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## OGC® GroundWaterML 2.0

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## **i. Abstract**

This specification describes a conceptual model, logical model, and GML/XML encoding rules intended for the exchange of groundwater data. In addition, this specification provides GML/XML encoding examples for guidance.

## **ii. Keywords**

The following are keywords to be used by search engines and document catalogues:

groundwater, hydrogeology, aquifer, water well, observation.

## **iii. Preface**

The primary goal of this profile is to capture the semantics and encoding syntax of key groundwater data, in order to enable information systems to interoperate with such data.

## **iv. Submitting Organizations**

The following organizations submitted this document to the Open Geospatial Consortium Inc.:

- a) Geological Survey of Canada (GSC), Canada
- b) United State Geological Survey (USGS), USA
- c) Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
- d) European Commission, Directorate General – Joint Research Centre (JRC), European Union
- e) Federation University Australia (FedUni), Australia
- f) Geological Surveys of Germany (GSG), Germany
- g) British Geological Survey (BGS), U.K.
- h) Bureau de Recherche Géologiques et Minières (BRGM), France
- i) International Groundwater Resources Assessment Centre (IGRAC), Unesco
- j) Salzburg University (U Salzburg), Austria
- k) Bureau of Meteorology (BOM), Australia
- l) Polish Geological Institute (PGI), Poland

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## vi. Future Work

Future work involves coordination with ongoing OGC hydrology standards for surface water and time series observations, to demonstrate how these emerging standards can operate together.

## vii. Changes to the OGC<sup>®</sup> Abstract Specification

The OGC<sup>®</sup> Abstract Specification template requires the following changes to accommodate this document:

1. ...



## Foreword

The work is operating under the Open Geospatial Consortium (OGC) Hydrology Domain Working Group [1].

*Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights. However, to date, no such rights have been claimed or identified.*

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## Introduction

### Motivation

A significant portion of global water supply can be attributed to groundwater resources. Effective management of such resources includes the collection, management and delivery of related data, which is impeded by issues related to data availability, distribution, fragmentation, and heterogeneity: not all collected data is available to the public, available data is distributed across many agencies in different sectors, often thematically fragmented, and similar types of data are diversely structured by the various data providers. This situation holds both within and between political entities, such as countries or states, thereby impairing groundwater management. Groundwater data networks are an emerging solution to this problem: they couple data providers into a unified data delivery vehicle, reducing or eliminating distribution, fragmentation, and heterogeneity through the incorporation of standards for data access and data content. The relative technical maturity of OGC data access standards, such as the Web Feature Service (WFS) and Sensor Observation Service (SOS), combined with the rise of water data networks, have created a need for GroundwaterML2 (GWML2), a common groundwater data content specification.

### Historical background

Several activities have influenced the development of GWML2:

- GWML1: a GML application schema for groundwater data developed at Natural Resources Canada, and used to exchange groundwater data within Canada, between Canada and the USA, and in some other international initiatives.
- GWIE1: an interoperability experiment held within the OGC Hydro Domain Working Group (HDWG), in which groundwater data was shared across the US-Canada border.
- INSPIRE: Data Specification on Geology is a conceptual model for geology and hydrogeology with anticipated regulatory force in the European Union, and for which GWML2 will be an encoding candidate.

# GroundWaterML2.0

## 1 Scope

This document is an OpenGIS® Encoding specification for the representation of core groundwater data. GroundWaterML2.0 is implemented as an application schema of the Geography Markup Language (GML) version 3.2.1, and makes use of the OGC Observations & Measurements standard and the GeoSciML 3.2.0 standard from the International Union of Geological Sciences (IUGS).

GroundWaterML2.0 (GWML2) is designed to enable a variety of data exchange scenarios. These scenarios are captured by its five motivating use cases, including:

- (1) a commercial use-case focused on drilling water wells with knowledge of aquifers,
- (2) a policy use case concerned with the management of groundwater resources,
- (3) an environmental use-case that considers the role of groundwater in natural eco-systems,
- (4) a scientific use-case concerned with modeling groundwater systems, and
- (5) a technologic use-case concerned with interoperability between diverse information systems and associated data formats.

GWML2 is designed in three stages each consisting of a schema that builds on previous stages. The three schemas include:

- (1) **Conceptual** (UML): a technology-neutral schema denoting the semantics of the domain,
- (2) **Logical** (UML): a GML-specific schema that incorporates the OGC suite of standards,
- (3) **XML** schema (XSD): one possible syntactical encoding of the logical schema.

In addition, this specification describes general and XML-specific encoding requirements, general and XML-specific encoding conformance tests, and XML encoding examples (instances) for some key features. Note the specification is designed for future extension into other non-XML encoding syntaxes, which would require for each such encoding a description of the related schema, requirements, conformance tests, and instances.

The GroundWaterML2 Logical and XML schemas are organized into 5 modular packages:

- (1) GWML2-Nucleus: core elements such as aquifers, their pores, and fluid bodies.
- (2) GWML2-Constituent: the biologic, chemical, and material elements of a fluid body.
- (3) GWML2-Flow: groundwater flow within and between containers.
- (4) GWML2-Well: water wells, springs, and monitoring sites.
- (5) GWML2-WellConstruction: the components used to construct a well.

Altogether, the schemas and packages represent a precise description of the key features associated with the groundwater domain, as well as their properties and relationships. This provides a semantics and syntax for the correct machine interpretation of the data, which promotes its proper use in further analysis. Existing systems can then use this to 'bridge' between existing schema or systems, allowing consistency of the data to be maintained and enabling interoperability.

## 2 Conformance

This specification has been written to be compliant with the OGC Specification Model – A Standard for Modular Specification (OGC 08-131r3). Extensions of this standard shall themselves be conformant to the OGC Specification Model.

### 2.1 XML implementation

The XML implementation (encoding) of the conceptual and logical groundwater schemas is described using the XML Schema language and Schematron.

Requirements for **one standardization target type** are considered:

- **data instances**

i.e. XML documents that encode groundwater data for exchange. Since data *producing* applications should generate conformant data instances, the requirements and tests described in this specification effectively also apply to that target.

Conformance with this specification shall be checked using all the relevant tests specified in Annex A (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in ISO 19105: Geographic information — Conformance and Testing. In order to conform to this OGC™ encoding standard, a standardization target shall implement the core conformance class, and choose to implement any one of the other conformance classes (i.e. extensions).

All requirements-classes and conformance-classes described in this document are owned by the standard(s) identified.

### 2.2 Use of vocabularies

Controlled vocabularies, also known as code-lists, are used in data exchange to identify particular concepts or terms, and sometimes relationships between them. For example, an organisation may define a controlled vocabulary for all observed phenomena that are to be exchanged between parties. Some of these definitions may be related by hierarchies or through other relationships such as equivalence.

GroundWaterML2.0 does not define a set of vocabularies for groundwater data exchange.

