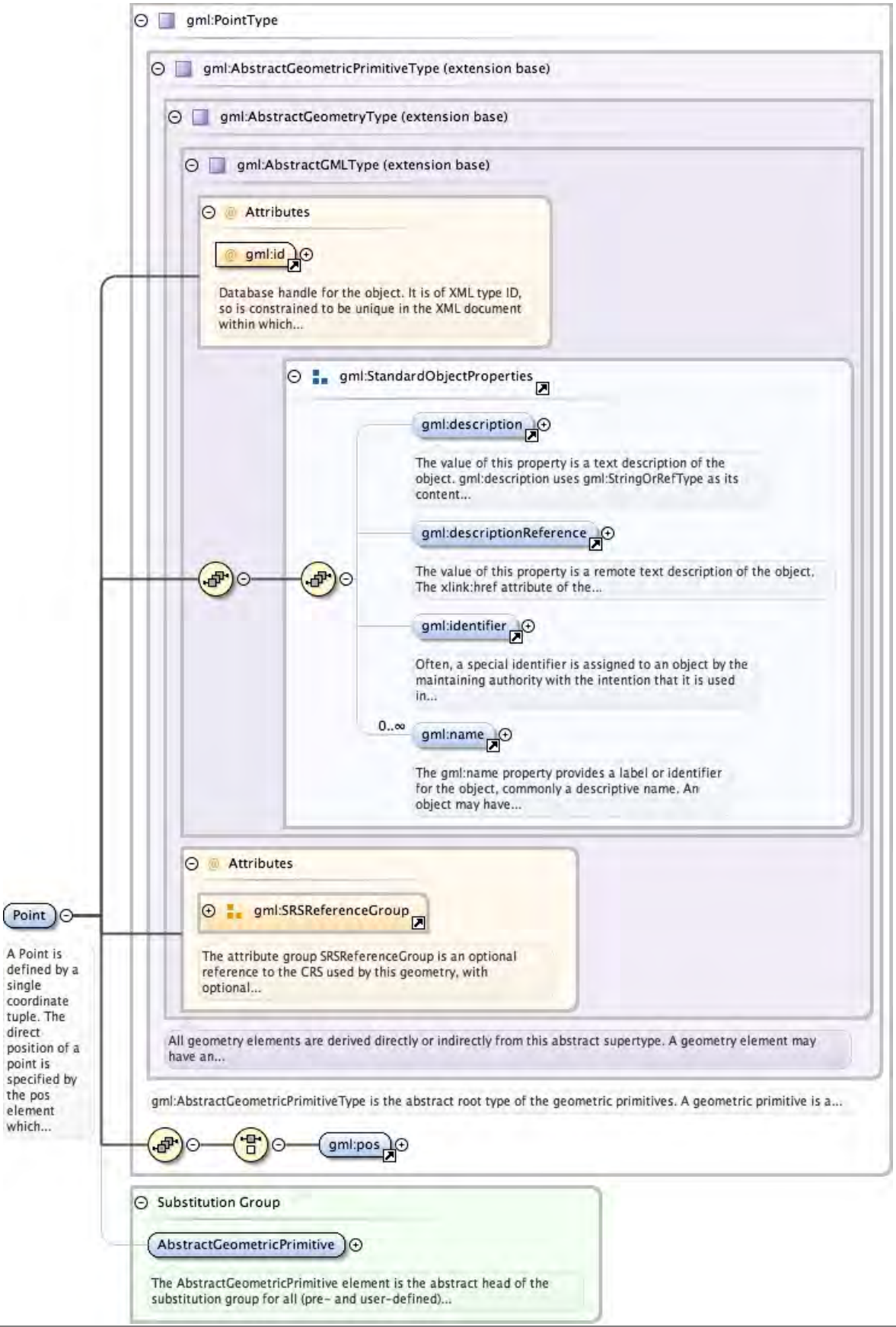
Included schema typ_baseType.xsd

Namespace	http://www.witsml.org/schemas/131
Properties	Attribute Form Default **unqualified** Element Form Default **qualified** Version **1.3.1**
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/witsml/1.3.1.1/typ_baseType.xsd

[top]

Element gml:Point

Namespace	http://www.opengis.net/gml/3.2
Annotations	A Point is defined by a single coordinate tuple. The direct position of a point is specified by the pos element which is of type DirectPositionType.
Diagram	

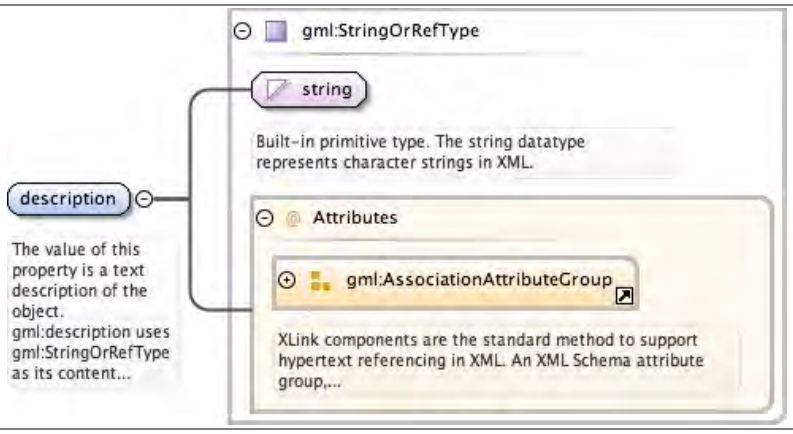


Type	**gml:PointType**
Type hierarchy	**gml:AbstractGMLType** **gml:AbstractGeometryType** **gml:AbstractGeometricPrimitiveType** **gml:PointType**
Properties	Content **complex**
Substitution Group Affiliation	**gml:AbstractGeometricPrimitive**

Used by	Complex Types	**gml:PointArrayPropertyType**, **gml:PointPropertyType**		
Model	**gml:description{0,1}** , **gml:descriptionReference{0,1}** , **gml:identifier{0,1}** , **gml:name*** , (**gml:pos**)			
Children	**gml:description**, **gml:descriptionReference**, **gml:identifier**, **gml:name**, **gml:pos**			
Instance	<gml:Point axisLabels="" gml:id="" srsDimension="" srsName="" uomLabels="" xmlns:gml="http://www.opengis.net/gml/3.2"> <gml:description xlink:actuate="" xlink:arcrole="" xlink:href="" nilReason="" xlink:role="" xlink:show="" xlink:title="" xlink:type="simple">{0,1}</gml:description> <gml:descriptionReference xlink:actuate="" xlink:arcrole="" xlink:href="" nilReason="" owns="false" xlink:role="" xlink:show="" xlink:title="" xlink:type="simple">{0,1}</gml:descriptionReference> <gml:identifier codeSpace="">{0,1}</gml:identifier> <gml:name codeSpace="">{0,unbounded}</gml:name> <gml:pos axisLabels="" srsDimension="" srsName="" uomLabels="">{1,1}</gml:pos> </gml:Point>			
Attributes	QName	Type	Use	Annotation
	axisLabels	**gml:NCNameList**	optional	
	gml:id	**ID**	required	Database handle for the object. It is of XML type ID, so is constrained to be unique in the XML document within which it occurs. An external identifier for the object in the form of a URI may be constructed using standard XML and XPointer methods. This is done by concatenating the URI for the document, a fragment separator, and the value of the id attribute.
	srsDimension	**positiveInteger**	optional	
	srsName	**anyURI**	optional	
	uomLabels	**gml:NCNameList**	optional	
Source	<element name="Point" type="gml:PointType" substitutionGroup="gml:AbstractGeometricPrimitive"> <annotation> <documentation>A Point is defined by a single coordinate tuple. The direct position of a point is specified by the pos element which is of type DirectPositionType.</documentation> </annotation> </element>			
Schema location	file:/Volumes/Capronno/DIGGS Revisions/2016-02-10/DIGGS2.0.bSchemas-01-20-2016/gml3.2Profile_diggs.xsd			

[top]

Element gml:description

Namespace	http://www.opengis.net/gml/3.2
Annotations	The value of this property is a text description of the object. gml:description uses gml:StringOrRefType as its content model, so it may contain a simple text string content, or carry a reference to an external description. The use of gml:description to reference an external description has been deprecated and replaced by the gml:descriptionReference property.
Diagram	
Type	**gml:StringOrRefType**
Properties	Content: **complex**
Used by	Element Group: **gml:StandardObjectProperties** Complex Types: **diggs:AbstractCurveType**, **diggs:AbstractDescriptionSystemType**, **diggs:AbstractDescriptionType**, **diggs:AbstractEquipmentType**, **diggs:AbstractEventType**, **diggs:AbstractFeatureBaseType**, **diggs:AbstractFeatureType**, **diggs:AbstractGeometricAggregateType**, **diggs:AbstractGeometricPrimitiveType**, **diggs:AbstractGeometryType**, **diggs:AbstractGroupType**, **diggs:AbstractInsituTestType**, **diggs:AbstractLaboratoryTestType**, **diggs:AbstractLinearSamplingFeatureType**, **diggs:AbstractMeasurementType**, **diggs:AbstractMetaDataType**, **diggs:AbstractNamedFeatureType**, **diggs:AbstractNamedObjectType**, **diggs:AbstractObjectBaseType**, **diggs:AbstractObjectType**, **diggs:AbstractPlanarSamplingFeatureType**, **diggs:AbstractPointSamplingFeatureType**, **diggs:AbstractProcedureTrialType**, **diggs:AbstractSamplingFeatureType**, **diggs:AbstractSurfaceType**, **diggs:AbstractTestProcedureType**, **diggs:AbstractTimeObjectBaseType**, **diggs:AbstractTimeObjectType**, **diggs:AddressType**, **diggs:AssociatedFileType**, **diggs:BackfillLayerType**, **diggs:BackfillType**, **diggs:BlockSampleDetailType**, **diggs:BoreholeDiameterType**, **diggs:BoreholeEventType**, **diggs:BoreholeType**, **diggs:BoundaryType**, **diggs:BusinessAssociateType**, **diggs:CalibrationType**, **diggs:CasingType**, **diggs:ChainOfCustodyEventType**, **diggs:ChiselingType**, **diggs:ColorDescriptionType**, **diggs:ColorSystemType**, **diggs:ColorType**, **diggs:ComponentLithologyType**, **diggs:ConstituentDescriptionType**, **diggs:ConstituentSystemType**, **diggs:ConstituentType**, **diggs:ConstructionMethodType**, **diggs:ContractType**, **diggs:CylindricalSampleDetailType**, **diggs:DelayEventType**, **diggs:DetectorType**, **diggs:DiscontinuityDescriptionType**, **diggs:DiscontinuitySystemType**, **diggs:EnvironmentType**, **diggs:EquipmentType**, **diggs:FieldPropertyType**, **diggs:FlushType**, **diggs:FractureDescriptionType**, **diggs:FractureSpacingType**, **diggs:GroupGroupType**, **diggs:LimitType**, **diggs:LineStringType**, **diggs:LinearSpatialReferenceSystemType**, **diggs:LithologyDescriptionType**, **diggs:LithologySystemType**, **diggs:LithologyType**, **diggs:MeasureOrStringType**, **diggs:MonitorType**, **diggs:MultiCurveType**, **diggs:MultiTimeInstantType**, **diggs:OrientationDescriptionType**, **diggs:OrientationSystemType**, **diggs:OrientationType**, **diggs:OtherDescriptionSystemType**, **diggs:OtherDescriptionType**, **diggs:ParameterType**, **diggs:ParticleDensityType**, **diggs:ParticleSizeDistributionType**, **diggs:ParticleSizeType**, **diggs:PlanarObservationRepresentationType**, **diggs:PointType**, **diggs:PolygonType**, **diggs:PostStrikeReadingType**, **diggs:ProjectGroupType**, **diggs:ProjectType**, **diggs:PropertyType**, **diggs:ReadingType**, **diggs:SampleGroupType**, **diggs:SampleProducedType**, **diggs:SampleType**, **diggs:SamplingActivityType**, **diggs:SamplingFeatureGroupType**, **diggs:SensorType**, **diggs:SimpleMultiPointType**, **diggs:SizeFractionType**, **diggs:SoftwareApplicationType**, **diggs:SoundingEventType**, **diggs:SpecificationType**, **diggs:SpecimenConditionsType**, **diggs:StationType**, **diggs:StratigraphyDescriptionType**, **diggs:StratigraphySystemType**, **diggs:TestType**, **diggs:TimeIntervalType**, **diggs:TrialPitEventType**, **diggs:TrialPitType**, **diggs:ValueAtTimeType**, **diggs:VectorLinearSpatialReferenceSystemType**, **diggs:WaterStrikeType**, **diggs_geo:AtterbergLimitsTestType**, **diggs_geo:CasagrandeTrialType**, **diggs_geo:DriveSetType**, **diggs_geo:DrivenPenetrationTestType**, **diggs_geo:FallConeTrialType**, **diggs_geo:GradingType**, **diggs_geo:HydrometerType**, **diggs_geo:LabCompactionTestTrialType**, **diggs_geo:LabCompactionTestType**, **diggs_geo:PanDataType**,

Appendix D: Feedback Tool

DIGGS Feedback Tool

Convert any Excel Spreadsheet, AGS File, HoleBASE SI or gINT project to DIGGS

Version 1.1
18th June 2016

Contents

Introduction

This tool has been created by Keynetix, the leading geotechnical data management company, to enable organisations piloting DIGGS to be able to create DIGGS data files from their current data sources.

Installation

There is no installation program for this version of the DIGGS feedback tool. To be able to use the program follow the instructions below

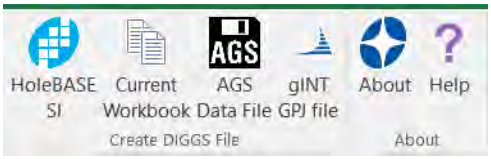
1. Save the DIGGSfeedback.zip file to a location on your machine.
2. Extract the contents of this file to a directory on your machine and you will have the following files in your directory
    a. DIGGSFeedbackTool.xlam
    b. DIGGSFeedbacKTool.PDF
    c. Conversions Folder with one Conversion mapping
    d. Demo Data folder with one Excel Spreadsheet.

Opening the DIGGS Feedback Tool

The tool is an Excel Add-in file and can be loaded by double clicking on the DIGGSFeedbackTool.xlam file in windows Explorer or opening the file using Excel's normal file open methods.

On opening you may see the following message. It is important to Enable Macros on this form otherwise the tool will not load.

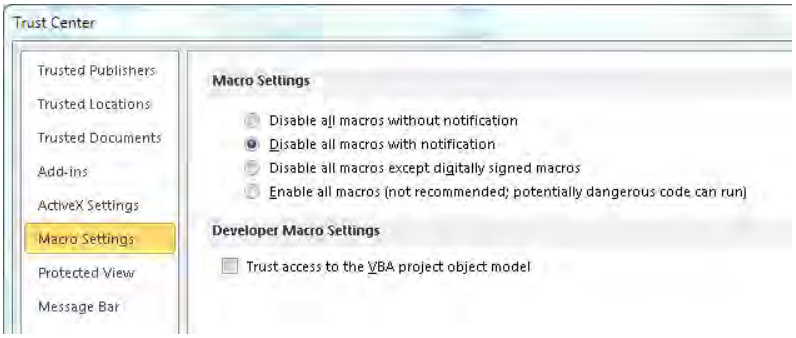
Once loaded the tool will add a Ribbons in Excel 2007, 2010, 2013 and will add a customer menu in Excel 2003.



If you are unable to see this ribbon it is likely that the security settings on your copy of Excel are set to not allow macros. If so you need to set your Excel security level to medium by following the steps below.

1. From the ***Developer*** tab select the ***Macro Security*** option as shown below

2. Select the second option in the list (as shown below). This option will ensure that you are prompted to enable macros each time you load a spreadsheet with code in it.



Creating your first DIGGS file

To show you how the system works a demo data set has been created. This takes a single Atterberg result and converts it to DIGGS data.

To run this example, follow the steps below.

1) Open the DIGGS Feedback Tool
2) Open the "ASTM Atterberg Input" Excel file shipped in the demo data directory
3) Select the "Current Workbook" option in the Create section of the DIGGS ribbon
4) Select "Atterberg Example" from the mapping folder.
5) You should see a default DIGGS filename has been completed based on the name and location of the spreadsheet you are converting.

6) Click the convert button. You will now see a successful message and the DIGGS file will have been created.

How does the system work?

The DIGGS file is created using snippets of XML that can be mapped to each Excel spreadsheet and assembled in a specific order. Each snippet is stored in a .txt file with instructions on what to do with the XML snippet at the top of the file.

The conversion starts by reading the start.txt file in the conversion mapping folder and creates the XML file using the rules below.

When reading the rules below it may help to review the example mapping file at the same time.

Referencing Additional Snippets

Each snippet file can reference one or more additional snippet files using the [[file]] syntax.

The Start file below shows how the DIGGS XML header and footer is written and the TRAN and PROJ snippets are included.

<Diggs>

[[TRAN]]

[[PROJ]]

</Diggs>

Referencing Columns in Snippets

Each snippet file contains a set of header parameters that link the snippet to a sheet in the current workbook. Each snippet of XML data is run for each row of data in the spreadsheet.

```
**sheet=PROJECT
**HeaderRow=1
**DataStartRow=2
-----------------
<project>
        <Project gml:id="{{Number}}">
            <gml:name>{{NAME}}</gml:name>
            <!--NO roles defined for this file conversion<role>
                <Role>
                    <rolePerformed>Client</rolePerformed>
                    <businessAssociate>{{PROJ_CLNT}}</businessAssociate>
                </Role>
            </role>-->
            <location>{{location}}</location>
        </Project>
</project>
```

Each snippet of XML contains header references {{column}} that are replaced with the data in the cells on the spreadsheet as they are run.

Additional fields in Snippets

A GML:ID can be automatically generated using the {{AUTOID}} label in a snippet file

Today's date can be inserted into a file using the {{NOW}} label in a snippet file

Excluding Sections of snippets

Within each snippet file NULL statements can be included that blank out the part of the XML file between the NULL and the NULLEND tags if the field contains a blank value or does not exist. In the example below the section of XML is not included in the output if the ISPT_PEN2 value is blank or not present in the spreadsheet.

```
NULL{{ISPT_PEN2}}
                    <diggs_geo:driveSet>
                        <diggs_geo:DriveSet gml:id="{{LOCA_ID}}-SPT-{{ISPT_TOP}}D2">
                            <diggs_geo:index>2</diggs_geo:index>
                            <diggs_geo:blowCount>{{ISPT_PEN2}}</diggs_geo:blowCount>
                            <diggs_geo:penetration uom="mm">{{ISPT_PEN2}}</diggs_geo:penetration>
                        </diggs_geo:DriveSet>
                    </diggs_geo:driveSet>
NULLEND
```

Excluding Snippets

Each snippet file can reference one or more additional snippet files using the [[file]] syntax.

To ensure that the snippet is only included for the rows of the spreadsheet that match certain requirements you can specify filters and conditions using the syntax shown below.

[[description filter=pointid:condition={{pointid}}]]

In this example the snippet will only be run for items on the spreadsheet that are for the current pointID

Header parameters

The following parameters can be added at the top of the snippet file.

**sheet=ISPT - AGS	Links the snippet to a sheet in the workbook
**HeaderRow=1	Defines what row on the sheet the headers are on
**UnitRow=2	Defined what row on the sheet the Units are on
**DataStartRow=4	Defines what row the data starts on

Creating DIGGS from an Excel Spreadsheet

At the core of the feedback is the routine that extracts data in an Excel file into a DIGGS data format.

1) Open the Excel file
2) Select the "Current Workbook" option in the Create section of the DIGGS ribbon
3) Select the required mapping folder.
4) You should see a default DIGGS filename has been completed based on the name and location of the spreadsheet you are converting.
5) Click the convert button. You will now see a successful message and the DIGGS file will have been created

Creating DIGGS data from gINT

The feedback tool includes a routine that extracts all the information from the gINT project file into an Excel spreadsheet. The routine then runs the conversion as explained above. This technique allows you to convert any gINT project file into a DIGGS data format.

Because of the unique nature of each gINT project there are no example gINT conversions that are shipped with the program but Keynetix will be happy to assist you in the creation of a mapping file. For more information please contact us at support@keynetix.com

Creating DIGGS data from AGS file

The feedback tool includes a routine that extracts all the information from an AGS file into an Excel spreadsheet. The routine then runs the conversion as explained above. This technique allows you to convert any AGS 4 project file into a DIGGS data format.

Because of the standardised way an AGS 4 file is structured a standard conversion file will be shipped with the program in a later version.

Appendix E: Validator Instructions

DIGGS Validator Overview

The DIGGS [1] Validator validates DIGGS version 2.0.b **Error! Reference source not found.** instance document files against DIGGS and Geography Markup Language (GML) [3] Extensible Markup Language (XML) [4] Schemas [5] and GML version 3.2.1 and 3.3 requirements. It also validates instance document files against Schematron [5] business rules. It is implemented as a Java [7] Servlet [8] web application hosted in an Apache Tomcat [9] web server based on the Open Geospatial Consortium (OGC) [10] Conformance and Interoperability Test and Evaluation (CITE) [11] TEAM Engine [12] and GML 3.2.1 [13] Executable Test Suite (ETS).

The DIGGS Validator TEAM Engine is also provided with an XSL Transformations (XSLT) [15] pseudo ETS that transforms DIGGS instance document files using XSLT Stylesheets.

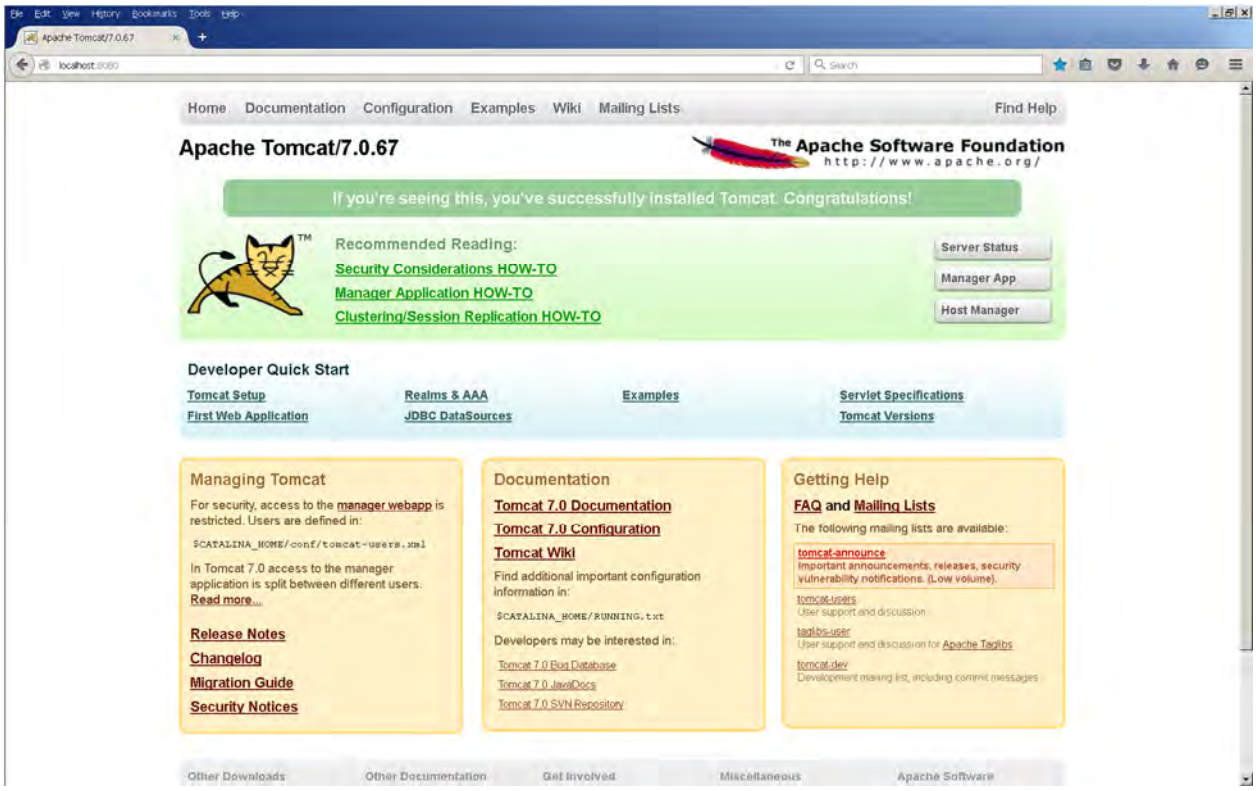
These tools are for

1. Geotechnical and Geoenvironmental specialists who develop and update the ASCE GeoInstitute standard DIGGS schemas, code lists, and dictionaries;
2. Software engineers working for vendors of Geotechnical and Geoenvironmental data collection, storage, analysis, and presentation tools, instruments, databases and applications who are enhancing them to support use of DIGGS instance document files for data input and output;
3. Geotechnical and Geoenvironnental specialists who what to “look under the hood” to see how DIGGS works and how it can be used. Once vendors have implemented DIGGS support in their products, there will be no need for practitioners to investigate these technical details.

The following screen shots and explanatory text provide an overview of Tomcat and DIGGS Validator implementation and use. They are intended to help DIGGS stakeholders assess whether this existing prototype can meet their needs as-is, or whether it is worth further investment in enhancements.

Apache Tomcat Home Page

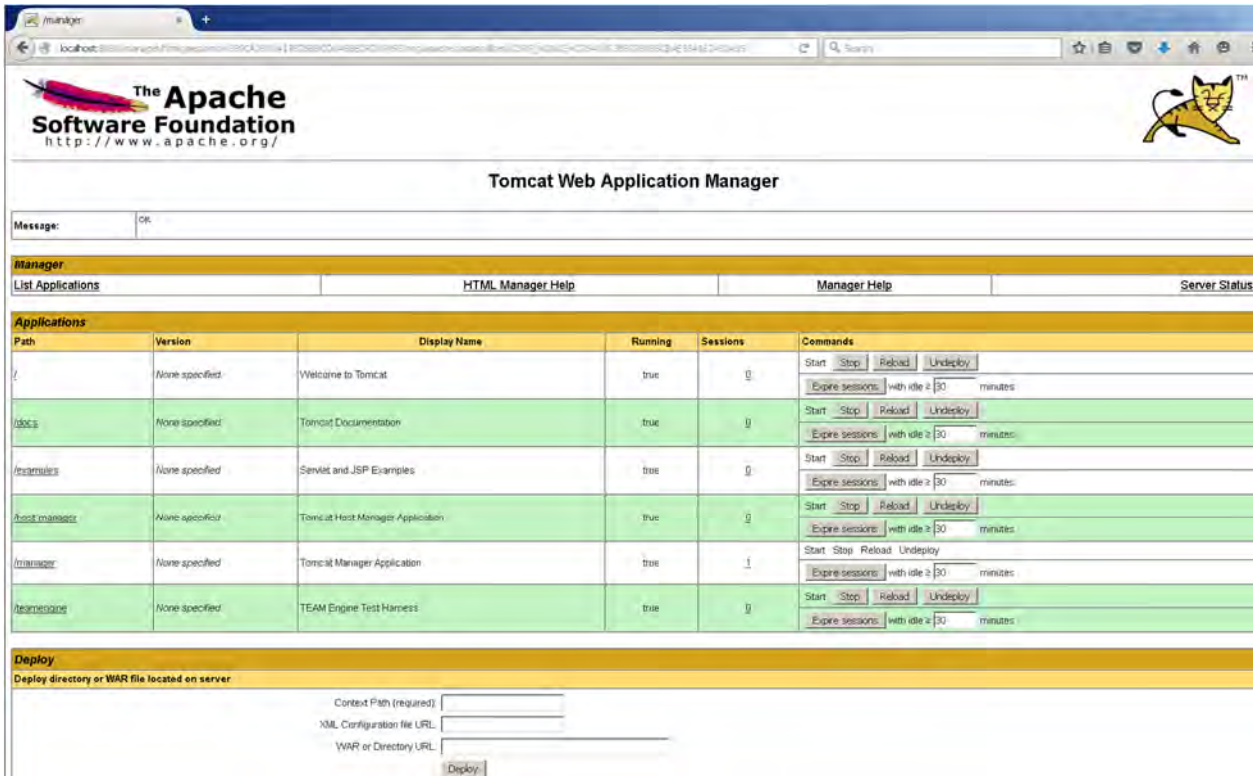
By default Apache Tomcat serves the following home page. It can be removed from a production installation.



Apache Tomcat Web Application Manager

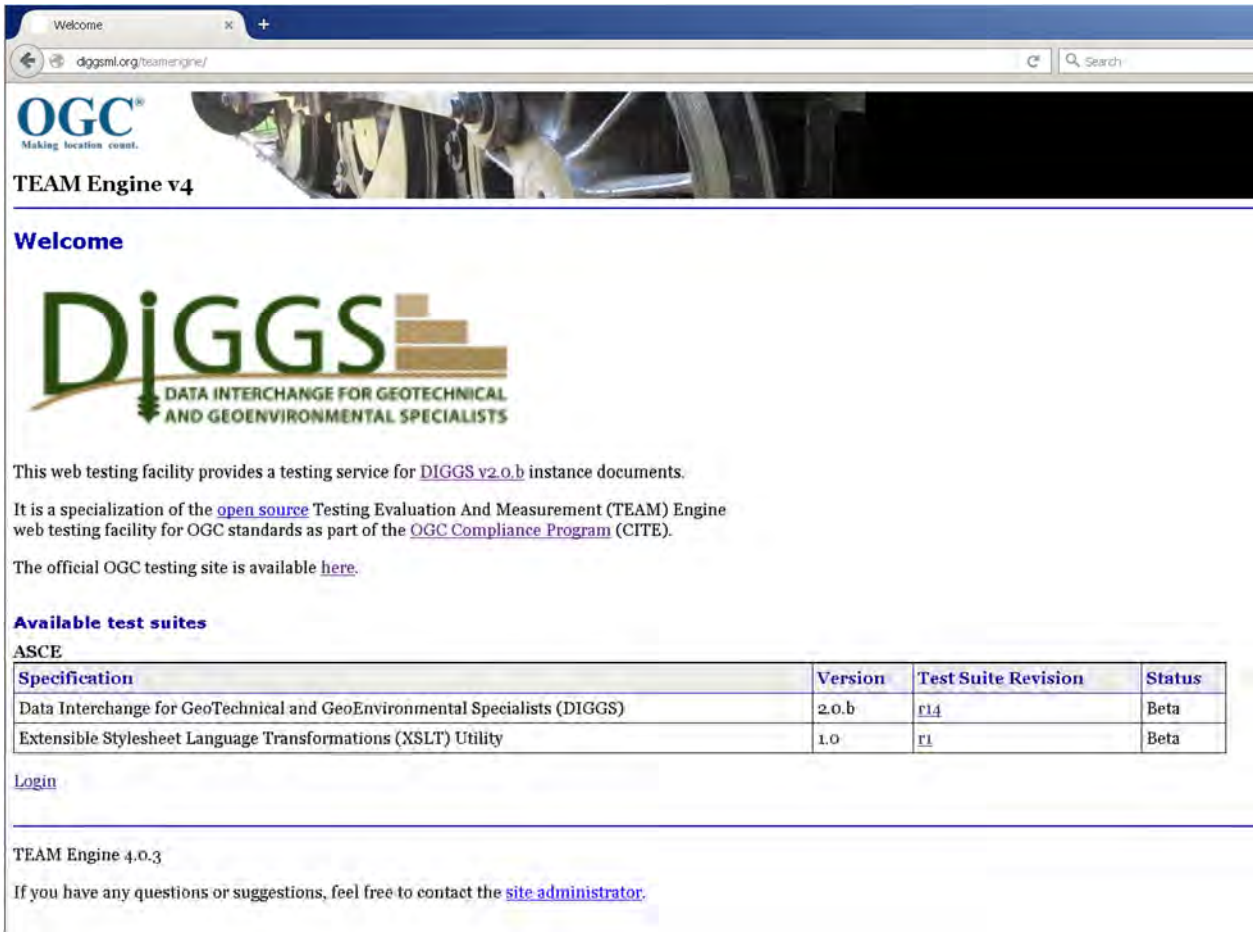
The Apache Tomcat home page includes a link to this Web Application Manager page that allows a Web Administrator to manage the Web applications Tomcat serves. Access to this page requires user authentication. DIGGS Validator users will never see it. By default Tomcat implements a username / password authentication mechanism, but it can be installed with other "security realm" mechanisms.

In addition to the home page and web application manager page applications, by default Tomcat is installed with documentation, examples, and host manager applications. The teamengine application listed at the bottom of the screen implements the DIGGS Validator.



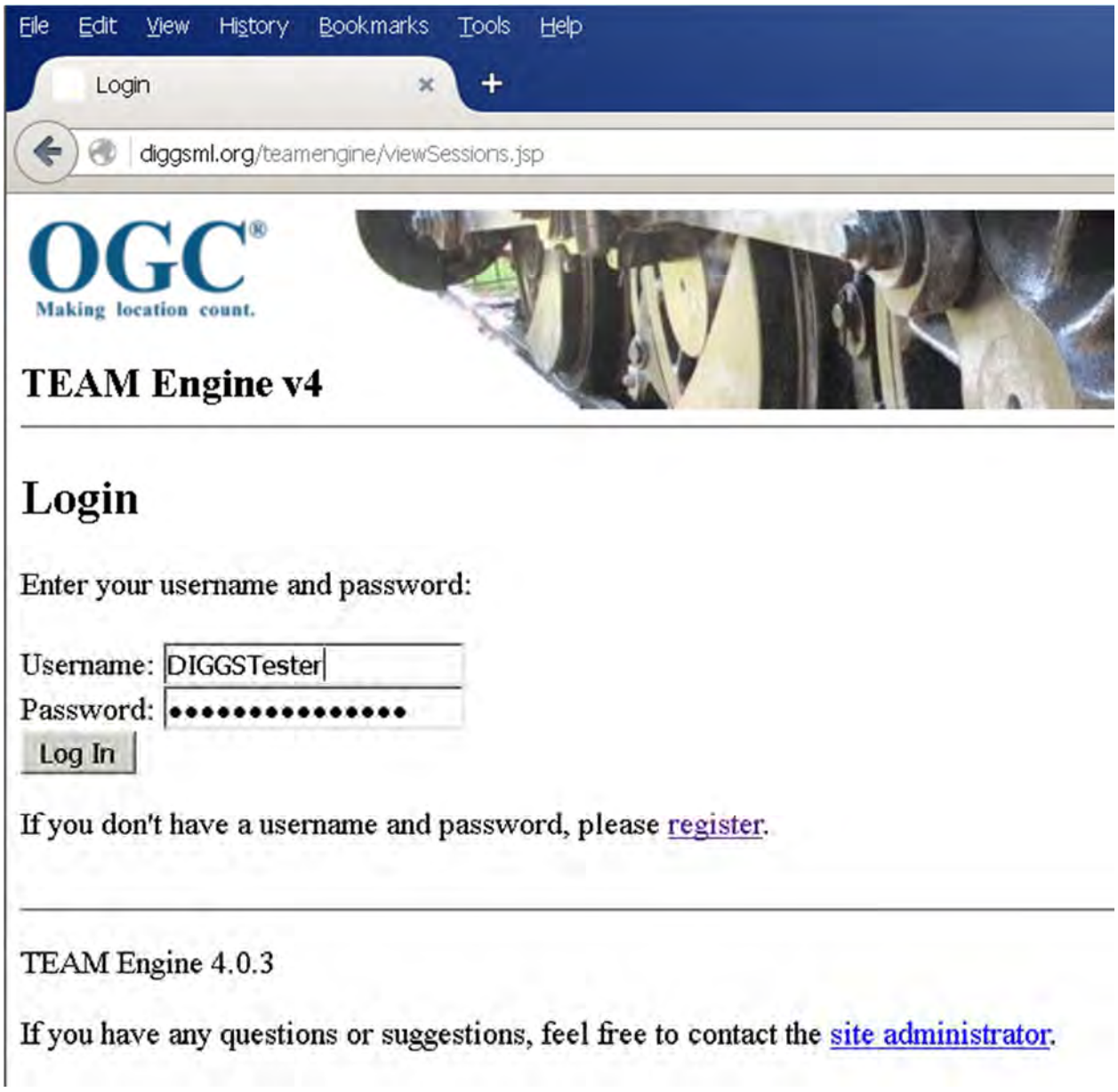
OGC TEAM Engine DIGGS Validator Welcome Page

Most TEAM Engine implementations include more than one Executable Test Suite (ETS). In this case the DIGGS Validator is the only true test suite that performs conformance testing, but an Extensible Stylesheet Language Transformations (XSLT) utility web application is also implemented using TEAM Engine facilities. A user clicks on the "login" link to access the engine and its available test suites.



TEAM Engine Login Page

A user enters their username and password on this page and clicks on the LogIn button to enter the TEAM engine and begin testing. A first-time user must click on the "register" link to establish their login credentials before entering via this page, as shown on the next page.



TEAM Engine Registration Page

A first-time user must establish login credentials on this page. The next page appears after the "Submit" button is pressed.

TEAM Engine User Registration Confirmation

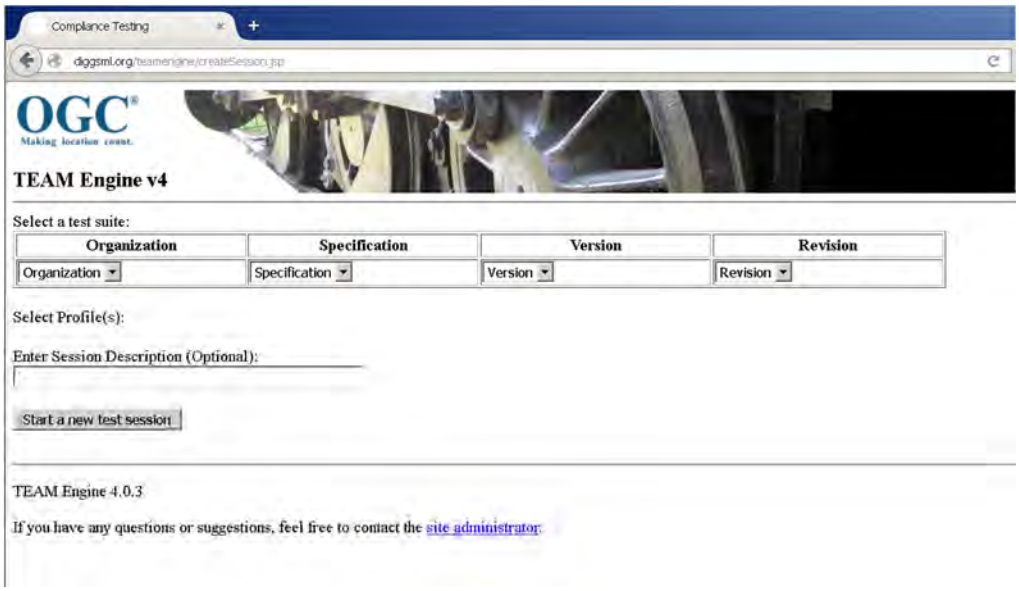
Upon successful registration, a first-time user can click on the "Start Testing" link on this page to begin testing.

TEAM Engine Test Sessions List

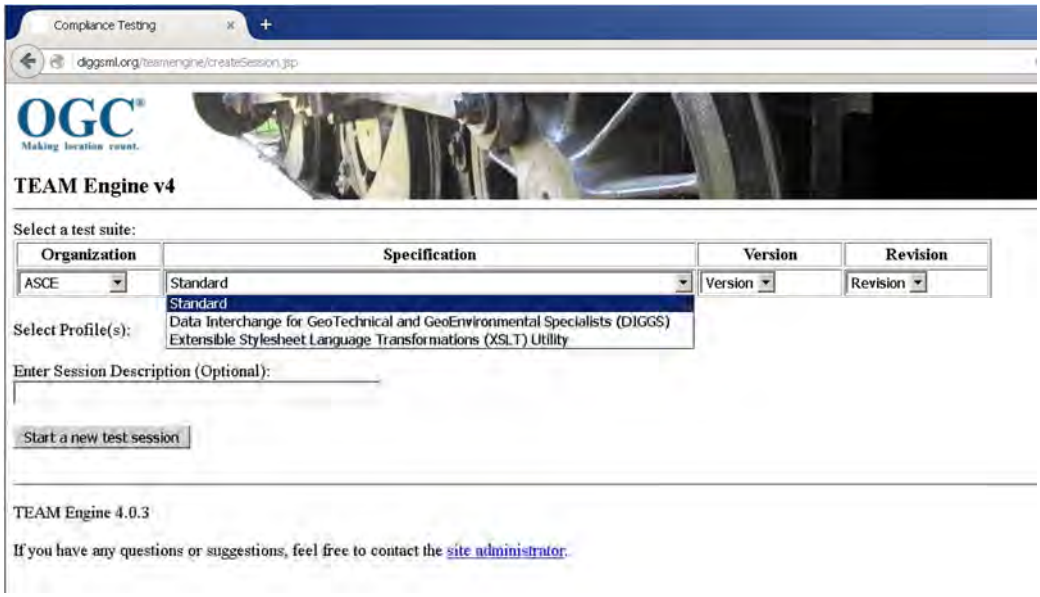
This page lists all test sessions for tests executed by a user. It allows test results to be reexamined, and for tests to be re-run with different parameters. As shown below, there are no existing test sessions for a first-time user, whose only option is to click on the "Create a new session" link. Private XML log files that record test session processing and results for each user are maintained on the TEAM Engine server until deleted by the user.

TEAM Engine Test Suite Selection

Most TEAM Engine installations include a variety of ETS test suites. A user can select an available ETS using the Organization, Specification, Version and Revision drop-down lists on this page.