It is envisaged that GroundWaterML2.0 will be used alongside existing sets of vocabularies as agreed upon within communities. The parties involved in exchange will determine the vocabularies that are to be used in the exchanged data. Future work within the Hydrology Domain Working Group should address the area of controlled vocabularies for the groundwater domain. These vocabularies require a governance structure that allows changes to be made as definitions evolve, possibly using the OGC definition namespace (<http://www.opengis.net/def/groundwaterml/2.0/>), which is governed by the OGC Naming Authority (OGC-NA). The OGC-NA is responsible for processing requests to change or add new

definitions to this namespace. The procedures for the OGC-NA are outlined in OGC document 09-046 (OGC-NA – Procedures) and the structure of URIs is outlined in OGC 09-048 (OGC-NA – Name type specification – definitions).

### 2.3 Groundwater data

Groundwater data conforming to this specification is encoded in GML-conformant XML documents. The standard MIME-type and sub-type for GML data should be used to indicate the encoding in internet exchange, as specified in *MIME Media Types for GML*, namely

**application/gml+xml.**

### 3 References

The following normative documents contain provisions which, through reference in this text, constitute provisions of document OGC 10-126. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this document are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies.

OGC 06-121r9, *OGC*<sup>®</sup> Web Services Common Standard

OGC 08-131r3 – The Specification Model – A Standard for Modular Specification

ISO 19103:2005 – Conceptual Schema Language

ISO 8601- Data elements and interchange formats – Information interchange – Representation of dates and times

OGC Abstract Specification Topic 20 – Observations and Measurements (aka ISO 19156:2011)

OGC Abstract Specification Topic 2 – Spatial Referencing by Coordinates (aka ISO 19111:2007)

OGC Abstract Specification Topic 6 – Schema for Coverage geometry and functions (aka ISO 19123:2005)

OGC Abstract Specification Topic 11 – Geographic information — Metadata (aka ISO 19115:2003)

OGC 07-036 Geography Markup Language (aka ISO 19136:2007)

OGC Observations and Measurements v2.0 OGC Document 10-004r1  
<http://www.opengis.net/doc/AS/Topic20> (also published as ISO/DIS 19156:2010, Geographic information — Observations and Measurements)

OGC SWE Common Data Model Encoding Standard v2.0 OGC Document 08-094r1  
<http://www.opengis.net/doc/IS/SWECCommon/2.0>

Schematron: ISO/IEC 19757-3, Information technology — Document Schema Definition Languages (DSDL) — Part 3: Rule-based validation — Schematron  
[http://standards.iso.org/ittf/PubliclyAvailableStandards/c040833\\_ISO\\_IEC\\_19757-3\\_2006\(E\).zip](http://standards.iso.org/ittf/PubliclyAvailableStandards/c040833_ISO_IEC_19757-3_2006(E).zip)

The Specification Model — A Standard for Modular specifications OGC Document 08-131r3.  
<http://www.opengis.net/doc/POL/SPEC>

Unified Code for Units of Measure (UCUM) – Version 1.8, July 2009

Unified Modeling Language (UML). Version 2.3. May 2010.

Extensible Markup Language (XML) – Version 1.0 (Fourth Edition), August 2006

XML Schema – Version 1.0 (Second Edition), October 2004

## 4 Terms and Definitions

This document uses the terms defined in Sub-clause 5.3 of [OGC 06-121r8], which is based on the ISO/IEC Directives, Part 2, Rules for the structure and drafting of International Standards. In particular, the word “shall” (not “must”) is the verb form used to indicate a requirement to be strictly followed to conform to this specification.

For the purpose of this document, the following terms and definitions apply:

### 4.1 coverage

Feature that acts as a function to return values from its range for any direct position within its spatial, temporal or spatiotemporal domain.

[ISO 19123:2005, definition 4.17]

### 4.2 domain feature

Feature of a type defined within a particular application domain

NOTE: This may be contrasted with observations and sampling features, which are features of types defined for cross-domain purposes.

[ISO 19156, definition 4.4]

### 4.3 element <XML>

basic information item of an XML document containing child elements, attributes and character data

NOTE From the XML Information Set: —Each XML document contains one or more elements, the boundaries of which are either delimited by start-tags and end-tags, or, for empty elements, by an empty-element tag. Each element has a type, identified by name, sometimes called its ‘generic identifier’ (GI), and may have a set of attribute specifications. Each attribute specification has a name and a value.

[ISO 19136:2007]

### 4.4 feature

Abstraction of real-world phenomena

[ISO 19101:2002, definition 4.11]

### 4.5 GML application schema

application schema written in XML Schema in accordance with the rules specified in ISO 19136:2007

[ISO 19136:2007]

#### 4.6 **GML document**

XML document with a root element that is one of the elements AbstractFeature, Dictionary or TopoComplex specified in the GML schema or any element of a substitution group of any of these elements

[ISO 19136:2007]

#### 4.7 **GML schema**

schema components in the XML namespace —<http://www.opengis.net/gml/3.2> as specified in ISO 19136:2007

[ISO 19136:2007]

#### 4.8 **measurement**

set of operations having the object of determining the value of a quantity

[ISO/TS 19101-2:2008, definition 4.20]

#### 4.9 **observation**

act of observing a property

NOTE The goal of an observation may be to measure or otherwise determine the value of a property

[ISO 19156:2011 definition 4.10]

#### 4.10 **observation procedure**

Method, algorithm or instrument, or system of these which may be used in making an observation

[ISO19156, definition 4.11]

#### 4.11 **observation result**

estimate of the value of a property determined through a known procedure

[ISO 19156:2011]

#### 4.12 **property <General Feature Model>**

Facet or attribute of an object referenced by a name

EXAMPLE: Abby's car has the colour red, where "colour red" is a property of the car instance

#### 4.13 **sampled feature**

the real-world domain feature of interest, such as a groundwater body, aquifer, river, lake, or sea, which the sampling feature makes observations concerning

[ISO 19156:2011]

#### 4.14 **sampling feature**

feature, such as a station, transect, section or specimen, which is involved in making observations concerning a domain feature

NOTE A sampling feature is purely an artefact of the observational strategy, and has no significance independent of the observational campaign.

[ISO 19156:2011, definition 4.16]

#### 4.15 **sampling point**

A specialized Sampling Feature (ISO19156) where the geometry of the feature is a point. In the context of this profile this is the point at which a sample is made and is analogous to site, location, measuring point. See Monitoring Point definition for further information.

#### 4.16 **schema <XML Schema>**

XML document containing collection of schema component definitions and declarations within the same target namespace

EXAMPLE Schema components of W3C XML Schema are types, elements, attributes, groups, etc.

NOTE The W3C XML Schema provides an XML interchange format for schema information. A single schema document provides descriptions of components associated with a single XML namespace, but several documents may describe components in the same schema, i.e. the same target namespace.

[ISO 19136:2007]



#### 4.17 **sensor**

Type of observation procedure that provides the estimated value of an observed property at its output

*Note: A sensor uses a combination of physical, chemical or biological means in order to estimate the underlying observed property. At the end of the measuring chain electronic devices often produce signals to be processed*

[OGC SWE Common 2.0, definition 4.5.]

## 5 Conventions

### 5.1 Requirements class

Each normative statement (requirement or recommendation) in this specification is a member of a requirements class. Each requirements class is described in a discrete clause or sub-clause, and summarized using the following template:

<b>Requirements class</b>	<code>/req/{classM}</code>
<b>Target type</b>	[artefact or technology type]
<b>Dependency</b>	[identifier for another requirements class]
<b>Requirement</b>	<code>/req/{classM}/{reqN}</code>
<b>Recommendation</b>	<code>/req/{classM}/{recO}</code>
<b>Requirement</b>	<code>/req/{classM}/{reqP}</code>
<b>Requirement /Recommendation</b>	[repeat as necessary]

All requirements in a class must be satisfied. Hence, the requirements class is the unit of re-use and dependency, and the value of a Dependency requirement is another requirements class. All requirements in a dependency must also be satisfied by a conforming implementation. A requirements class may consist only of dependencies and introduce no new requirements.

### 5.2 Requirement

All requirements are normative, and each requirement is presented using the following template:

<code>/req/[classM]/[reqN]</code>	[Normative statement]
-----------------------------------	-----------------------

where `/req/[classM]/[reqN]` identifies the requirement or recommendation. The use of this layout convention allows the normative provisions of this Standard to be easily located by implementers.

### 5.3 Conformance class

Conformance to this Standard is possible at a number of levels, specified by conformance classes (Annex A). Each conformance class is summarized using the following template:

<b>Conformance class</b>	<b>/conf/{classM}</b>
<b>Dependency</b>	[identifier for another conformance class]
<b>Requirements</b>	/req/{classA}
<b>Tests</b>	[reference to clause(s) containing tests]

All tests in a class must be passed, so dependencies are on other conformance classes. Each conformance class tests conformance to a set of requirements packaged in a requirements class.

### 5.4 Identifiers

Each requirements class, requirement and recommendation is identified by a URI. The identifier supports cross-referencing of class membership, dependencies, and links from each conformance test to requirements tested. In this standard identifiers are expressed as partial URIs or paths, which can be appended to a base URI that identifies the standard as a whole in order to construct a complete URI for identification in an external context

The URI for each requirements class has the form

[http://www.opengis.net/spec/groundwaterml/2.0/req/\[classM\]](http://www.opengis.net/spec/groundwaterml/2.0/req/[classM])

The URI for each requirement or recommendation has the form

[http://www.opengis.net/spec/groundwaterml/2.0/req/\[classM\]/\[reqN\]](http://www.opengis.net/spec/groundwaterml/2.0/req/[classM]/[reqN])

The URI for each conformance class has the form

[http://www.opengis.net/spec/groundwaterml/2.0/conf/\[classM\]](http://www.opengis.net/spec/groundwaterml/2.0/conf/[classM])

The URI for each conformance test has the form

[http://www.opengis.net/spec/groundwaterml/2.0/conf/\[classM\]/\[testN\]](http://www.opengis.net/spec/groundwaterml/2.0/conf/[classM]/[testN])

### 5.5 Conceptual and Logical schemas

Conceptual and logical schemas in the normative part of this specification are presented in the Unified Modeling Language (UML). UML diagrams are presented in compliance with ISO/IEC 19505-2.

## 5.6 External package abbreviations

Concepts from schemas defined in some other International Standards are designated with names that start with alpha codes as follow:

GF	ISO 19109:2005 General Feature Model
GFI	ISO 19156:2011 General Feature Model Instances
TM	ISO 19108:2002 Temporal Schema, Temporal Objects
MD	ISO 19115 Metadata
CV	ISO 19123:2005 Schema for Coverage Geometry and Functions
OM	ISO 19156:2011 Observations and Measurements
DQ	ISO 19157:201X Data Quality
WML2	OGC® WaterML 2.0: Part 1- Timeseries

## 5.7 Abbreviated terms

In this document the following abbreviations and acronyms are used or introduced:

ANS	
API	Application Program Interface
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSML	Climate Science Modelling Language
CSV	Comma Separated Values
GeoSciML3.2	GeoScience Mark-up Language version 3.2
GML	OGC Geography Mark-up Language
GWML2	Groundwater Markup Language version 2.0 (this specification)
GWML2-Nucleus	UML Logical Model of the primary GroundWaterML2 elements (namespace <a href="http://www.opengis.net/gwml-nucleus/2.0">http://www.opengis.net/gwml-nucleus/2.0</a> )
GWML2-Flow	UML Logical Model of the elements required to capture groundwater flow (namespace <a href="http://www.opengis.net/gwml-flow/2.0">http://www.opengis.net/gwml-flow/2.0</a> )
GWML2-Constituent	UML Logical Model of the groundwater fluid body constituents and their relationships (namespace <a href="http://www.opengis.net/gwml-constituent/2.0">http://www.opengis.net/gwml-constituent/2.0</a> )

GWML2-Well	UML Logical Model of the features and properties associated with water well (namespace <a href="http://www.opengis.net/gwml-well/2.0">http://www.opengis.net/gwml-well/2.0</a> )
GWML2-WellConstruction	UML Logical Model of the well drilling and construction details (namespace <a href="http://www.opengis.net/gwml-wellconstruction/2.0">http://www.opengis.net/gwml-wellconstruction/2.0</a> )
ISO	International Organization for Standardization
OGC	Open Geospatial Consortium
O&M	OGC Observations and Measurements Conceptual Model
OMXML	Observations and Measurements XML Implementation
SensorML	Sensor Model Language
SI	Système International (International System of Units)
SOS	Sensor Observation Service
SWE	Sensor Web Enablement
TVP	Time-Value Pair
UML	Unified Modeling Language
USGS	United States Geological Survey
UTC	Coordinated Universal Time
WML2	WaterML 2.0 – Part 1
XML	Extensible Markup Language
XSD	W3C XML Schema Definition Language

## 5.8 UML notation

The diagrams that appear in this standard are presented using the Unified Modeling Language (UML) static structure diagram.

**Note:** Within the context of this profile, the following color scheme is used to identify the package in which the class exists. This is just for informative purposes.

Amber: GWML2 defined within this specification

Green and Purple: from GeoSciML

Blue: from Observations & Measurements

## 5.9 Finding requirements and recommendations

This specification is identified as <http://www.opengis.net/spec/groundwaterml/2.0>. For clarity, each normative statement in this standard is in one and only one place and defined within a requirements class table and identified with a URI, whose root is the specification URI. In this

standard, all requirements are associated to tests in the abstract test suite in Annex A using the URL of the requirement as the reference identifier. Recommendations are not tested but are assigned URLs and are identified using the 'Recommendation' label in the associated requirements table.