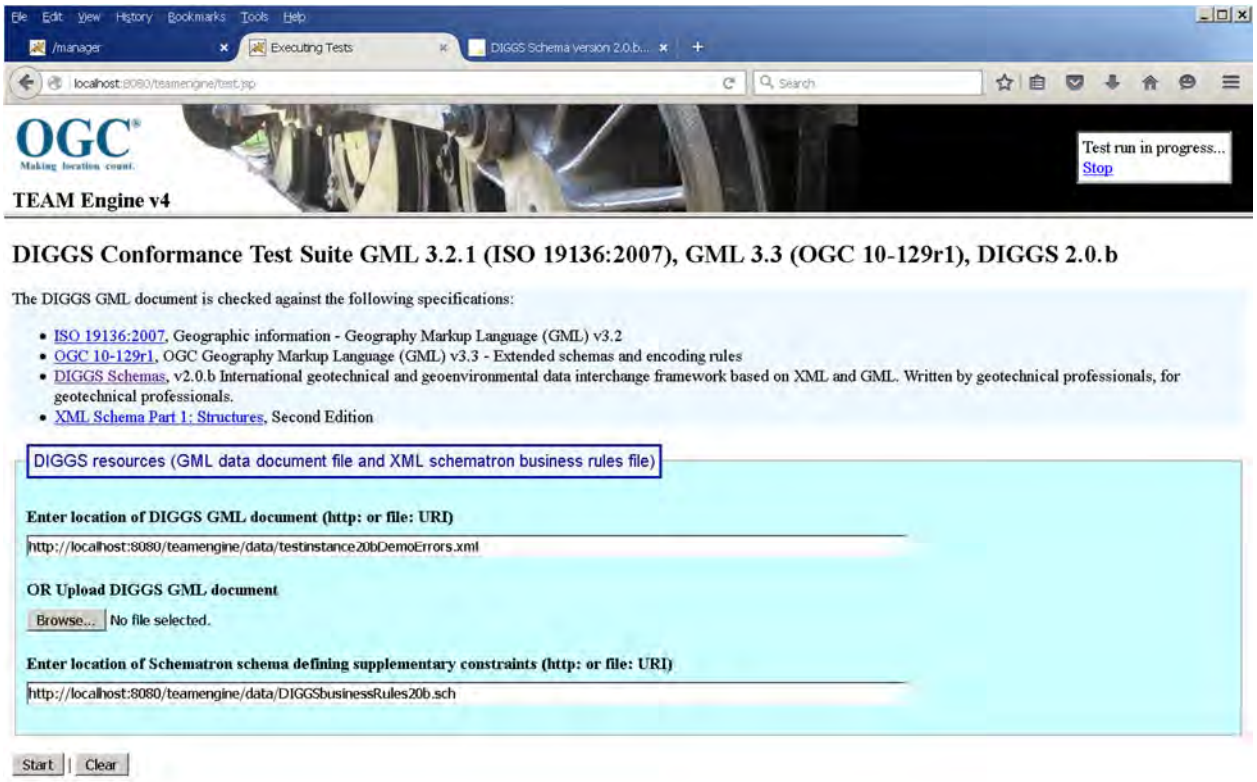
The TEAM Engine installation for DIGGS has been modified to include the DIGGS Validator implemented by the OGC GML version 3.2.1 ETS, and an XSLT Utility Web Application.



With the DIGGS Validator ETS selected, a user can enter a test session description and click on the "Start a new test session" button to start the DIGGS Validator.

DIGGS Validator Parameters Page

This page solicits a DIGGS GML document, which can be specified as a URI to a file: // or html:// or ftp:// document source, or uploaded from the local file system on the user's computer. The default location supplied is beta test instance XML file for use with the current draft DIGGS GML v 2.0.b Schemas. It is included in the DIGGS Validator installation. For testing, a user can also upload a local test file, or reference an online one, that references the online DIGGS GML schemas. Note that the default input file contains errors because it is intended to demonstrate how the Validator reports them.



The user can also specify a Schematron XML file containing business rules in addition to the schema rules that the DIGGS GML document must follow. The default schematron file referenced is a test properties and Coordinate Reference System (CRS) business rules validation .xml file that produces an instance document error report.

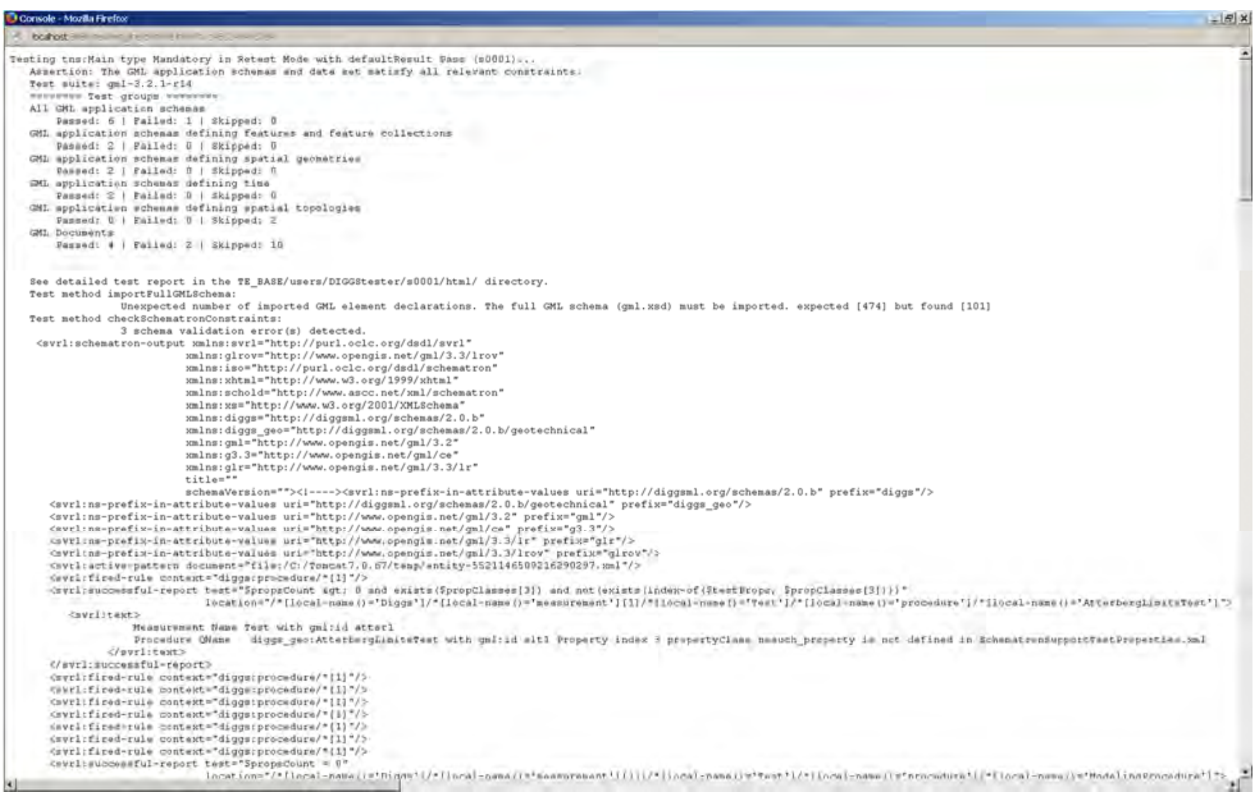
After entering the DIGGS Validator test suite parameters, the user presses the "Start" button to execute the test suite on the specified instance document file.

TEAM Engine Executing Tests Page

On this page, the “Executing tests …” blue gears icon is the equivalent of the traditional “please wait … working” message.

Once the test completes, the contents of its log file are displayed in a separate Test Console window.

TEAM Engine Test Console Window



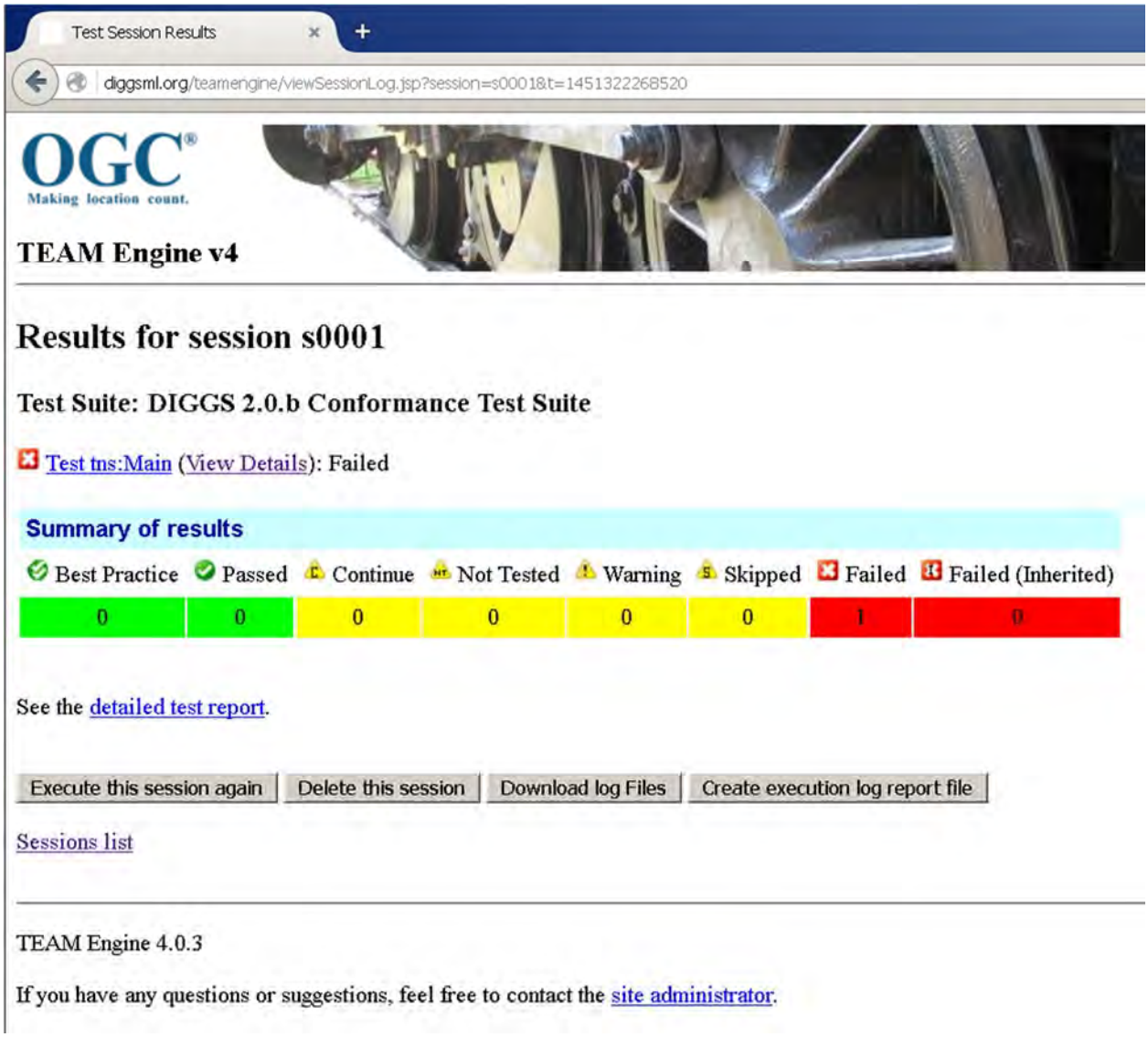
The "Full GML Schema" error message here is expected and may be ignored, because DIGGS uses a profile of GML Schemas. The following error messages are samples from Schematron "business rules" tests to demonstrate test failures. Only the first of these is visible above.

```
Measurement Name Test with gml:id atter1
Procedure QName diggs_geo:AtterbergLimitsTest with gml:id alt1
Property index 3 propertyClass nosuch_property
is not defined in SchematronSupportTestProperties.xml

Measurement Name Test with gml:id pm1
Procedure QName diggs_geo:ModelingProcedure with gml:id mp-1
is not defined in SchematronSupportTestProperties.xml

@srsName attribute value urn:diggs:def:crs:DIGGS:0.1:nonesuch
of PointLocation with gml:id a33 or a parent element thereof
must be defined in a (vector)LinearSpatialReferenceSystem
or in DIGGS_GML_CRS_DICTIONARY.xml
```

TEAM Engine DIGGS Validator Summary of Test Results

This page shows summary results for groups of tests in the user's first test session. It includes the following links and buttons:

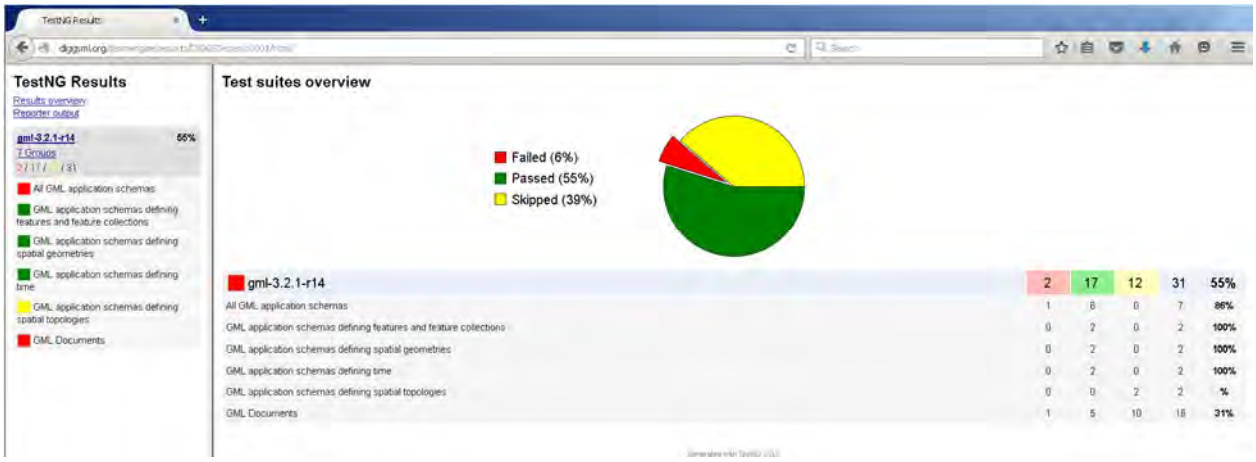
- Test tns:Main link - link to an HTML page showing the test script that was run
- (View Details) link - link to the test session log presented as an HTML page
- Detailed Test Report link - link to a set of detailed test result metric HTML pages
- Execute This Session Again - button to rerun test with different input parameters
- Delete This Session - button to delete this session from web view
- Download Log Files - button to download all log files and detailed HTML pages
- Create Execution Report Log - button to download the (View Details) test session log



Detailed Test Report – Suite Overview

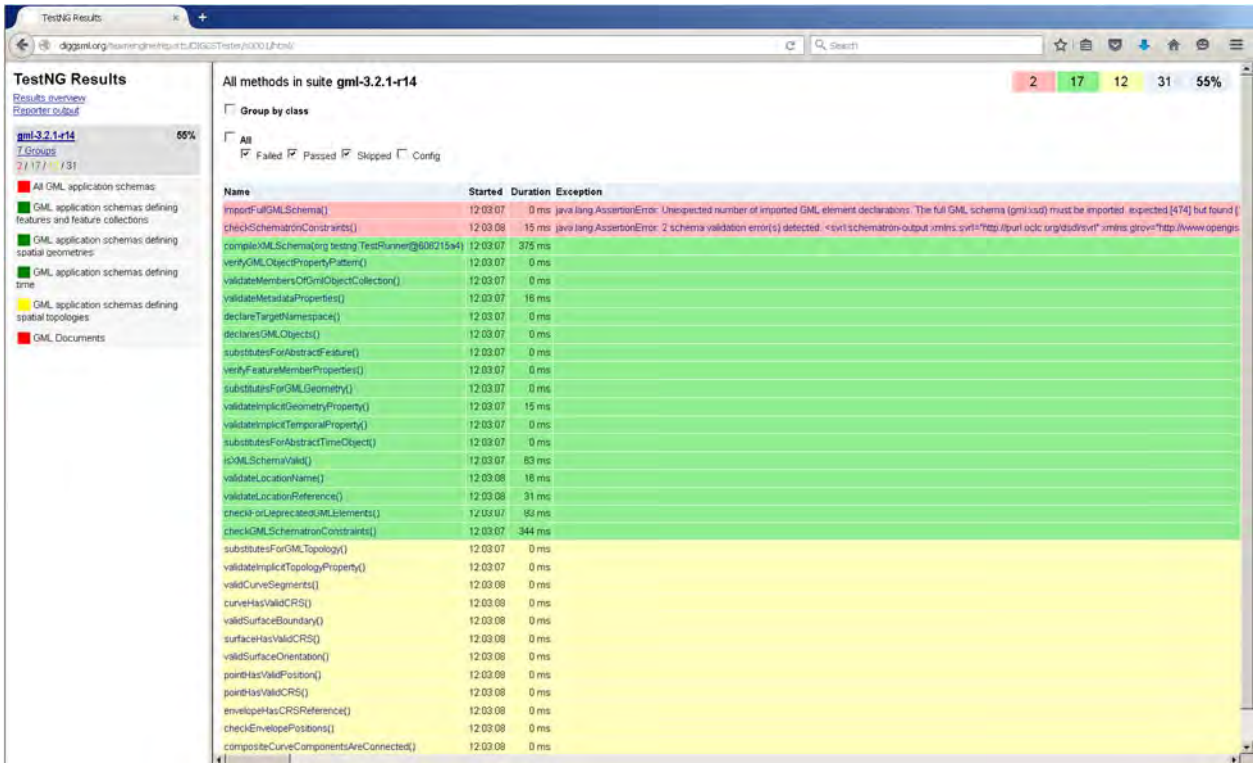
This is the first page shown when a user clicks on the "Detailed Test Report" button on the previous page. The links in the menu on the left hand side provide access to more detailed result metric pages. Those with green icons link to pages where all individual tests passed. Those with red icons link to pages where one or more individual tests failed, or all pages were skipped (which should have yellow icons). Note that DIGGS application schemas do not define temporal or spatial topology types. Despite the red icons, those tests were skipped, i.e. they were not applicable.

The **gml-3.2.1-r14** link leads to the next page where the status of all tests run on the DIGGS schemas are shown. Green indicates tests that passed. Yellow indicates tests that were skipped because either the schemas or the test instance document did not contain the GML definitions or data to support the test. Red indicates tests that failed. The errors in DIGGS schemas (yes, there are some, the schemas are still in development) and instance document are shown at the top of the page.



All Methods in Suite gml-3.2.1-r14

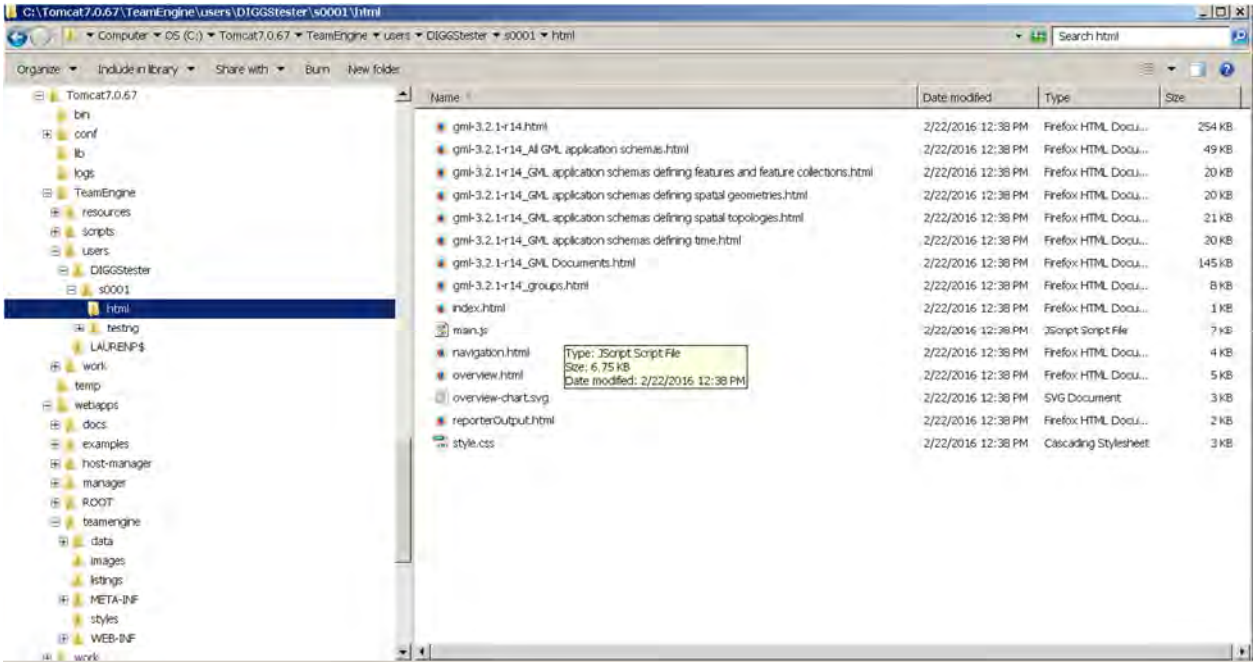
This page displays when the user clicks on the **gml-3.2.1-r14** link on the Test Suites Overview page above. There is one DIGGS schema error on the first pink line below, and one DIGGS instance document file error on the second pink line below. The green lines are tests that passed. The yellow lines are tests that were skipped. To get more details, a user needs to look at the test session console window or the test session log file that saves the console contents.



DIGGS Validator Tomcat Files

The directory listing below shows a sample Tomcat installation of the DIGGS Validator TEAM Engine on a Windows Laptop. The TEAM Engine Web application software is in the webapps/teamengine directory. The testing configuration, test scripts, and data, including user credentials and testing results are in the TeamEngine directory. User testing results are in the TeamEngine/users/{user-name}/s00nn directories, and their html and testng sub directories. Test session results The selected html directory contains all the detailed test results shown in previous pages. These are produced from the actual log files named log.xml in the s00nn directories and sub-directories. The "Download Log Files" button on the test summary page puts an entire s00nn directory tree containing all the results of a test session in a zip archive file for download.

A DIGGS Validator user can only access his or her own test results. A DIGGS Validator Web administrator can see and manage the test results for all users.



Test Session Log Excerpts

The following are excerpts from the log.xml for the sample DIGGS Validator test session shown on previous pages. It resulted in one schema error, which as described above is expected because DIGGS uses profiles of the full GML schemas to improve performance. So this error may be ignored.

```
…
<message id="d68e196_1"><![CDATA[
Test method importFullGMLSchema:
        Unexpected number of imported GML element declarations.
The full GML schema (gml.xsd) must be imported. expected [474] but found [101]
        ]]></message>
…
```

It also includes three DIGGS instance document file errors that failed CRS and test properties business rules:

```
…
<message id="d68e196_2"><![CDATA[
Test method checkSchematronConstraints:
        3 schema validation error(s) detected.
…
<svrl:text>
Measurement Name Test with gml:id atter1
Procedure QName   diggs_geo:AtterbergLimitsTest with gml:id alt1
Property index 3 propertyClass nosuch_property is not defined in
SchematronSupportTestProperties.xml
</svrl:text>
…
<svrl:text>
Measurement Name Test with gml:id pm1
Procedure QName   diggs_geo:ModelingProcedure with gml:id mp-1
is not defined in SchematronSupportTestProperties.xml
</svrl:text>
…
<svrl:text>
@srsName attribute value urn:diggs:def:crs:DIGGS:0.1:nonesuch of
PointLocation with gml:id a33 or a parent element thereof
must be defined in a (vector)LinearSpatialReferenceSystem or in
DIGGS_GML_CRS_DICTIONARY.xml
</svrl:text>
…
</message>
…
```

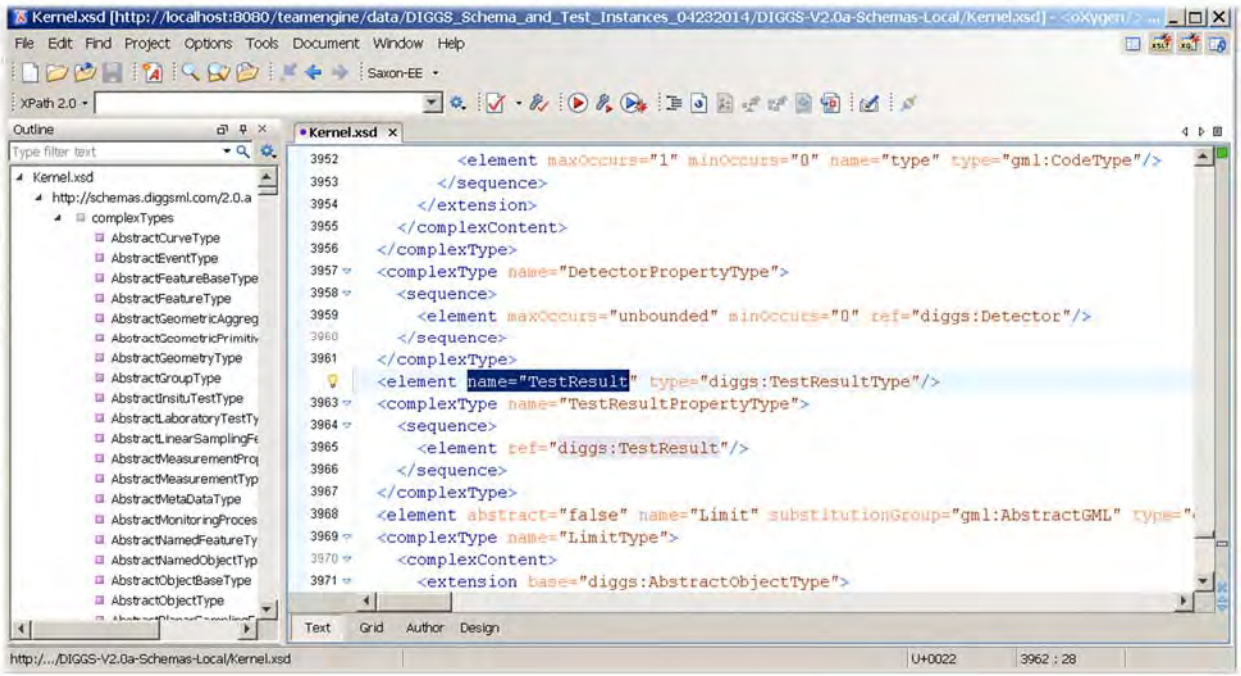

A software engineer working to implement DIGGS support might see instance document errors like those above, whereas a Geotechnical / Geoenvironmental specialists working on developing or extending the DIGGS schemas, code lists, and dictionaries might encounter a schema validation error like the following:

```
…
<message id="d1e199_1"><![CDATA[
Test method substitutesForAbstractFeature:
        Element {http://schemas.diggsml.com/2.0.b}TestResult cannot substitute for
gml:AbstractFeature. expected [true] but found [false]
        ]]></message>
…
```

The following pages will show how to use the Oxygen XML editor to discover and correct these errors.

DIGGS Schema Error Resolution

The test that failed is that the digs:TestResult element does not substitute for the gml:AbstractFeature element.



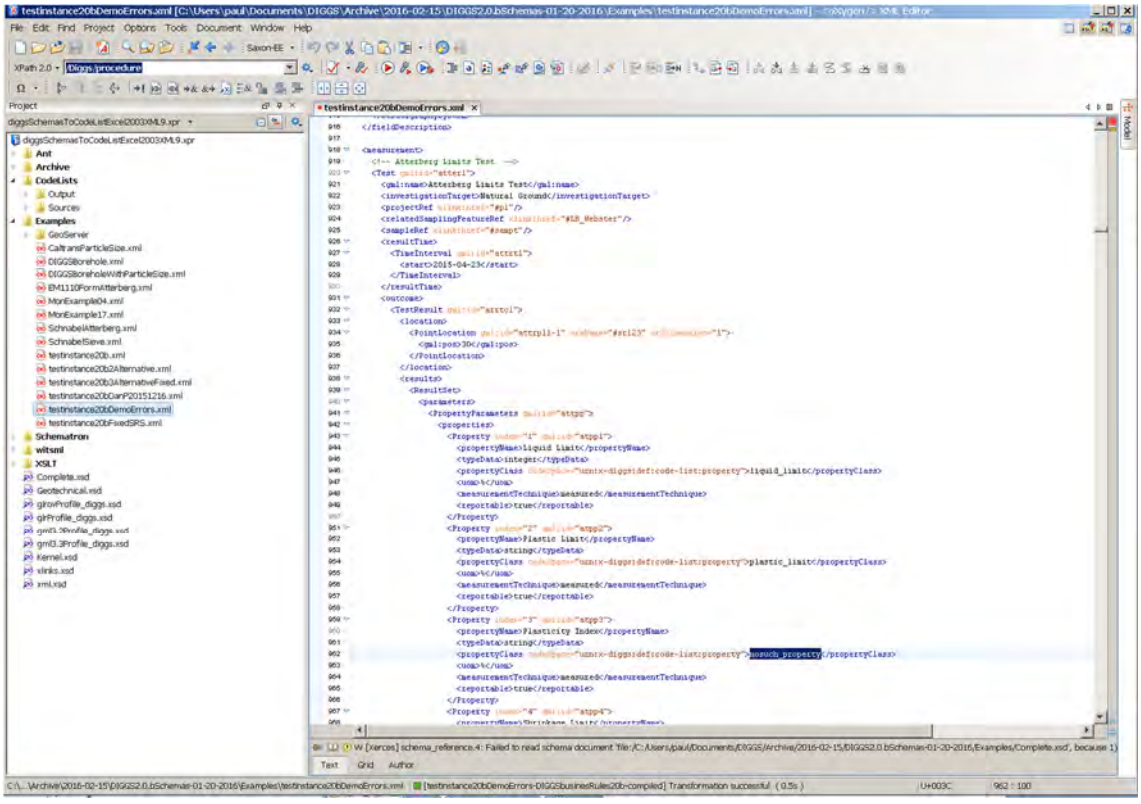
Since digs:TestResultType is a <restriction base="gml:AbstractCoverageType">, what's missing here is a substitutionGroup attribute on the diggsTestResult element:


```
<element name="TestResult" type="diggs:TestResultType"
         substitutionGroup="gml:AbstractCoverage"/>
<!--2014-04-15 PwD added substitutionGroup
      so this element is recognized as a GML Feature by the GML 3.2.1 CITE ETS.
     (This works because gml:AbstractCoverage is in the gml:AbstractFeature substitution group.)
 -->
```

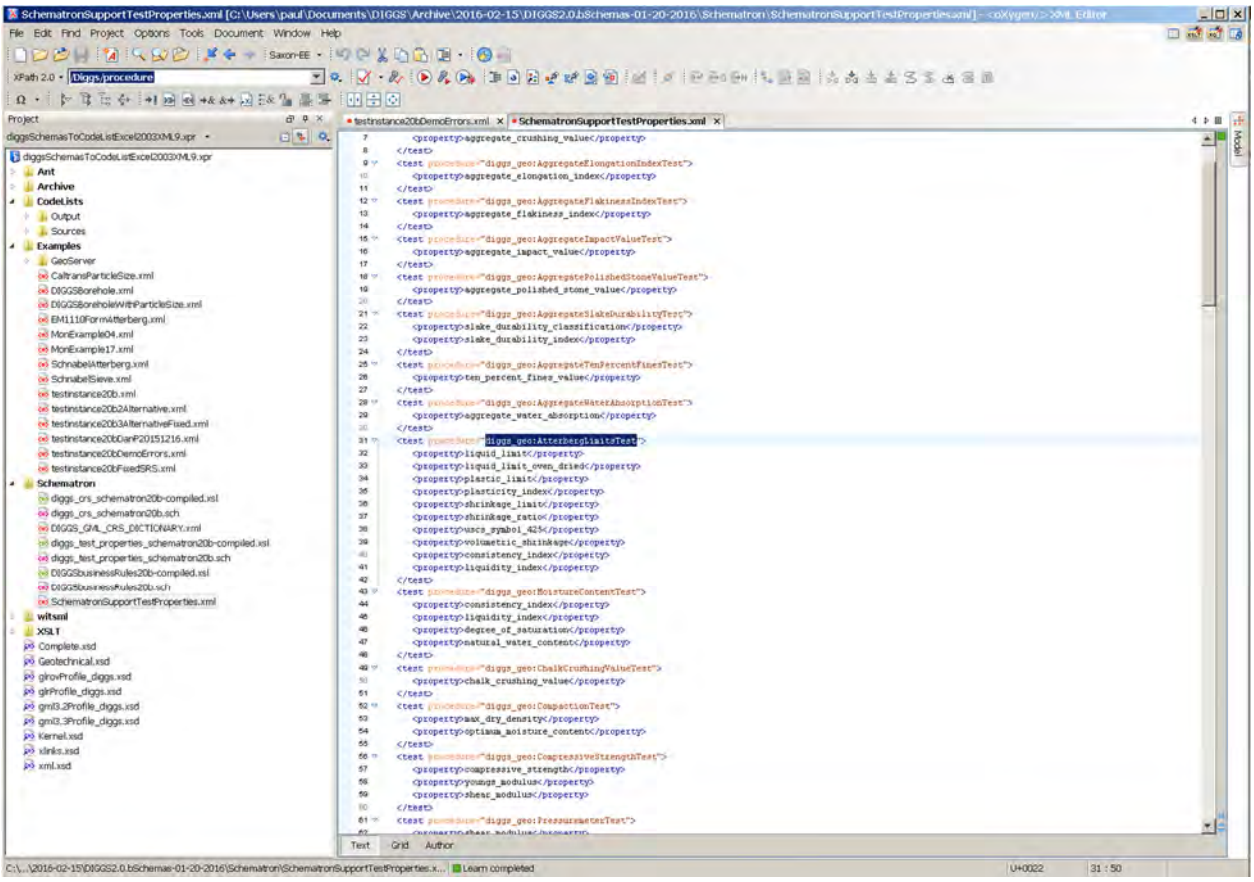
DIGGS Instance Document File Error Resolution

```
…
<svrl:text>
Measurement Name Test with gml:id atter1
Procedure QName   diggs_geo:AtterbergLimitsTest with gml:id alt1
Property index 3 propertyClass nosuch_property is not defined in
SchematronSupportTestProperties.xml
</svrl:text>
…
```

The test that failed is that “nosuch_property” is not defined as a valid test property for the digs_geo:AtterbergLimitsTest in the SchematronSupportTestProperties.xml dictionary. To find this, search first for the gml:id value “atter1”, then search for “nosuch_property”in the DIGGS instance document file:



Note that “nosuch_property” follows propertyClasses “liquid_limit” and “plastic_limit” and is followed by “shrinkage_limit”. Then open SchematronSupportTestProperties.xml and search for “diggs_geo:AtterbergLimitsTest”:



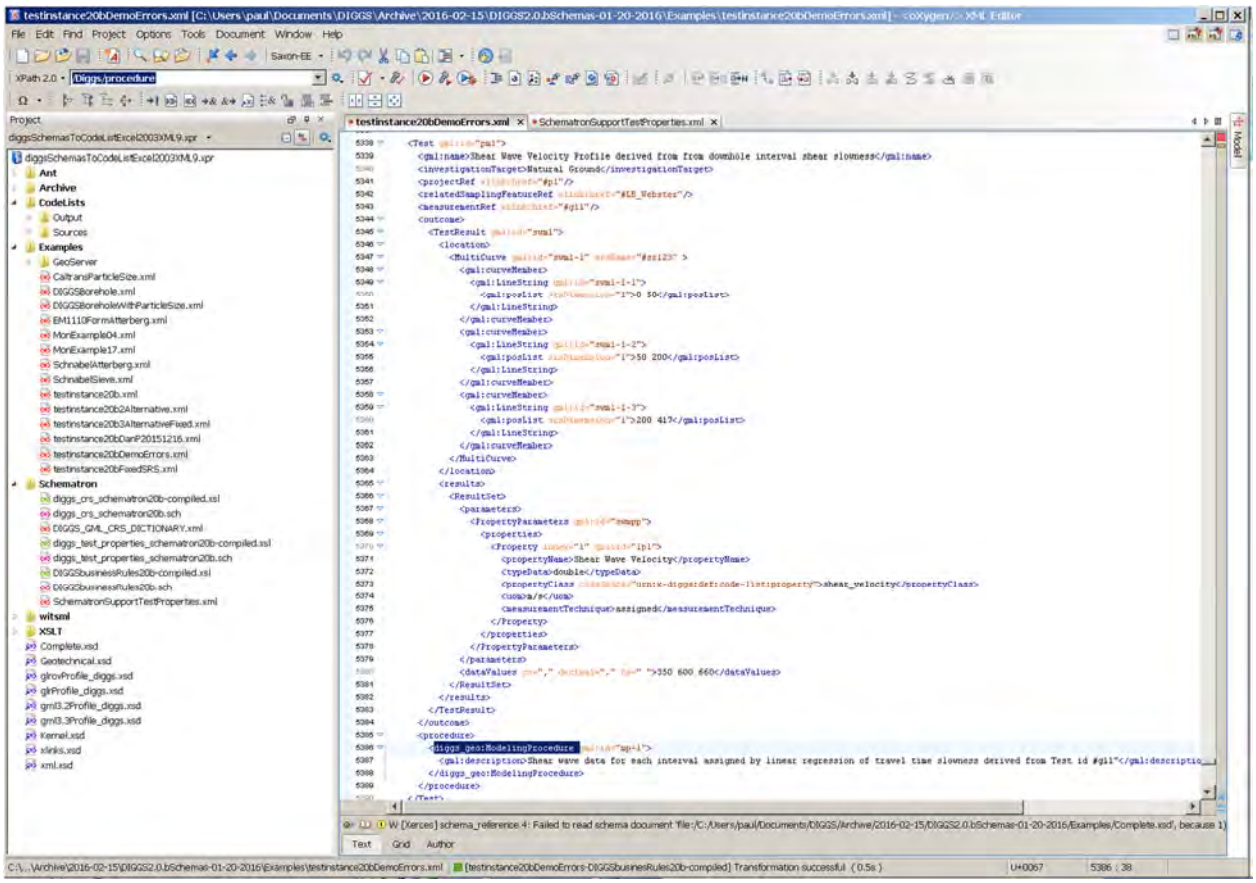
Having found

```
<test procedure="diggs_geo:AtterbergLimitsTest">
    <property>liquid_limit</property>
    <property>liquid_limit_oven_dried</property>
    <property>plastic_limit</property>
    <property>plasticity_index</property>
    <property>shrinkage_limit</property>
    <property>shrinkage_ratio</property>
    <property>uscs_symbol_425</property>
    <property>volumetric_shrinkage</property>
    <property>consistency_index</property>
    <property>liquidity_index</property>
  </test>
```

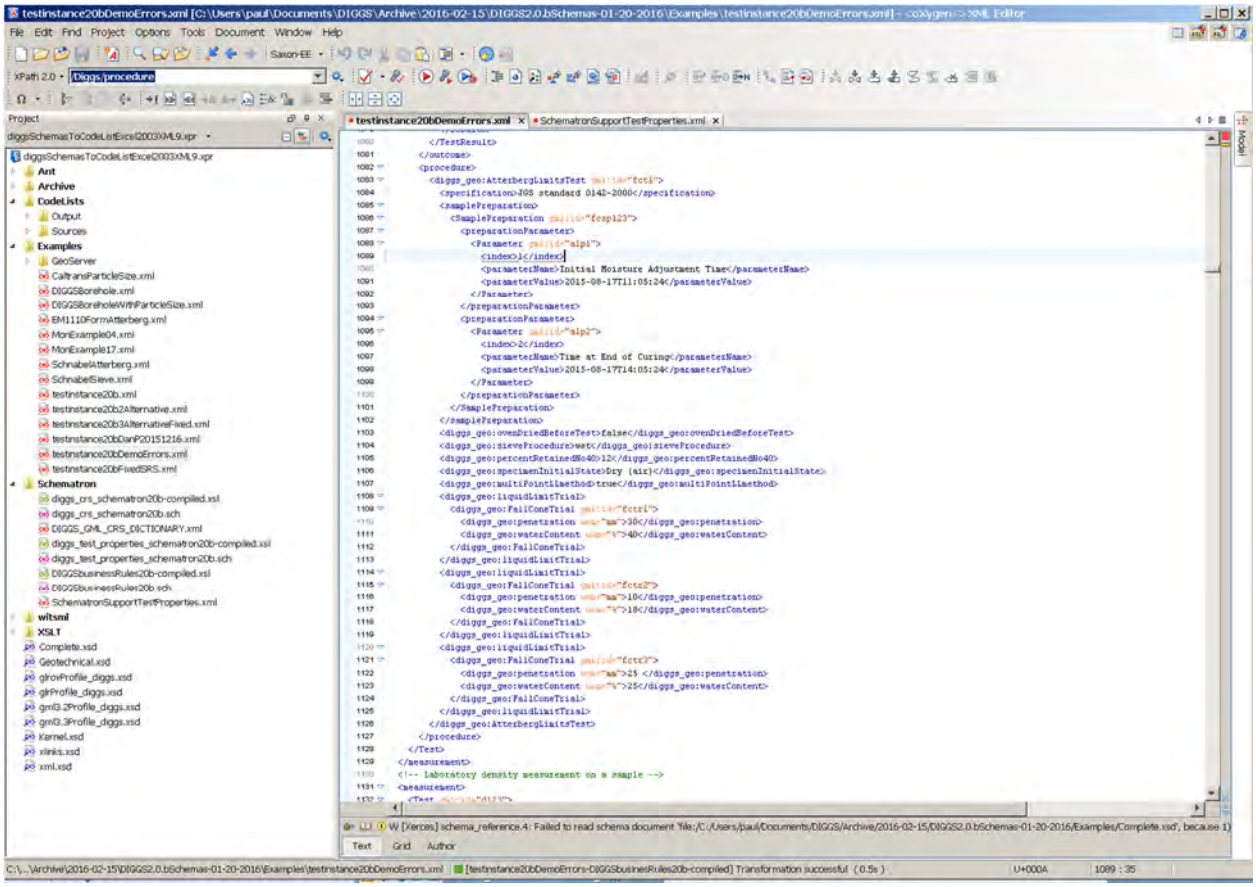
where “plasticity_index” is in between “plastic_limit_ and “shrinkage_limit”, it is likely that “nosuch_property” should be “placticity_index”.


```
…
<svrl:text>
Measurement Name Test with gml:id pm1
Procedure QName   diggs_geo:ModelingProcedure with gml:id mp-1
is not defined in SchematronSupportTestProperties.xml
</svrl:text>
…
```

The test that failed is that the specified procedure is not defined in the test properties dictionary. First search the instance document for the specified procedure:



This procedure has only a gml:description element, but no other child elements. It looks like a "stub" in development, perhaps for future addition to the DIGGS standard. So it is not surprising that it is not found in SchematronSupportTestProperties.xml. The resolution of this error has two parts. First, add child elements to the procedure so that it is complete, like the following example :

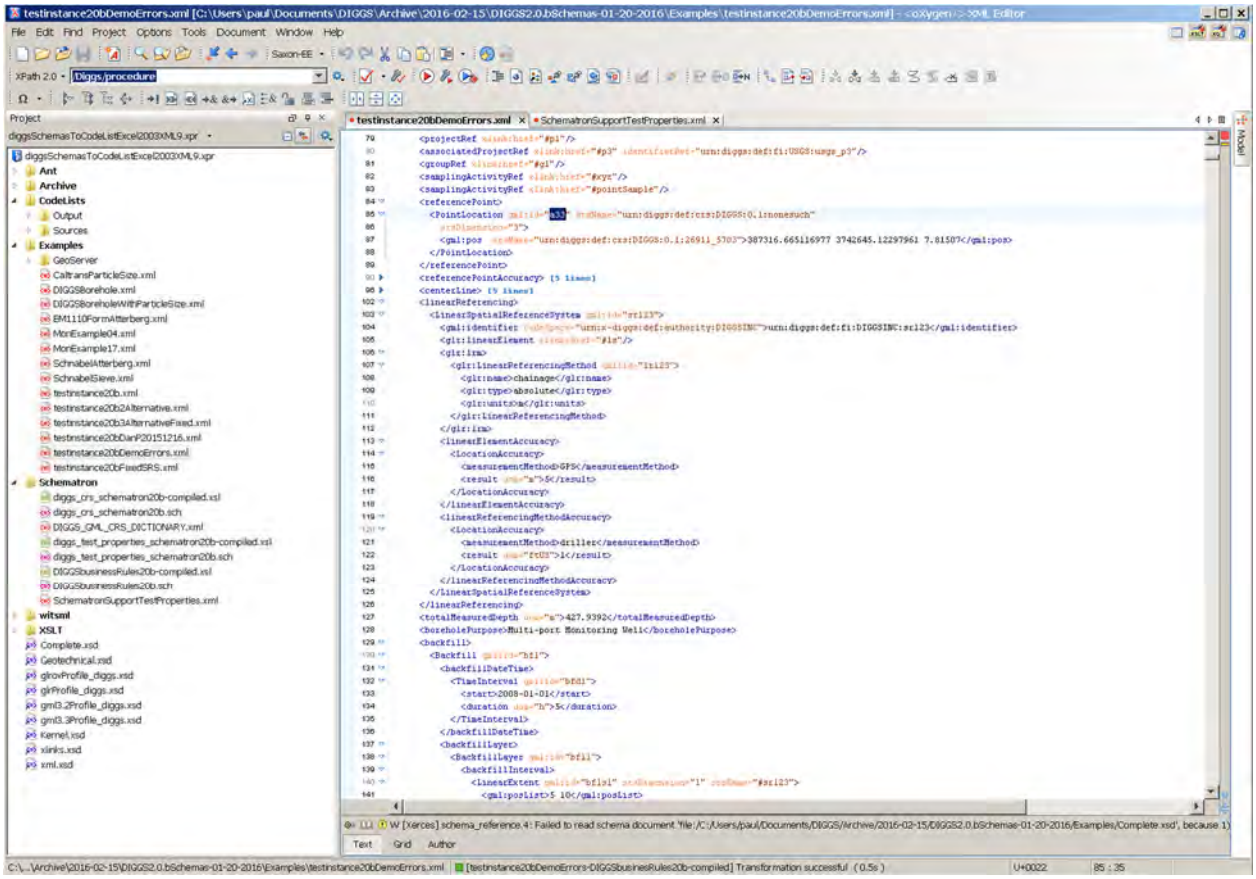


Then add <test> and <property> elements to SchematronSupportTestProperties.xml to define the procedure and it output property “shear_velocity” and any others that are allowed.

```
…
<svrl:text>
@srsName attribute value urn:diggs:def:crs:DIGGS:0.1:nonesuch of
PointLocation with gml:id a33 or a parent element thereof
must be defined in a (vector)LinearSpatialReferenceSystem or in
DIGGS_GML_CRS_DICTIONARY.xml
</svrl:text>
…
```

An srsName attribute value on a gml:geometry for most features refers to external definition in the DIGGS_GML_CRS_DICTIONARY.xml. However, for sampling features that use linear referencing, the srsName attribute value for locations in the sampling feature is an XML “fragment identifier” for the gml:id value of the linear spatial reference system, i.e. “#” followed by the gml:id value.