Requirements classes are separated into their own clauses and named, and specified according to inheritance (direct dependencies). The Conformance test classes in the test suite are similarly named to establish an explicit and mnemonic link between requirements classes and conformance test classes.

## 6 Background

### 6.1 Technical Basis

This specification builds on a number of standards for encoding XML data, including:

- OMXML
- sweCommon (OGC 08-094r1)
- GML ISO 19136:2007 (OGC 07-036)
- ISO 19139 (Metadata)
- W3C XSD

This specification also builds on two existing schema: Observations & Measurements (O&M) and GeoSciML 3.2. It accomplishes this by (a) extending these schema with groundwater specializations, (b) referring to a class in these schema to type a named property, or (c) using a class from the schemas as one of the two participants in a binary relationship.

### 6.2 Overview of Observations & Measurements

ISO19156 – Observations and Measurements is a generic GML schema for observations. As shown in Figure 1, it defines an observation as “...*an act associated with a discrete time instant or period through which a number, term or other symbol is assigned to a phenomenon. It involves application of a specified procedure, such as a sensor, instrument, algorithm or process chain. The procedure may be applied in-situ, remotely, or ex-situ with respect to the sampling location. The result of an observation is an estimate of the value of a property of some feature.*”

#### 6.2.1 Sampling features

Sampling features in O&M are defined as a “*feature, such as a station, transect, section or specimen, which is involved in making observations concerning a domain feature.*” Sampling features in the groundwater domain are features along which, or upon, observations are made. The most relevant are water wells and boreholes, which effectively host observations along staged intervals; a collection of these intervals and their observations constitutes a log.

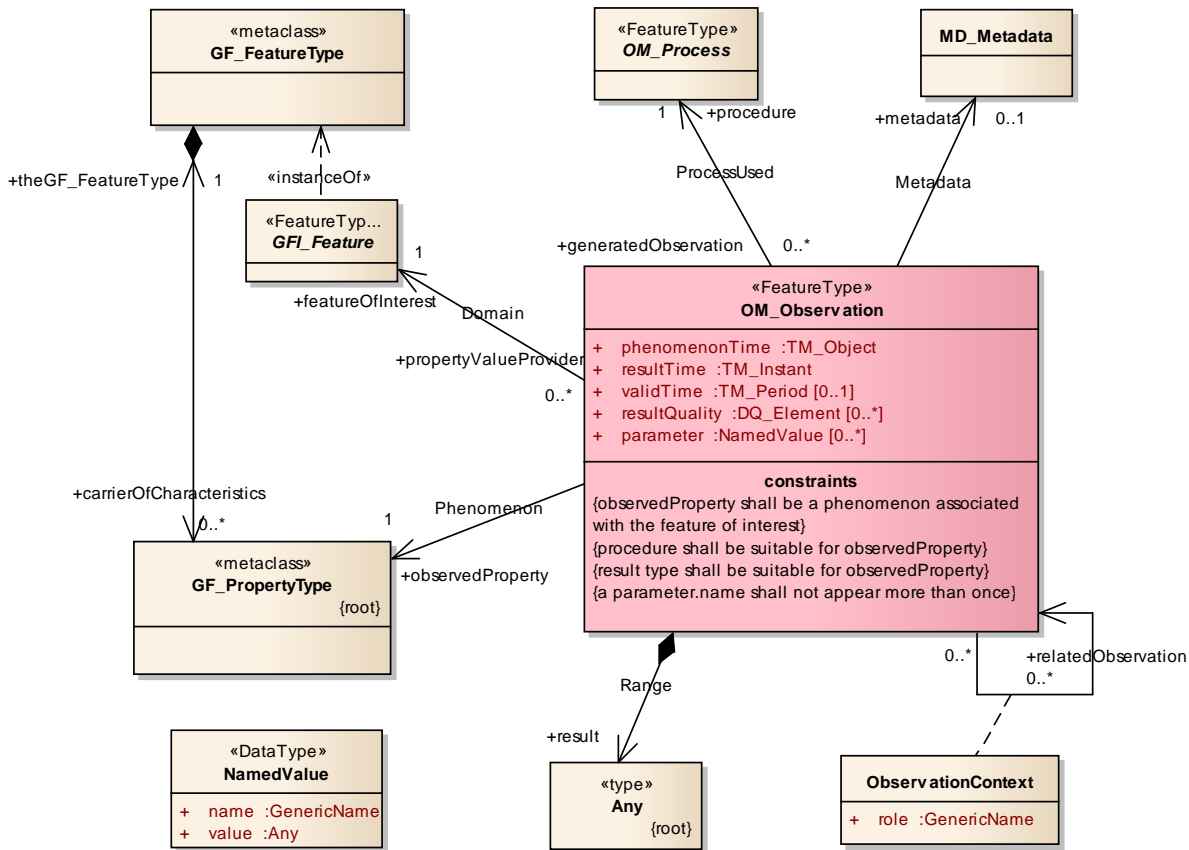


Figure 1: Observation in O&M

### 6.3 Overview of GeoSciML 3.2

GeoSciML is a GML schema for core geological entities including geological units, structures, and earth materials. It is particularly relevant to GWML2 because bodies of rock serve as containers for subsurface water bodies. Such rock bodies possess variable hydrogeologic properties according to their material composition and topological organization. Thus, geological units and earth materials are the key GeoSciML entities required by GWML2.

GeoSciML defines a geological unit as “a body of material in the Earth whose complete and precise extent is inferred to exist (NADM *GeologicUnit*, *Stratigraphic unit in sense of NACSN or International Stratigraphic Code*), or a classifier used to characterize parts of the Earth (e.g. *lithologic map unit like 'granitic rock' or 'alluvial deposit', surficial units like 'till' or 'old alluvium'*).”

GeoSciML defines an earth material as “naturally occurring substance in the Earth” and intuitively refers to various types of rocks such as sandstone, granite, and gneiss.



## 7 Conceptual Model

The GWML2 conceptual model is designed to be technology-neutral, and focused on the semantics of the groundwater domain. It consists of five main components, as well as related properties and other entities: hydrogeological units, fluid bodies, voids, groundwater flow, and wells. Conceptually, these entities form a simple template for a subsurface water container: the fluid container (a unit or its materials), the fluid itself (fluid body), the spaces in the container occupied by the fluid (void), the flow of fluid within and between containers and their spaces (flow), and the natural and artificial artifacts used to withdraw, inject, or monitor fluid with respect to a container (wells, springs, monitoring sites).

Well construction details are excluded from the conceptual model, but are included in the logical model for two reasons: (1) thematic, inasmuch as well construction was considered on the periphery of groundwater science, but important to resource management, and (2) practical, as it is sufficiently modeled in GWML1 and could thus be directly imported with few changes. This eliminates the need for its re-conceptualization in the GWML2 conceptual model, thereby keeping it parsimonious.

### 7.1 Hydrogeological Units

These are distinct bodies of ground that serve as containers for subsurface water. The boundaries of a unit are typically discriminated from those of another unit using properties related to the potential or actual ability to contain or move water. The properties can be geological or hydraulic, and typically include influences from the surrounding hydrological environment. More specifically, the conceptual model delineates two types of hydrogeological units, with slightly different orientations: aquifer-related units have boundaries delimited by the hydrogeological properties of the rock body, while groundwater basins have boundaries delimited by distinct flow regimes. Aquifer-related units are subdivided into aquifer systems, which are collections of aquifers, aquifers, and confining beds. Confining beds are units that impede water flow to surrounding units, and supersede notions such as aquitards and aquicludes, which are not included herein, as it is difficult to differentiate these in practice.

Several significant properties are typically attributed to hydrogeological units, such as porosity, permeability, and conductivity, but these and others are modeled more accurately here as occurring necessarily concurrent with (dependent on) voids or fluid bodies. For example, porosity, in its various flavors, requires both the presence of a unit (container) and its voids, as it is typically defined as the proportion of void volume to total unit + void volume. Likewise, properties such as hydraulic conductivity and yield require the presence of units and fluid bodies, as they are concerned with the degree of movement of a fluid through a unit. Note that permeability and hydraulic conductivity are differentiated here: permeability refers to intrinsic permeability, which measures the ability of a unit to host fluid flow, independent of fluid properties and based solely on the connectivity and size of voids, whereas hydraulic conductivity additionally considers fluid properties.

Likewise, management areas are also relational entities in the sense that they are typically necessarily linked with a unit (or system) and possibly a fluid body. Management areas are bodies

of ground identified for groundwater management purposes and their boundaries can be delineated by social factors, such as policy or regulation, in addition to physical factors related to hydrogeology or hydrology.

## 7.2 Fluid Bodies

These are distinct bodies of fluid (liquid or gas) that fill the voids in hydrogeological units. Fluid bodies are made of biologic (e.g. organisms), chemical (e.g. arsenic), or material constituents (e.g. sediment). While it is expected that the major constituent of a fluid body will be water, the conceptual model allows for other types of major constituents such as petroleum; minor constituents are not necessarily fluids but can be gases, liquids, or solids, and are included in the fluid body in various forms of mixture, such as suspension, emulsion, precipitation, etc. Fluid bodies can also have other fluids as parts, such as pollution plumes, or gas bubbles. Surfaces can be identified on a fluid body, such as a water table, piezometric or potentiometric surface, and some such surfaces can contain divides, which are lines projected to the fluid surface that denote divergence in the direction of flow systems.

## 7.3 Voids

Voids are the spaces inside a unit (e.g. aquifer) or its material (e.g. sandstone), and might contain fluid bodies. Voids are differentiated from porosity, in that porosity is a ratio of void volume to total volume of unit + voids, while voids are the spaces themselves. It is important to conceptually differentiate voids from units, their containers, in order to represent, for example, the volume of fractures, caves, or pores in a particular unit or portion thereof.

## 7.4 Flow

Groundwater flow denotes the process by which a fluid enters or exits a container (unit) or its voids, or flows within them. Flow **between** one container or void and another is called *InterFlow*, and flow **within** a container or void is called *IntraFlow*. Recharge is the flow into a groundwater container or void, and discharge is flow out of a groundwater container or void. The reciprocal source or destination entity can be any appropriate container or void such as a river, lake, pipe, dam, canyon, flood plain, etc. A flow system is then a collection of flows ordered in a sequence from recharge to discharge, such that the flow segments of the system make up a connected flow path from source to destination. A water budget is a measure of the balance of recharge and discharge valid for a specific time and relative to a specific groundwater feature, such as a basin, aquifer, management area, or well.

## 7.5 Wells

Well-related entities include water wells, springs, and monitoring sites. Water wells are man-made constructions for withdrawing or injecting water from/into the ground, while springs are natural features where water discharges to the surface. Both wells and springs possess important links to the hydrogeological environment, including their host units and its materials, as well as

the intersecting fluid body. Monitoring sites are locations where devices are placed to measure various properties of significance to hydrogeology, such as water level, flow rate, water temperature, or chemical composition, or to take samples. As such, monitoring sites are roles played by other features, for example, a water well or spring might be monitored.