Open the DIGGS test instance document file, and search for the gml:id value “a33”.



For example, in the <BackfillLayer gml:id="bfl1">, note the

<LinearExtent gml:id="bfls1" srsDimension="1" srsName="#sr123">

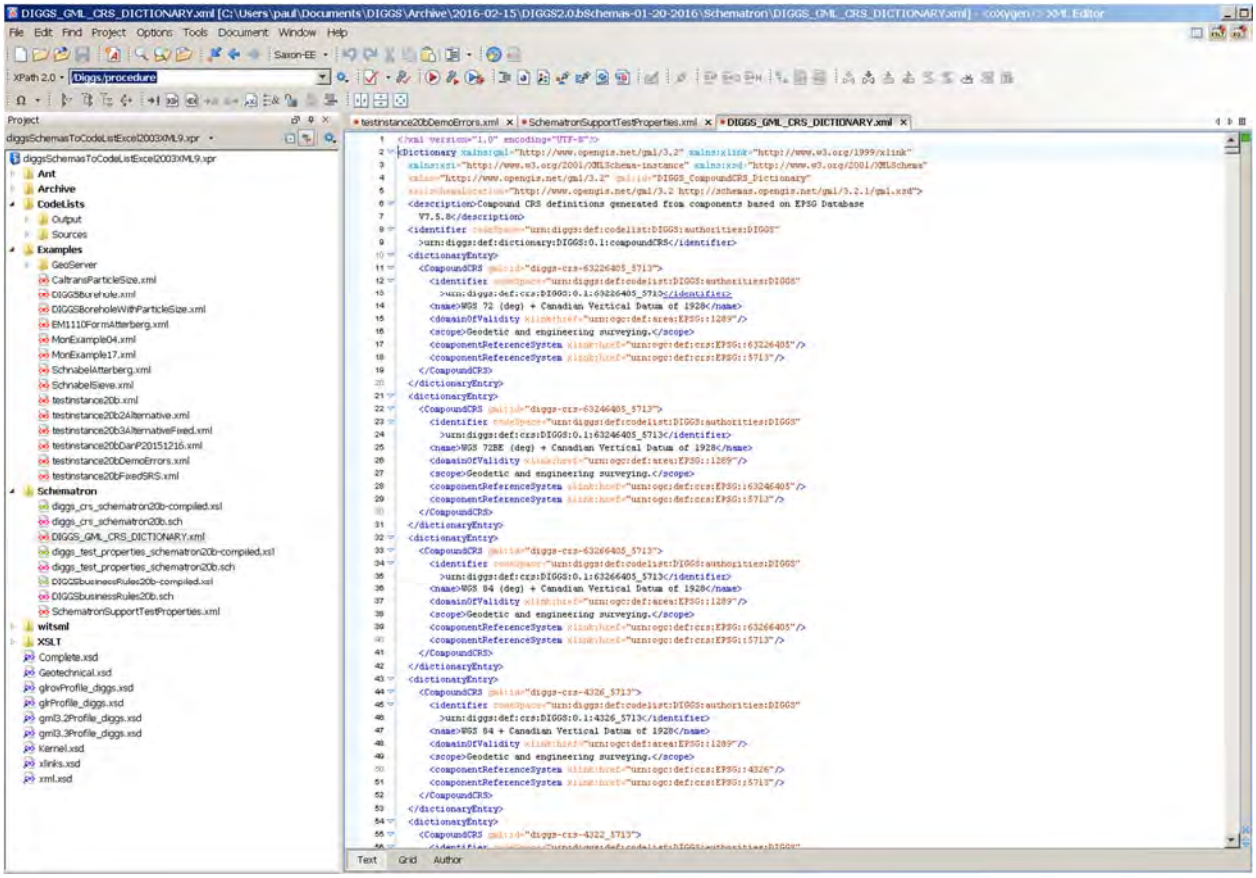
srsName value “#sr123” refers to

<LinearSpatialReferenceSystem gml:id="sr123">

But since this error

<referencePoint>
<PointLocation gml:id="a33" srsName="urn:diggs:def:crs:DIGGS:0.1:nonesuch"

is on the reference point, not within the sampling feature, to fix it we need to refer to the referenced DIGGS dictionary and select a legal value for the srsName attribute:



Each <dictionaryEntry> in the dictionary defines a 3D compound coordinate reference system by referring to existing standard definitions of a 2D horizontal coordinate reference system and a 1D vertical coordinate reference system. For example, in

```
<dictionaryEntry>
  <CompoundCRS gml:id="diggs-crs-63226405_5713">
    <identifier codeSpace="urn:diggs:def:codelist:DIGGS:authorities:DIGGS"
      >urn:diggs:def:crs:DIGGS:0.1:63226405_5713</identifier>
    <name>WGS 72 (deg) + Canadian Vertical Datum of 1928</name>
    <domainOfValidity xlink:href="urn:ogc:def:area:EPSG::1289"/>
    <scope>Geodetic and engineering surveying.</scope>
    <componentReferenceSystem xlink:href="urn:ogc:def:crs:EPSG::63226405"/>
    <componentReferenceSystem xlink:href="urn:ogc:def:crs:EPSG::5713"/>
  </CompoundCRS>
</dictionaryEntry>
```

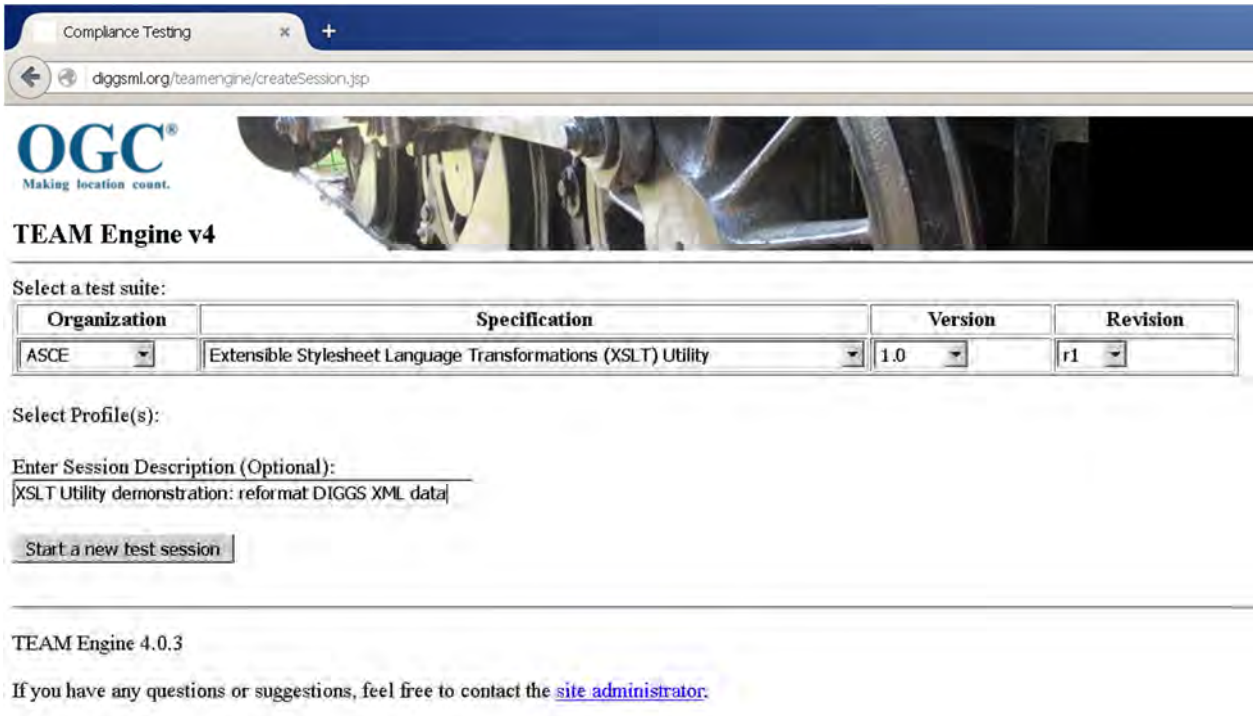
The <componentReferenceSystem> definitions are provided by the European Petroleum Survey Group (EPSG), which maintains a canonical online registry [17]. The <identifier> value urn:diggs:def:crs:DIGGS:0.1:63226405_5713 would be used as the instance document srsName attribute value.

TEAM Engine Test Sessions List

Here is the user's sessions list after completing the test session described in the preceding pages. The user can return to the session by clicking on the "S0001" link, create a new session, log out, or email the site administrator from links on this page.

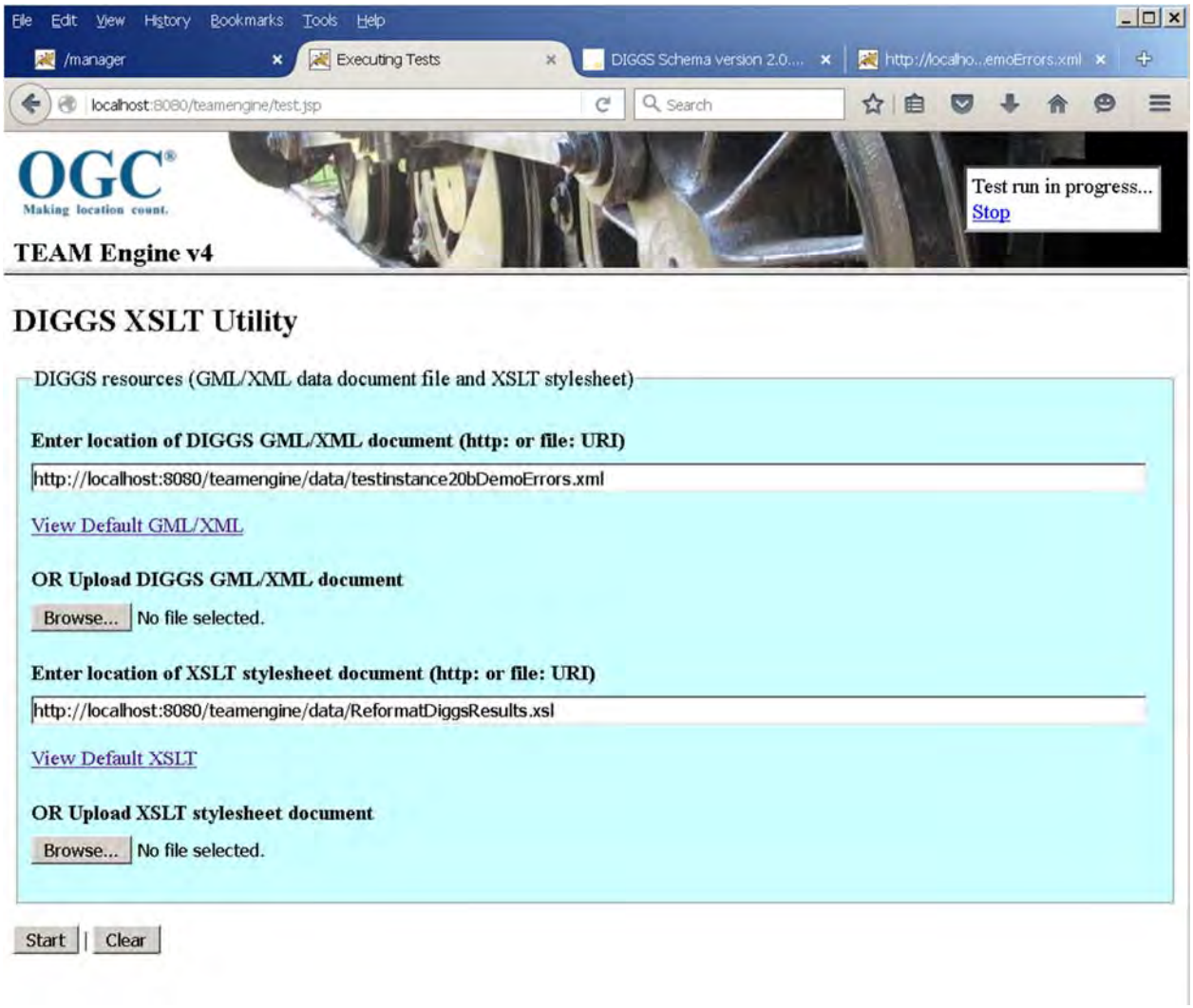
DIGGS XSLT Utility "Test Suite" Web App Selection

With the DIGGS XSLT Utility Web Application selected, a user can enter a test session description and click on the "Start a new test session" button to start the XSLT utility.

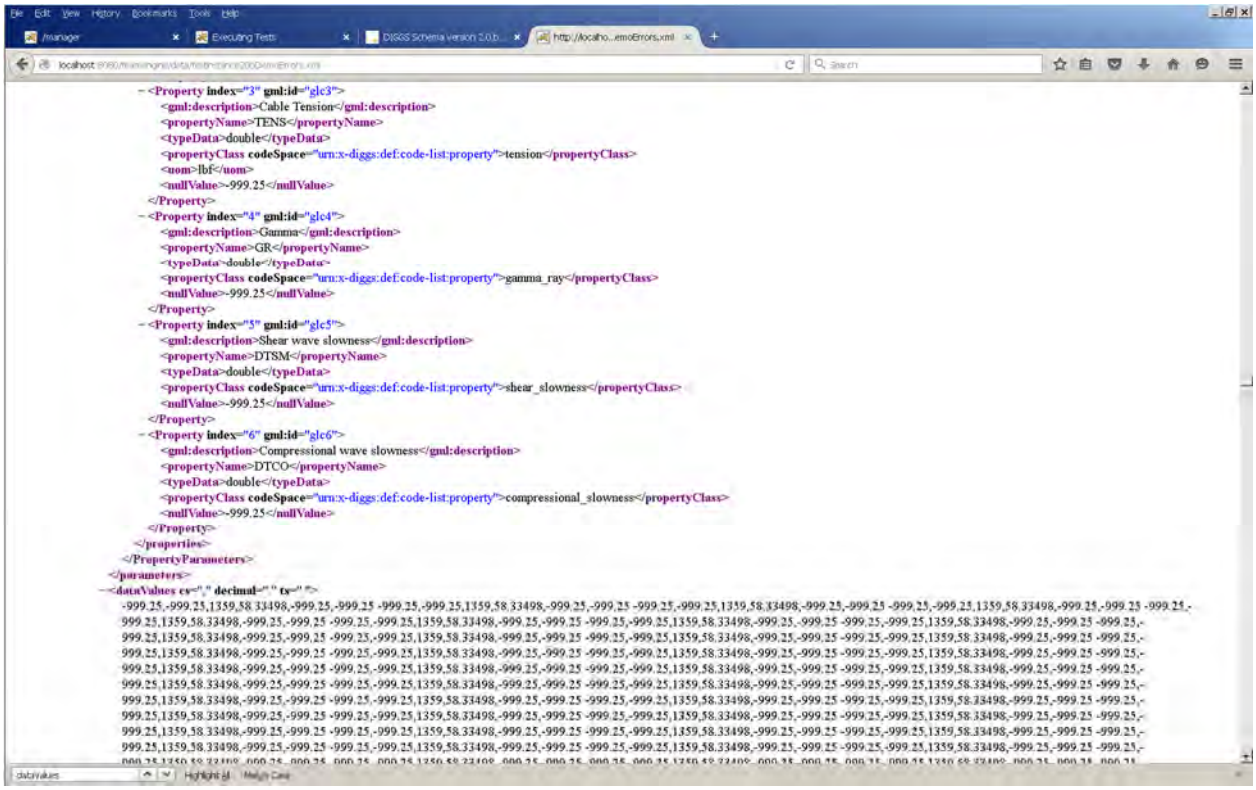


DIGGS XSLT Utility Web App Parameters Page

This page solicits a DIGGS GML document, which can be specified as a URI to a file:// or html:// or ftp:// document source, or uploaded from the local file system on the user's computer. The default location supplied is beta test instance XML file for use with the current draft DIGGS GML v 2.0.b Schemas. It is included in the DIGGS Validator installation. For testing, a user can also upload a local test file, or reference an online one, that references the online DIGGS GML schemas.



The user can also specify an XSLT Stylesheet document containing transformation rules that are applied to the DIGGS GML instance document. The default XSLT Stylesheet file referenced transforms the names of test results, and the test results themselves, which are in different parts of the DIGGS GML instance document because the results are encoded in an OGC Sensor Web Enablement Data Block designed for efficient (minimum size) encoding, which makes it hard to read:



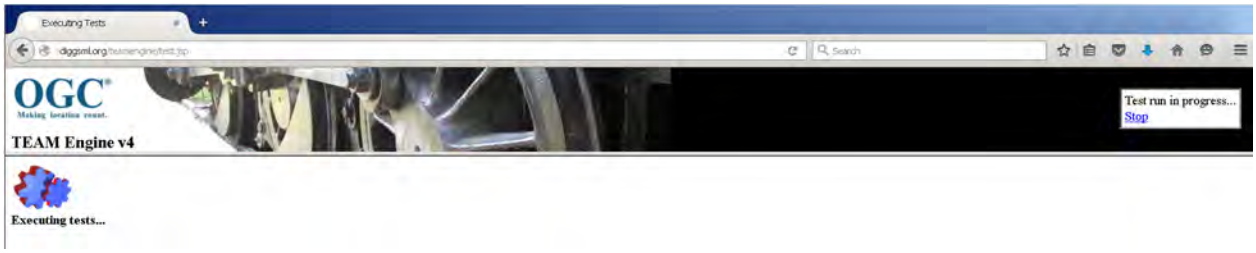
,
The default XSLT Stylesheet file ReformatDiggsResults.xsl transforms these into a more convenient and familiar

```
<dataRecords>
        <Record/>
                <ValueNameOne/>
                <valueNametwo/>
                …
        <Record/>
        …
</dataRecords>
```

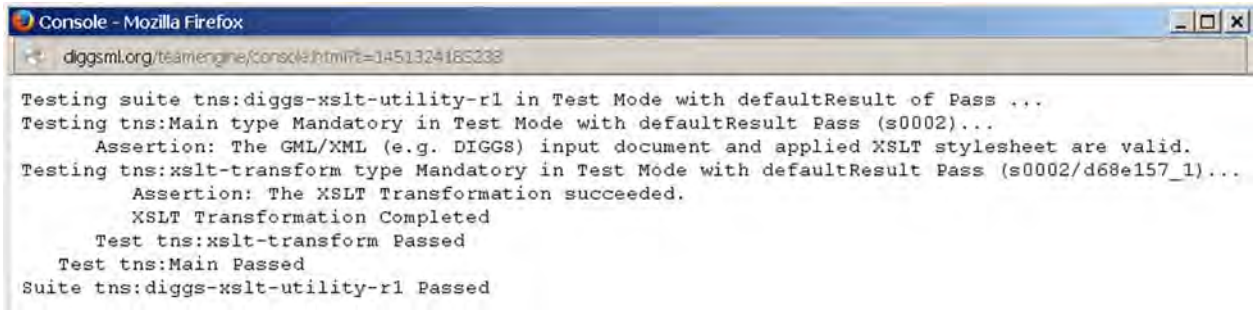
structure. See the example below. It could be modified to transform DIGGS test results into Comma Separated Values (CSV), Excel Spreadsheet XML, or another data format, such as a proprietary data format used by a Geotechnical / Geoenvironmental tools vendor.

TEAM Engine Executing Tests Page

On this page, the "Executing tests …" blue gears icon is the equivalent of the traditional "please wait … working" message.



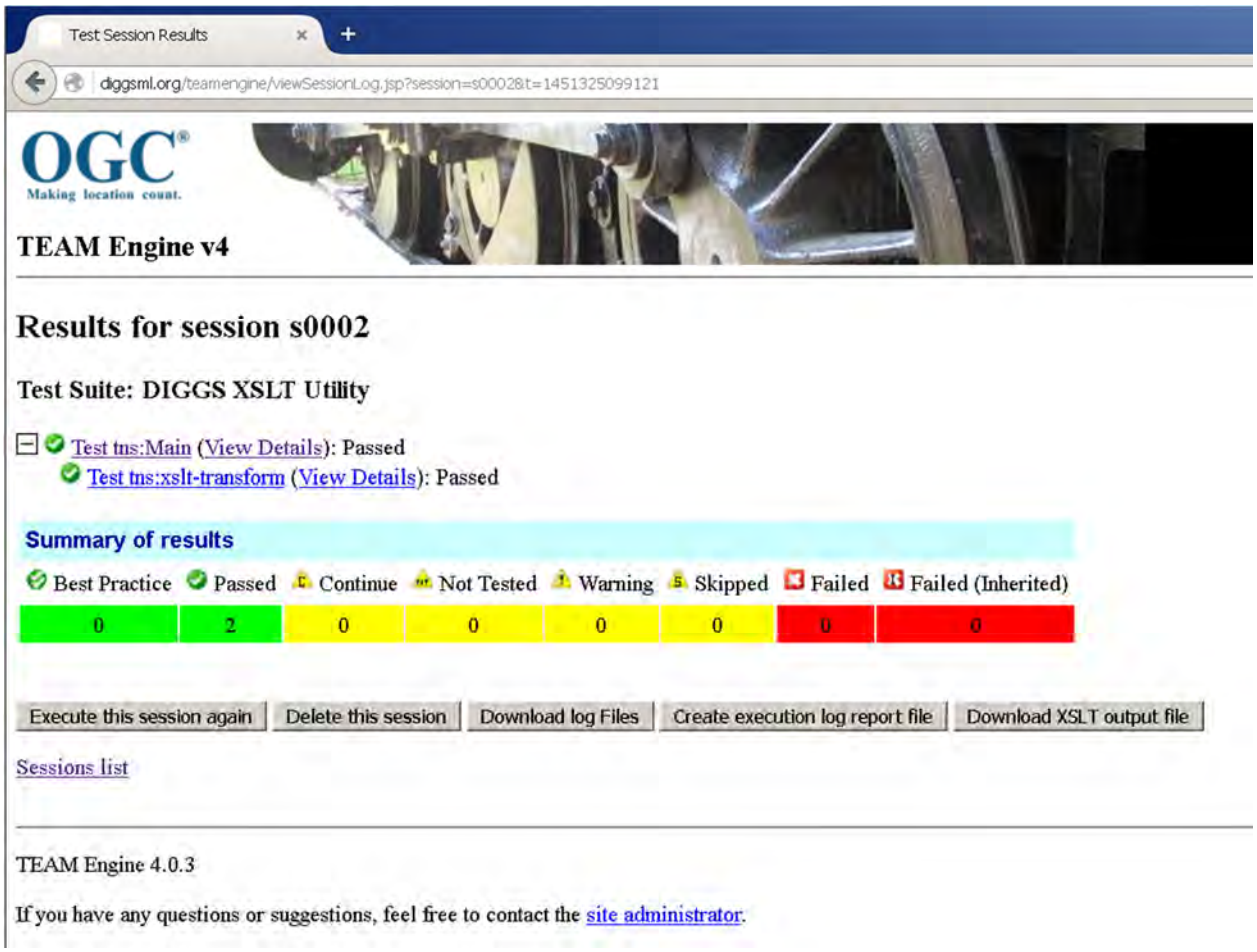
Once the test completes, the contents of its log file are displayed in a separate Test Console window.



TEAM Engine DIGGS XSLT Utility Summary of Test Results

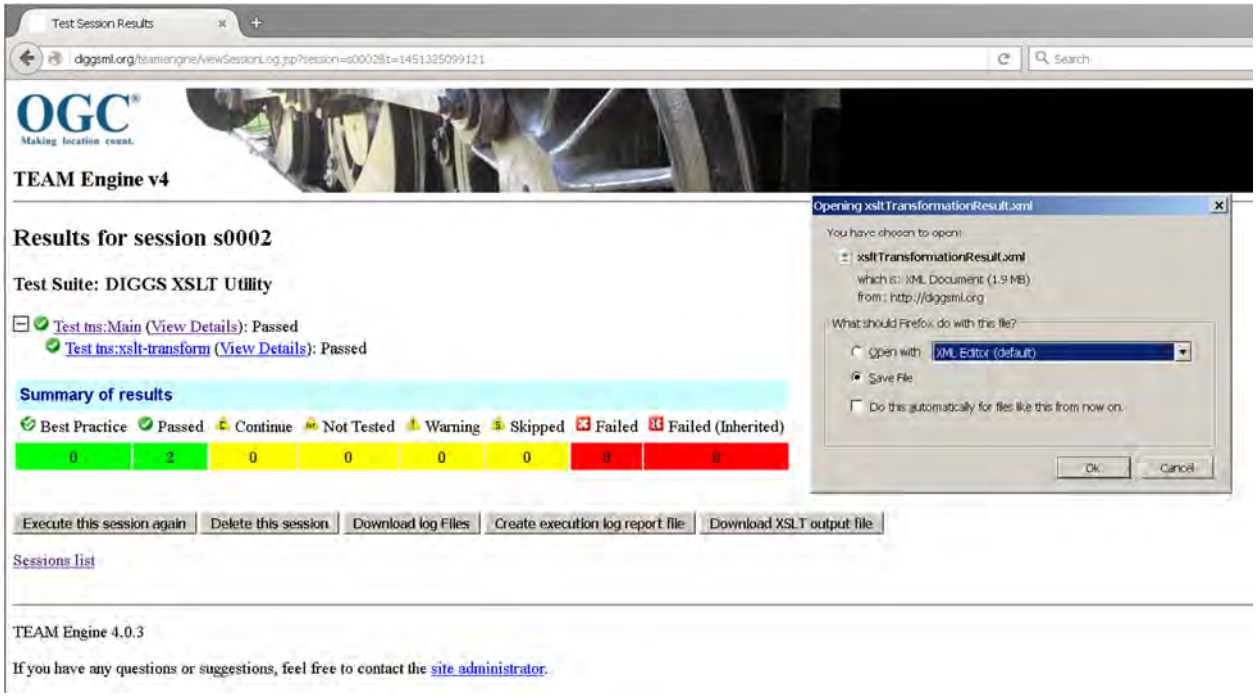
This page shows summary results for a single group of XSLT transformation "tests" in the user's second test session. It includes the following links and buttons:

- Test tns:Main link - link to an HTML page showing the test script that was run
- (View Details) link - link to the test session log presented as an HTML page
- Execute This Session Again - button to rerun test with different input parameters
- Delete This Session - button to delete this session from web view
- Download Log Files - button to download all log files and detailed HTML pages
- Create Execution Report Log - button to download the (View Details) test session log
- Download XSLT Output File - button to download the XSLT transformation output file

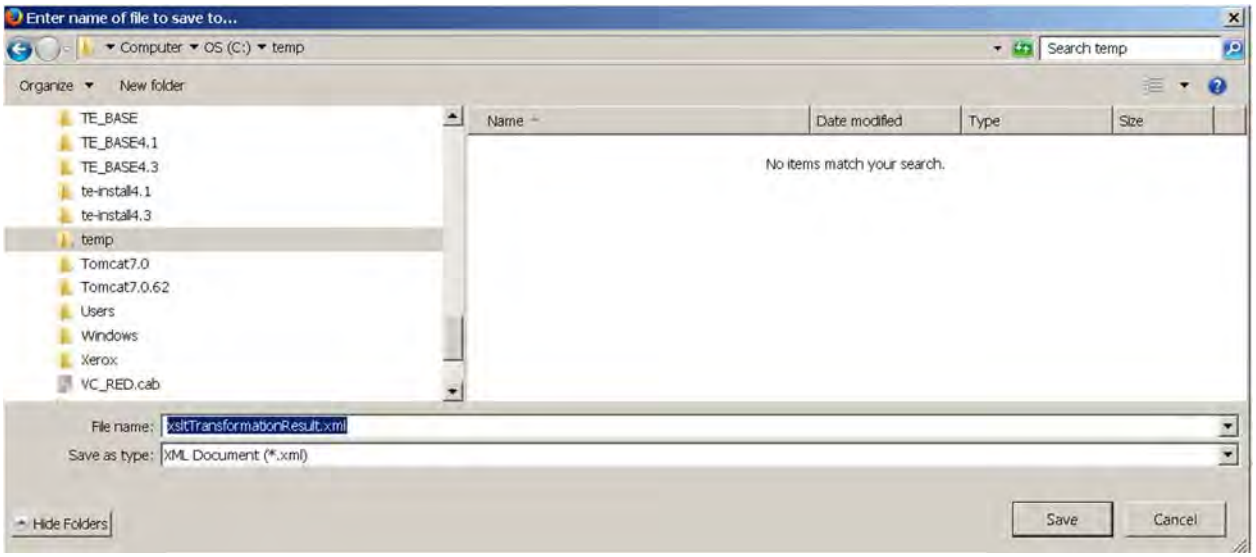


Download XSLT Output File

Clicking on the Download XSLT Output File button initiates a Save File dialog that allows the user to open the file in a text editor or save it to disk on their local computer.

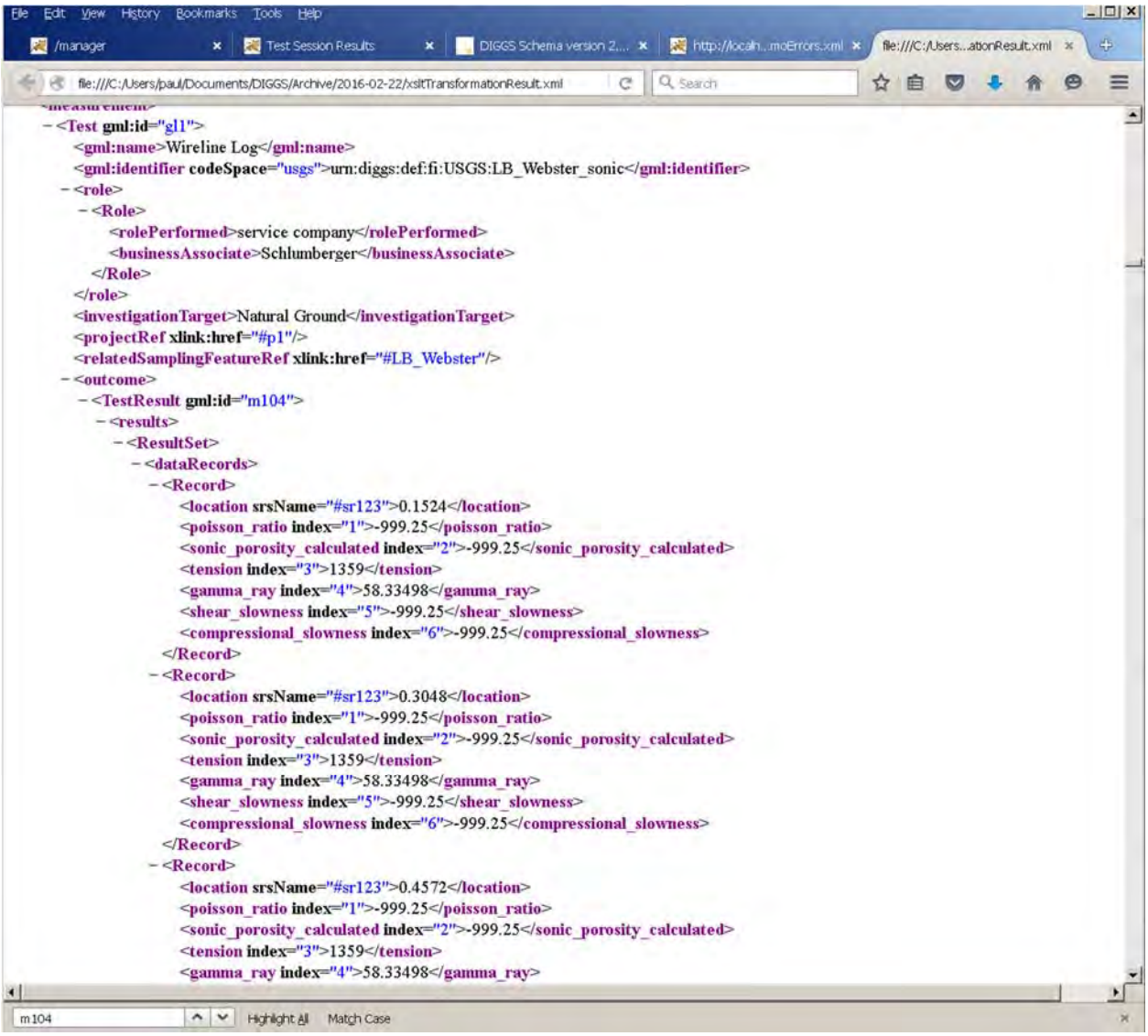


Clicking the "OK" button brings up a dialog box to let the user save the file. The default name "xsltTransformationResult" can be changed to a more descriptive file name if desired.

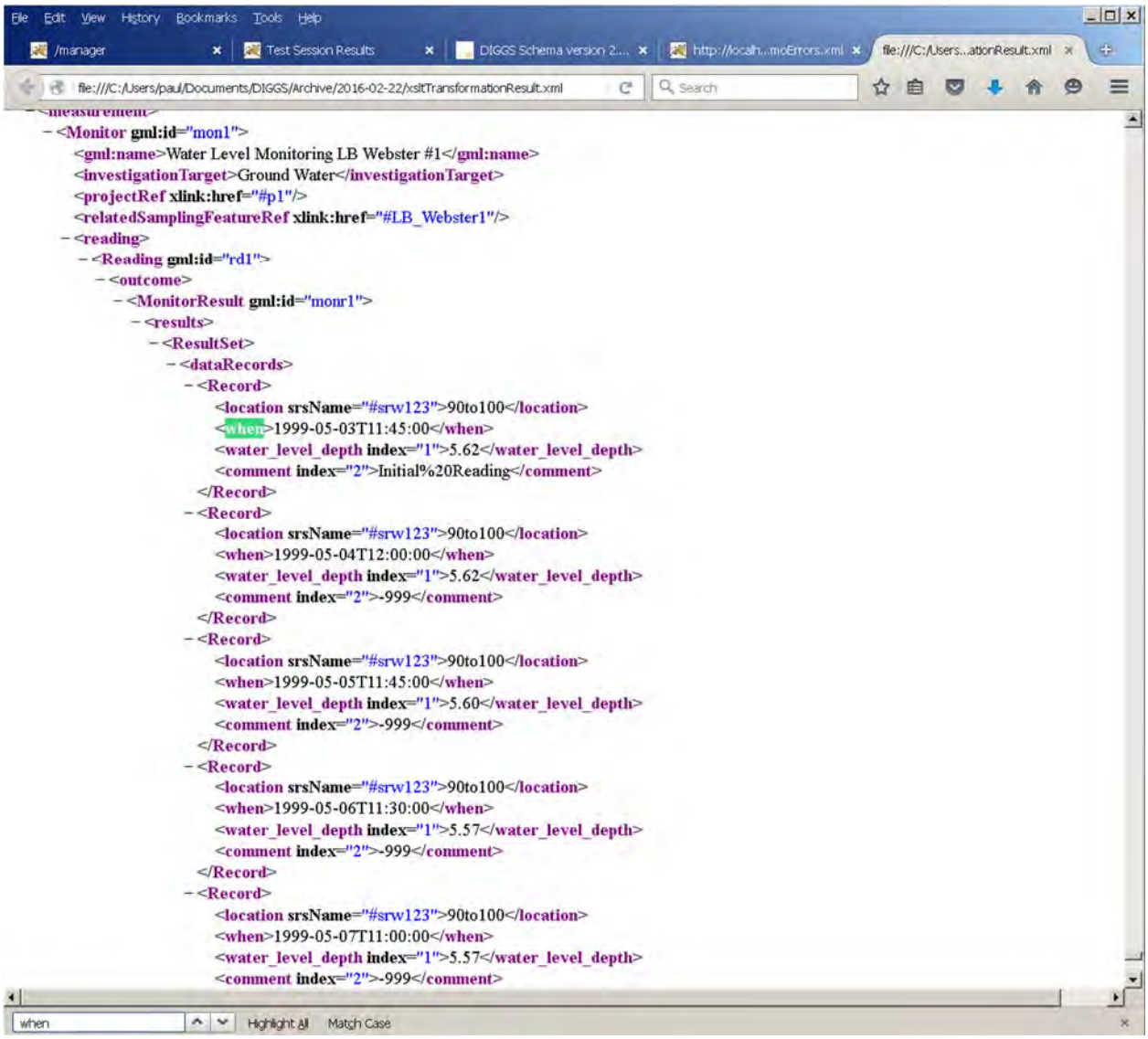


View XSLT Output File

The user can display the default output XML file in a web browser, and scroll down to see the dataRecords results:



Note that for a Monitor measurement, the data records also include timestamps:



Bibliography

[1] Data Interchange for Geotechnical and GeoEnvironmental Specialists http://diggsml.org/
[2] http://diggsml.org/diggs-schema-version-20b
[3] http://www.opengeospatial.org/standards/gml
[4] http://www.w3.org/XML/
[5] http://www.w3.org/XML/Schema.html
[6] http://www.schematron.com/
[7] http://www.java.com/en/
[8] http://www.oracle.com/technetwork/java/index-jsp-135475.html
[9] http://tomcat.apache.org/
[10] http://www.opengeospatial.org/
[11] http://www.opengeospatial.org/compliance
[12] http://cite.opengeospatial.org/teamengine/
[13] http://cite.opengeospatial.org/teamengine/about/gml/3.2.1-r11/web
[14] http://www.w3.org/TR/xpath/
[15] https://www.w3.org/standards/xml/transformation
[16] http://www.oxygenxml.com/
[17] https://www.epsg-registry.org/

Appendix F: GeoServer Overview

DIGGS Geoserver Overview

Any organization that converts its GeoTechnical / GeoEnvironmental data holdings into DIGGS 1 format can be a DIGGS data provider. This includes commercial and governmental organizations such as professional engineering consultants, laboratories and service providers, real estate development and investment companies, and national, state, county, metropolitan and municipal departments of transportation, commerce, interior, parks and environment. As explained in DiggsGeoserverInstallationInstructions2016.docx, any DIGGS data provider can use GeoServer together with other free applications to manage DIGGS data and share it via the Web. 2

GeoServer is "an open source server for sharing geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards."3 "GeoServer is built on GeoTools 4, an open source Java 5 GIS 6 toolkit."7 Open Geospatial Consortium (OGC) 8 open standards supported by GeoServer include:

- Geography Markup Language (GML) 9
- KML (formerly Keyhole Markup Language) 10
- Web Map Service (WMS) 11
- Web Feature Service (WFS) 12
- Web Processing Service (WPS) 13

DIGGS version 2.0.b schemas 14 are based on GML, (which is in turn based on Extensible Markup Language (XML) 15 and XML Schemas 16). "GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet." As GML, DIGGS can be a spatial data source for GeoServer. So GeoServer, being open source, offers an inexpensive way for DIGGS data providers to organize and share their DIGGS document data files on the Web for internal and/or public use.