## 7.6 Conceptual Model Specification

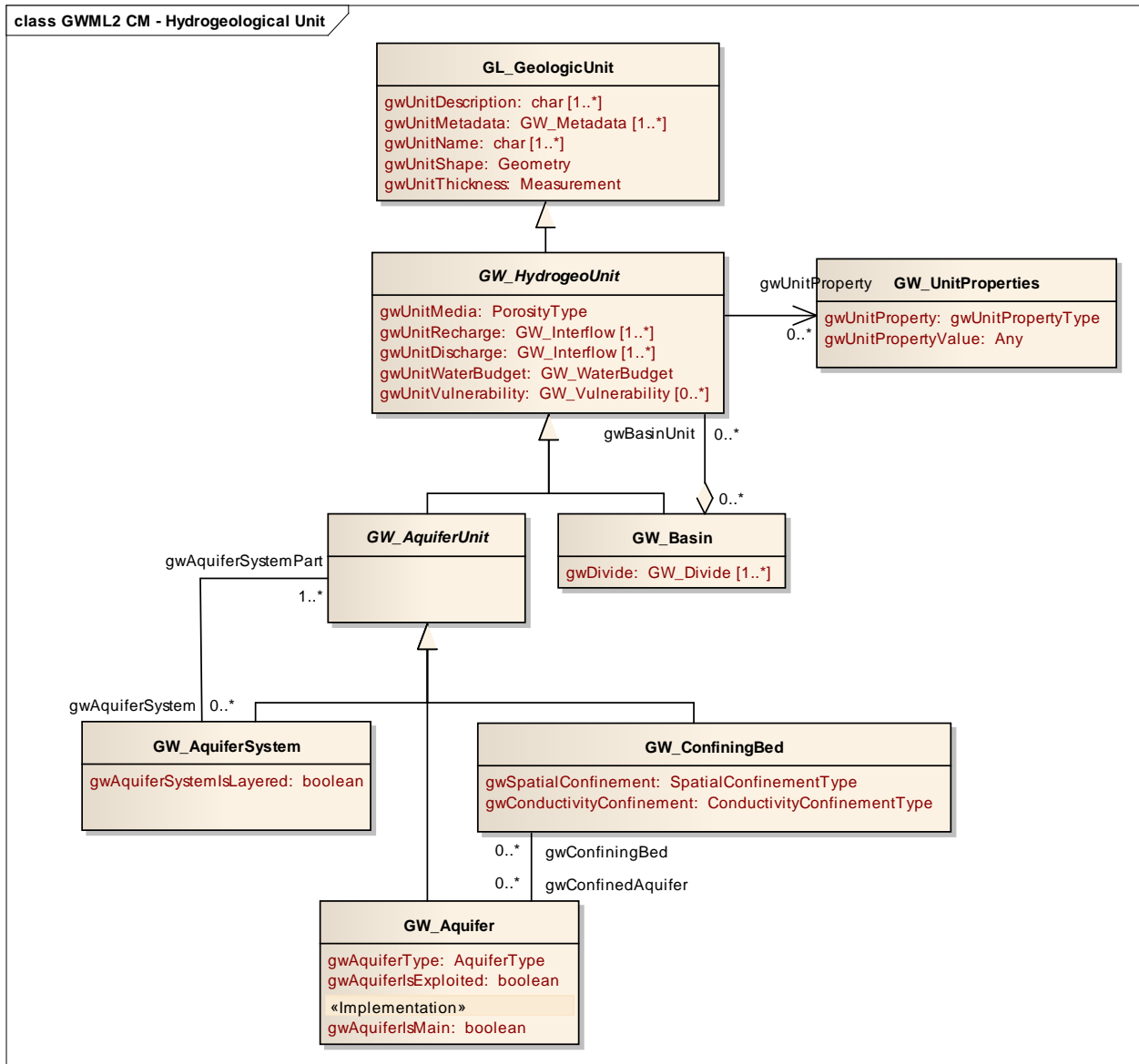
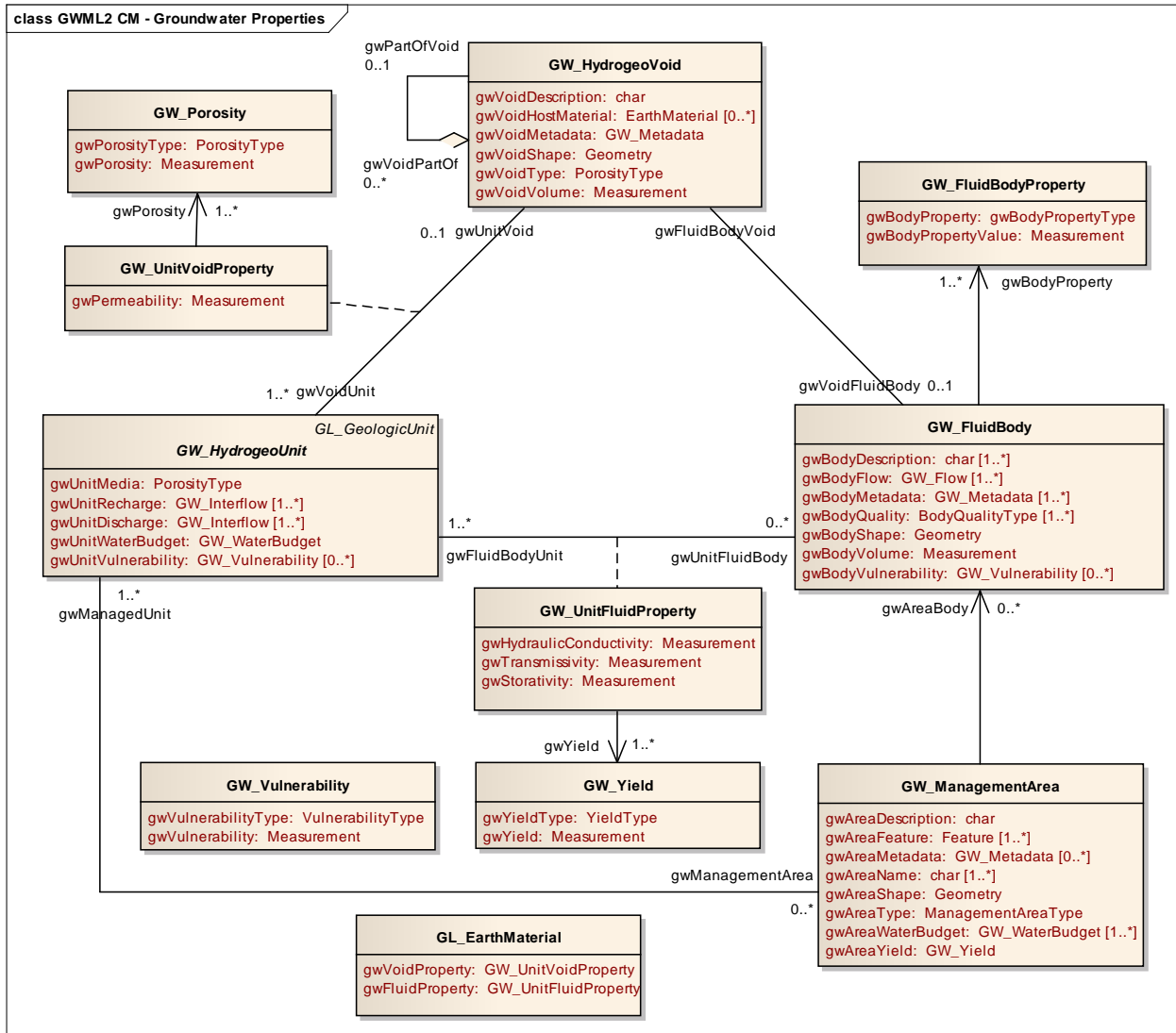
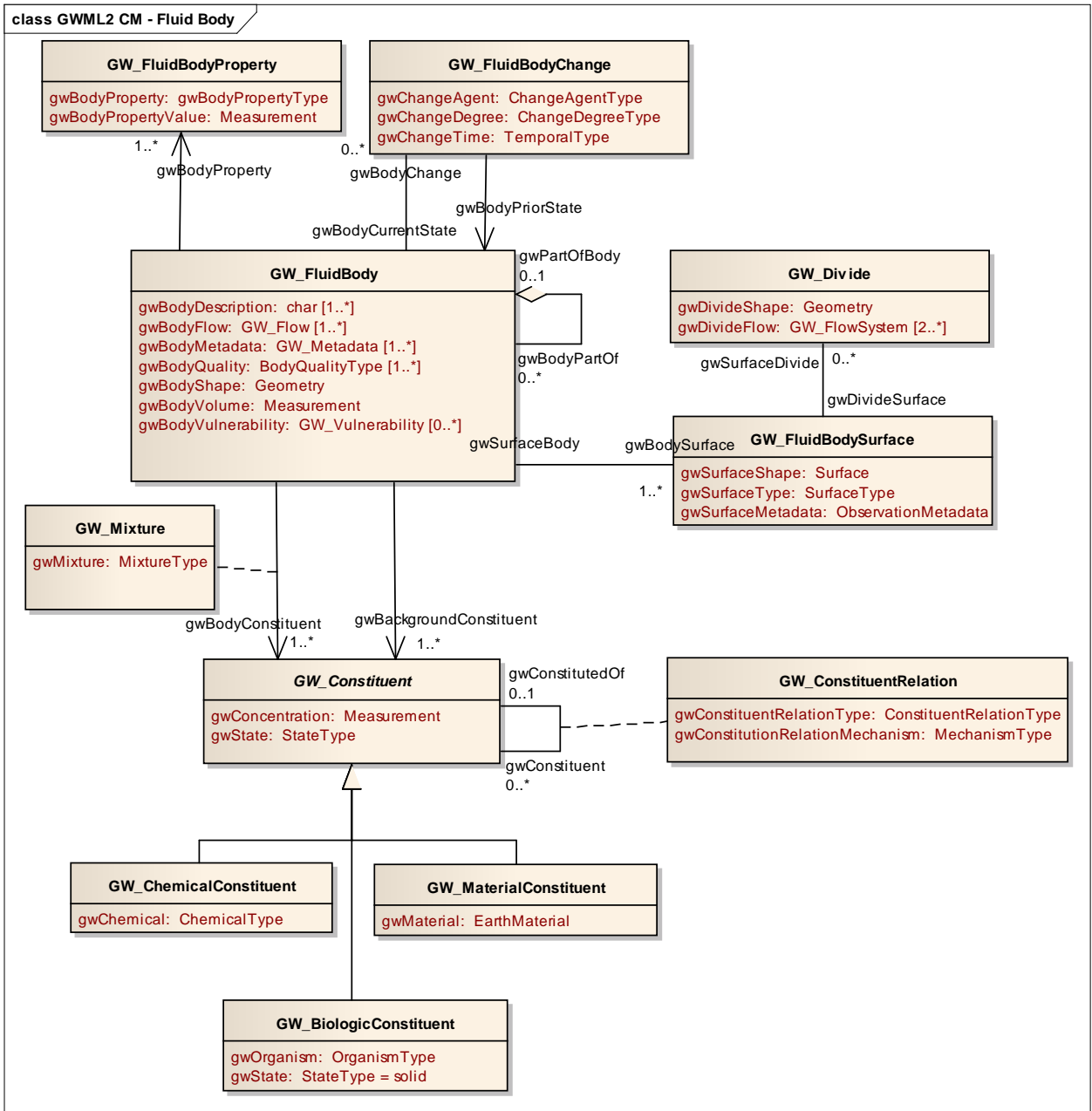