Because GeoServer is based on open standards, it may be hosted by and combined with other freely available software based on open standards. GeoServer is implemented as a Java Servlet 17 web application that may be hosted by an Apache Tomcat 18 web server.

EXPath 19 Packages 20 and HTTPClient 21 modules allow an XSL Transformations (XSLT) 22 Stylesheet that takes a directory of DIGGS files as input to be run by the Saxon 23 XSLT processor to call the GeoServer WPS to transform DIGGS geographic coordinates into the standard, world-wide Coordinate Reference System (CRS) WGS84 for inclusion in Java Properties Files 2425 that can serve as a free (but relatively low performance) Geoserver geospatial data store index to DIGGS files. (A higher performance open source alternative is to use a PostGIS 2627database, but doing so requires considerably more work to set up and administer, so it is not covered in DiggsGeoserverInstallationInstructions2016.docx.)

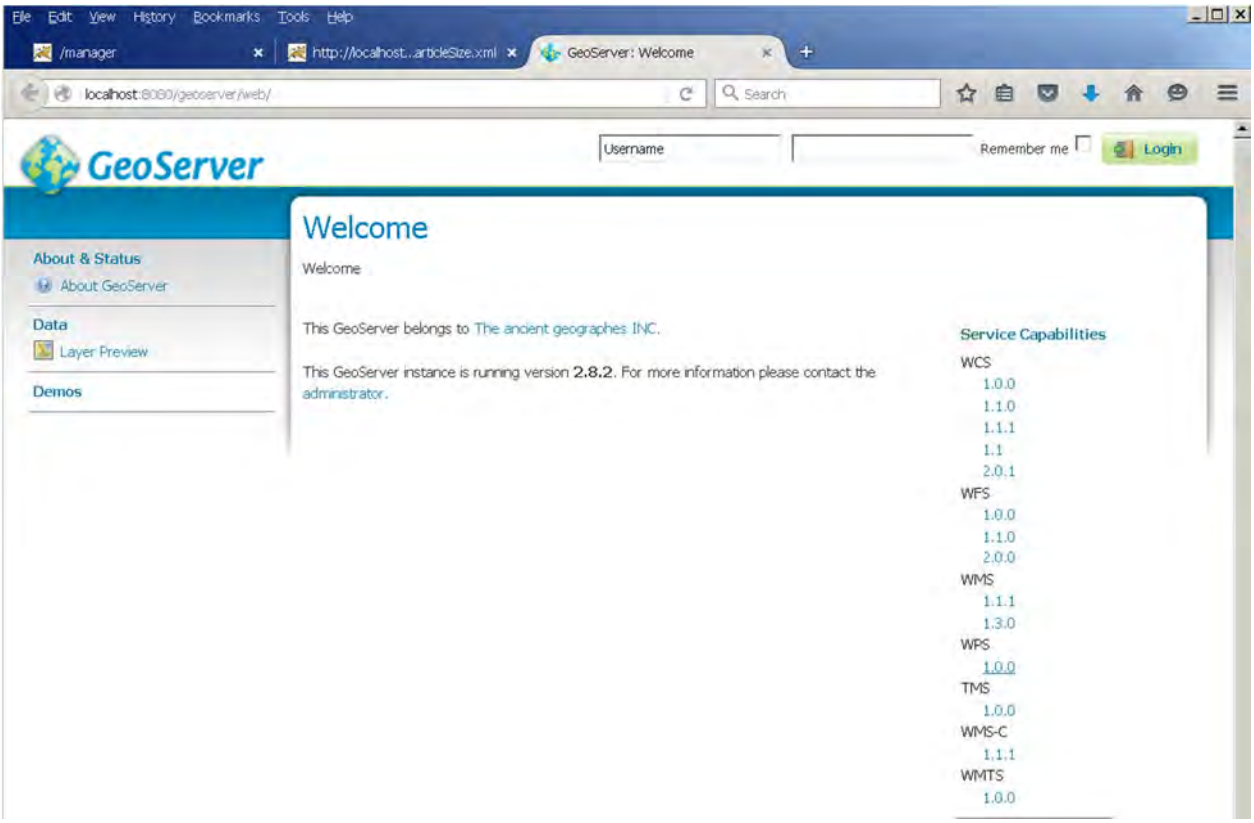
Google Earth28 may be used to display KML placemarks produced by GeoServer for DIGGS sampling features. A DIGGS GeoServer user can click on these placemarks to see index (project name, sampling feature name, test name(s), test property name(s)) properties about each sampling feature, and to obtain a URL 29 hyperlink to the source DIGGS file.

OpenLayers 30 (which is integrated with GeoServer) may be used to display KML and GML in WMS map layers. OpenLayers supports the OGC Common Query Language (CQL) 31 specified by OGC Catalog Service. 32 A DIGGS GeoServer user can select DIGGS sampling features for display by specifying CQL queries based on the index properties, a geographic bounding box spatial query, or combinations thereof.

The following screen shots and explanatory text provide an overview of and basic user instructions for viewing DIGGS data served by GeoServer. Before continuing, please see 33 to download and install Google Earth, if you don't have it installed already.

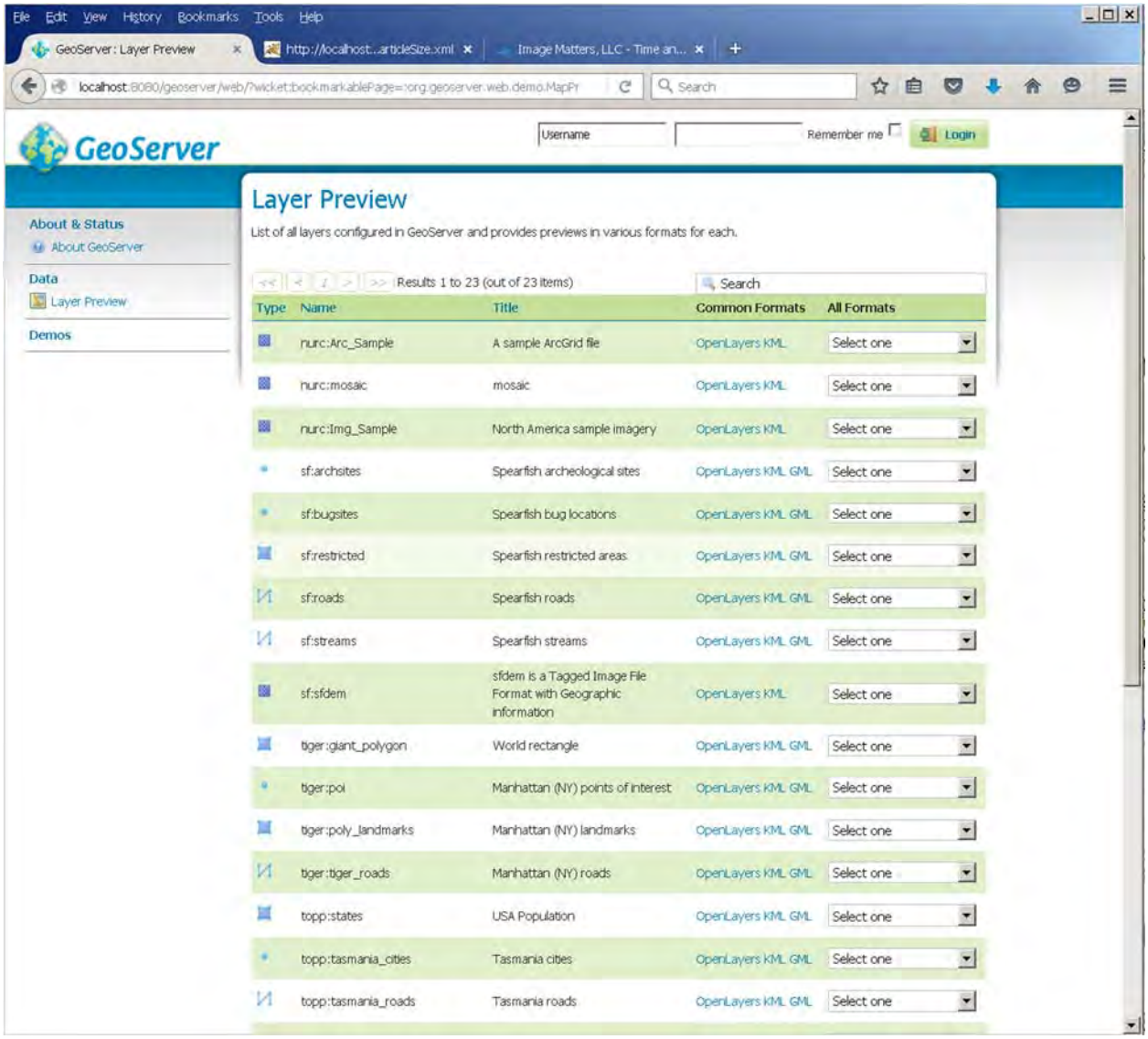
Using GeoServer for DIGGS

Begin by entering the URL of a GeoServer Web Application that has been configured to serve DIGGS Document Files in your Web Browser. You will see the following GeoServer Welcome page:



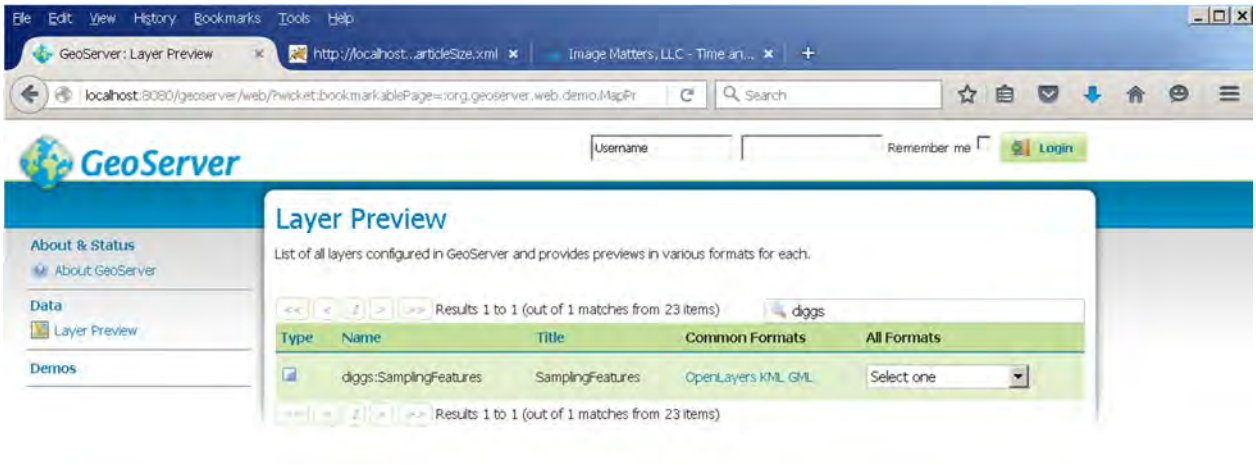
The "Username" and "Password" fields and "Login" button at the top of the page are for the GeoServer Administrator to log in. You don't need to do that; anyone can view the data in a GeoServer installation because that is its purpose.

Under the "Data" category in the menu on the left hand side of the page, click on the "Layer Preview" link. You will see a page that lists all of the data layers available:

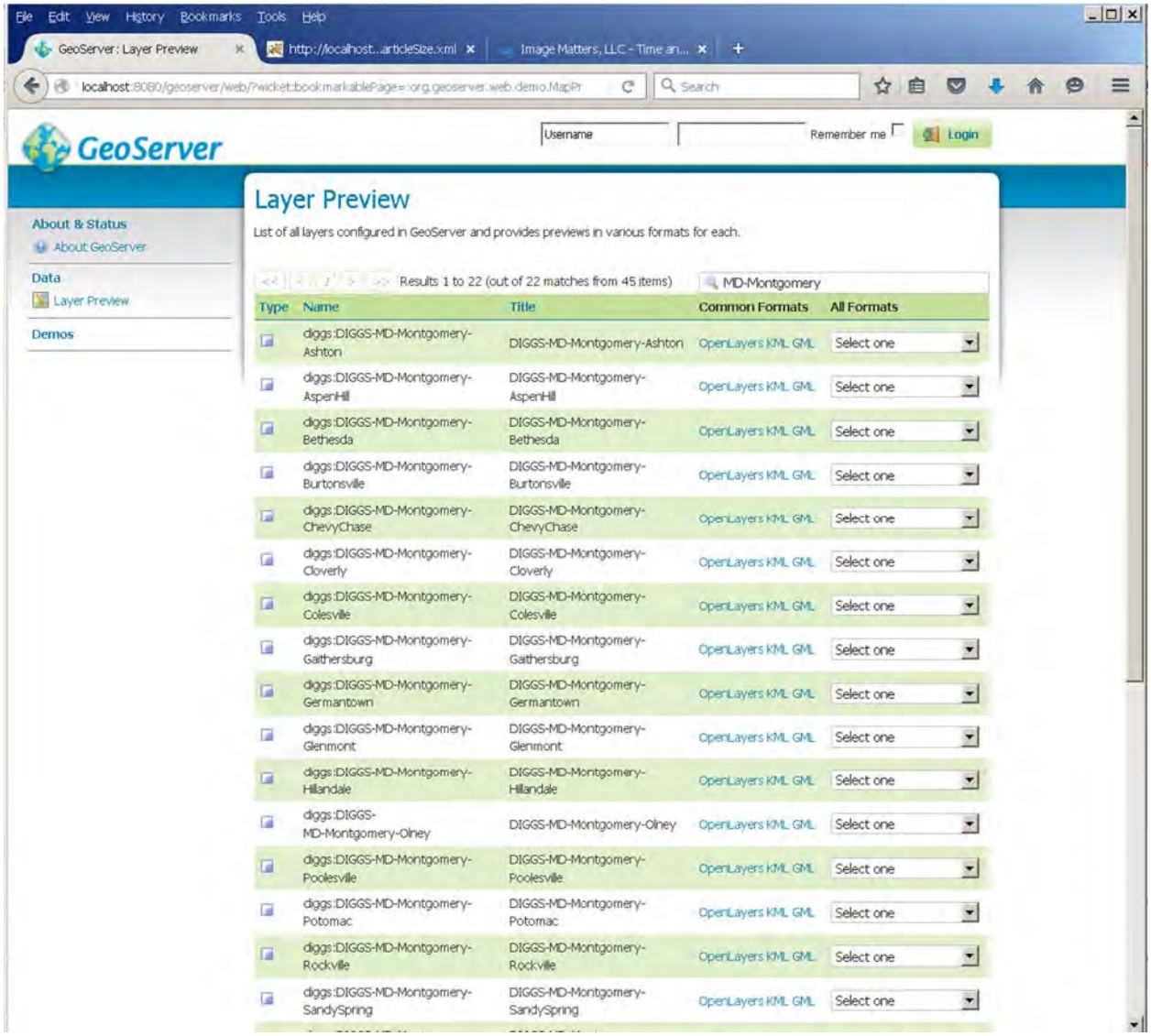


As shown above, these may include twenty or more sample layers that come with GeoServer, if the installation administrator has not deleted them. To locate DIGGS layers, you may scroll down, or assuming that the installation administrator followed the instructions in DiggsGeoserverInstallationInstructions2016.docx, you may enter "diggs" in the "Search" field and press Enter.

How many layers you will then see depends on how may DIGGS layers are being served. DiggsGeoserverInstallationInstructions2016.docx describes creating a single layer with five SamplingFeatures in California USA from two DIGGS instance document sample files:



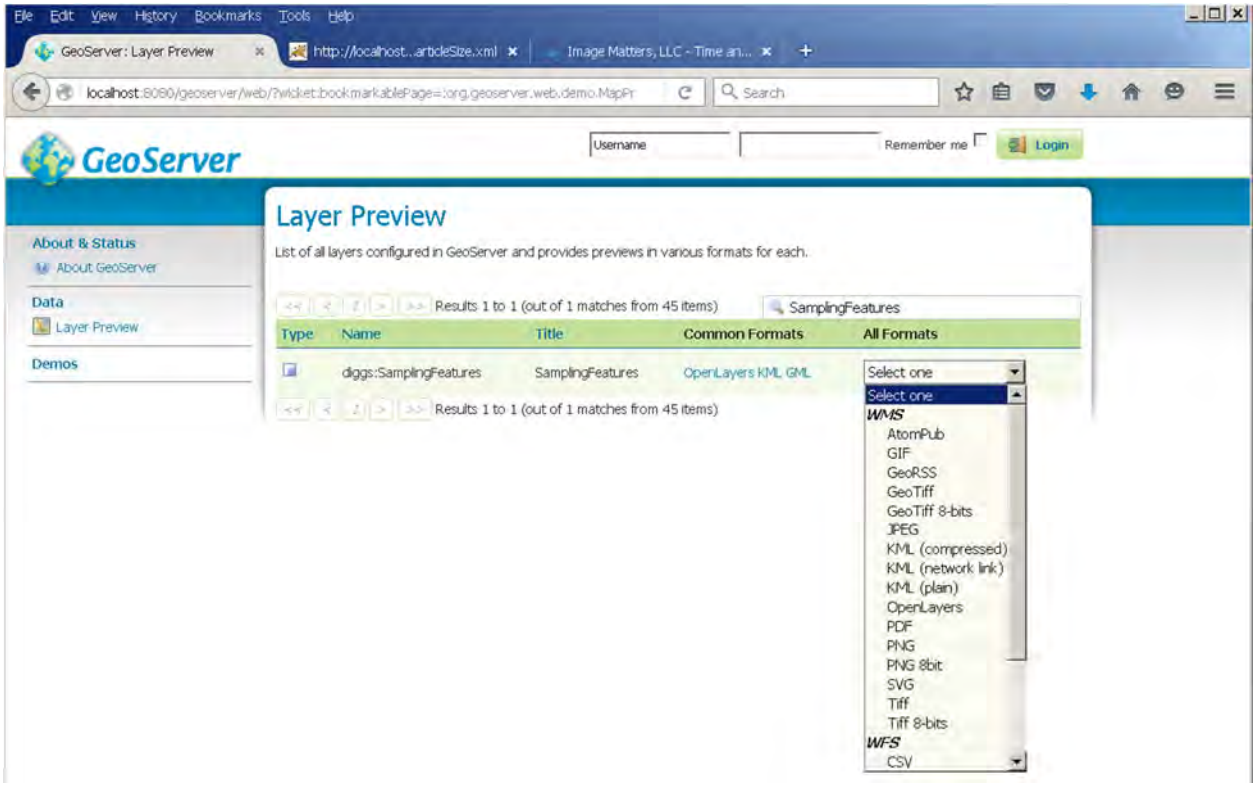
For better GeoServer performance, DiggsGeoserverInstallationInstructions2016.docx instructs the DIGGS GeoServer Administrator to distribute DIGGS files into separate directories (e.g. by state, county, county subdivision, township, place, Census Block, etc.) in a hierarchical structure so that each lowest level directory holds a thousand files or less. These files have names that include the geographic hierarchy so that they identify the corresponding smallest area geographies. This makes it easy to search for them. For example, search for "MD-Montgomery" returns the following (incomplete example) Layer Preview with a separate layer for each (Census Designated or Incorporated) place in Montgomery County MD.



In any case, you need to scroll or search until you locate the layer you are interested in. Then you can have GeoServer produce an index KML placemark of it that you can view in Google Earth or in a OpenLayers Web Browser WMS client.

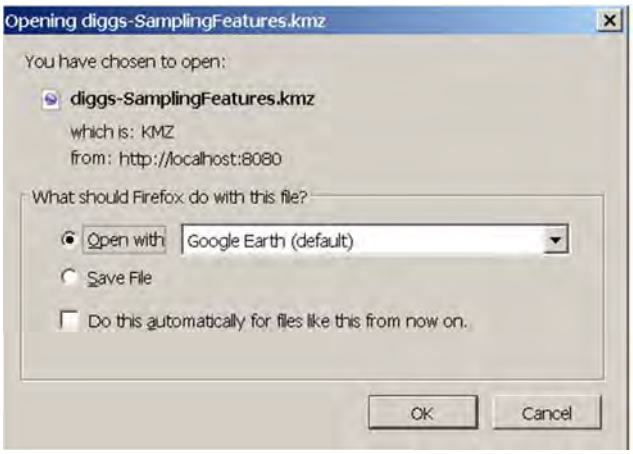
Selecting a DIGGS Display Format

In the "All Formats" column on the right hand side of the page, click on the down-arrow for the selection box widget for the layer you are interested in.

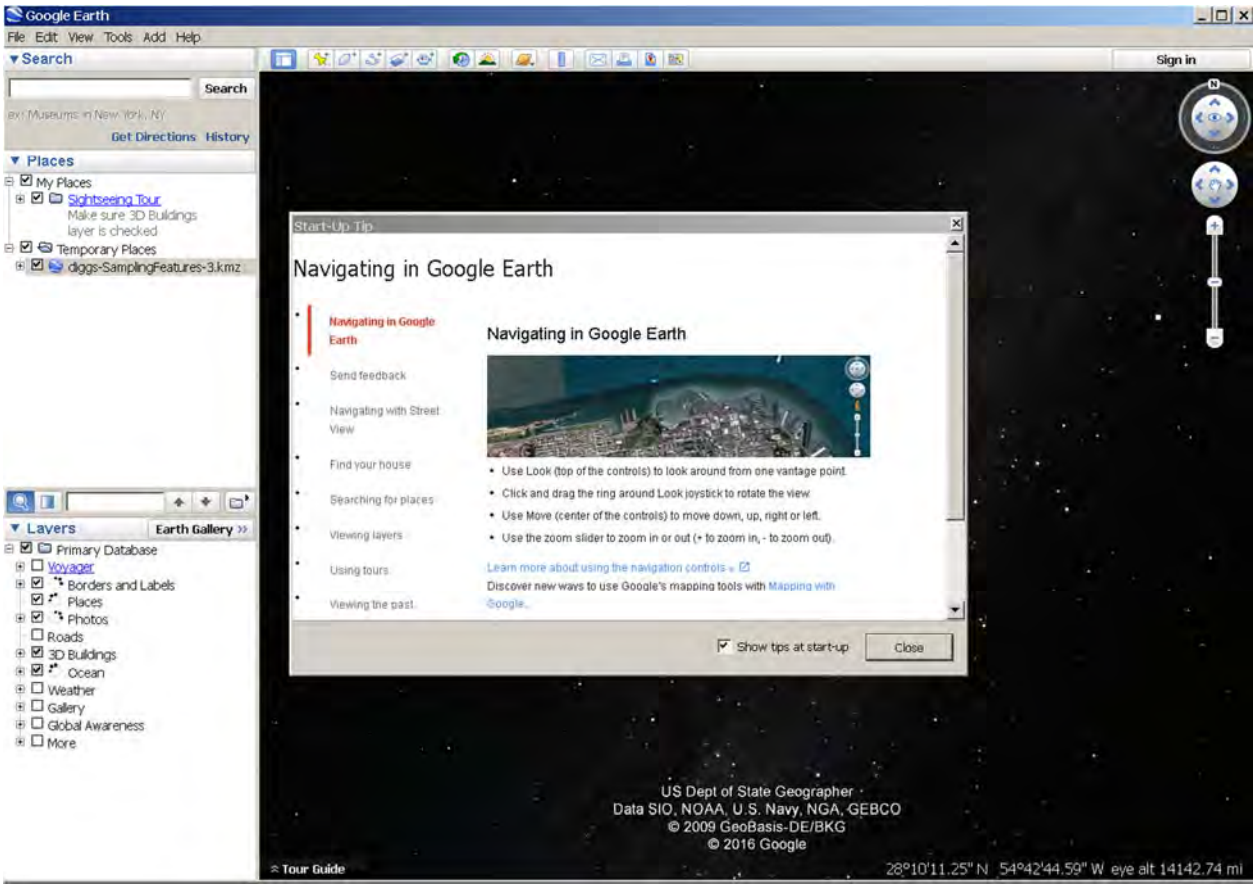


Viewing DIGGS Placemarks in Google Earth

Select "KML (compressed). GeoServer will present you with a dialog box:

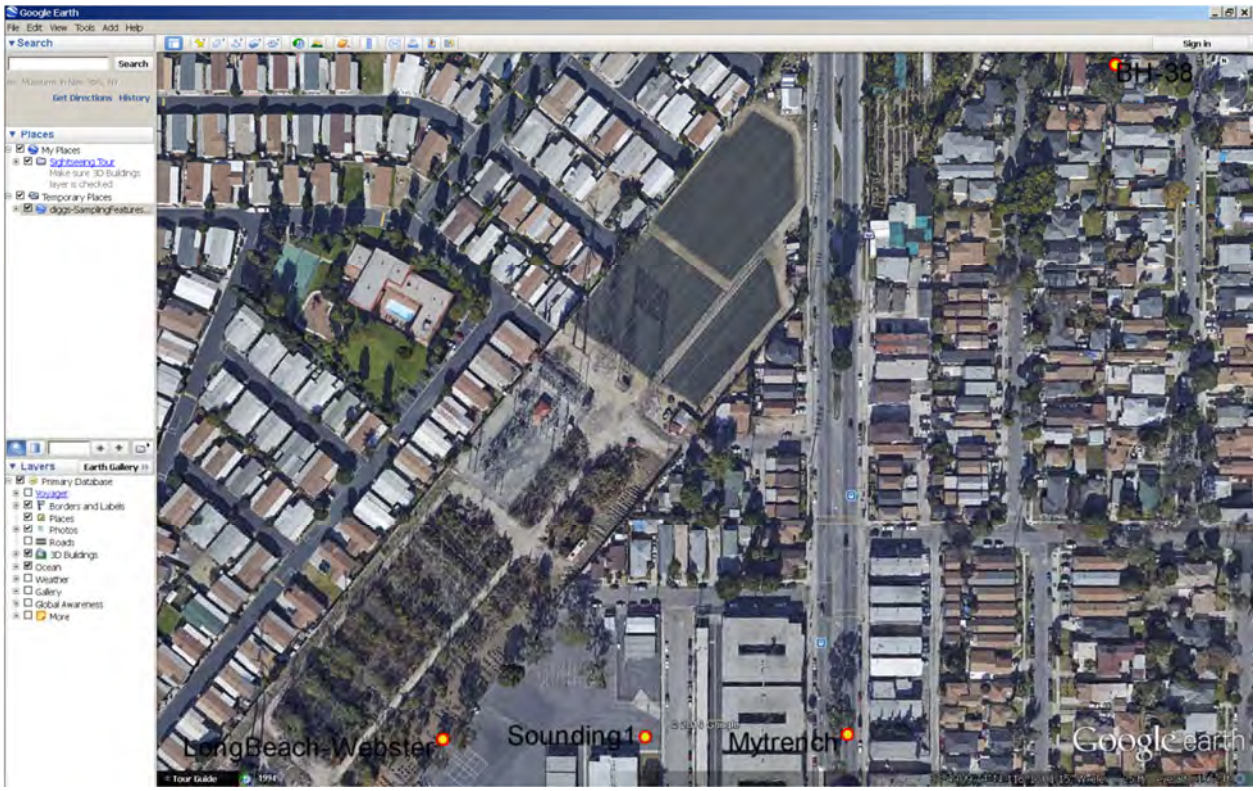


Select “Open with Google Earth (default)” and click on the “OK” button. Google Earth will start up with the downloaded DIGGS KMZ file.



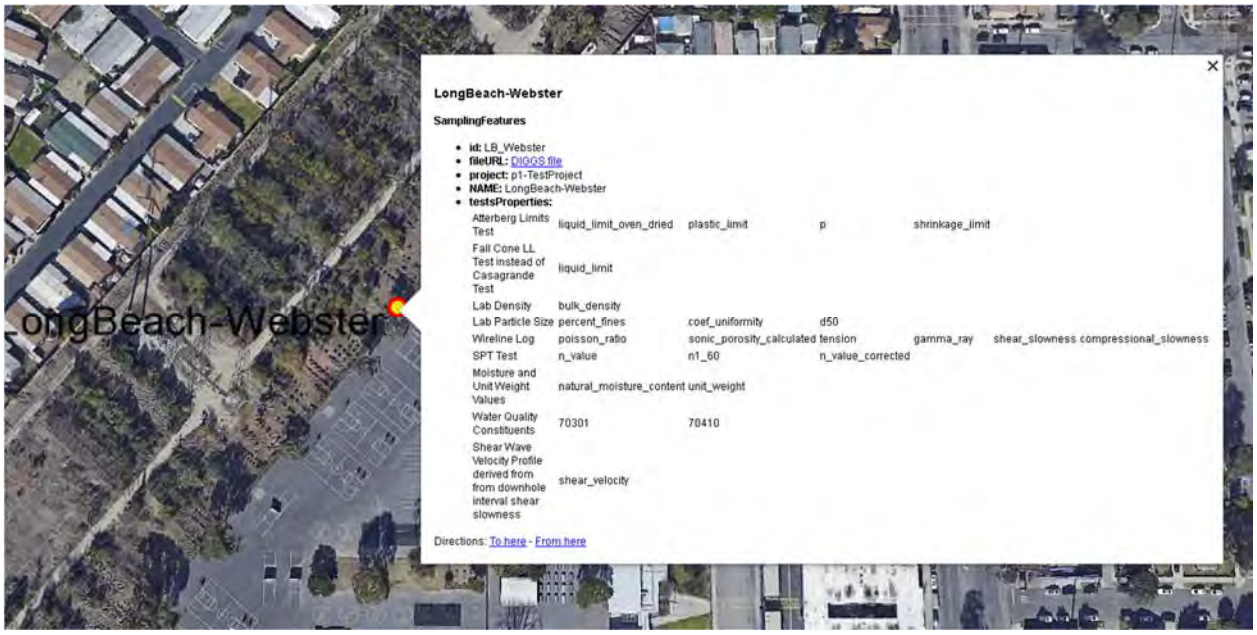
If you have “Show tips at startup” selected, it will open with a start-up tip. Click on the “Close” button. Google Earth will display the geographic area containing all of the DIGGS features in the layer you selected. You can zoom in and pan the display until you see a placemark for the sampling feature you are interested in.

Here is the display of the sample single layer with five SamplingFeatures in California USA from two DIGGS instance document sample files:



Only four red and yellow concentric circle place marks appear, because there are two "Long Beach – Webster" Sampling Features very close together. If you zoom in and click on the place mark for those two Sampling Features, Google Earth will display separate place marks for each one:

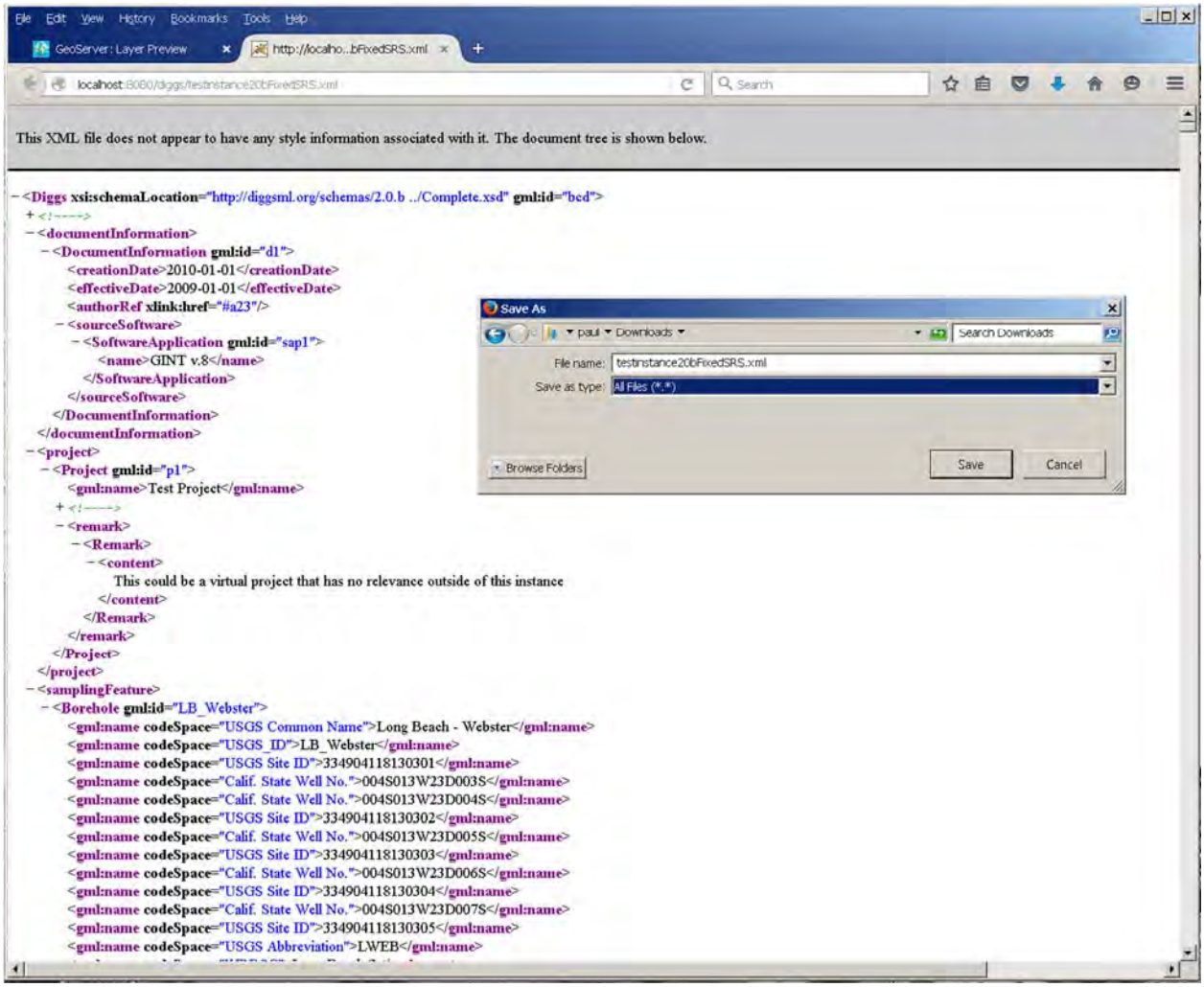
Then you can click on one of the placemarks to see index information about the Sampling Feature; its id, name and project, the tests that were run on it, the properties that were recorded for those tests, and a hyperlink to the source DIGGS instance document file:



If you click on the fileURL: "DIGGS file" hyperlink, Google Earth will display its text contents in another window.

But all the XML element tags have been removed, so this isn't very helpful. Click on the "Back to Google Earth" button at the top left of the text display. Then righ-click on the fileURL: "DIGGS file" hyperlink, and select "Copy Link".

Now you can paste the link into a new Web Browser Tab or Window, and see the DIGGS instance document file contents:

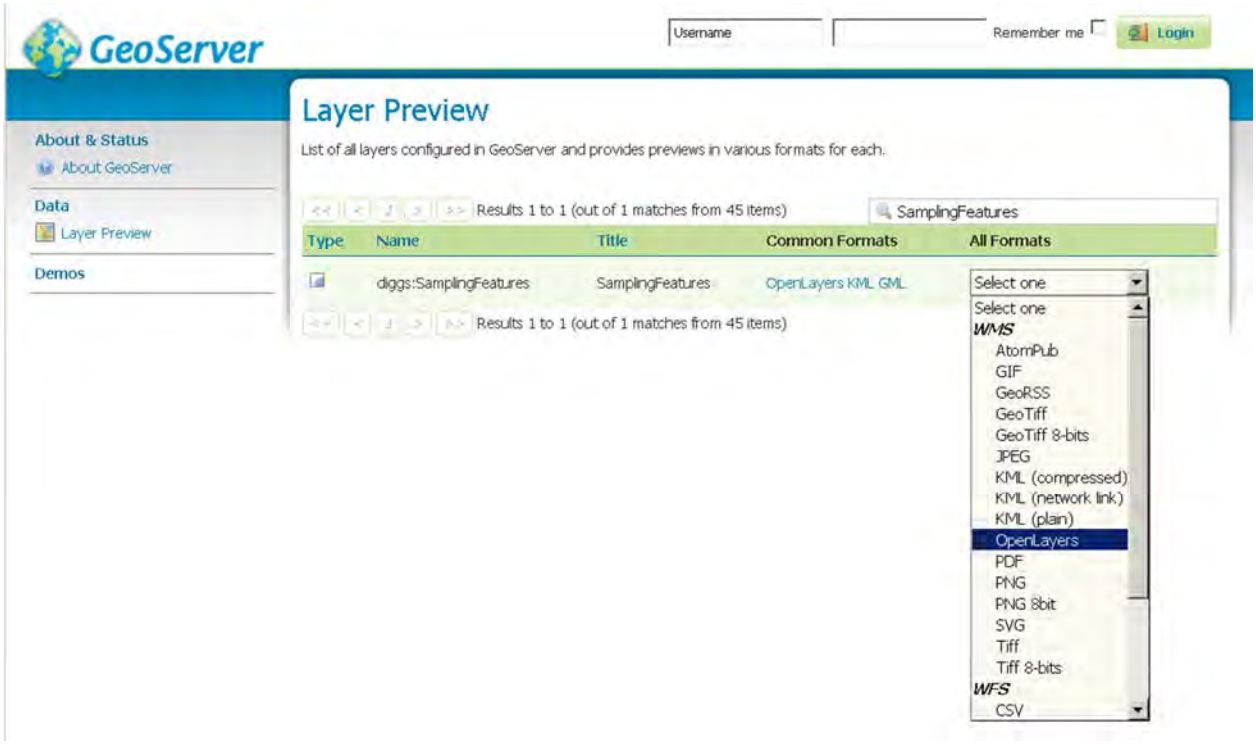


You may also select "File/SaveAs" to download the DIGGS file to your own computer.

Viewing DIGGS Placemarks in OpenLayers

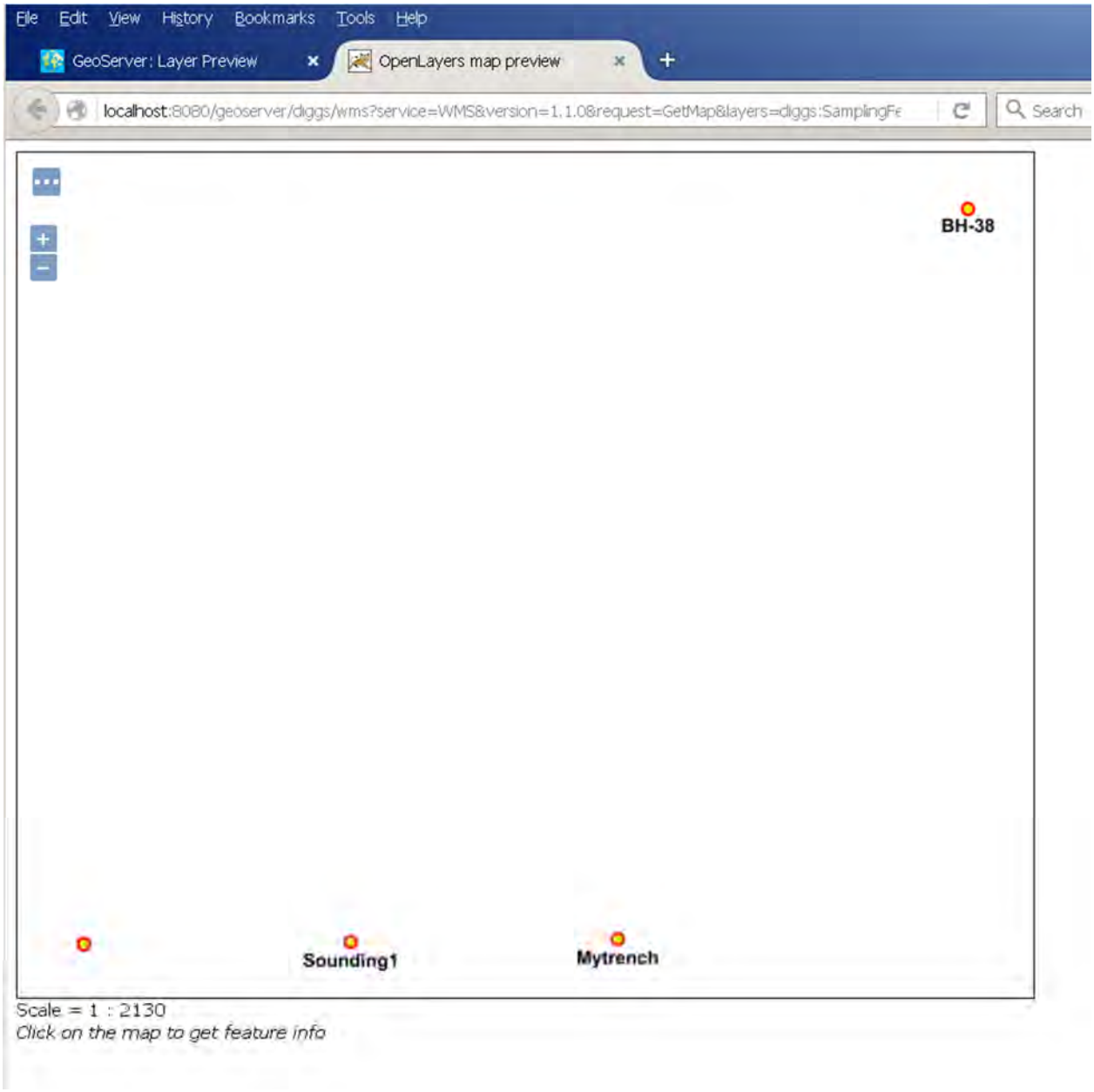
Google Earth lets you see the geographic context of DIGGS Sampling Features, but if you are looking at a large layer, you may have to spend a lot of time zooming and panning the display to find the one(s) you are interested in. The OpenLayers Web Browser WMS client lets you select by geographic bounding box, or by the Sampling Feature index properties – its id, name and project, the tests that were run on it, and the properties that were recorded for those tests. Unfortunately, as configured for DIGGS, it does not provide you any map background.

In the "All Formats" column on the right hand side of the page, click on the down-arrow for the selection box widget for the layer you are interested in.



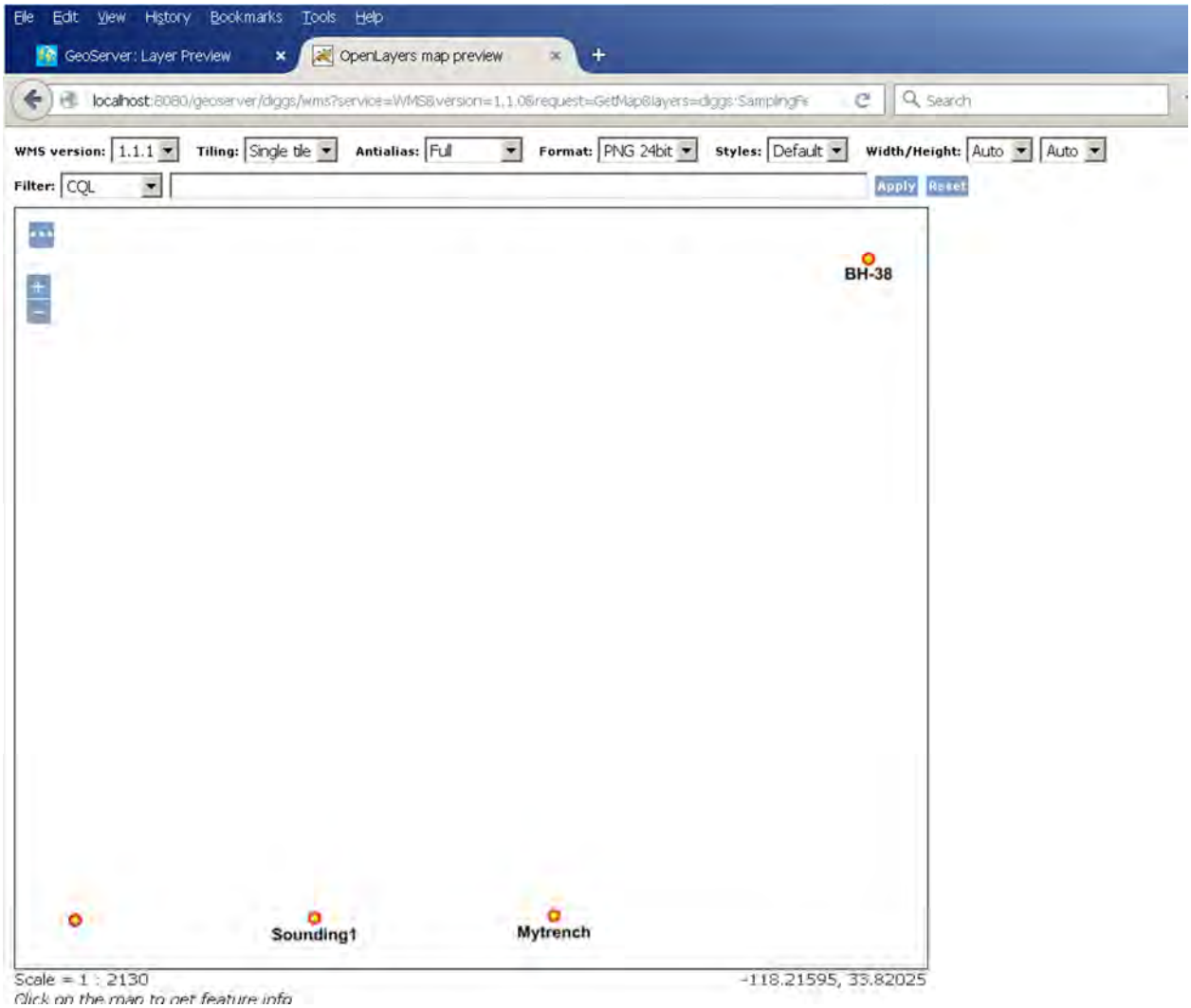
Select OpenLayers.

GeoServer will create a KML file containing placemarks with index information for Sampling Features in the selected Layer, and open it for you in OpenLayers in a new Web Browser Tab:



The placemark in the lower left does not have a name because it represents two sampling features that are close together.

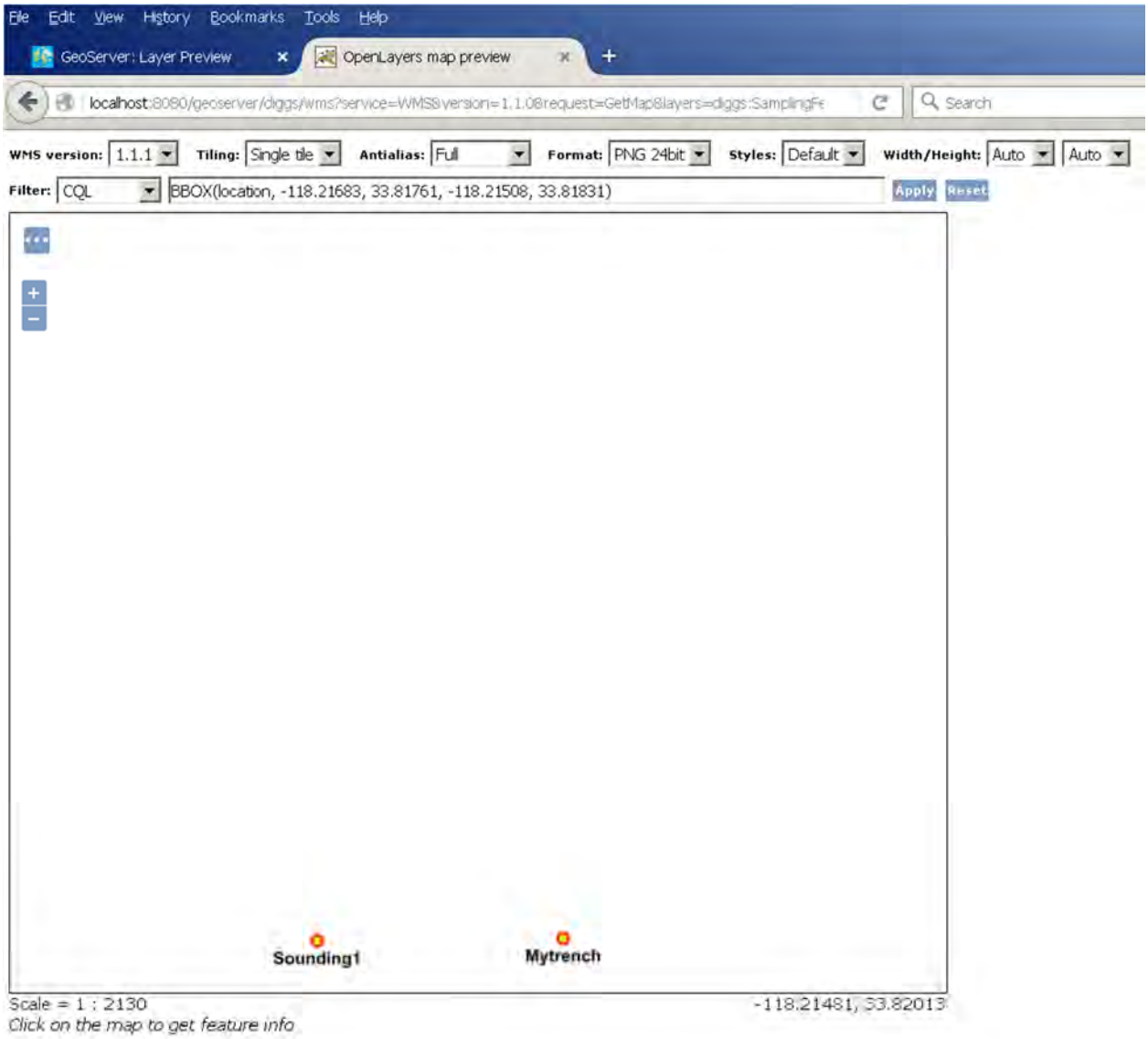
Click on the "…" button in the top left of the display to access feature selection query options.



Leave the "Filter" entry field as "CQL", which stands for the OGC Common Query Language [31].

DiggsGeoserverInstallationInstructions2016.docx tell Diggs GeoServer administrators how to create GeoServer data stores using the DIGGS2GeoServerJavaProperties.xsl XSLT stylesheet that creates a geographic feature (index) DIGGS data store for GeoServer.

"BBOX(location, -118.21683, 33.81761, -118.21508, 33.81831)" is a geographic bounding box query with ordinates in WGS84. "-118.21683, 33.81761" is the lower left corner longitude, latitude. ", -118.21508, 33.81831" is the upper right corner longitude,latitude. This bounding box query will select just two of the Sampling Features when you click the "Apply" button.



Now only the two Sampling Features within that bounding box are displayed.

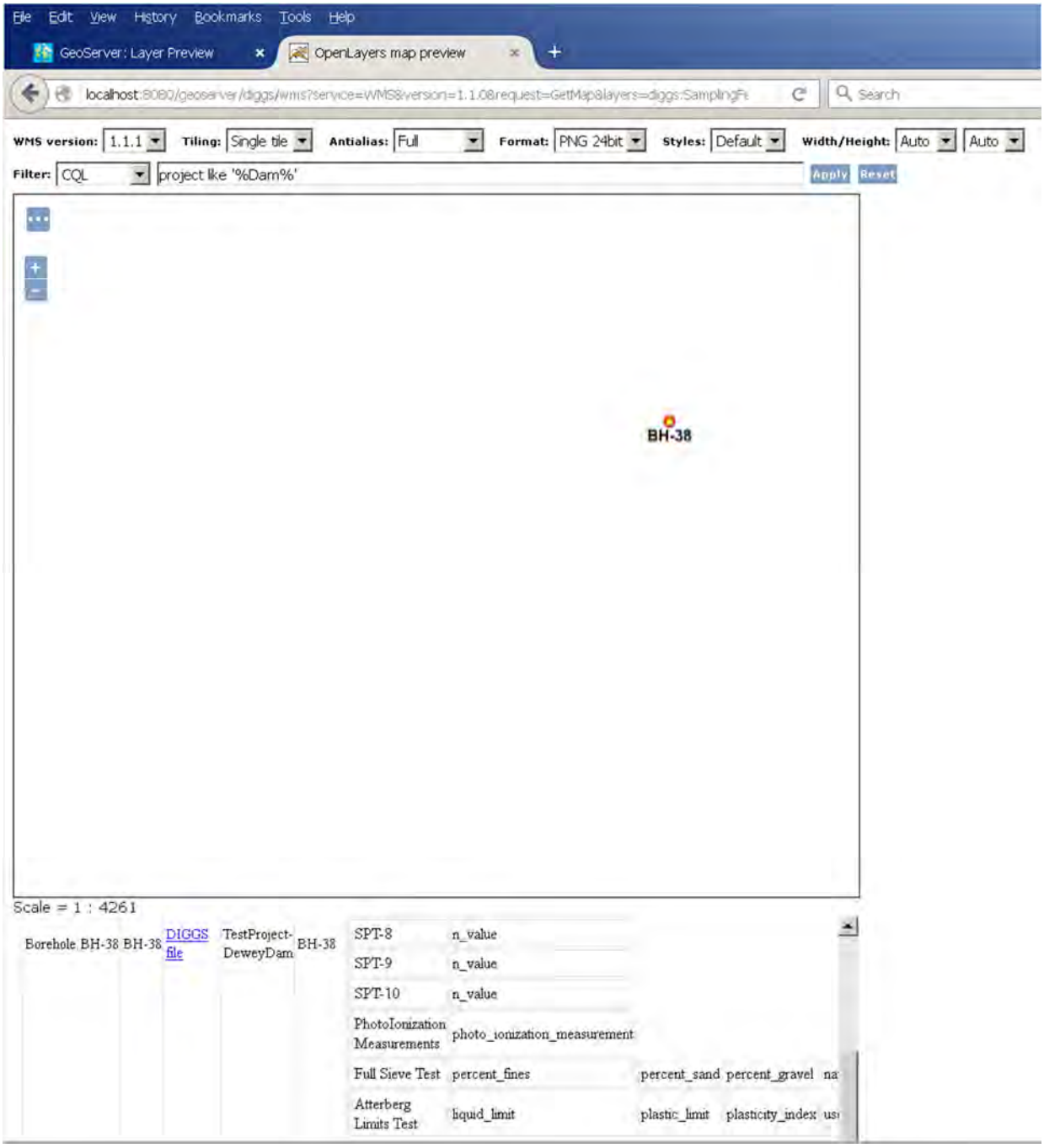
As in Google Earth, if you click on a placemark, e.g. “Sounding1”, index properties for the Sampling Feature are displayed in an HTML table:

SamplingFeatures

fid	id	fileURL	project	NAME	testsProperties				
Sounding.cpt-1	cpt-1	DIGGS file	p1-TestProject	Sounding1	CPT Sounding	tip_resistance	sleeve_friction	friction_ratio	pore_water_pressure

Click the “Reset” button at the top right to return to the previous display of all Sampling Features in the selected layer.

You can also query by the index properties of a Sampling Feature – its id, name and project, the tests that were run on it, and the properties that were recorded for those tests. For example, the CQL query "project like '%Dam%'" will select the one Sampling Feature in this layer that has a project name that contains 'Dam" with anything before or after it when you press the "Apply " button:



Bibliography

1. Data Interchange for Geotechnical and GeoEnvironmental Specialists http://diggsml.org/
2. https://www.w3.org/
3. http://geoserver.org/
4. http://geotools.org/
5. http://www.java.com/en/
6. https://en.wikipedia.org/wiki/Geographic_information_system
7. http://geoserver.org/about/
8. http://www.opengeospatial.org
9. http://www.opengeospatial.org/standards/gml
10. http://www.opengeospatial.org/standards/kml
11. http://www.opengeospatial.org/standards/wms
12. http://www.opengeospatial.org/standards/wfs
13. http://www.opengeospatial.org/standards/wps
14. http://diggsml.org/diggs-schema-version-20b
15. http://www.w3.org/XML/
16. http://www.w3.org/XML/Schema.html
17. http://www.oracle.com/technetwork/java/index-jsp-135475.html
18. http://tomcat.apache.org/
19. http://expath.org/
20. http://expath.org/modules/pkg/
21. http://expath.org/modules/http-client/
22. https://www.w3.org/standards/xml/transformation
23. http://www.saxonica.com/welcome/welcome.xml
24. https://docs.oracle.com/javase/tutorial/essential/environment/properties.html
25. http://docs.geoserver.org/latest/en/user/data/vector/properties.html
26. http://postgis.net/
27. http://docs.geoserver.org/latest/en/user/data/database/postgis.html
28. https://www.google.com/earth/
29. https://www.w3.org/Addressing/
30. http://openlayers.org/
31. http://docs.geoserver.org/stable/en/user/tutorials/cql/cql_tutorial.html
32. http://www.opengeospatial.org/standards/cat
33. https://www.google.com/earth/download/ge/agree.html
34. https://www.epsg-registry.org/
35. http://postgis.net/

Appendix G: GeoServer Instructions

DIGGS GeoServer Installation

GeoServer Overview

Any organization that converts its GeoTechnical / GeoEnvironmental data holdings into DIGGS [1] format can be a DIGGS data provider. This includes commercial and governmental organizations such as professional engineering consultants, laboratories and service providers, real estate development and investment companies, and national, state, county, metropolitan and municipal departments of transportation, commerce, interior, parks and environment. As explained in the following paragraphs, any DIGGS data provider can use GeoServer together with other free applications to manage DIGGS data and share it via the Web. [2]

GeoServer is "an open source server for sharing geospatial data. Designed for interoperability, it publishes data from any major spatial data source using open standards."[3] "GeoServer is built on GeoTools [4], an open source Java [5] GIS [6] toolkit."[7] Open Geospatial Consortium (OGC) [8] open standards supported by GeoServer include:

- Geography Markup Language (GML) [9]
- KML (formerly Keyhole Markup Language) [10]
- Web Map Service (WMS) [11]
- Web Feature Service (WFS) [12]
- Web Processing Service (WPS) [13]

DIGGS version 2.0.b schemas [14] are based on GML, (which is in turn based on Extensible Markup Language (XML) [15] and XML Schemas [16]). "GML serves as a modeling language for geographic systems as well as an open interchange format for geographic transactions on the Internet." As GML, DIGGS can be a spatial data source for GeoServer. So GeoServer, being open source, offers an inexpensive way for DIGGS data providers to organize and share their DIGGS document data files on the Web for internal and/or public use.

Because GeoServer is based on open standards, it may be hosted by and combined with other freely available software based on open standards. GeoServer is implemented as a Java Servlet [17] web application that may be hosted by an Apache Tomcat [18] web server.

EXPath [19] Packages [20] and HTTPClient [21] modules allow an XSL Transformations (XSLT) [22] Stylesheet that takes a directory of DIGGS files as input to be run by the Saxon [23] XSLT processor to call the GeoServer WPS to transform DIGGS geographic coordinates into the standard, world-wide Coordinate Reference System (CRS) WGS84 for inclusion in Java Properties Files [24][25] that can serve as a free (but relatively low performance) Geoserver geospatial data store index to DIGGS files. (A higher performance open source alternative is to use a PostGIS [26][27]database, but doing so requires considerably more work to set up and administer, so it is not covered in this document.)

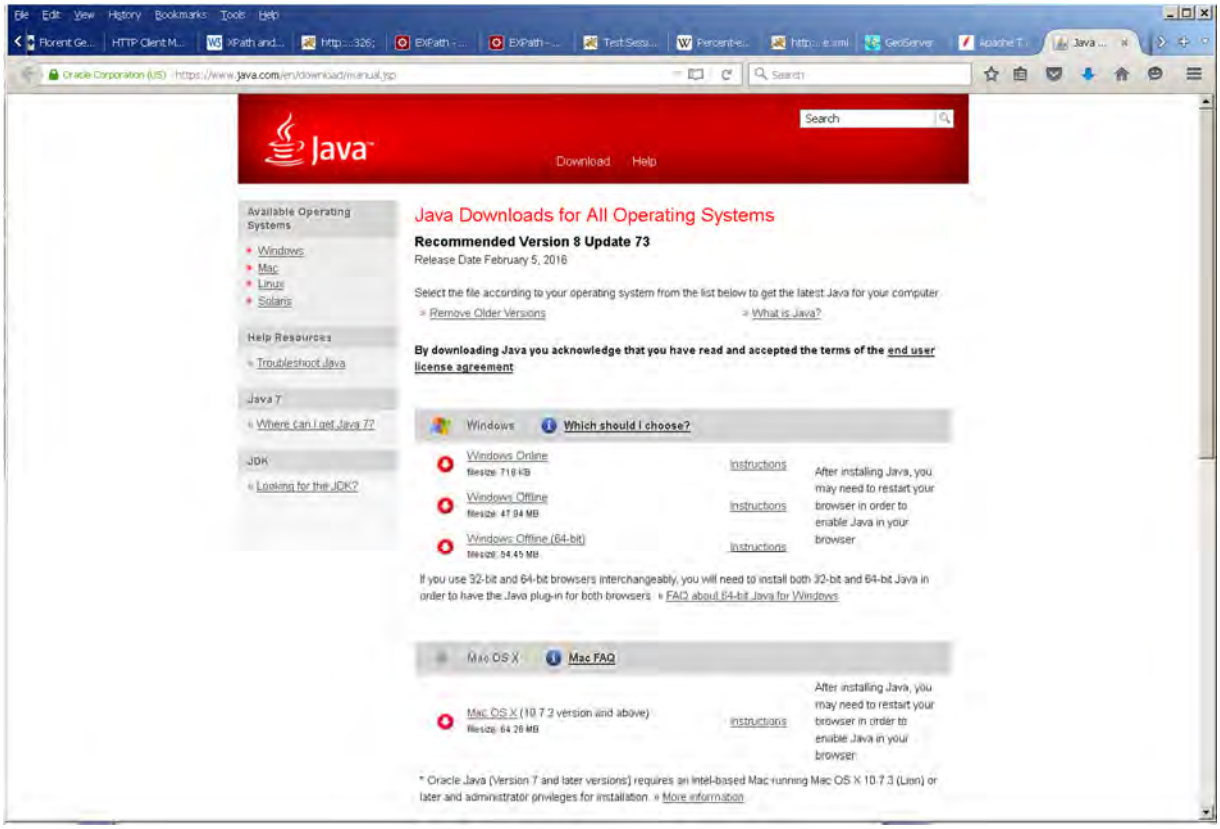
Google Earth[28] may be used to display KML placemarks produced by GeoServer for DIGGS sampling features. A DIGGS GeoServer user can click on these placemarks to see index (project name, sampling feature name, test name(s), test property name(s)) properties about each sampling feature, and to obtain a URL [29] hyperlink to the source DIGGS file.

OpenLayers [30] (which is integrated with GeoServer) may be used to display KML and GML in WMS map layers. OpenLayers supports the OGC Common Query Language (CQL) [31]specified by OGC Catalog Service. [32] A DIGGS GeoServer user can select DIGGS sampling features for display by specifying CQL queries based on the index properties, a geographic bounding box spatial query, or combinations thereof.

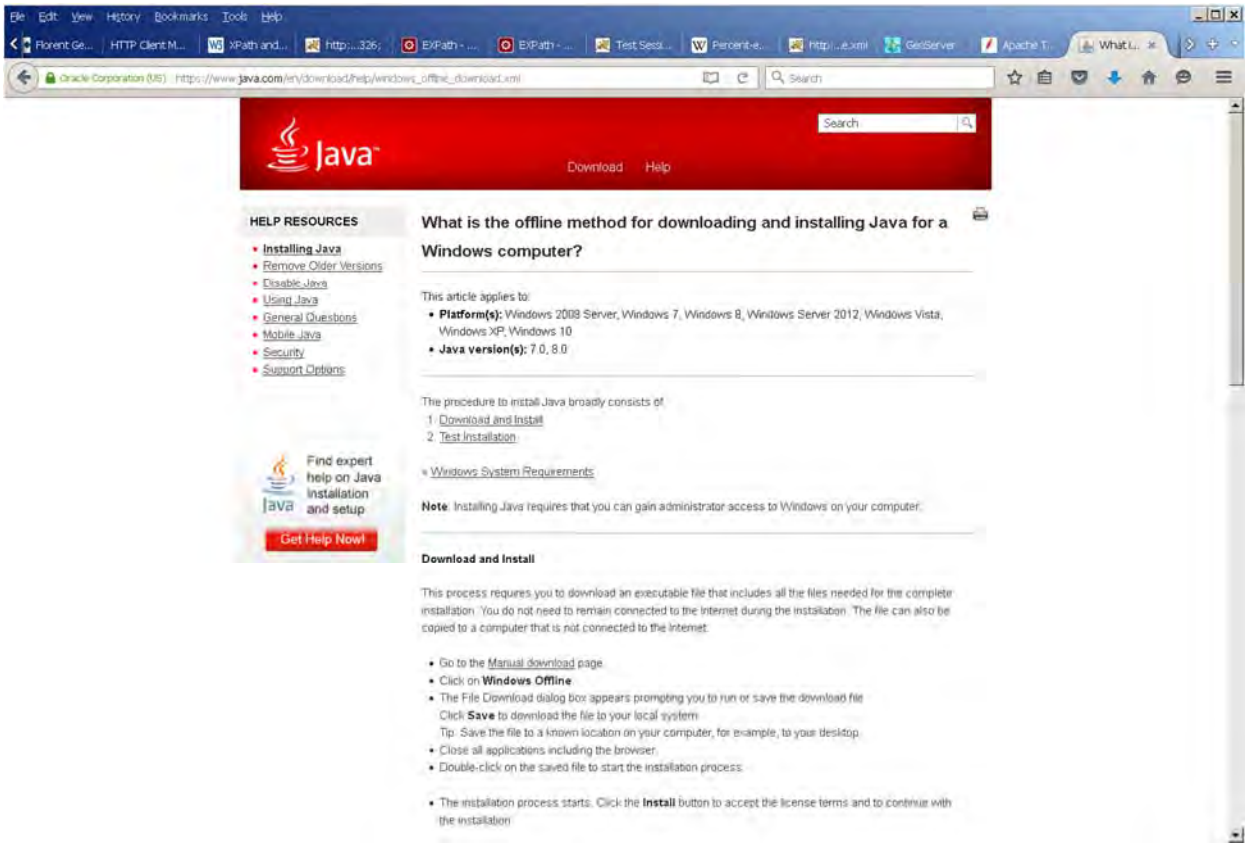
The following screen shots and explanatory text provide basic installation instructions for Java, Tomcat, GeoServer, EXPath, and the DIGGS2GeoServerJavaProperties.xsl XSLT stylesheet. See [33] to download and install Google Earth.

Java Download Page

To support Apache Tomcat, Image Matters recommends the latest release of Java 8, currently update 73. Go to https://www.java.com/en/download/manual.jsp, select the appropriate version for your server platform and download it.



Then click on the installation Instructions link for that version, and follow the instructions you find there to install Java. For example, the Windows 32 bit instructions look like this:

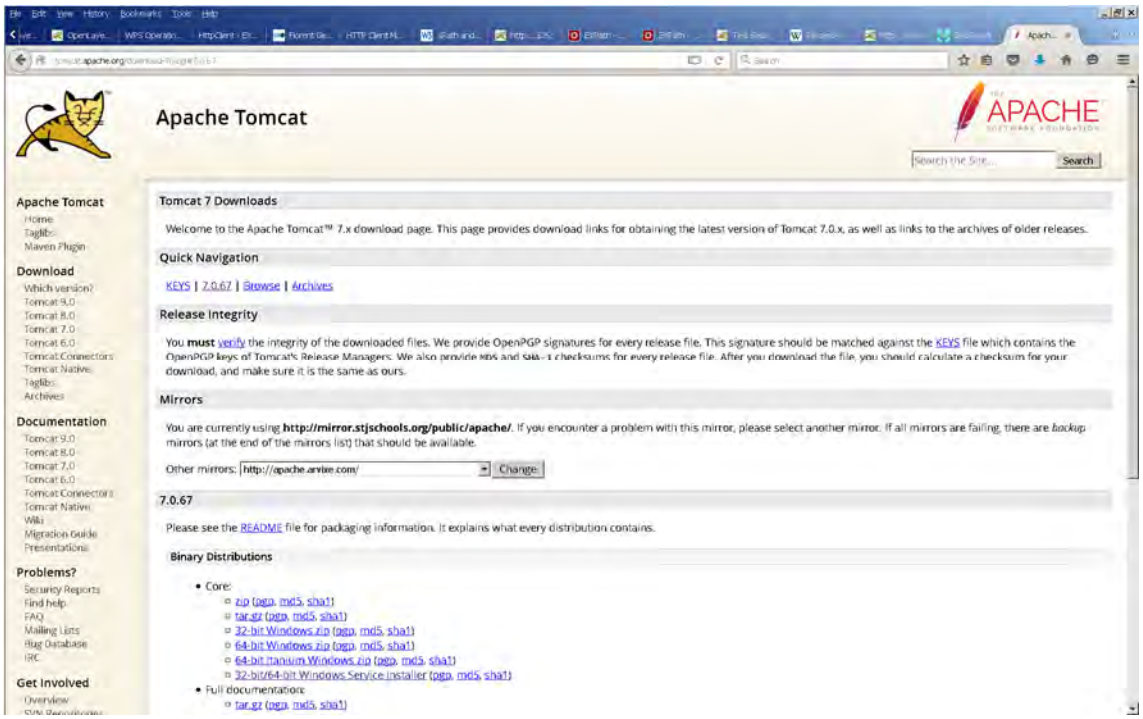


At the bottom of the instructions screen, click on the test applet link to test your Java installation:

Test Installation
To test that Java is installed and working properly on your computer, run this test applet.

Apache Tomcat Download Page

To support the DIGGS Validator web application, Image Matters recommends the latest release of Tomcat version 7.0, currently release 67. Open a web browser and go to http://tomcat.apache.org/download-70.cgi#7.0.67



Click on the link for a binary distribution appropriate for your server platform and download it. Open the online documentation for Tomcat 7.0.67 at http://tomcat.apache.org/tomcat-7.0-doc/.

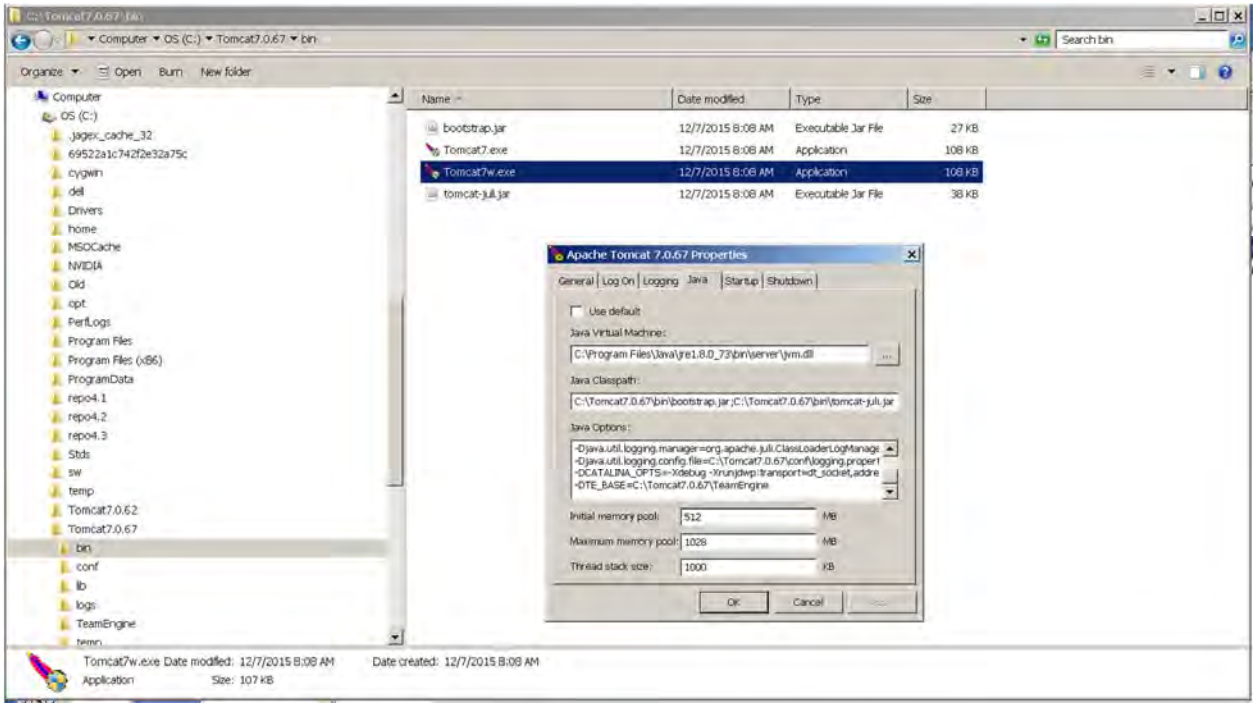
Read the introduction, then click on the 2) Setup link in the user guide menu on the left, read and follow the instructions at http://tomcat.apache.org/tomcat-7.0-doc/setup.html. As it says in the introduction, "There are several ways to set up Tomcat for running on different platforms. The main documentation for this is a file called RUNNING.txt." That file walks you through

unpacking the distribution and editing startup and setenv configuration scripts (.bat for Windows, .sh for Unix). The environment variable "CATALINA_HOME" refers to the directory where you unpacked the distribution, e.g. C:\Tomcat7.0.67. Here is a developer's setenv.bat for a 32 bit Windows installation:

```
REM environment values to run tomcat
set "JRE_HOME=C:\Program Files (x86)\Java\jre8"
echo Using JRE_HOME:      %JRE_HOME%

REM envionment values to debug tomcat servlets from eclipse and for OGC Teamengine
set "CATALINA_OPTS=-Xdebug -
Xrunjdwp:transport=dt_socket,address=8000,server=y,suspend=n
echo Using CATALINA_OPTS: %CATALINA_OPTS%
```

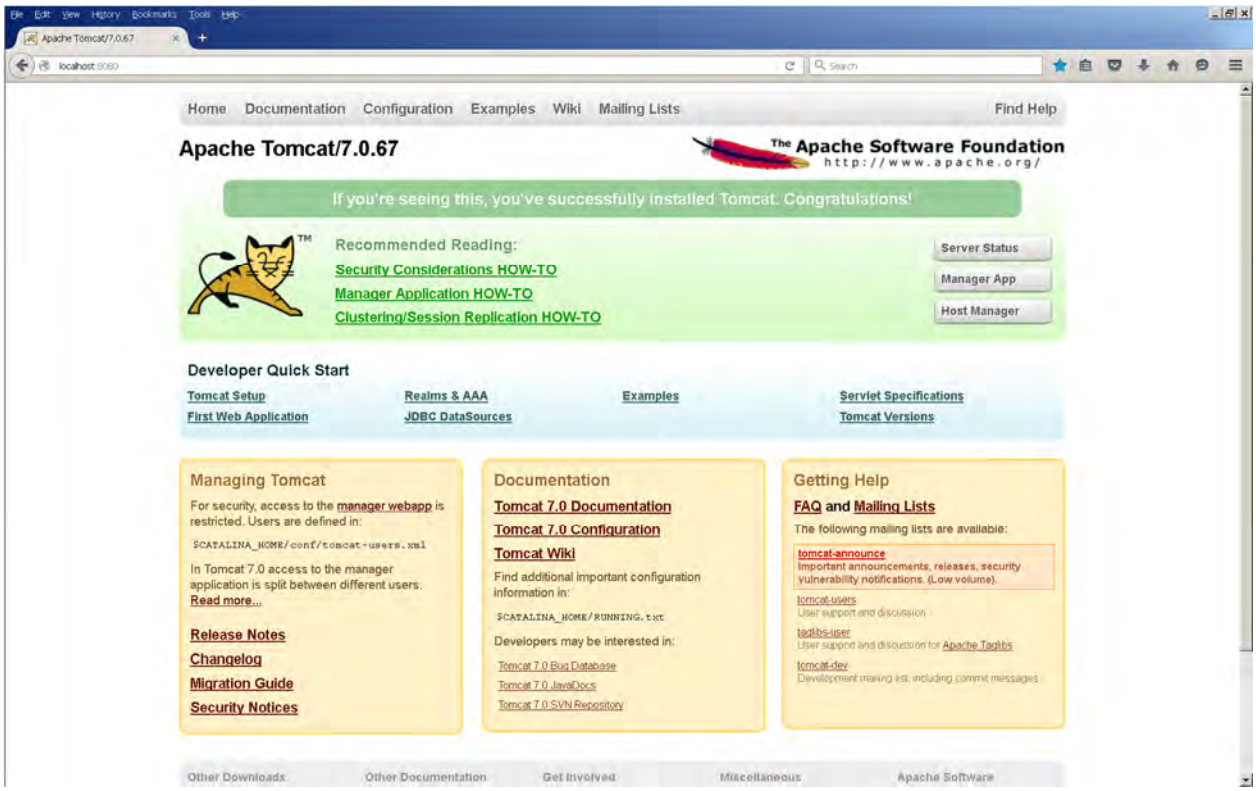
Notes:

1. CATALINA_HOME should be a top level directory, and must be a top level directory if this TomCat installation also serves the DIGGS TeamEngine Validator and XSLT utility webapps.
2. CATALINA_OPTS is explained in setenv.bat comments above
3. As explained in RUNNING.txt, setenv.bat is not invoked when Tomcat is installed and run as a Windows Service. In that case you need to invoke the Tomcat7w configuration utility and define the environment variables as Java Opts:



RUNNING.txt also tells you how to start and shutdown Tomcat. Once you have Tomcat installed, start it up.

By default Apache Tomcat serves the following home page. It can be removed from a production installation.



By default Tomcat implements a username / password authentication mechanism, but it can be installed with other "security realm" mechanisms. For a production installation, check the advice at the **Security Considerations HOW-TO** on this page.

To get access to the Tomcat Web Application Manager, you have to edit the users.xml file in "CATALINA_HOME"/conf, e.g. C:\sw\apache-tomcat-7.0.67\conf\users.xml and set up a username with roles="manager-gui". For example, add the following lines to get started.

```
<role rolename="tomcat"/>
<role rolename="manager-gui"/>
<user username="tomcat" password="tomcat" roles="tomcat"/>
<user username="admin" password="tcadmin" roles="manager-gui"/>
```

But be sure to change the admin username and password to something more robust for a production server!

Manifest of GeoServer and EXPath Utility Installation Files

The files used to install GeoServer, the EXPath package and HTTPClient utilities, and supporting files to populate the Diggs data document files directory below are listed in the following table.

File	Source	Purpose
DIGGSBoreholeWithParticleSize.xml	http://diggsml.org	Sample DIGGS document file with WGS84 CRS that does not need transformation
testinstance20bFixedSRS.xml	http://diggsml.org	Sample DIGGS document file with other CRS that does need transformation
geoserver-2.8.x-war.zip	http://geoserver.org/release/stable/	GeoServer WebApp
geoserver-2.8.x-wps-plugin.zip	http://geoserver.org/release/stable/	GeoServer OGC WPS extension plugin for EXpath calls to WPS CRS geo:reproject CRS transformation
expath-repo-installer-0.13.1.jar	http://expath.org/files	EXPath packaging system; repository for HTTP Client software files
expath-http-client-saxon-0.12.0.zip	http://expath.org/files	EXPath HTTP Client to send HTTP requests from XSLT stylesheet
DIGGS2GeoServerJavaProperties.xsl	http://diggsml.org	XSLT stylesheet that creates a geographic feature (index) DIGGS data store for GeoServer.
DIGGS_GML_CRS_DICTIONARY.xml	http://diggsml.org	GML Coordinate Reference System (CRS) dictionary used by XSLT stylesheet

DIGGS Data Document Files Directory Configuration

Create a directory where DIGGS data document files to be served by GeoServer will reside. Set the permissions on this directory so that TomCat can read the files in it. These instructions will refer to this directory using the environment variable "DIGGS_HOME". This directory can be anywhere EXCEPT under the CATALINA_HOME directory where you installed TomCat. The DIGGS_HOME example used here is "C:/Diggs".

Download DIGGSBoreholeWithParticleSize.xml and testinstance20bFixedSRS.xml. Copy them to DIGGS_HOME.

Stop TomCat.

Edit the server.xml file in "CATALINA_HOME"/conf, e.g. C:\sw\apache-tomcat-7.0.67\conf\server.xml. Scroll down to the bottom and locate the <Host> elemnt:

```
    <Host name="localhost"  appBase="webapps"
        unpackWARs="true" autoDeploy="true">
…
```

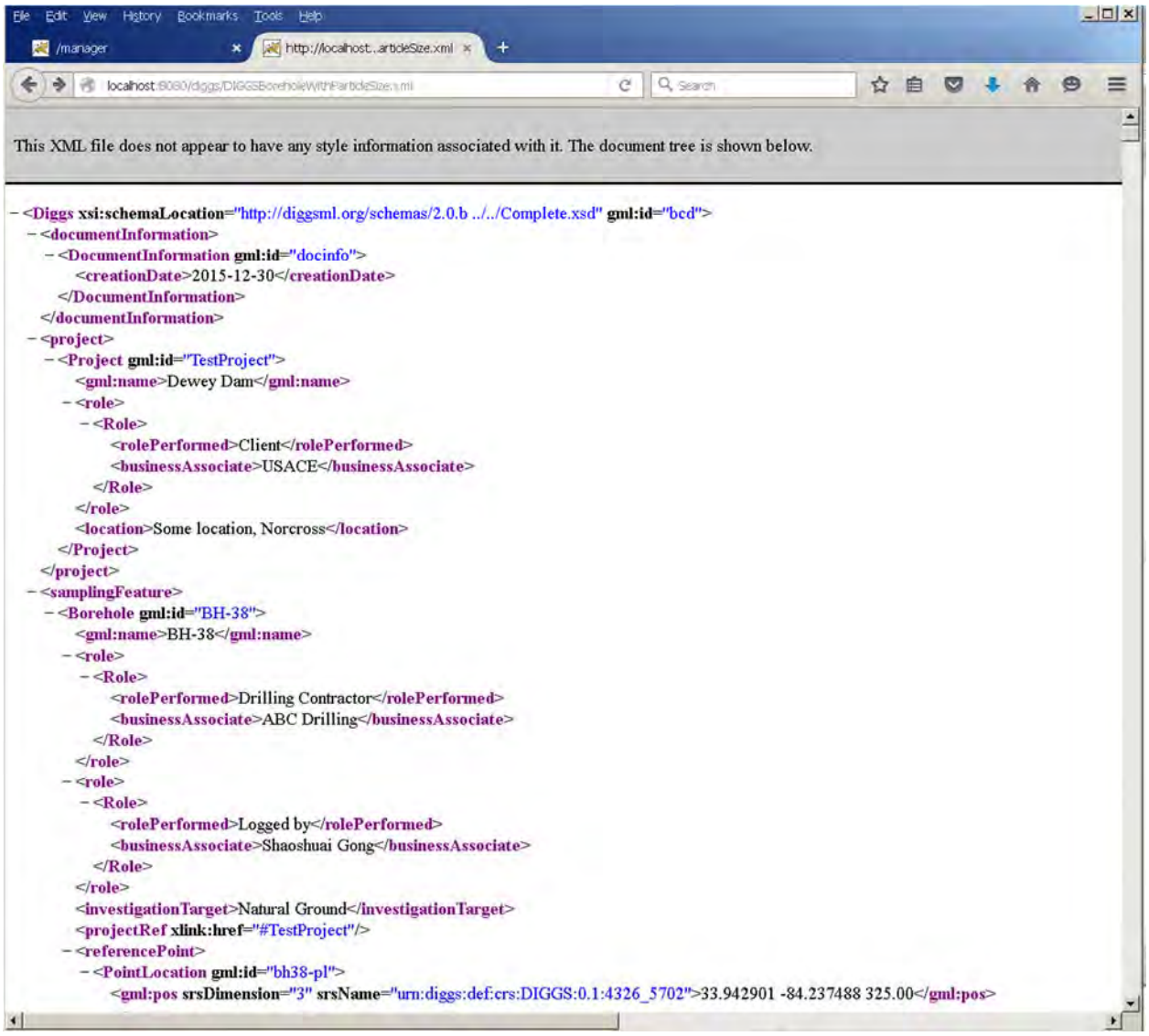
Insert the following descriptive <!-- XML comment --> and <Context> element definition as the first contents of the <Host> element, replacing "C:/Diggs" with the DIGGS_HOME path for your configuration:

```
    <Host name="localhost"  appBase="webapps"
        unpackWARs="true" autoDeploy="true">

                <!-- Context definition to serve static DIGGS files -->
                <Context docBase="C:/Diggs" path="diggs"/>
```

Save the edited server.xml file.