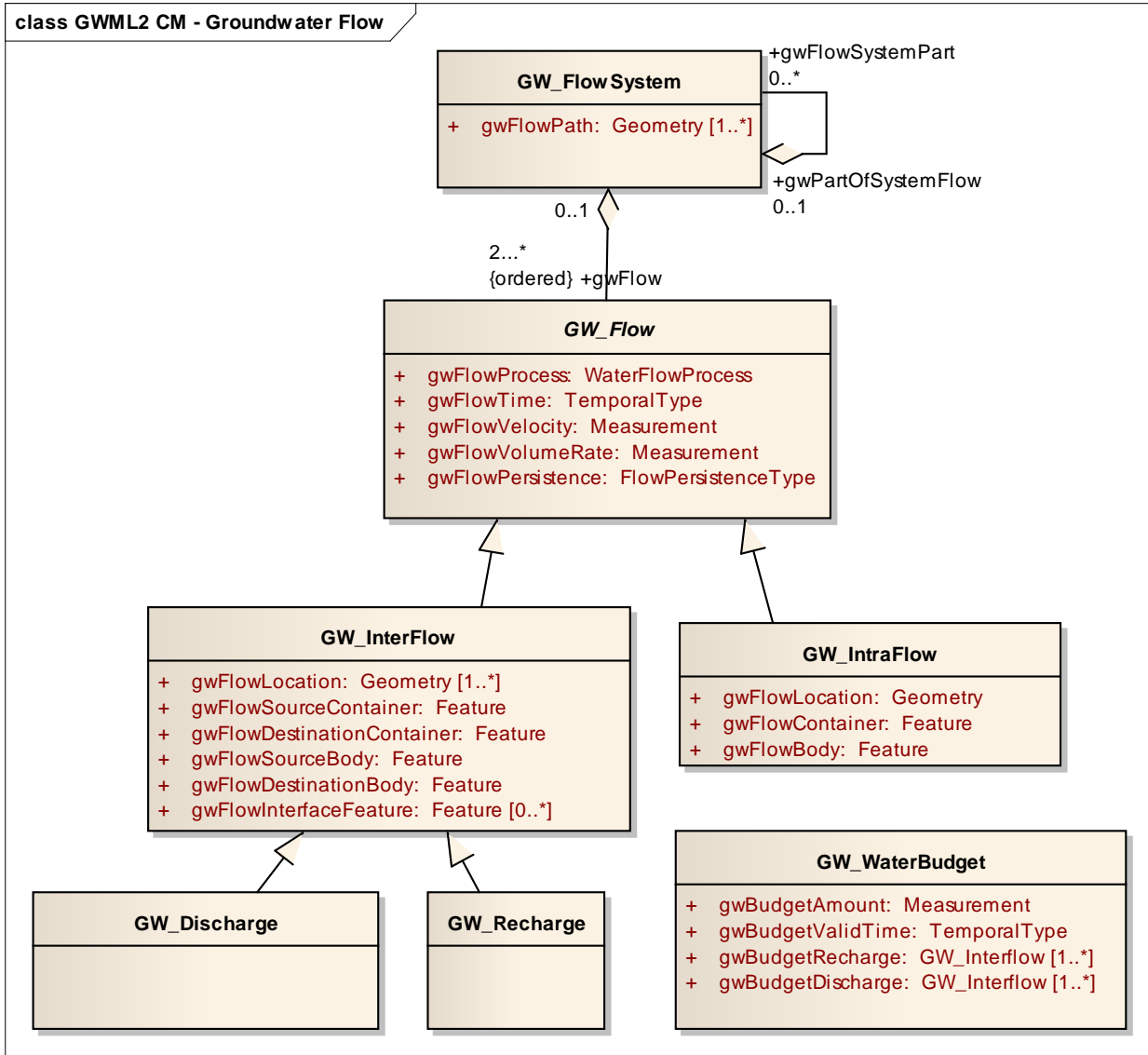
Figure 2: GWML2 CM - Hydrogeological Unit



**Figure 3: GWML2 CM - Groundwater Properties**



**Figure 4: GWML2 CM - Fluid Body**



**Figure 5: GWML2 CM - Groundwater Flow**

**class GWML2 CM - Wells**

**GW\_MonitoringSite**

gwSiteName: char [0..\*]  
gwSiteLocation: Geometry  
gwSiteReferenceElevation: ElevationType [1..\*]  
gwSiteType: SiteType  
gwMonitoringHost: Feature