Start TomCat.

Check that TomCat successfully serves your sample DIGGS document file:



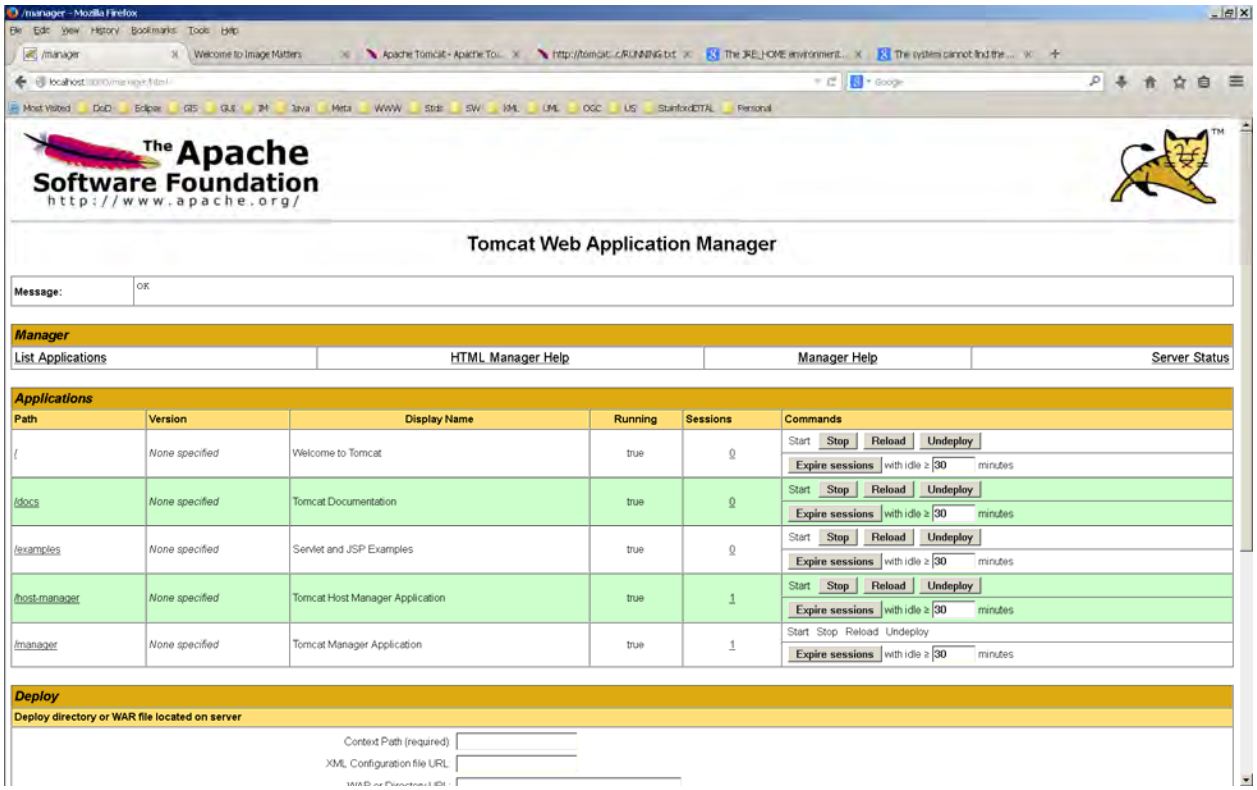
Proxy Server Configuration

If you run Tomcat behind a proxy server (or a web server such as Apache that is configured to behave like a proxy server) see http://localhost:8080/docs/proxy-howto.html for general instructions. The Apache reverse proxy has a problem doing a POST on forms, which the TEAM engine requires to work correctly. Apache ignores the directives and uses the backend server in the URL. If you see the backend server name in the header, then you will need to setup the correct rewrite rule(s) as shown in the following sample for the DIGGS Validator installation at http://diggsml.org/teamengine/ (instructions provided by jkiechlin@asce.org). Replace "tomcat.asce.org" with your proxy server path and "teamengine" with "geoserver" in the following sample:

```
ProxyPreserveHost on
#
ProxyPass /diggs   http://tomcat.asce.org:8080/diggs
ProxyPassReverse / http://tomcat.asce.org:8080/
#
ProxyPass /teamengine   http://tomcat.asce.org:8080/teamengine
ProxyPassReverse / http://tomcat.asce.org:8080/
```

Apache Tomcat Web Application Manager

The Apache Tomcat home page includes a "Manager App" button link to this Web Application Manager page at http://localhost:8080/manager/html that allows a Web Administrator to manage the Web applications Tomcat serves, and a **Manager Application HOW-TO** link on how to use it. Access to this page requires user authentication. DIGGS Validator users will never see it. In addition to the home page and web application manager page applications, by default Tomcat is installed with documentation, examples, and host manager applications.



All of these applications are installed in the Tomcat "webapps" subdirectory. New applications are installed by copying a Java Web Application aRchive (.war) file to the "webapps" subdirectory. This can be done by hand (static deployment), or by using the "deploy" operations further down on the manager web page. See http://tomcat.apache.org/tomcat-7.0-doc/deployer-howto.html for more information on Tomcat web app deployment. Once you have installed GeoServer following the instructions below, an application with the Path /geoserver and DisplayName GeoServer will be listed in the middle of the screen

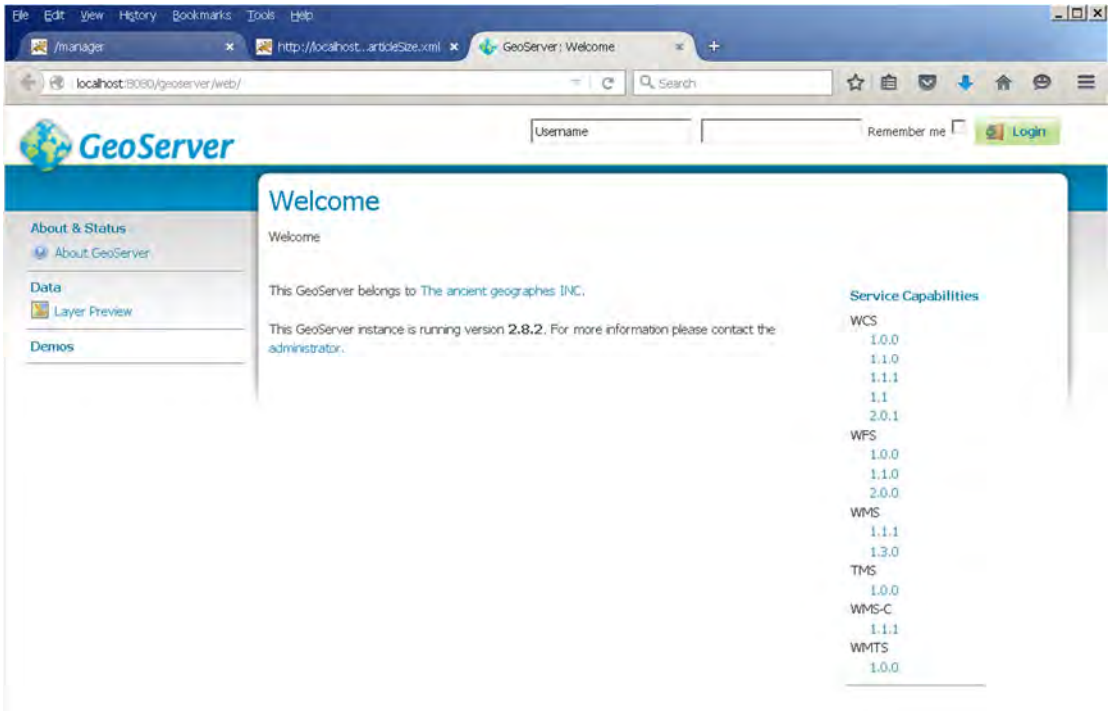
GeoServer Installation

Download geoserver-2.8.x-war.zip from http://geoserver.org/release/stable/

Extract geoserver.war from geoserver-2.8.x-war.zip and copy it to CATALINA_HOME/webapps.

Start TomCat if it is not already running.

Access the GeoServer welcome page at http://localhost:8080/geoserver



Note that there is no WPS service link in the left hand services column.

Stop TomCat.

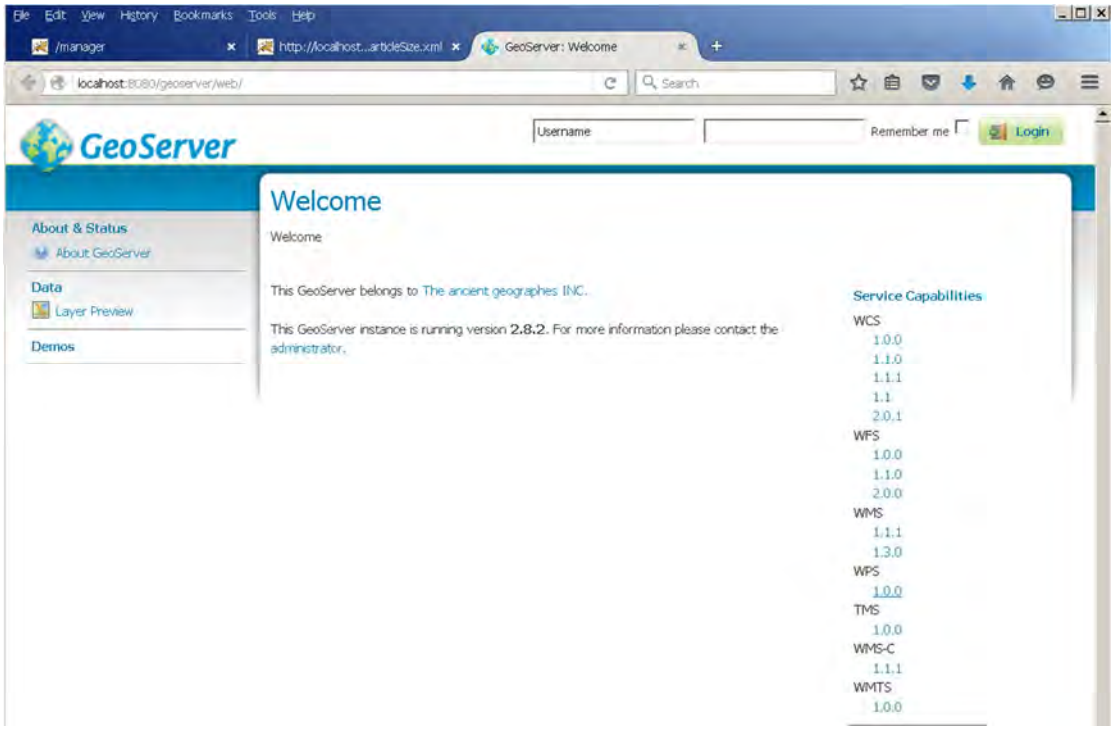
Download geoserver-2.8.x-wps-plugin.zip from from http://geoserver.org/release/stable/
It contains the file shown below, which implement an OGC Web Processing Service (WPS):

Name	Type	Compressed size	Password p...	Size	Ratio
gs-web-wps-2.8.2.jar	Executable Jar File	131 KB	No	145 KB	10%
gs-wps-core-2.8.2.jar	Executable Jar File	357 KB	No	391 KB	9%
gt-process-geometry-14.2.jar	Executable Jar File	11 KB	No	12 KB	14%
gt-xsd-wps-14.2.jar	Executable Jar File	36 KB	No	40 KB	10%
net.opengis.wps-14.2.jar	Executable Jar File	177 KB	No	192 KB	9%
serializer-2.7.1.jar	Executable Jar File	255 KB	No	272 KB	7%

Extract these Java Archive (.jar) files to CATALINA_HOME/webapps/geoserver/WEB-INF/lib/

Start TomCat.

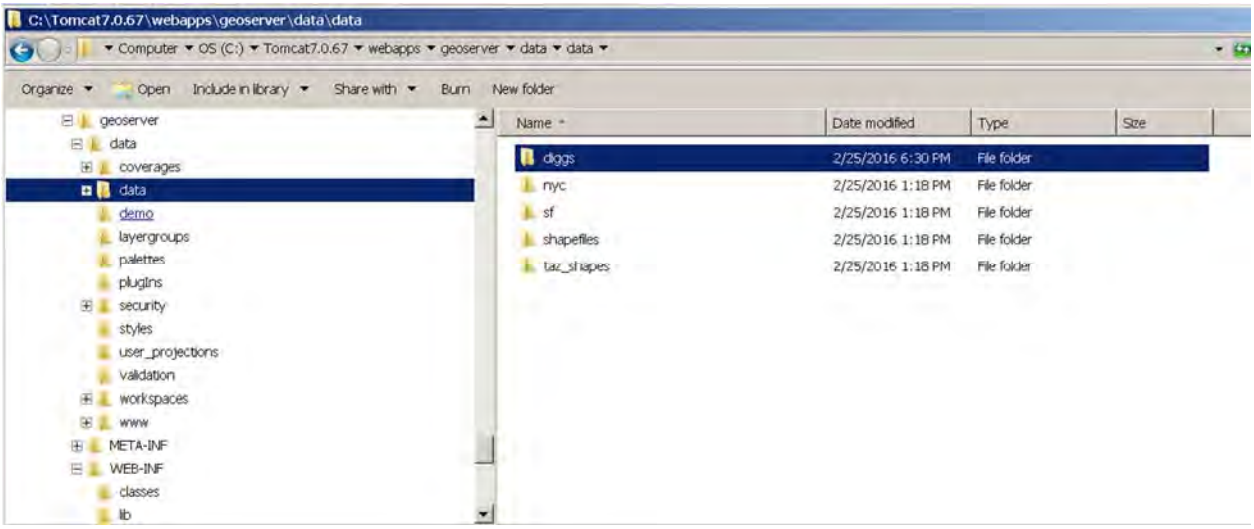
Access the GeoServer welcome page at http://localhost:8080/geoserver again (refresh it if still displayed). Note that there is now a WPS service link in the left hand service column.



GeoServer DIGGS Data Store Directory Configuration

Create the directory CATALINA_HOME/webapps/geoserver/data/data/diggs. This directory will contain the DIGGS GeoServer Java Properties files that serve as a geographic feature (index) DIGGS data store for GeoServer. These instructions will refer to this directory using the environment variable "GEOSERVER_DIGGS_STORE".

The CATALINA_HOME/webapps/geoserver directory tree should look like this:



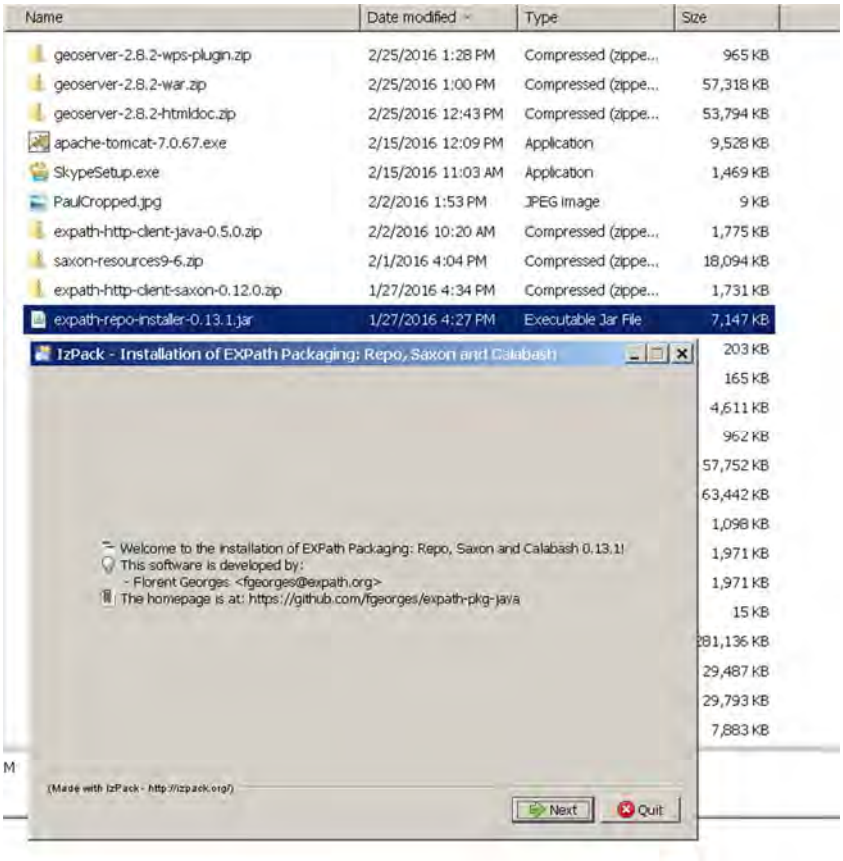
The other directories in CATALINA_HOME/webapps/geoserver/data/data contain GeoServer sample files.

GeoServer Web Processing Service (WPS) Intialization

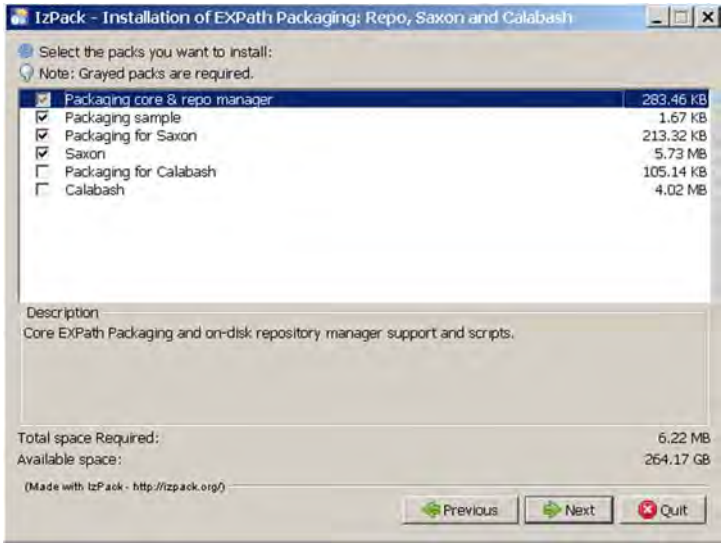
From the GeoServer Welcome page shown on page 13 above, log in to GeoServer as user "admin". To initialize the WPS Service used by the DIGGS2GeoServerJavaProperties.xsl XSLT stylesheet via the EXPath HTTPClient module (see below), you must do this once after the TomCat Web Application Server that runs GeoServer is started. If you do not, stylesheet execution will stall upon issuing a WPS request that is not answered. The default password is "geoserver". Click on the "change it" link and set a more secure password. You do not have to remain logged in as user "admin" for the WPS to continue to operate correctly.

EXPath Installation

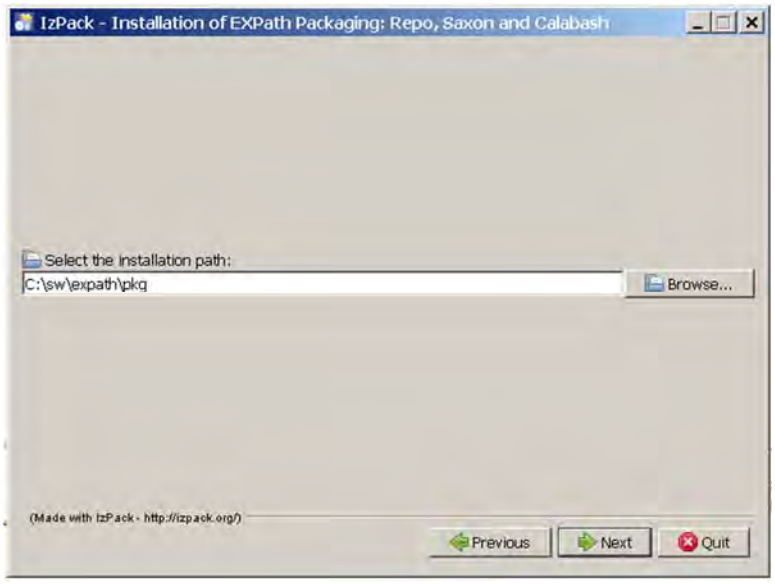
Download expath-repo-installer-0.13.1.jar from http://expath.org/files. It is an executable .jar file. Double click on it to run it



Click Next.

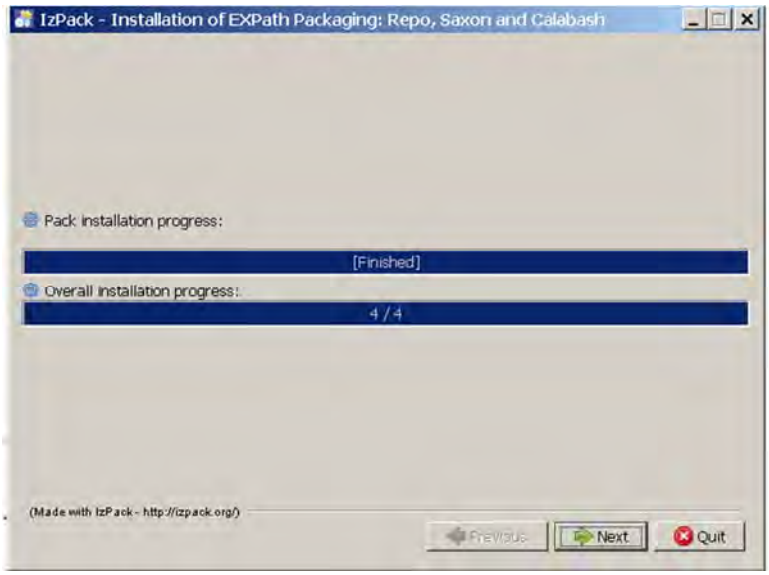


De-select “Packaging for Calabash” and “Calabash” and click Next.

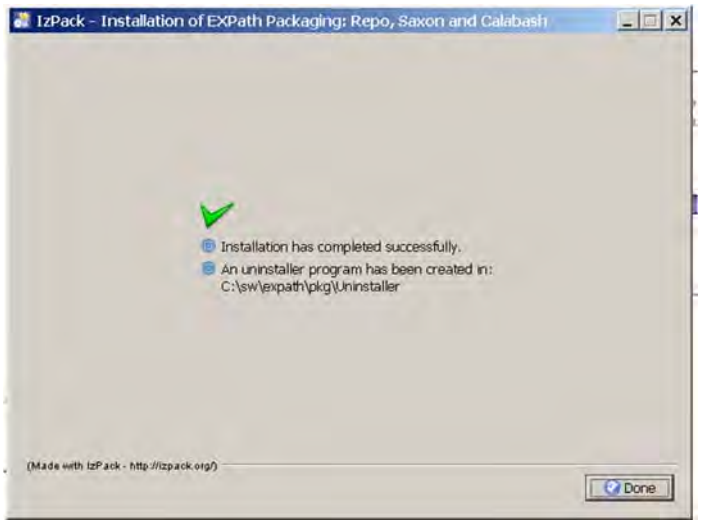


Select an installation path and click Next. In the following instructions, this path will be referred to as EXPATH_PKG.

Click OK.



Click Next.

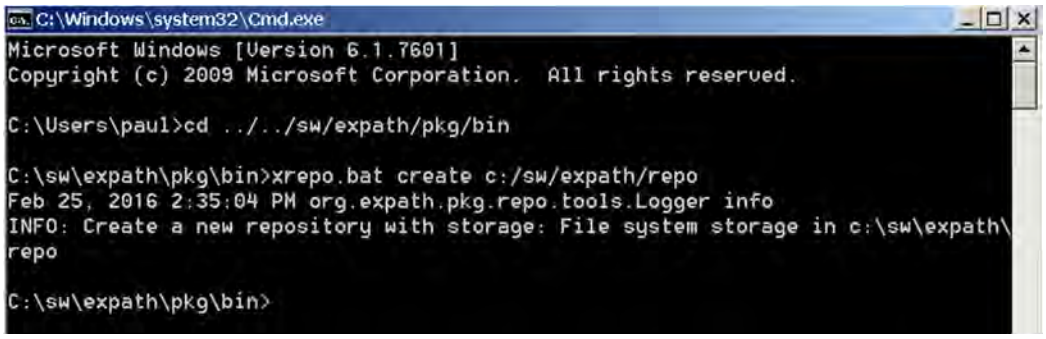


Click Done.

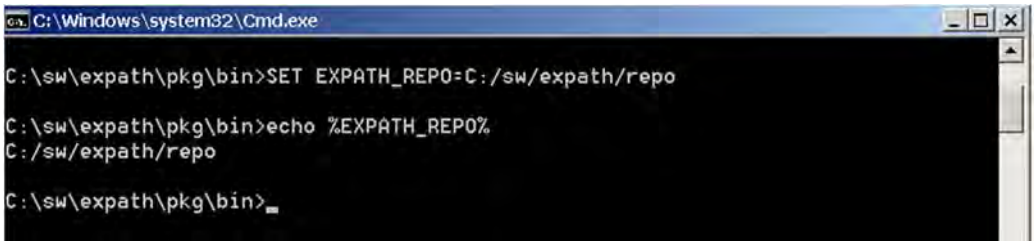
Start / Run Cmd to open a Cmd.exe shell.

Change Directory to your installation EXPATH_PKG/bin: >cd ../../sw/expath/pkg/bin

Create EXPath repository: >xrepo.bat create c:/sw/expath/repo

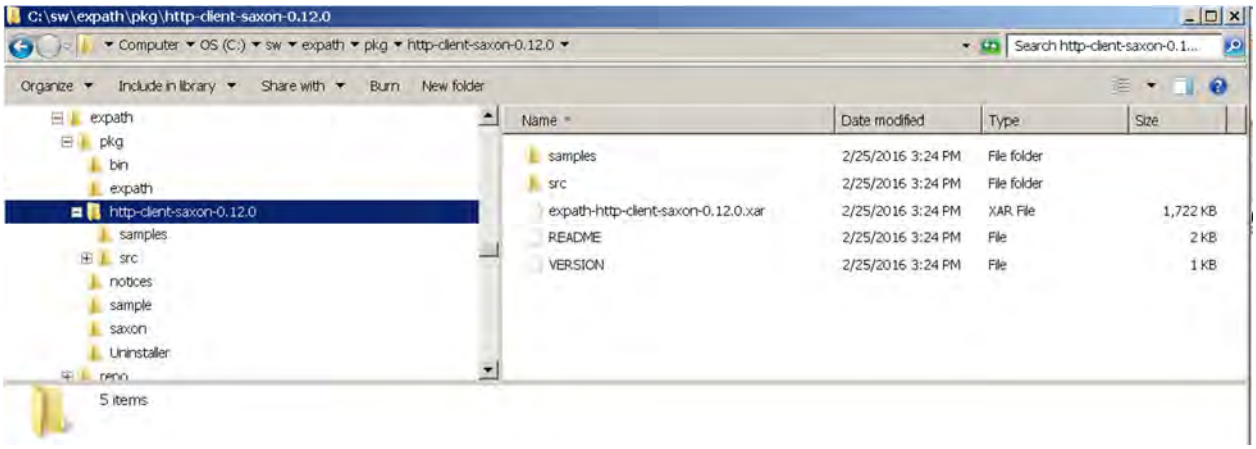


Set the EXPATH_REPO environment variable to refer to that repository:



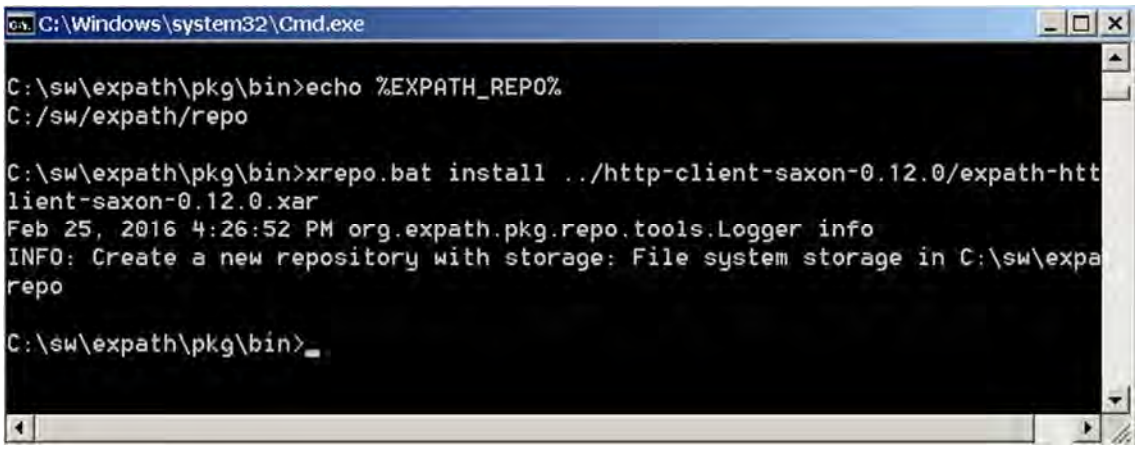
Download expath-http-client-saxon-0.12.0.zip from http://expath.org/files. It contains the EXPath HTTP Client installation files.

Unzip expath-http-client-saxon-0.12.0.zip into EXPATH_PKG. The EXPath installation directory should now look like this:



Run xrepo.bat again to install the EXPath HTTP Client installation files into EXPATH_REPO:

>xrepo.bat install ../http-client-saxon-0.12.0/expath-http-client-saxon-0.12.0.xar



EXPATH_REPO should now look like this:

XSLT Stylesheet Installation

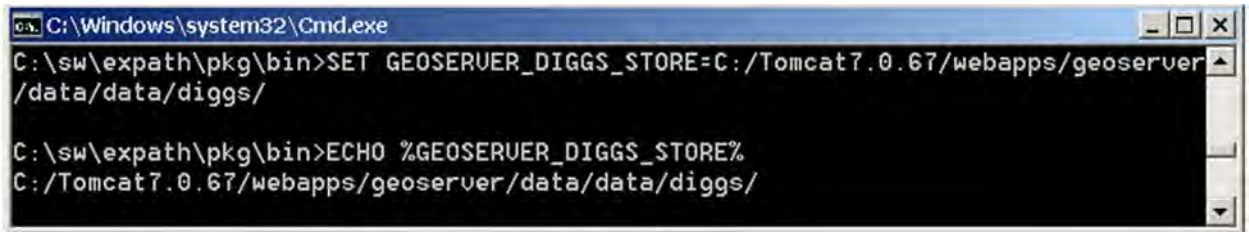
Download DIGGS_GML_CRS_DICTIONARY.xml from http://digsml.org .

Copy it to EXPATH_PKG/samples

Download DIGGS2GeoServerJavaProperties.xsl from http://digsml.org .

Copy it to EXPATH_PKG/samples

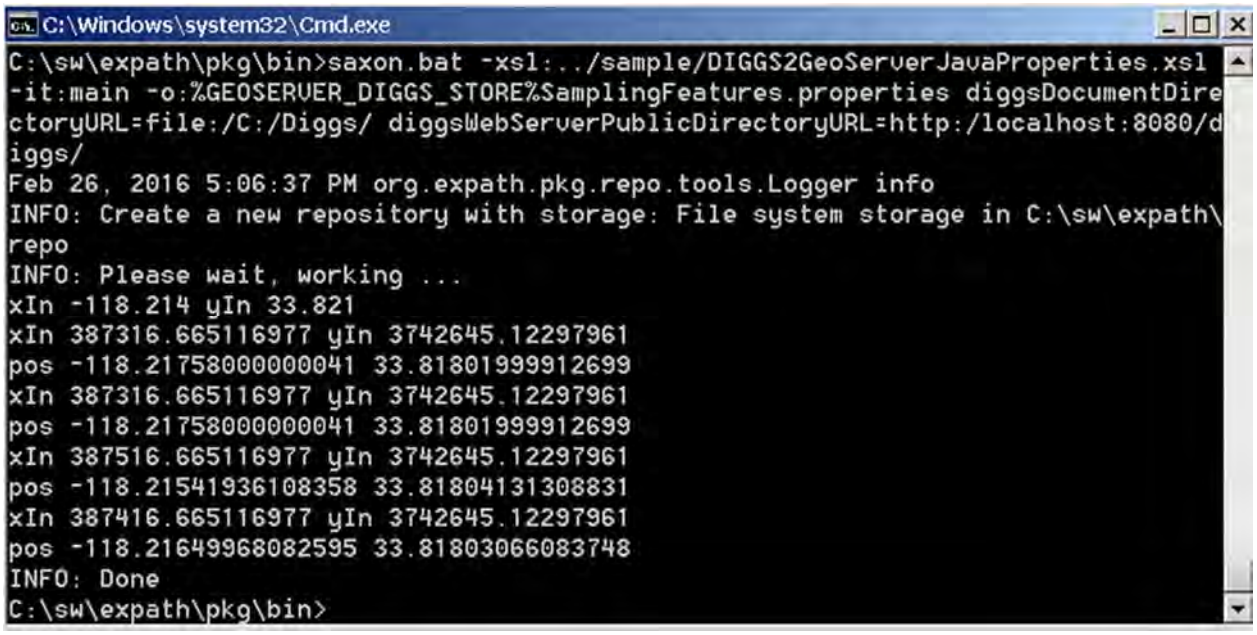
Set the GEOSERVER_DIGGS_STORE environment variable:



Note: Its value must end with "/". If it does not, the generated file property href attribute values will be incorrect.

Be sure that you have logged into GeoServer as "admin" since TomCat was started so that the WPS service is initialized; you may then log out.

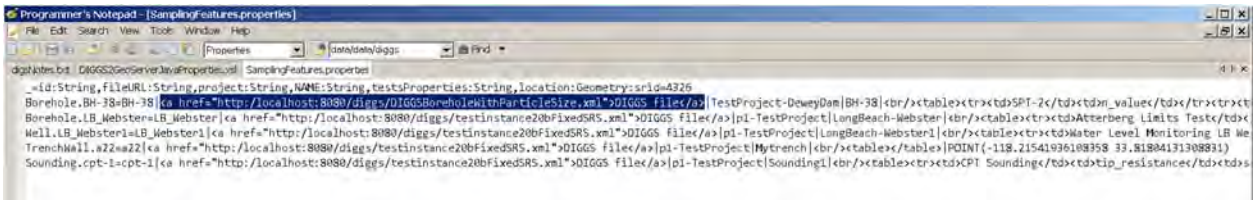
Run the DIGGS2GeoServerJavaProperties.xsl stylesheet with the EXPath Saxon processor:



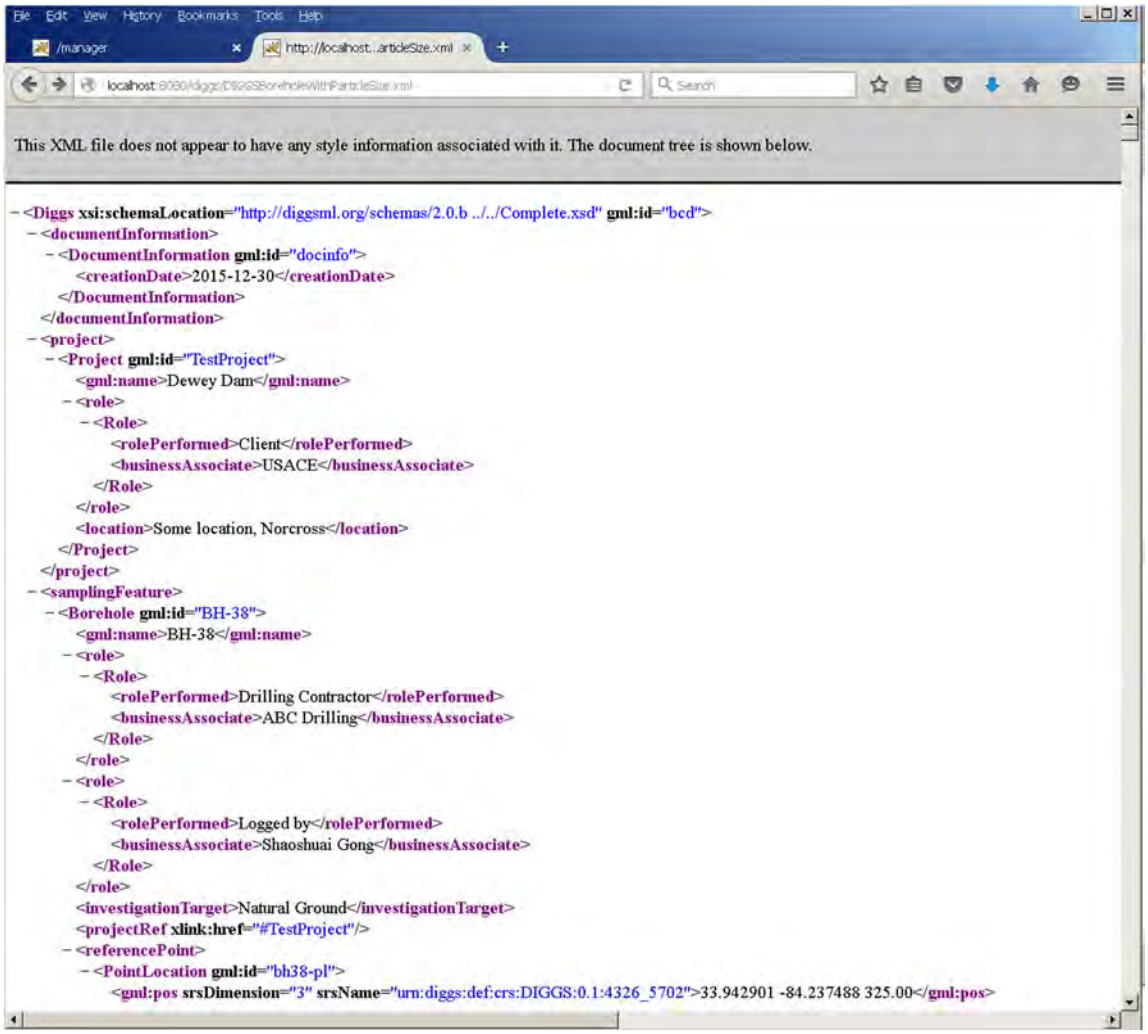
Note: the diggsDocumentDirectoryURL must have a “file:” protocol and end with “/” the diggsWebServerPublicDirectoryURL must have an “http:” protocol and end with “/”; both must use “/” instead of “\” as path delimiters.

Open the output %GEOSERVER_DIGGS_STORE%SamplingFeatures.properties in a text editor.

Check that the file property href attribute values are correct:



Cut and paste one into a web browser:

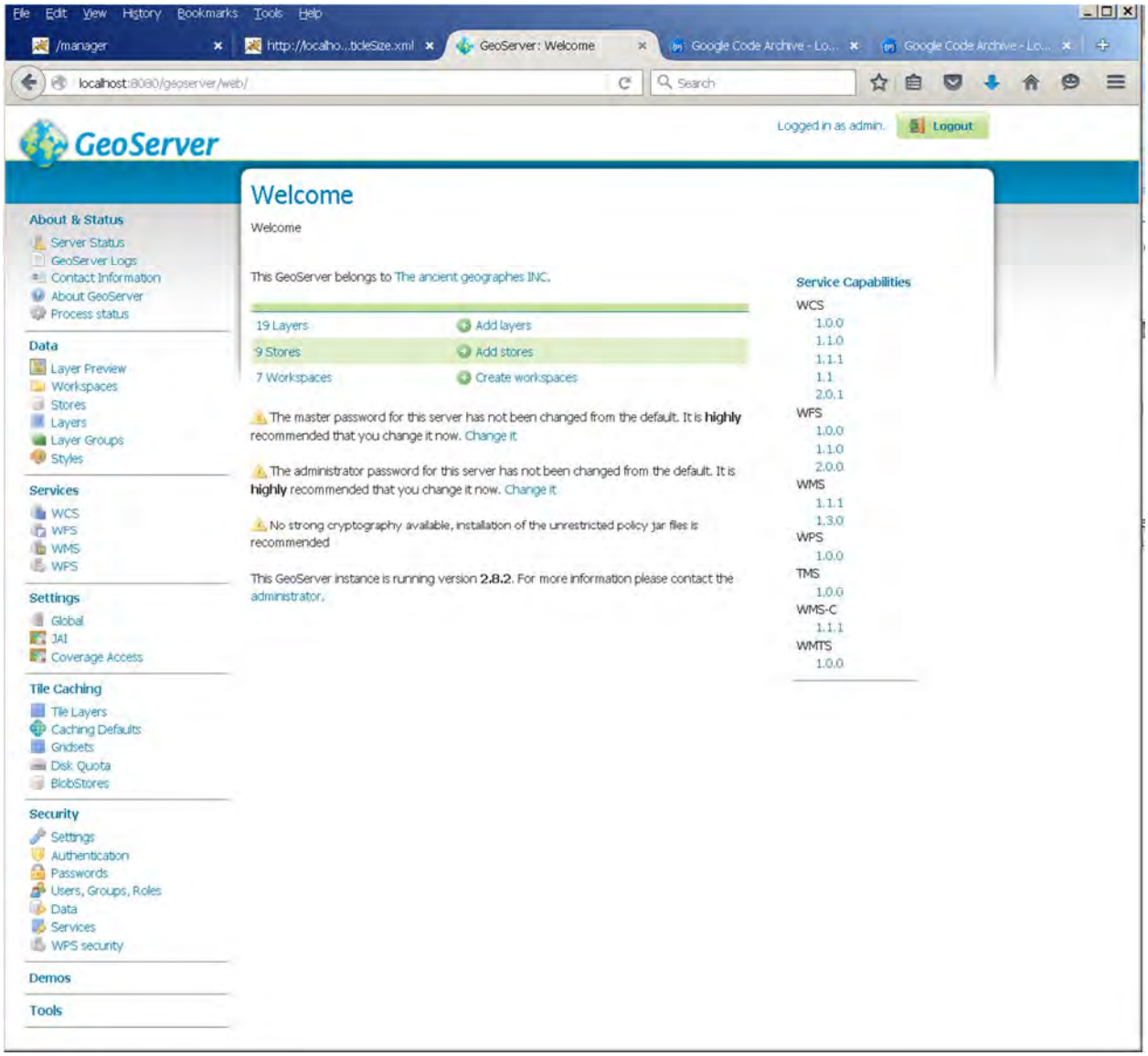


GeoServer Workspace Configuration

Close SamplingFeatures.properties in the text editor.

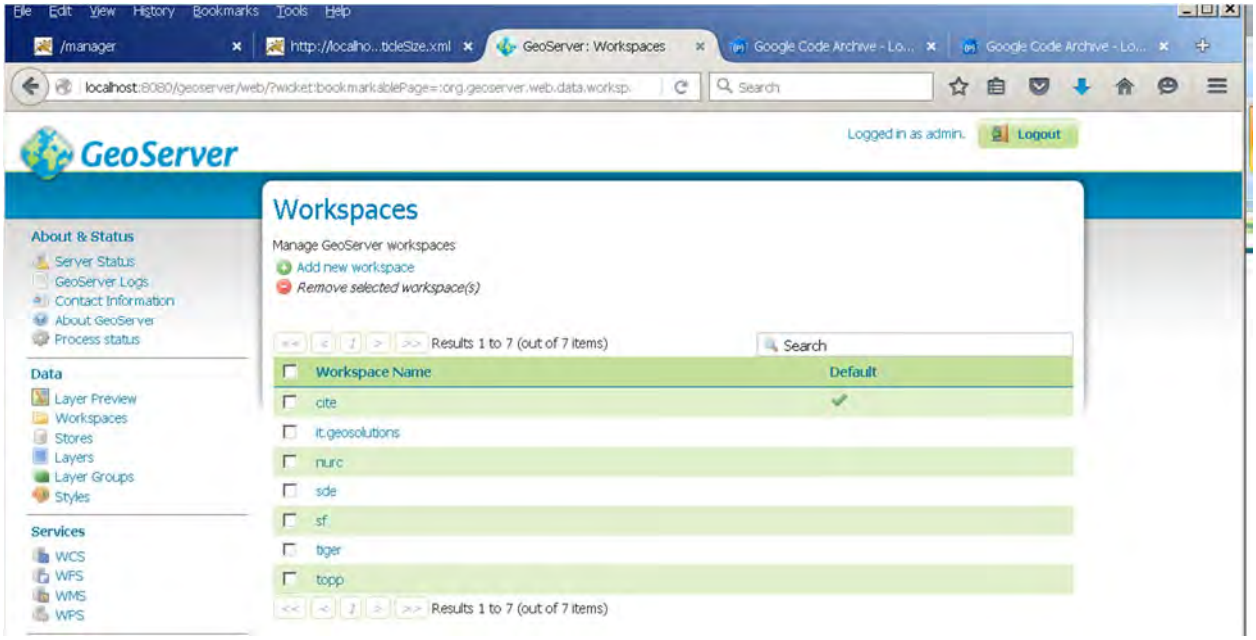
Restart TomCat so that GeoServer will read the newly created SamplingFeatures.properties file.

From the GeoServer Welcome page shown on page 13 above, log in to GeoServer as user "admin". The default password is "geoserver". Click on the "change it" link and set a more secure password.



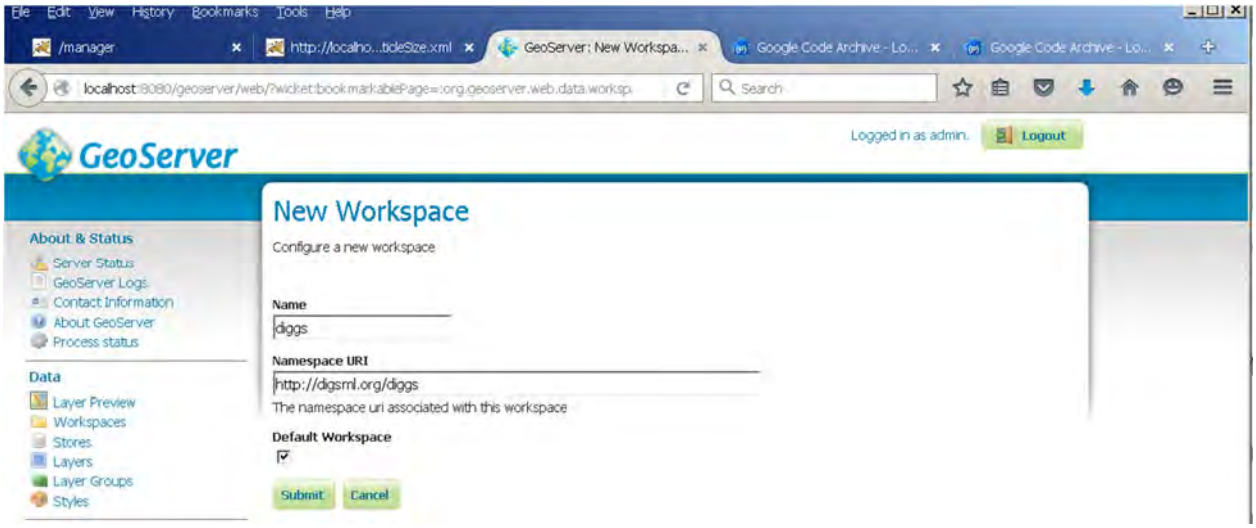
You need to configure a GeoServer Workspace that groups all of your DIGGS data.

Click on the "Workspaces" link in the "Data" category in the left hand menu column.



The workspaces shown are for GeoServer sample data.

Click on the “Add a new workspace” link.

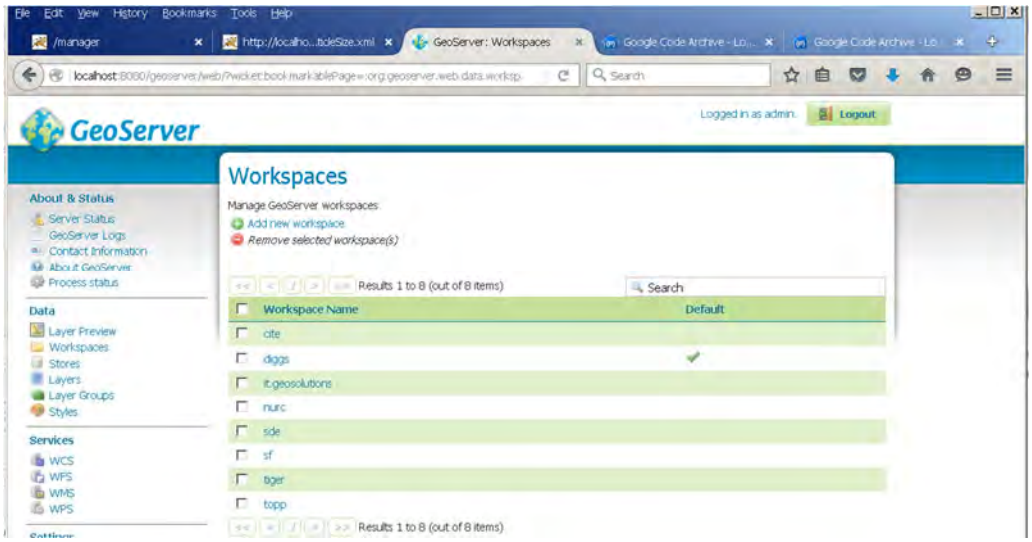


Enter “diggs” in the Name field and http://digsml.org/diggs in the Namespace URI field.

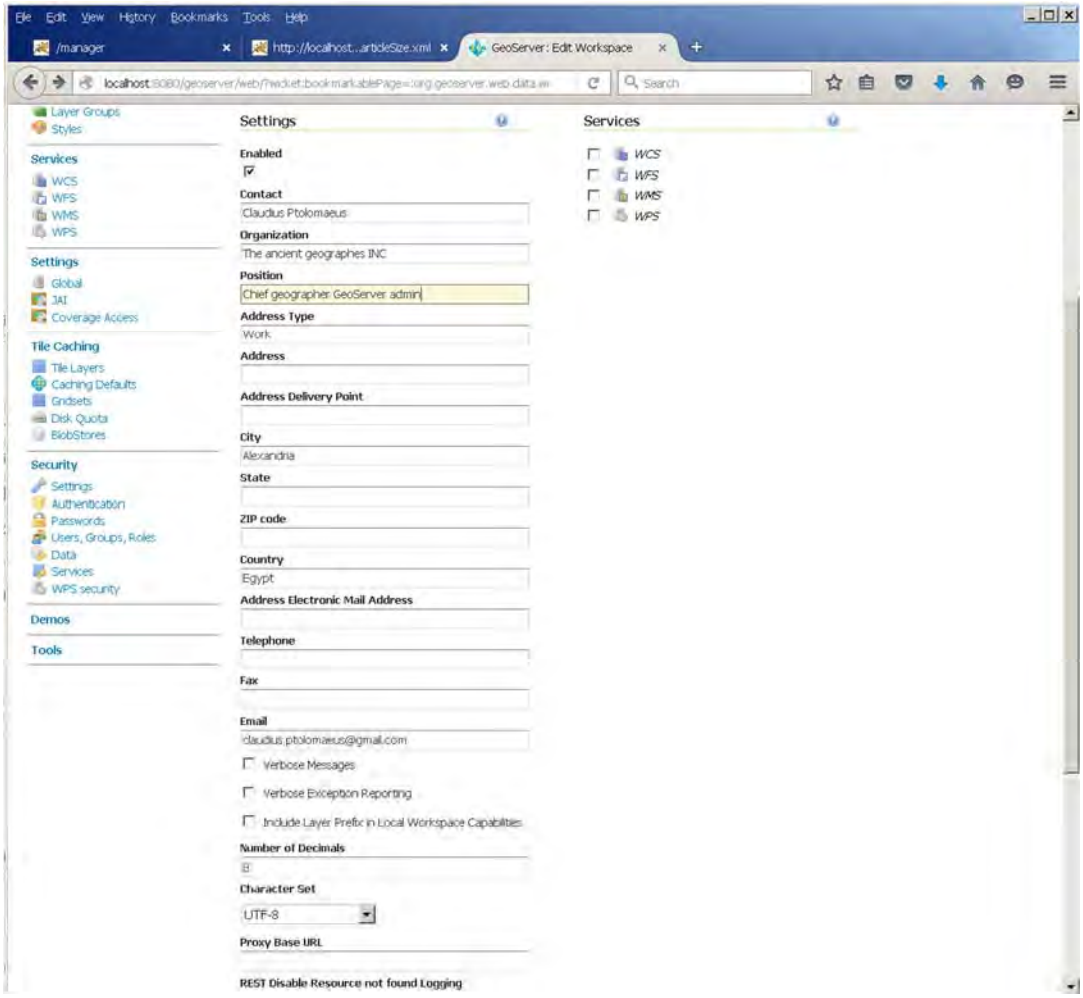
Click in the Default Workspace check box.

Click Submit.

The diggs Workspace is now listed as the default:



Click on the diggs WorkspaceNameLink. Then click in the Enabled checkbox.



Enter the GeoServer Administrator identifying information in the fields displayed.

Enter "C:\Tomcat7.0.67\webapps\geoserver\data\data\diggs" in the REST Pathmapper root directory path field.

Click in the WFS, WMS, and WPS checkboxes.

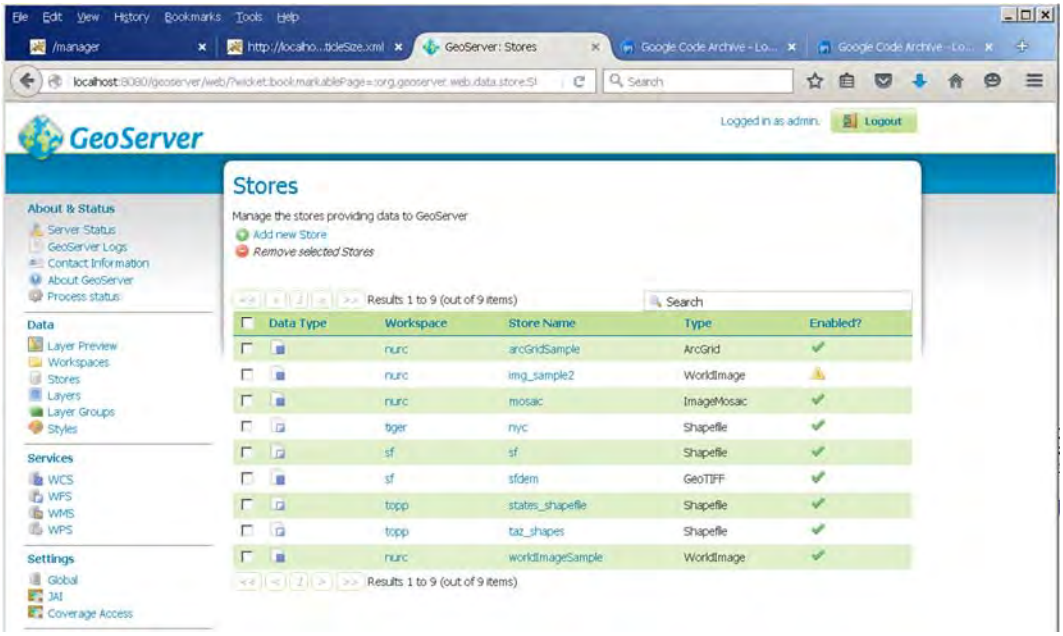
Click the "Save" button.

GeoServer Data Store Configuration

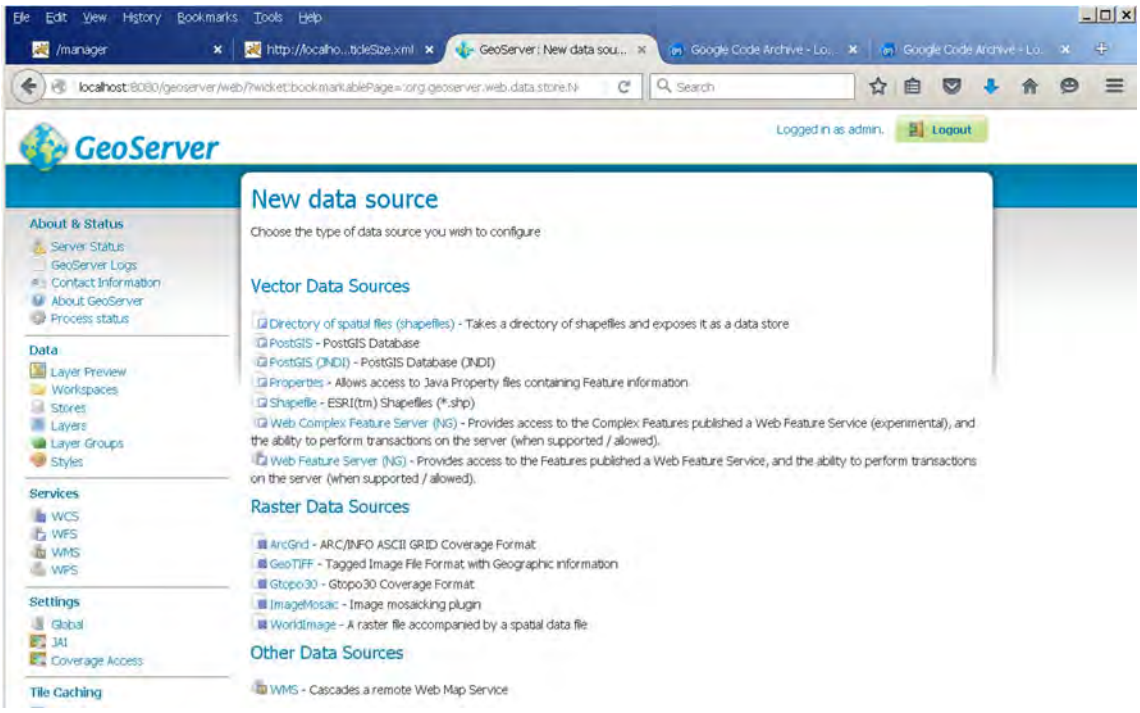
You need to create a GeoServer Java Properties Vector Data Store (and a map layer, see below) for each *.properties file you create with the DIGGS2GeoServerJavaProperties.xsl XSLT stylesheet, such as the sample SamplingFeatures.properties file shown on page 22.

Click on the "Stores" link in the "Data" category in the left-hand menu column.

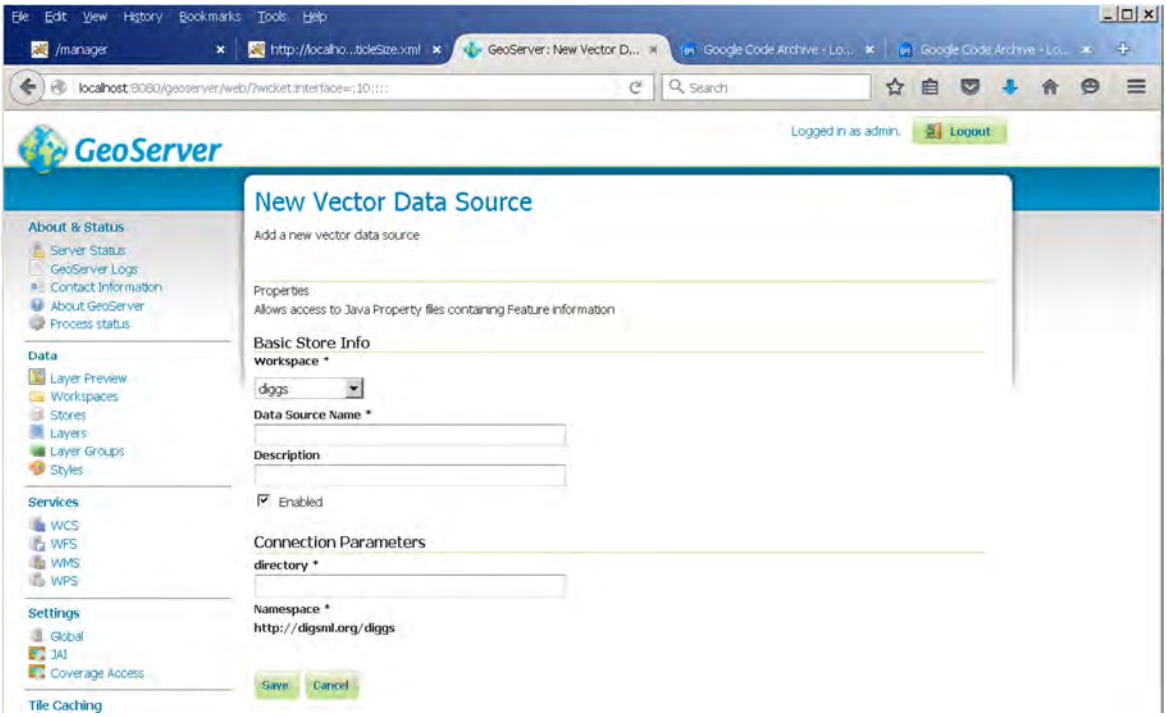
The stores shown are for GeoServer sample data.



Click on the "Add a new Store" link.



Under "Vector Data Sources", click on the "Properties" link that Allows access to Java Property files containing Feature information.



Under Basic Store Info, "diggs" is entered for the Workspace because we made it the default Workspace.

Enter “SamplingFeatures” as the Data Source name. This must be the file name of the .properties file you created with the DIGGS2GeoServerJavaProperties.xsl XSLT stylesheet.

Enter “DIGGS Installation Sample Data Source” as the Description.

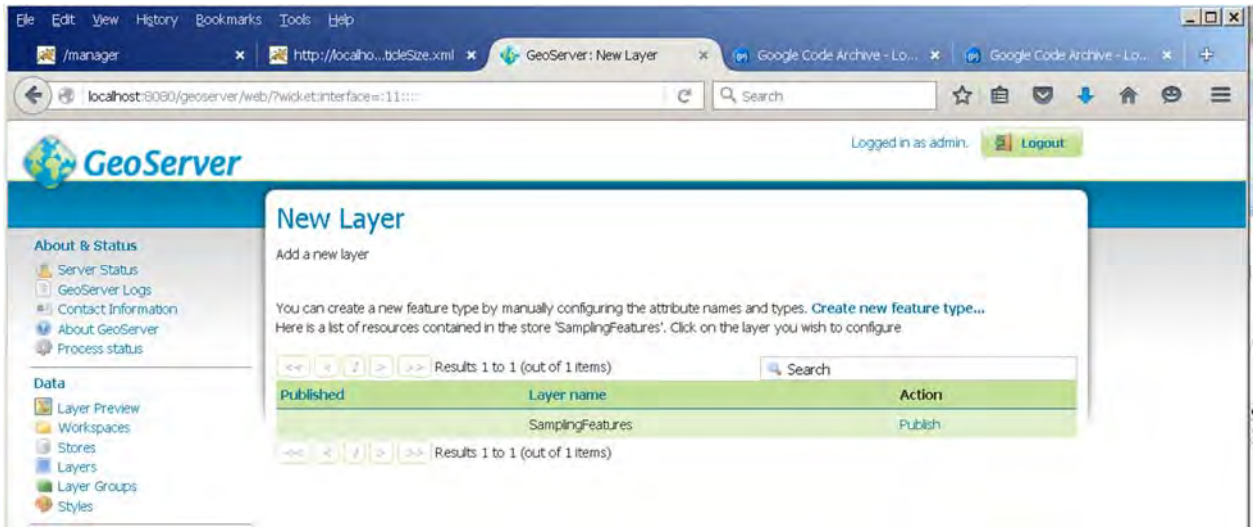
Leave the “Enabled” check box checked.

Under Connection Parameters, enter the value of the GEOSERVER_DIGGS_STORE environment variable that points to the directory you created on page 15 above,_ (e.g. C:\Tomcat7.0.67\webapps\geoserver\data\data\diggs) .

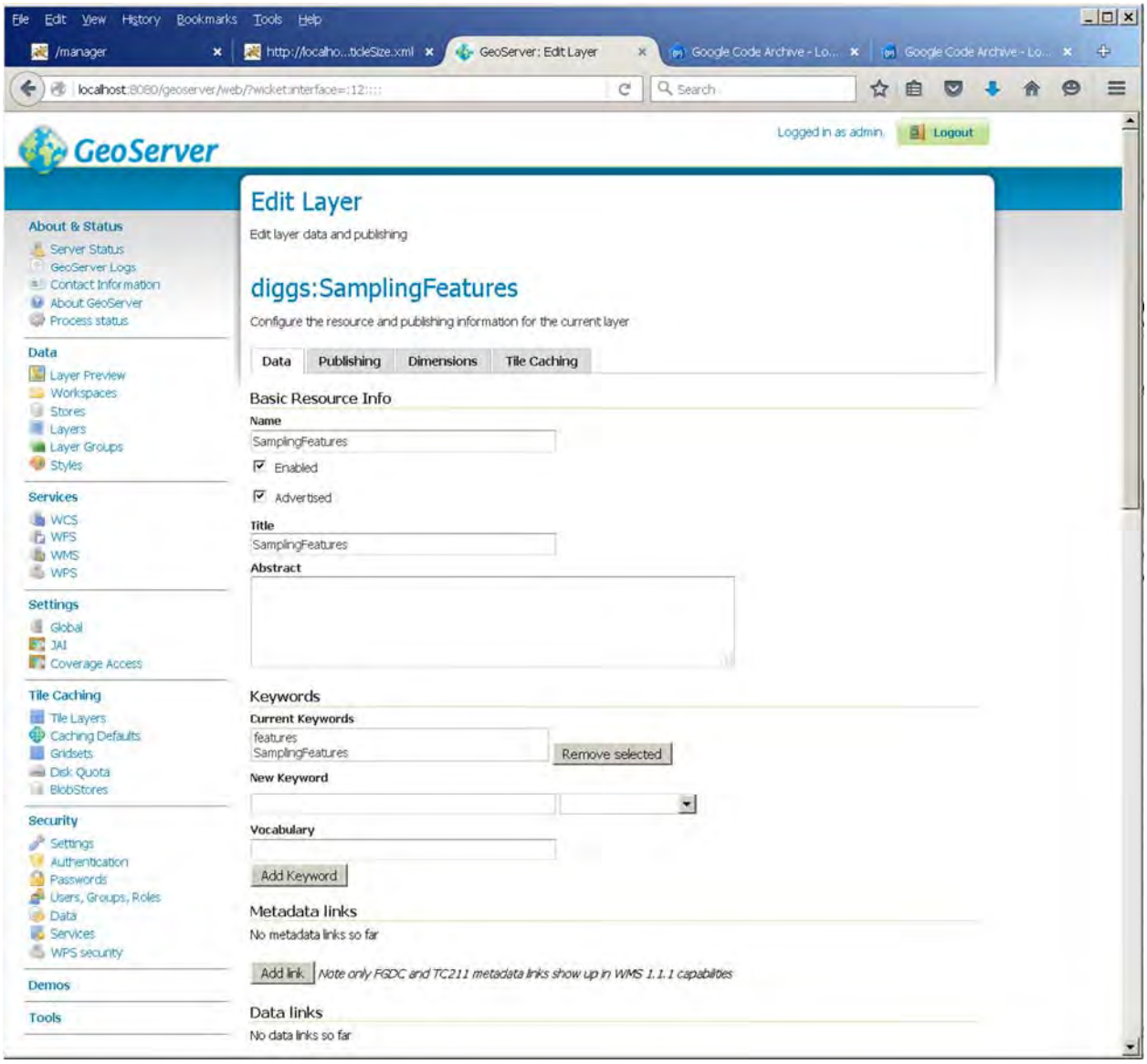
http://digsml.org/diggs is entered for the Namespace because we made diggs the default Workspace.

Click the “Save” button. A New Layer page will be displayed.

GeoServer Layer Data Configuration



Click on the “Publish” link for the SamplingFeatures layer.



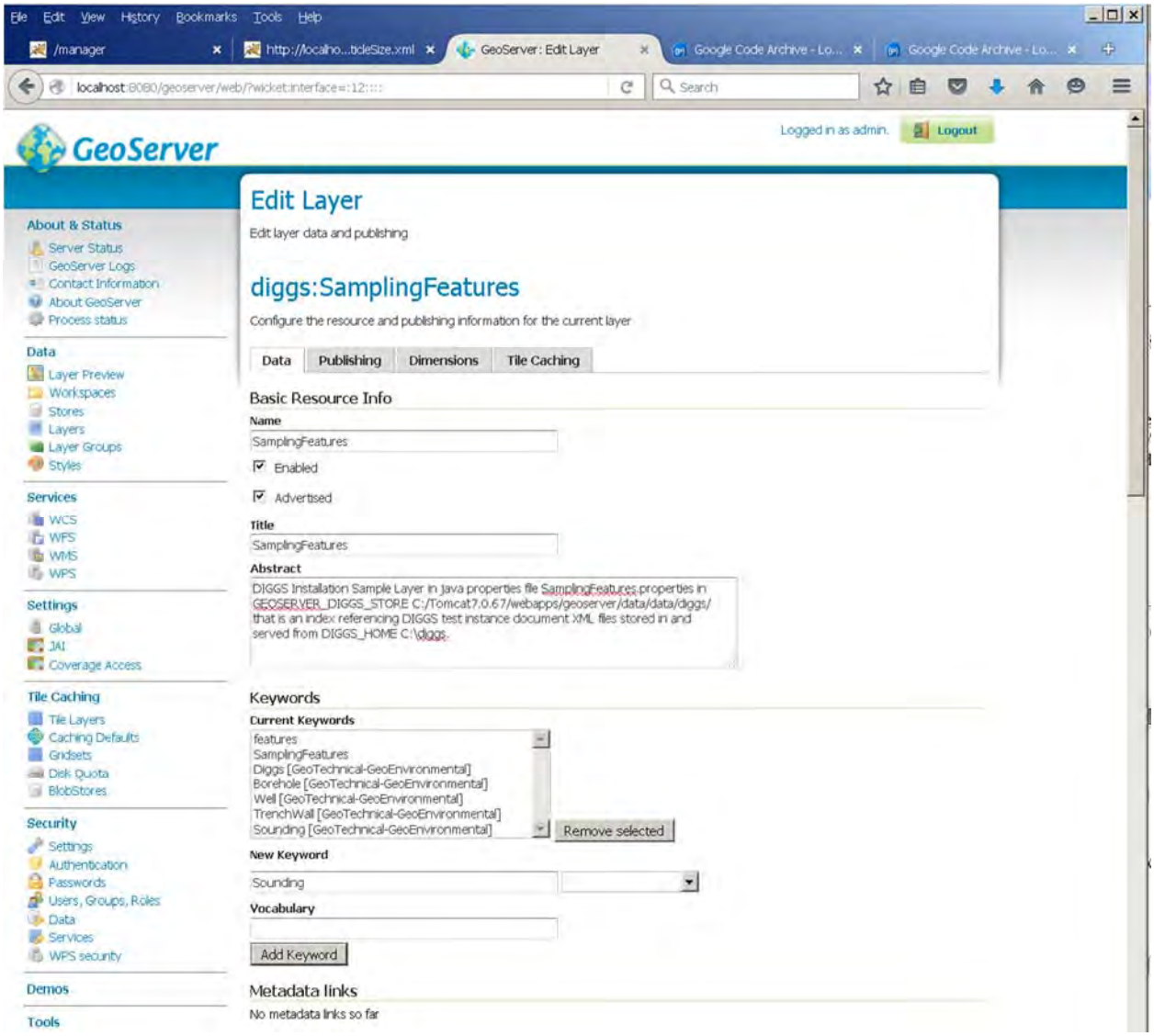
Under “Basic Resource Info”, the “SamplingFeatures” Store name has been repeated.

Leave the “Enabled” and “Advertised” check boxes checked.

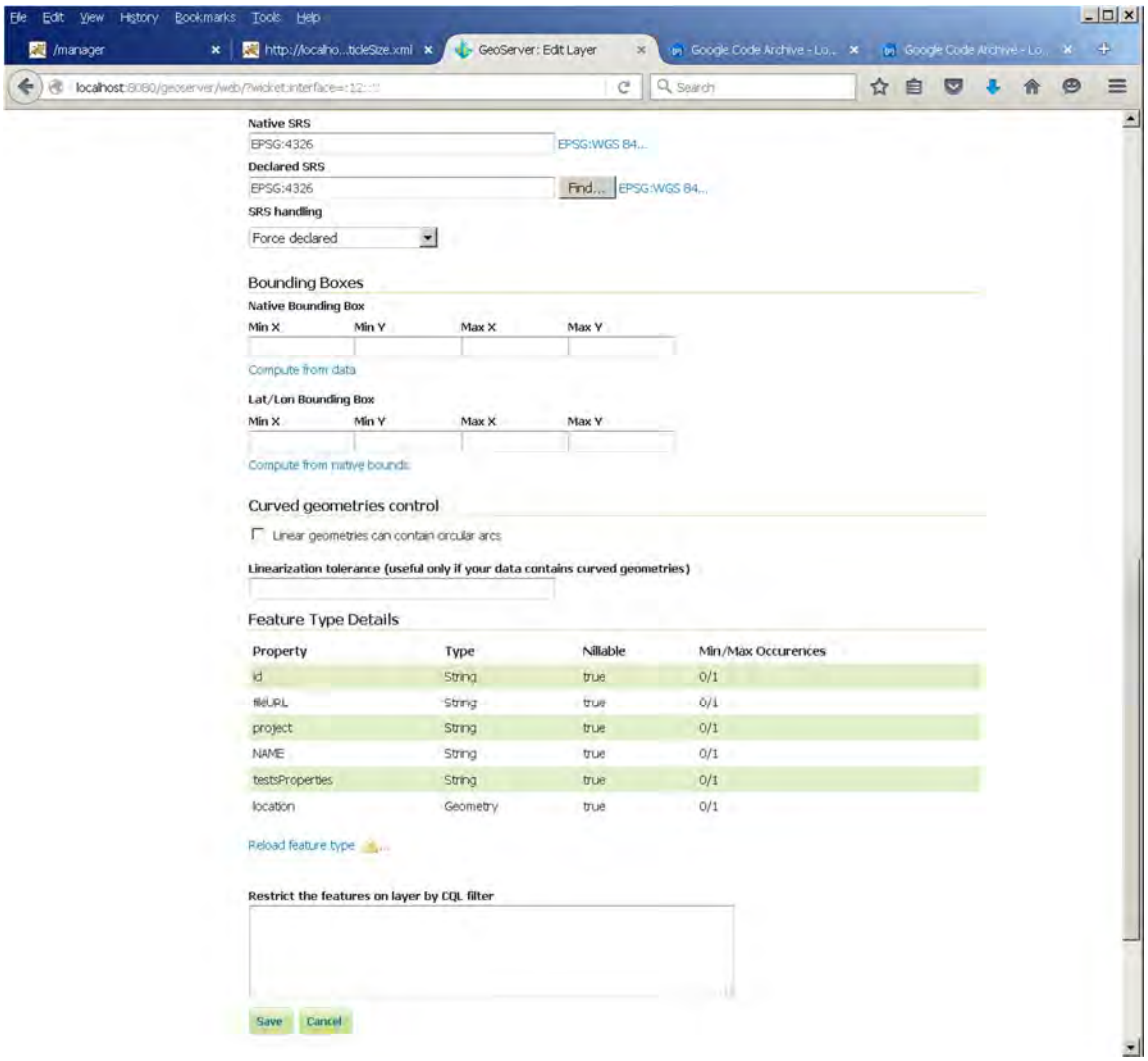
Enter “DIGGS Installation Sample Layer in java properties file SamplingFeatures.properties in GEOSERVER_DIGGS_STORE C:/Tomcat7.0.67/webapps/geoserver/data/data/diggs/ that is an index referencing DIGGS test instance document XML files stored in and served from DIGGS_HOME C:\diggs.” as the Abstract.

Enter “GeoTechnical-GeoEnvironmental” in the Vocabulary field.

Enter each of the keywords “Diggs”, “Borehole”, “Well”, “TrenchWall”, and “Sounding” in the NewKeyword field and press the “AddKeyword” button for each one.



Scroll down until “Coordinate Reference Systems” is at the top of the window.



Note that both the Native SRS and Declared SRS fields are filed with “EPSG:4326”. Scroll back up to page 22 above and note that at the end of the first line in SamplingFeatures.properties, it says “SRID=4326” “SRID” is an abbreviation for “Spatial Reference IDentifier”.. This is the European Petroleum Survey Group (EPSG) online Geodetic Parameter Dataset registry [34] code for WGS84. GeoServer populated those fields from that SRID value.

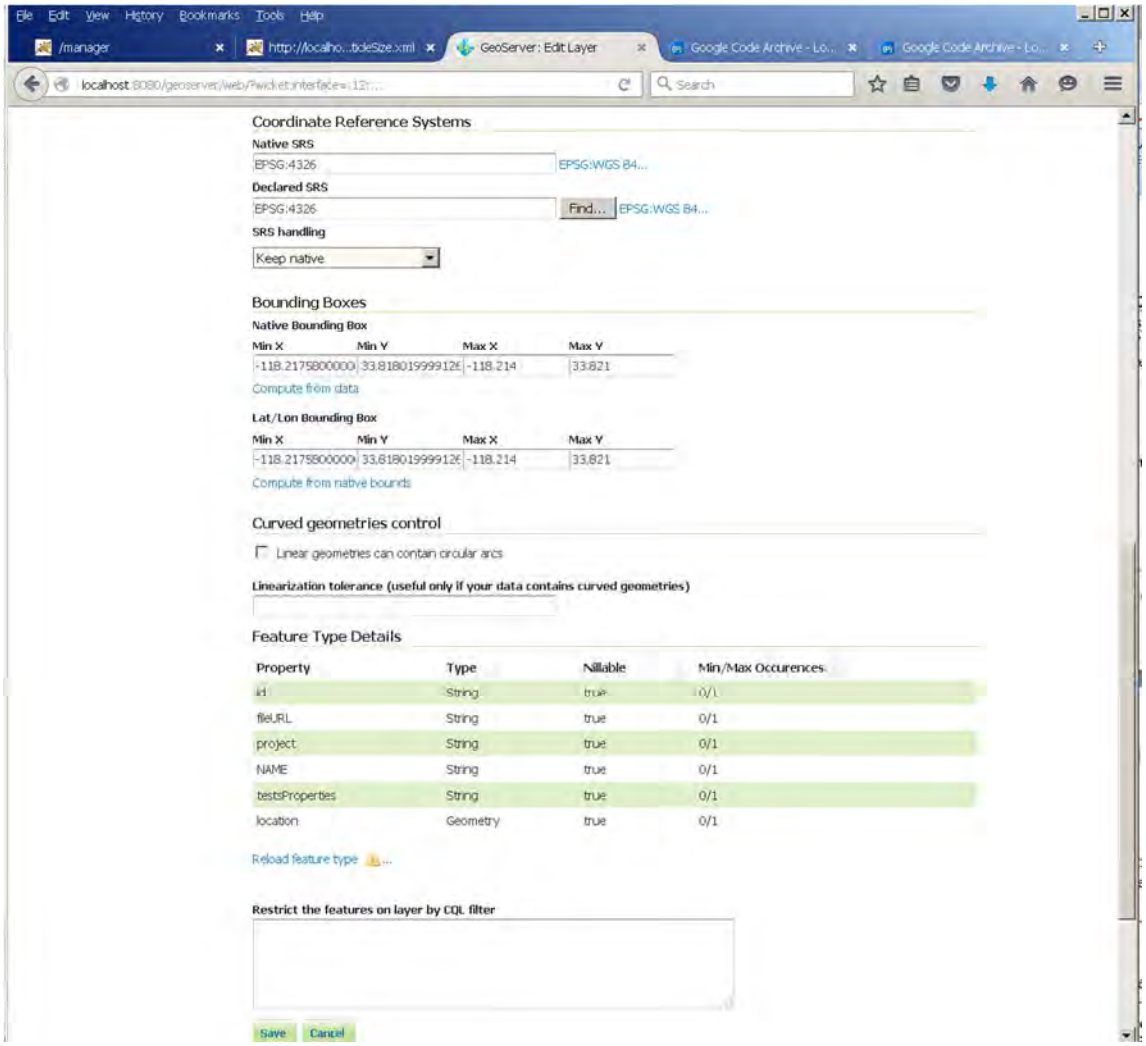
For the “SRS handling” field, select “Keep native”.

Under “Bounding Boxes”, click the “Compute from data” link under “Native Bounding Box”. Click the “Compute from native bounds” link under “Lat/Lon Bounding Box”.

Leave the “Linear geometries can contain circular arcs” checkbox unchecked.
Leave the “Linearization tolerance” field empty.

Note that the “FeatureTypeDetails” Property list contains the heading names from SamplingFeatures.properties shown in a text editor on page 22 above. This is the index data

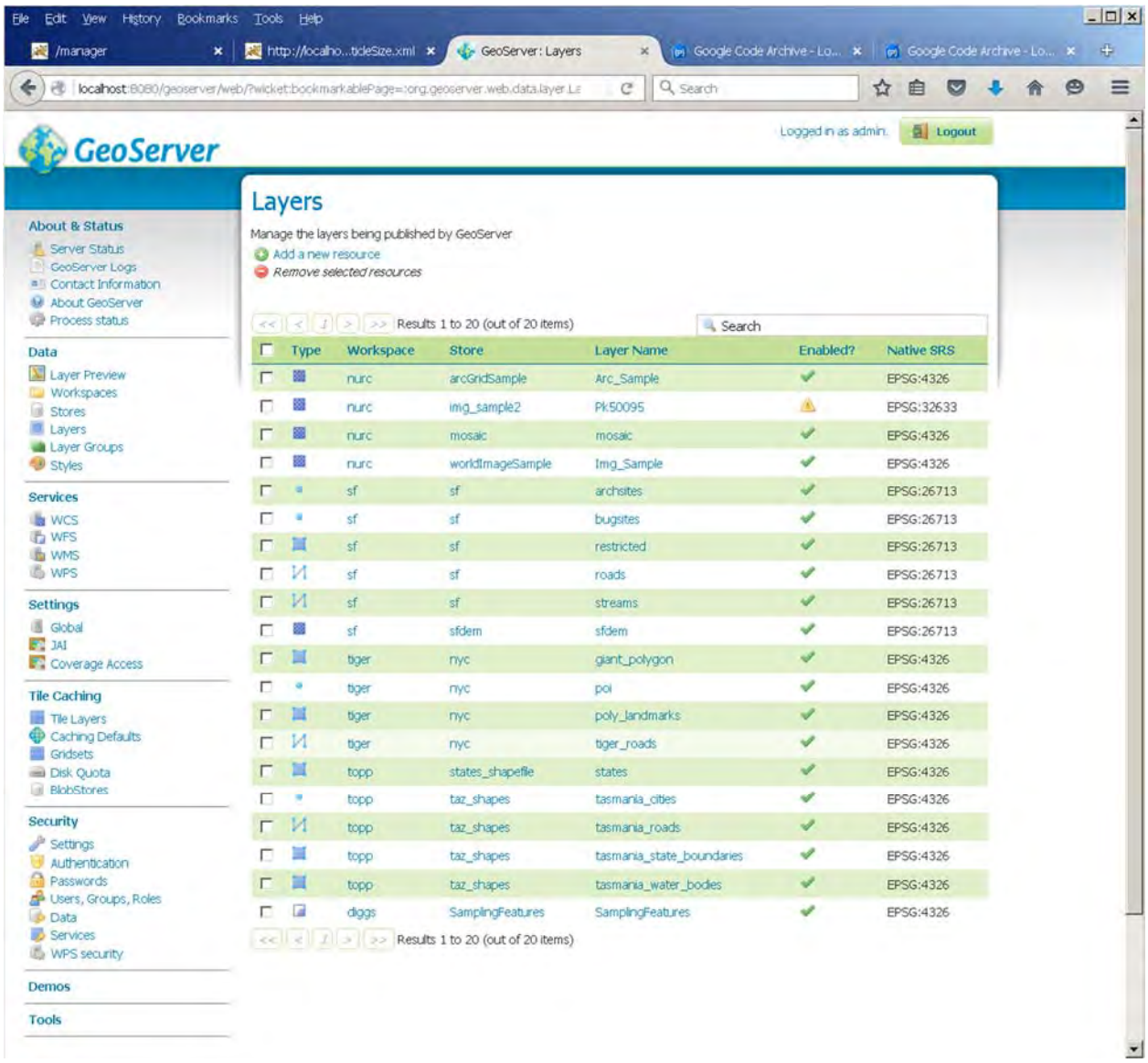
extracted from the DIGGS instance document XML files by the DIGGS2GeoServerJavaProperties.xsl XSLT stylesheet. These properties are all of the data that GeoServer can use in various displays of DIGGS data.



If you need to be able to see or search on a few more properties, you may edit the stylesheet to extract them from the DIGGS files and output them to the properties file. If you need to be able to see or search on a lot more properties, or all DIGGS data, then you will need to insert DIGGS data into a database such as PostGIS [35] and configure GeoServer to use it. Doing that is beyond the scope of these instructions.

Leave the "Restrict the features on layers by CQL Filter" field blank. (CQL is the OGC Common Query Language [31]).

Click on the "Save" button.

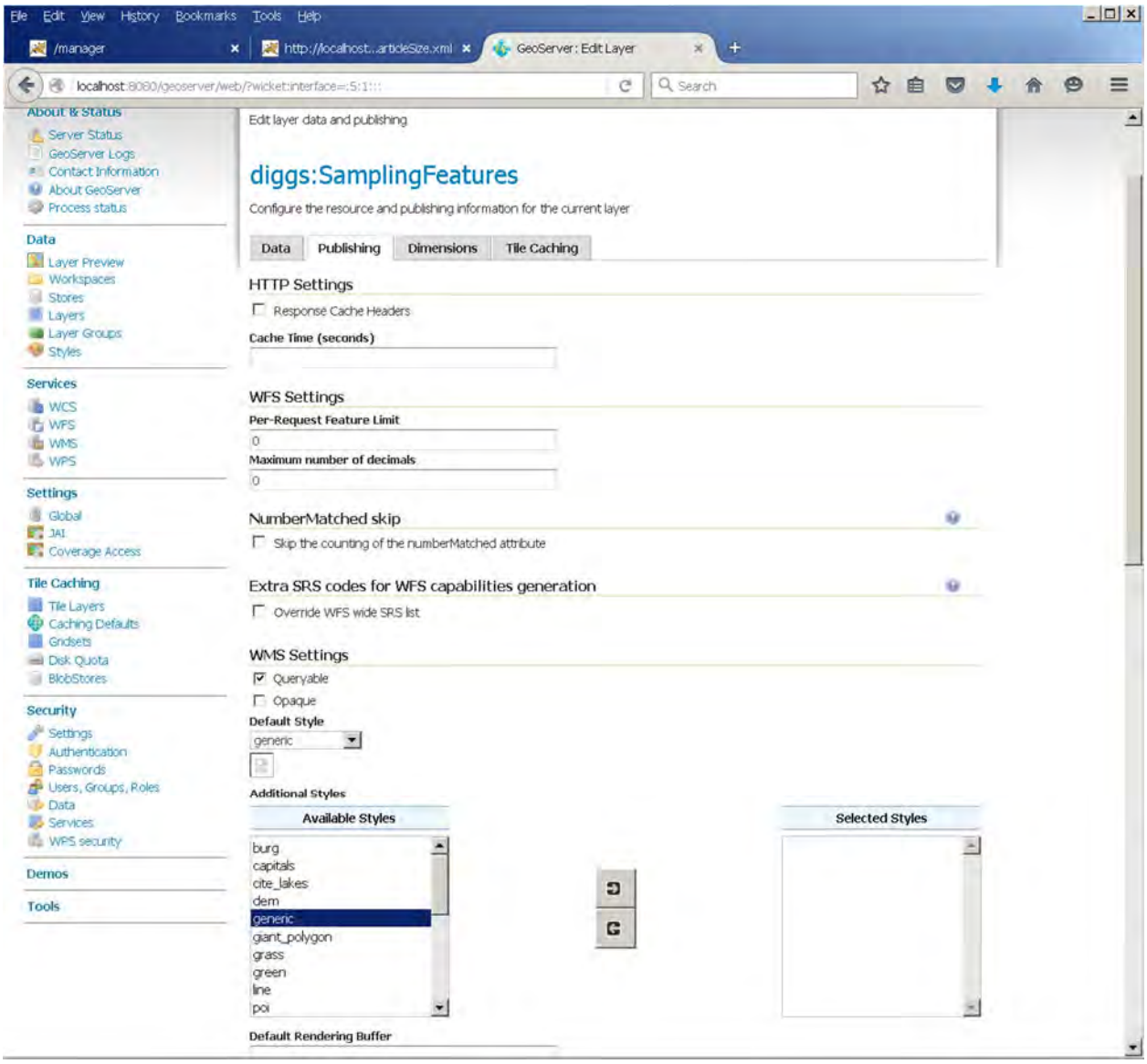


The new SamplingFeatures Store and Layer are at the bottom of the Layers list. The other layers shown are for GeoServer sample data.

GeoServer Layer Publishing Configuration

Click on the SamplingFeatures layer name link.

In the window that appears, click on the Publishing tab.



Under HTTP Settings, leave the “Response Cache Headers”checkbox unchecked.

Leave the “Cache Time” field empty.

Don’t change anything under WFS Settings.

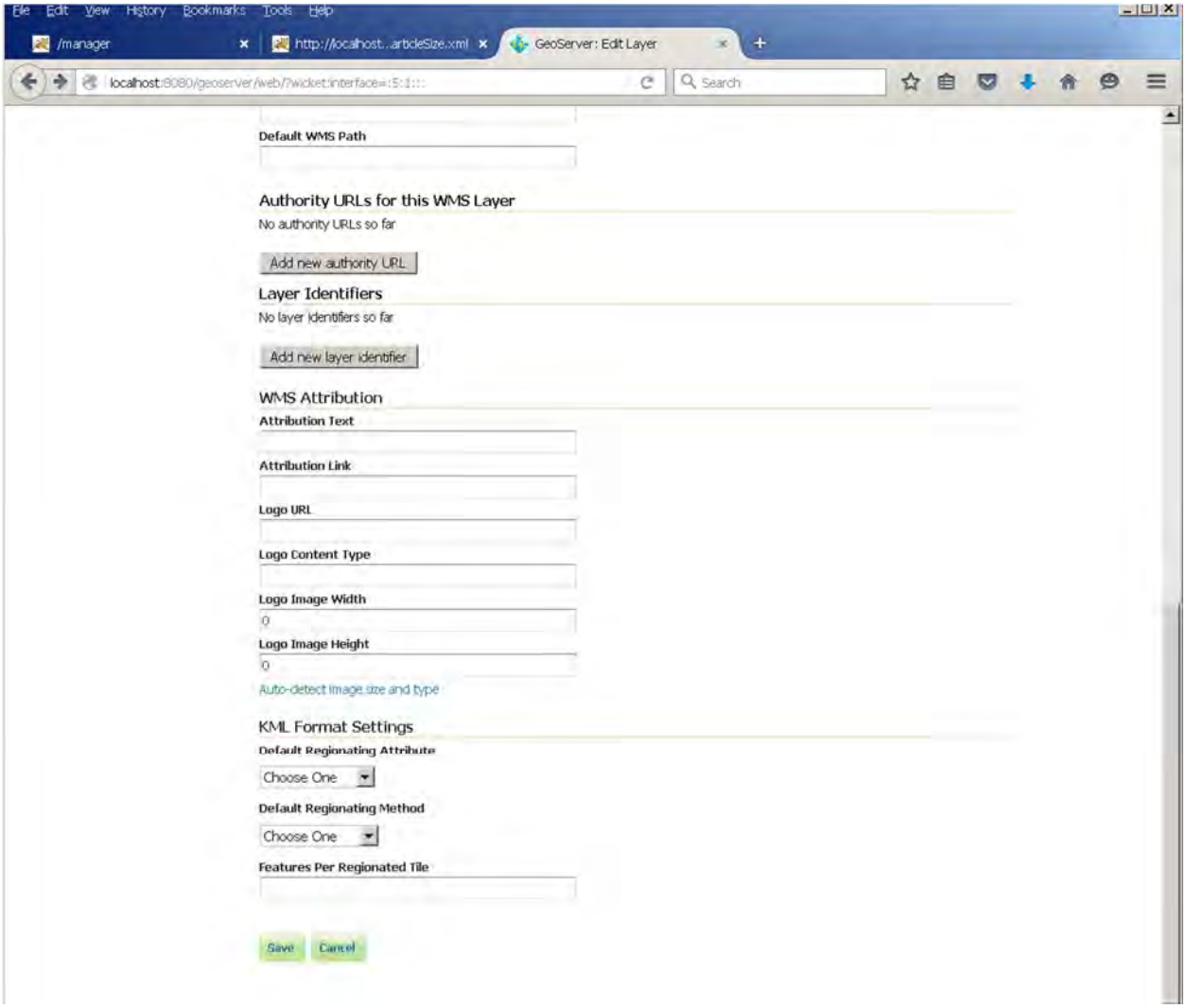
Under WMS Settings, leave check boxes “Queryable” checked and “Opaque” unchecked.

Select the “Default Style” poi (Point of Interest).

Under “Additional Styles”, “Available Styles”, select poi. Click on the arrow pointing right to select it. It suouuld appear under “Selected Styles”.

Leave the “Default Rendering Buffer” field blank.

Scroll down so that the "DefaultWMS Path" field is at the top of the window. Leave it blank.



Enter "DIGGSML" in the "Attribution Text" field.

Enter http://diggsml.org in the "Attribution Link" field.

Enter http://diggsml.org/sites/default/files/joint-logos.png in the Logo URL field.

Click on the "Auto-detect image size and type" link. This will populate the other Logo fields.

Choose "id" for the "Default Regionating Attribute".

Choose "random" for the "Default Regionating Method".
Enter 1000 in the "Features Per Regionated Tile" field.

Click on the “Save” button.

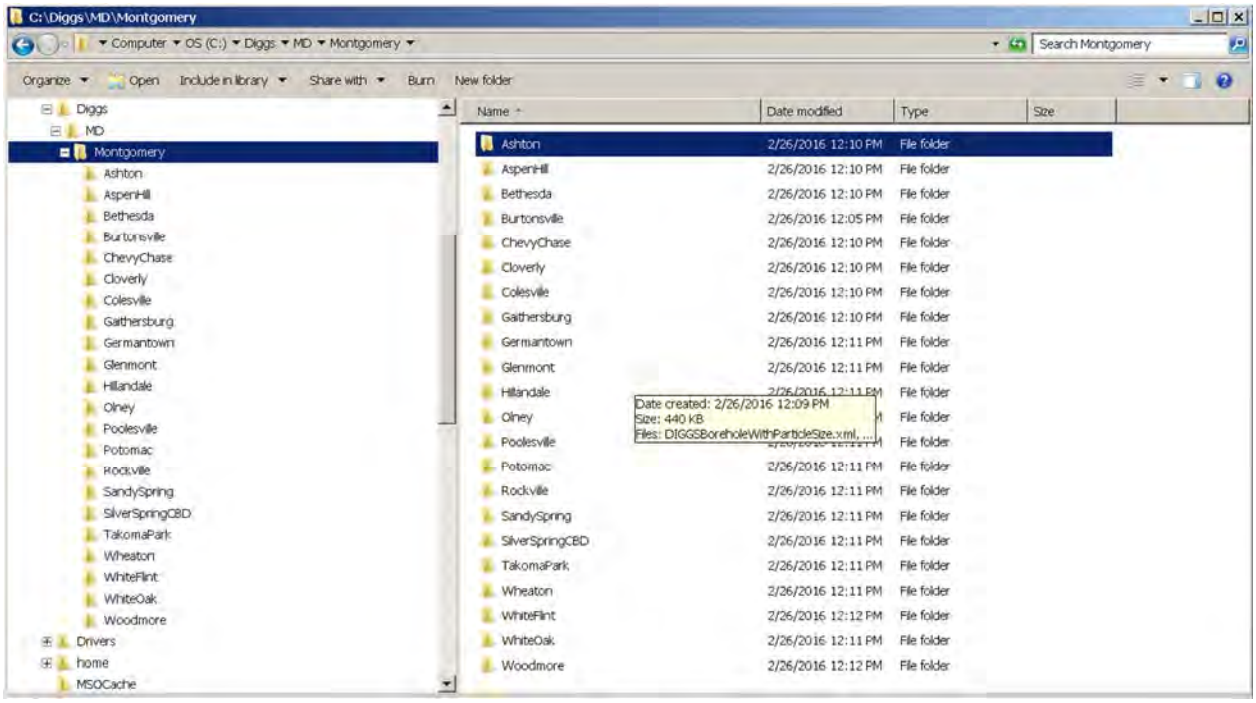
You may now preview the SamplingFeatures layer by clicking on the “Layer Preview” link under the “Data” category in the menu on the left side of the window. You do not have to be logged in as “admin” to do this. See DiggsGeoserverOverview2016.docx for the display and query options that are available without any further configuration.

Once you are finished with the sample installation SamplingFeatures layer, you can delete the corresponding Layer and Store from GeoServer, delete the SamplingFeatures.properties file from GEOSERVER_DIGGS_STORE and the two source XML files from DIGGS_HOME. Then you are ready to configure DIGGS_HOME and GeoServer for your own DIGGS data.

DIGGS_HOME and GeoServer Configuration for Big Data

You should distribute DIGGS files into separate directories (e.g. by state, county, county subdivision, township, place, Census Block, etc.) in a hierarchical structure so that each lowest level directory holds a thousand files or less. This will improve GeoServer performance when serving data from the Java.properties files output by the DIGGS2GeoServerJavaProperties.xsl XSLT stylesheet when it is run on those directories, by limiting the size of those files to 1001 lines or less. After all, they are simple Comma Separate Values (CSV) text files, not high-performance databases. If this work-around is not acceptable, you will need to insert DIGGS data into a database such as PostGIS [35] and configure GeoServer to use it. Doing that is beyond the scope of these instructions.

For example, the following (incomplete example) directory structure shows how to divide Maryland up by county and place:



When you run the DIGGS2GeoServerJavaProperties.xsl XSLT stylesheet on the lowest level directories (the only ones that contain DIGGS instance document XML data files), you need to create output file names that identify the corresponding smallest area geographies, and the corresponding parameter values, using the DIGGS_HOME subdirectory names and GeoServer Store and Layer Names shown in the following table.

DIGGS_HOME Subdirectory	GeoServer Store and Layer Names
MD/Mongtomery/Ashton	DIGGS-MD-Montgomery-Ashton
MD/Montgomery/AspenHill	DIGGS-MD-Montgomery- AspenHill
MD/Montgomery/Bethesda	DIGGS-MD-Montgomery-Bethesda
MD/Montgomery/Burtonsville	DIGGS-MD-Montgomery-Burtonsville
MD/Montgomery/ChevyChase	DIGGS-MD-Montgomery-ChevyChase
MD/Montgomery/Cloverly	DIGGS-MD-Montgomery-Cloverly
MD/Montgomery/Colesville	DIGGS-MD-Montgomery-Colesville
MD/Montgomery/Gaithersburg	DIGGS-MD-Montgomery-Gaithersburg
MD/Montgomery/Germantown	DIGGS-MD-Montgomery-Germantown
MD/Montgomery/Glenmont	DIGGS-MD-Montgomery-Glenmont
MD/Montgomery/Hillandale	DIGGS-MD-Montgomery-Hillandale
MD/Montgomery/Olney	DIGGS-MD-Montgomery-Olney
MD/Montgomery/Poolesville	DIGGS-MD-Montgomery-Poolesville
MD/Montgomery/Potomac	DIGGS-MD-Montgomery-Potomac
MD/Montgomery/Rockville	DIGGS-MD-Montgomery-Rockville
MD/Montgomery/SandySpring	DIGGS-MD-Montgomery-SandySpring
MD/Montgomery/SilverSpringCBD	DIGGS-MD-Montgomery-SilverSpringCBD
MD/Montgomery/TakomaPark	DIGGS-MD-Montgomery-TakomaPark
MD/Montgomery/Wheaton	DIGGS-MD-Montgomery-Wheaton
MD/Montgomery/WhiteFlint	DIGGS-MD-Montgomery-WhiteFlint
MD/Montgomery/WhiteOak	DIGGS-MD-Montgomery-WhiteOak
MD/Montgomery/Woodmore	DIGGS-MD-Montgomery-Woodmore

The DIGGS_HOME Sub-directory table values are used to create stylesheet parameter values:

(1) diggsDocumentDirectoryURL with the “file:/C:/Diggs/” prefix, e.g.

“file:/C:/Diggs/MD/Mongtomery/Ashton/”,

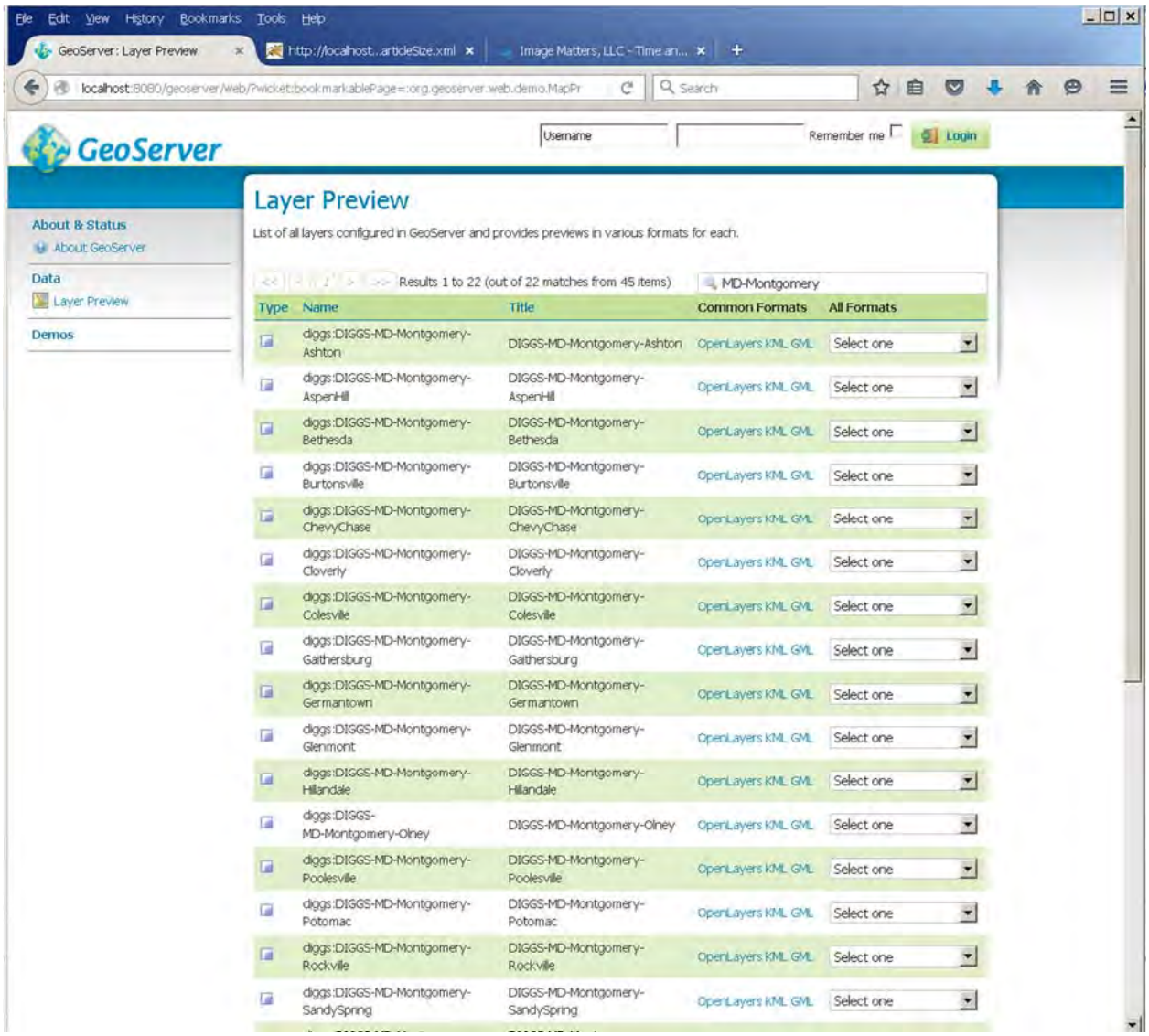
(2) diggsWebServerPublicDirectoryURL with the “http:/localhost:8080/diggs/ prefix”, e.g.

“http:/localhost:8080/diggs/MD/Montgomery/Ashton/”.

The “-o” output file parameter values are created using the “%GEOSERVER_DIGGS_STORE%” prefix, the GeoServer Store and Layer Names table values, and the “.properties” file type suffix, e.g.

“%GEOSERVER_DIGGS_STORE%/DIGGS-MD-Montgomery-Ashton.properties”.

You have to configure a data store and layer for each of these .properties files as was explained above for SamplingFeatures.properties. Once you have done that, they will appear in the LayerPreview list, and may be selected using a common part of their names:



See DiggsGeoServerOverview2016.docx for instructions on selecting and viewing DIGGS layers in GeoServer.

Bibliography

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[3] http://geoserver.org/
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[7] http://geoserver.org/about/
[8] http://www.opengeospatial.org
[9] http://www.opengeospatial.org/standards/gml
[10] http://www.opengeospatial.org/standards/kml
[11] http://www.opengeospatial.org/standards/wms
[12] http://www.opengeospatial.org/standards/wfs
[13] http://www.opengeospatial.org/standards/wps
[14] http://diggsml.org/diggs-schema-version-20b
[15] http://www.w3.org/XML/
[16] http://www.w3.org/XML/Schema.html
[17] http://www.oracle.com/technetwork/java/index-jsp-135475.html
[18] http://tomcat.apache.org/
[19] http://expath.org/
[20] http://expath.org/modules/pkg/
[21] http://expath.org/modules/http-client/
[22] https://www.w3.org/standards/xml/transformation
[23] http://www.saxonica.com/welcome/welcome.xml
[24] https://docs.oracle.com/javase/tutorial/essential/environment/properties.html
[25] http://docs.geoserver.org/latest/en/user/data/vector/properties.html
[26] http://postgis.net/
[27] http://docs.geoserver.org/latest/en/user/data/database/postgis.html
[28] https://www.google.com/earth/
[29] https://www.w3.org/Addressing/
[30] http://openlayers.org/
[31] http://docs.geoserver.org/stable/en/user/tutorials/cql/cql_tutorial.html
[32] http://www.opengeospatial.org/standards/cat
[33] https://www.google.com/earth/download/ge/agree.html
[34] https://www.epsg-registry.org/
[35] http://postgis.net/

Appendix H: Business Plan

DIGGS Consortium, a Division of the Geo-Institute of ASCE

1. Business

DIGGS is the language for seamless transmission of geotechnical data.

Mission statement: The DIGGS Consortium develops and maintains an open source common data transfer structure that facilitates communication of data from source, throughout the evaluation process to final archival for asset and performance management. This common structure provides software and hardware vendors, engineers, scientists, contactors, and owners a way of exchanging and storing information efficiently so that each entity can focus on what they do best.

Vision: DIGGS is the necessary open standard protocol for data communication that allows the geo-community to do our part in sustaining the infrastructure of today and accelerating the cost effective development of infrastructure of generations to come.

2. Products

Product description: DIGGS is a data transfer structure (Schema) using the worldwide standard XML programming language extended to include geographic information (GML) so that data (readings and results) can be exchanged between hardware and software tools. DIGGS allows the data to be transferred and archived in a format that was developed and is maintained in an open (industry consensus) format so that accessing data for current and future needs is facilitated for all stakeholders.

DIGGS can be thought of as the ASCII structure which has been used for decades in the computer programming industry. ASCII defines a symbol to be represented by a number that computer languages can recognize. (A=41, B=42, a=97, b=98, $=36, &=38, …). Insofar as we never see the numerical representation of an ASCII symbol, we also don't see the structure DIGGS defines for data transfer.

Another example ubiquitous to our world today is the use of a web browser to explore the internet. We focus on the images and text presented on each page. However, if we view the source code for a web page we are presented an extensive listing of HTML code language that defines how the page is displayed. DIGGS is effectively a code similar to HTML which is used to transfer information so that a viewer, application, or database can use or present the information in a suitable user experience.

As a user, we think of this like a computer today. When we plug a peripheral into our computer it just works. We don't have any idea how it is communicating but we know we can send and receive data to accomplish the task at hand. Similarly, DIGGS allows us to choose a data collection tool, i.e. CPT, Laboratory direct shear device, etc. and collect data readings. We send those readings in a common structure to any software that recognizes the DIGGS structure the software will know how to import that data into a format suitable for the software.

The next step is the delivery of data to a final client. If the final client (owner, DOT, Contractor) requires delivery of data as part of the final product, all clients that can import data in DIGGS structure will be able to readily interpret or store this information in their desired structure. No longer will custom reporting and data file translation tools be required to be developed at each data transfer step.

Development schedule: The DIGGS Version 2.0b has just completed beta testing and verification of the viability of this system. Implementation of this now requires ongoing advancement of the schema (addition of more test/objects), initiation of vendor incorporation of this method into hardware and software tools, and a common requirement by significant owners/agencies to require delivery of data in a clear format. It is key that Owners recognize the difference between requiring data delivery vs information delivery.

Differentiation: DIGGS is the only open standard for geotechnical and geoenvironmental data transfer. This format has been uniquely developed to be implemented for various testing protocols, various geometric structures (linear, rectangular shapes, etc.) to address the needs of subsurface engineering and science. Further it is uniquely developed to utilize the universal open sources of XML and GML languages ubiquitous to web browser technologies. By housing this open source standard within an ASCE Institute, this standard can reach civil engineering professionals worldwide.

Implementation: Implementation of DIGGS into daily use across the profession will require a bi-directional approach. First

Part 1: Tools must be generated to demonstrate the ease of use, benefit of the protocol and flexibility of the open source system.

Part 2: The recognition of owners, agencies, and vendors that capturing and transmitting data is fundamental to the industries advancement. Further, Vendors will recognize that where data is readily exchangeable, their tools can focus on their core value proposition rather than chasing the data transfer and storage functionality.

For far too long, we have collected information in various forms that has proven to be of limited use. Collecting and housing data in a common format that can be easily exchanged will enhance our ability to utilize this knowledge in an efficient (price, quality and schedule) manner.

Part 1 will be the responsibility of the DIGGS Consortium. Led by the Geo-Institute of ASCE, the consortium will continue to expand and enhance the Schema in an Open format leveraging the technical depth of the GI Technical Committees; encourage creative applications of the protocol, host competitions for the creation of tools and applications, and lead the marketing and branding of DIGGS as the industry standard. The DIGGS web site hosted by the GI and directed by the Consortium will be the source for documentation and tools to enhance the use of DIGGS. The Consortium will further explore and support as appropriate the exchange of data through a public portal. This consortium will facilitate prioritization, advancement and quality assurance of the DIGGS protocol. The Consortium will be open to representatives from the Owner, Agency, Vendor, and Engineering and Scientific Consultant communities.

Part 2 will be the result of efforts from Federal agencies (FHWA, USACE) to educate and enforce policies for collection of required data in suitable formats that will allow ready access, communication across platforms. The DIGGS Consortium will work with these Federal, State and Local agencies to ensure the DIGGS protocol meets their needs, that vendors are prepared to delivery data in such an open and common format, and that there are tools available to facilitate this exchange.

A follow on phase of this would be to pursue getting the protocol recognized as a standard in accordance with ANSI protocols. This will become a higher priority once the integration into software and operations begins. Moving this through a consensus standard process will help maintain the open platform and clearly document version progression of DIGGS.

Price point: The schema access will be provided as an open source tool at no charge to users. However, there are vehicles such as Sponsorships, licensing fees, development grants that will fund the Consortium management of this product.

Participation in the Consortium will have a basic membership fee structure. Dues paid to the Consortium will be used for management, marketing, development, and workshops. Although the use of the schema will remain open and free to utilize, a membership fee will be charged to firms to demonstrate their support of the protocol. This membership fee will be based on the size of the company (small, medium, or large). The distinction of these categories and the annual fee will be determined by the Consortium. Member organizations will have their names listed on the DIGGS web site and will be allowed to use the DIGGS logo on company materials if desired.

The Consortium will have an Advisory Board. A seat on this advisory board will be available to member firms for an additional fee.

Education programs will be held to train people about data management and utilization as well as the fundamentals of the DIGGS protocol. Profit from these programs will support the Consortiums efforts to advance DIGGS.

3. Market

Trends: Technology continues to move to automation, online information storage, and common format structures to facilitate data access and flow. Further, Owners are expecting to receive their work products electronically for storage, sustainability, and asset/performance management needs. This has led to a plethora of methods for storing and presenting information and data with each owner defining their own standards. As a result, producing these unique standards has become onerous (costly and time consuming) for engineers and vendors at all levels. Further, the delivery standards are constantly evolving which renders historic information more difficult if not impossible to access.

Historic and projected sizes in dollars: The development of this standard Schema structure has evolved from university research, through DOT state pooled funding studies and a Pilot testing contract. Hard dollar fund to date has exceeded $680,000. In kind and volunteer services have likely doubled this value. Ongoing open source efforts will continue to be required and will be accomplished through the Geo-Institute Technical Committee vehicles. Further Vendor commitment to this process will be imperative as will owner and user interest in the value of this common data structure. Continued interest is reasonably expected provided a functional protocol is available and tools are available for ready implementation by users and owners.

Product match to market definition: Examples of large agency value includes the United States Army Corps of Engineers (USACE), where their dam and levee management systems are increasingly requiring data and information to be provided and compiled into online accessible geographic information systems. Another driver is tied to the original development of this tool. DOTs and FHWA collect hundreds of millions of dollars of subsurface data annually. Having the ability to access this information over life cycles of infrastructure elements (generations) is imperative to their ability to manage costs, accelerate delivery, and improve asset and performance management. Currently both of these examples demonstrate organizations with ever evolving data/information management systems often resulting in significant expenditures of time and money through internal and external development cost.

4. Distribution

Sales channels

Partners: Large agencies, consulting firms, as well as software and hardware vendors are our partners. Each of these groups demand tools that will make their processes more efficient. Each group needs to concentrate on what they do well, not on developing tools to help get them to the task at hand (data conversion, importing, customizing)

Customers: Similar to partners, it is the full spectrum of data users in the geoscience and geoengineering profession; from those developing tools to collect data (in situ, laboratory, instrumentation) to the professionals reducing the readings and developing reports, to the analysist and researchers that compile big data to reach broader understanding, to owners that are archiving the data for future needs. Most if not all have a connection to ASCE either as members or clients of members.

5. Competition

Competitors: Currently the only known open source data transfer standard is the AGS system developed initially in the UK. Implementation of this standard has begun to spread around the world driven by software sales as well as natural disaster driven needs for rapid data collection and sharing. The developers of AGS continue to maintain and expand this system however are watching (and are involved in) the development of DIGGS as the model for the next generation of AGS.

Competitive advantages: The DIGGS system is based on XML and GML which are common open standards which are significantly more robust than the CSV (comma separated value) format currently built into AGS.

6. Team

Background of management: The GeoInstitute of ASCE will be the manager of this Consortium. Lead by the Director of the GI, a technical staff person will initially be devoted to this on a part time basis (likely 10-20%) to advance the goals of the Consortium. This is likely to grow and require a full time technical lead as adoption takes hold and available funding grows.

Board composition: A DIGGS Consortium Advisory Board will lead decision making and actions for the DIGGS Consortium. This Board will include the Director of the GI, at least one Governor of the GI, and 5-10 industry advocates representing the breadth of users, vendors and owners. The Advisory Board members will be representatives of organizations supporting the Consortium and will be approved by the GI Board of Governors upon recommendation of the GI

Director. Board members will serve three year terms, renewable. Terms of members shall be staggered.

7. Financials

Projected Income & Expense: This projection considers that the Consortium will be sustainable within the funding allotment of its member firms and agencies. The first two years have been based on a conservative estimate of members with a growth in the size of the Consortium as the tools are developed and the brand expands. Funding is projected to come from a variety of sources (partners identified above). The rate of development (and expenses) will be dictated by the level of funding generated. Realistic efforts were made to spread the development of this funding over a reasonable development period as was the expenditures for advancement of the tool. The graphs and tables attached detail these projections. Expenses are primarily driven by GI staff cost projections.

Funding in future years will become driven by sponsorship of the system, development grants, licensing fees, and data portal access.

Defining data structure is the key driver for the DIGGS Consortium. The Business Model of the future for the Geo-Institute and ASCE will be in providing services related to this data structure. Serving of data, tools for interpreting data, support for implementation of the Schema will be income streams of the future.

ASCE and the Geo-Institute has the reach to attract partnerships to advance this development as well as the influence to build delivery channels and reliable long term relationships with customers to ensure reliability of this open standard and service delivery models.

Assumptions

ODOT pilot testing is completed in June 2016
Funding requests are initiated in May 2016 through September 2016 for continued development and implementation
Funding is received January 2017 to the levels defined

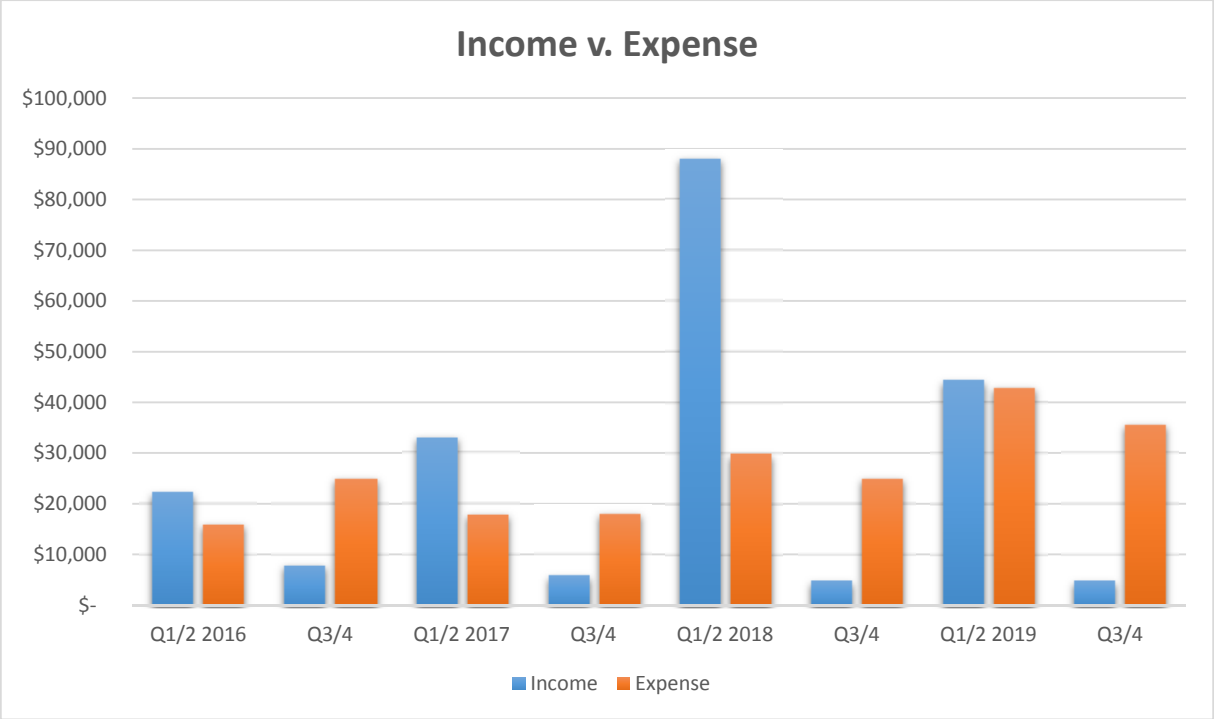
Consortium Membership	**Annual Dues**	License fee	#	$/yr		
Founding Members (potential Board seat)	$ 2,000	Small Firm	5	$ 100	$ 500	
Sustaining Members (potential Board seat)	$ 2,000	Medium	5	$ 250	$ 1,250	
Affiliate	$ 500	Large	5	$ 500	$ 2,500	
Agency	$ 1,000				$ 4,250	$/yr Yr 1

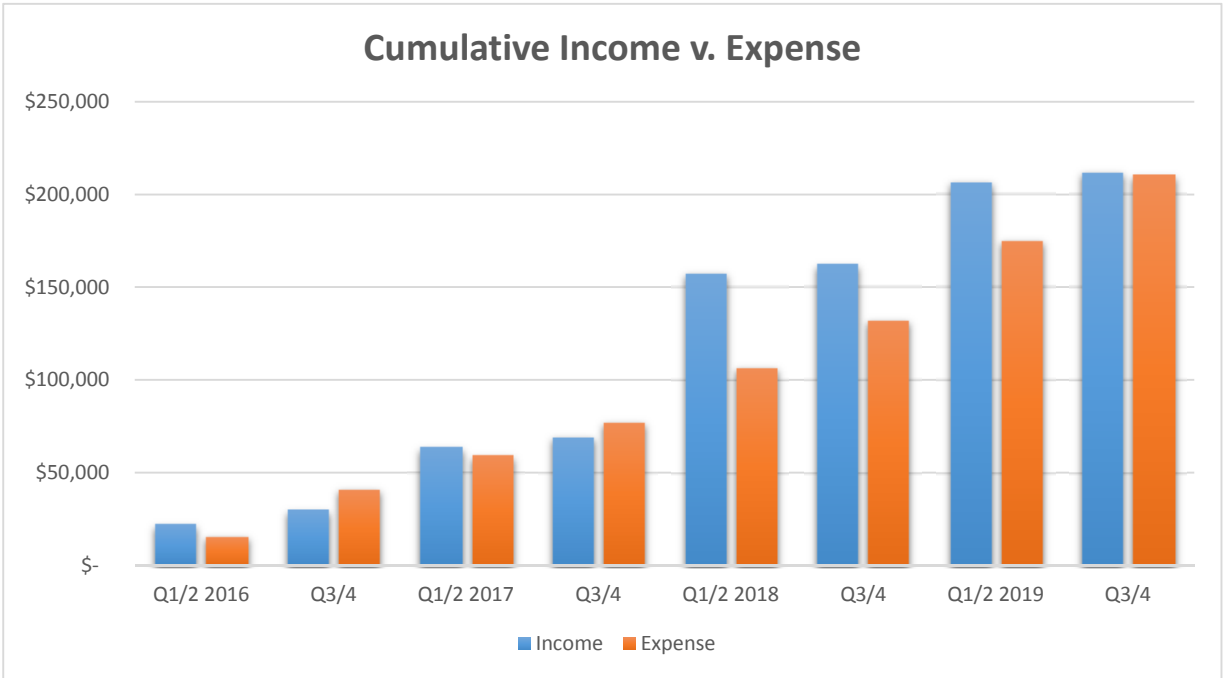
Expenses

	2017		2018		2019		2020	
Time	Q1/2 2016	Q3/4	Q1/2 2017	Q3/4	Q1/2 2018	Q3/4	Q1/2 2019	Q3/4
Item								
GI Staff	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 7,000	$ 7,000	$ 7,000	$ 7,000
Advisory Team Meeting (tech and refreshments)	$ 1,000	$ 1,000	$ 1,000	$ 2,500		$ 3,000		$ 3,500
Funding request travel to sponsor meetings	$ 500	$ 500	$ 500	$ 500				
Management Meeting (Advisory Board)								
Marketing		$ 1,000	$ 1,000		$ 500		$ 500	
Education and Messaging Sessions		$ 500	$ 500		$ 500		$ 500	
-- Student competition @ Geocongress	$ 2,000		$ 3,000		$ 5,000		$ 5,000	
Tech Committee Development Meetings (mgt travel)								
-- Grouting Committee Task Force (w tech support)		$ -						
-- Deep Foundation Committee TF (w tech support)			$ -		$ 10,000	$ 10,000	$ 10,000	$ 10,000
Other Committee (tied to TRB or other grant)					$ -	$ -	$ -	$ -
Technical Support (Image Matters) 2019 tied to TRB or othe	$ 2,500	$ 2,000	$ 2,000	$ 5,000	$ 2,000		$ 15,000	$ 10,000
Vendor Support from Image Matters								
virtual data center	$ 5,000	$ 15,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
Total	$ 16,000	$ 25,000	$ 18,000	$ 18,000	$ 30,000	$ 25,000	$ 43,000	$ 35,500
Running Expense	$ 16,000	$ 41,000	$ 59,000	$ 77,000	$ 107,000	$ 132,000	$ 175,000	$ 210,500

Income

Founding Members (6)	$ 12,000		$ 12,000		$ 12,000		$ 12,000	
Sustaining Members		$ 2,000	$ 4,000		$ 6,000		$ 8,000	
Affiliate Members		$ 1,000	$ 2,000		$ 3,000		$ 5,000	
Agency Members			$ 2,000	$ 1,000	$ 3,000		$ 4,000	
Sponsorship	$ 1,000		$ 3,000		$ 3,000		$ 3,000	
Grants					$ 50,000			
GeoInstitute of ASCE	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000	$ 5,000
license fees 20% growth after yr 1	$ 4,250		$ 5,100		$ 6,120		$ 7,344	
Total	$ 22,250	$ 8,000	$ 33,100	$ 6,000	$ 88,120	$ 5,000	$ 44,344	$ 5,000
Running Income	$ 22,250	$ 30,250	$ 63,350	$ 69,350	$ 157,470	$ 162,470	$ 206,814	$ 211,814


Income v. Expense
$100,000
$90,000
$80,000
$70,000
$60,000
$50,000
$40,000
$30,000
$20,000
$10,000
$-
Q1/2 2016
Q3/4
Q1/2 2017
Q3/4
Q1/2 2018
Q3/4
Q1/2 2019
Q3/4
Income
Expense


Cumulative Income v. Expense
$250,000
$200,000
$150,000
$100,000
$50,000
$-
Q1/2 2016
Q3/4
Q1/2 2017
Q3/4
Q1/2 2018
Q3/4
Q1/2 2019
Q3/4
Income
Expense