**GW\_Well**

gwWellName: char [0..\*]  
gwWellLocation: Geometry  
gwWellReferenceElevation: ElevationType [1..\*]  
gwWellContributionZone: Geometry  
gwWellGeology: GeologyLog [0..\*]  
gwWellUnit: GW\_HydrogeoUnit [1..\*]  
gwWellBody: GW\_FluidBody [0..\*]  
gwWellPurpose: WellPurposeType [1..\*]  
gwWellStatus: WellStatusType  
gwWellWaterUse: WellWaterUseType [1..\*]  
gwWellTotalLength: Measurement  
gwWellConstructedDepth: Measurement [0..1]  
gwWellStaticWaterDepth: Measurement  
gwWellYield: GW\_Yield  
gwWellConstruction: WellConstruction

**GW\_Spring**

gwSpringName: char [0..\*]  
gwSpringLocation: Geometry  
gwSpringReferenceElevation: ElevationType [1..\*]  
gwSpringType: SpringType  
gwSpringCauseType: SpringCauseType  
gwSpringPersistence: SpringPersistenceType  
gwSpringGeology: GL\_GeologicUnit [0..\*]  
gwSpringUnit: GW\_HydrogeoUnit [1..\*]  
gwSpringBody: GW\_FluidBody [0..\*]  
gwSpringConstruction: SpringConstruction [0..1]

**Figure 6: GWML2 CM - Wells**

### 7.6.1 GL\_EarthMaterial

Substances that constitute physical bodies, e.g. sandstone, granite, water

Attribute	Type and Multiplicity	Definition
<i>gwVoidProperty</i>	<i>GW_UnitVoidProperty</i>	The porosity or permeability of a particular earth material that hosts a void.
<i>gwFluidProperty</i>	<i>GW_UnitFluidProperty</i>	The hydraulic conductivity, transmissivity, or storativity of an earth material.

Relation	Source	Target
<i>Association</i>	<i>Entity: GL_GeologicUnit</i> <i>Role: constitutedUnit</i>	<i>Entity: GL_EarthMaterial</i> <i>Role: constituentMaterial</i>

### 7.6.2 GL\_GeologicUnit

From GeoSciML: Conceptually, may represent a body of material in the Earth whose complete and precise extent is inferred to exist (NADM GeologicUnit, Stratigraphic unit in sense of NACSN or International Stratigraphic Code), or a classifier used to characterize parts of the Earth (e.g. lithologic map unit like 'granitic rock' or 'alluvial deposit', surficial units like 'till' or 'old alluvium').

Attribute	Type and Multiplicity	Definition
<i>gwUnitDescription</i>	<i>char [1..*]</i>	Description of the unit.
<i>gwUnitMetadata</i>	<i>GW_Metadata [1..*]</i>	Metadata for the unit .
<i>gwUnitName</i>	<i>char [1..*]</i>	Name of the unit (common local name or formal name).
<i>gwUnitShape</i>	<i>Geometry</i>	The geometry of the unit.
<i>gwUnitThickness</i>	<i>Measurement</i>	Typical thickness of the unit.



<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Association</i>	<i>Entity: GL_GeologicUnit</i> <i>Role: constitutedUnit</i>	<i>Entity: GL_EarthMaterial</i> <i>Role: constituentMaterial</i>
<i>Generalization</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role:</i>	<i>Entity: GL_GeologicUnit</i> <i>Role:</i>

### 7.6.3 GW\_Aquifer

A body of ground that contains / potentially contains / potentially contained sufficient saturated permeable material to yield significant quantities of water to wells and springs (after Lohman and others, 1972).

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwAquiferType</i>	<i>AquiferType</i>	Water in an Aquifer is, or is not, under pressure. Based on that unconfined, confined, artesian, subartesian, or aquitard types are distinguished. (INSPIRE v3.0)
<i>gwAquiferIsExploited</i>	<i>boolean</i>	Boolean denotes whether groundwater from the hydrogeo unit is being exploited by wells or other intakes.
<i>gwAquiferIsMain</i>	<i>boolean</i>	Boolean denotes whether the unit is the primary unit in an Aquifer System.  Modeling note: not implemented as an attribute of the AquiferSystem part relation, to avoid ConfiningBed being a primary unit.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Association</i>	<i>Entity: GW_Aquifer</i> <i>Role: gwConfinedAquifer</i>	<i>Entity: GW_ConfiningBed</i> <i>Role: gwConfiningBed</i>

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Generalization</i>	<i>Entity: GW_Aquifer</i> <i>Role:</i>	<i>Entity: GW_AquiferUnit</i> <i>Role:</i>

#### 7.6.4 GW\_AquiferSystem

Aquifer system - A body of permeable and poorly permeable material that functions regionally as a water-yielding unit; it comprises two or more permeable beds separated at least locally by confining beds that impede groundwater movement but do not greatly affect the regional hydraulic continuity of the system; includes both saturated and unsaturated parts of permeable material (after ASCE, 1985).

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwAquiferSystemIsLayered</i>	<i>boolean</i>	True if this aquifer / system is a layered system.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Association</i>	<i>Entity: GW_AquiferSystem</i> <i>Role: gwAquiferSystem</i>	<i>Entity: GW_AquiferUnit</i> <i>Role: gwAquiferSystemPart</i>
<i>Generalization</i>	<i>Entity: GW_AquiferSystem</i> <i>Role:</i>	<i>Entity: GW_AquiferUnit</i> <i>Role:</i>

#### 7.6.5 GW\_AquiferUnit

Denotes aquifer-related hydrogeological units: aquifer systems, aquifers, or confining beds.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Generalization</i>	<i>Entity: GW_AquiferUnit</i> <i>Role:</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role:</i>
<i>Association</i>	<i>Entity: GW_AquiferSystem</i>	<i>Entity: GW_AquiferUnit</i>

<b>Relation</b>	<b>Source</b>	<b>Target</b>
	<i>Role: gwAquiferSystem</i>	<i>Role: gwAquiferSystemPart</i>
<i>Generalization</i>	<i>Entity: GW_AquiferSystem</i> <i>Role:</i>	<i>Entity: GW_AquiferUnit</i> <i>Role:</i>
<i>Generalization</i>	<i>Entity: GW_ConfiningBed</i> <i>Role:</i>	<i>Entity: GW_AquiferUnit</i> <i>Role:</i>
<i>Generalization</i>	<i>Entity: GW_Aquifer</i> <i>Role:</i>	<i>Entity: GW_AquiferUnit</i> <i>Role:</i>

#### 7.6.6 GW\_Basin

A large hydrogeologically defined body of ground typically consisting of hydraulically connected hydrogeological units, whose waters are flowing to a common or multiple outlets, and which is delimited by a groundwater divide.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwDivide</i>	<i>GW_Divide [1..*]</i>	Line on a water table or piezometric surface on either side of which the groundwater flow diverges. IGH0556.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Generalization</i>	<i>Entity: GW_Basin</i> <i>Role:</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role:</i>
<i>Aggregation</i>	<i>Entity: GW_Basin</i> <i>Role:</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role: gwBasinUnit</i>

### 7.6.7 GW\_BiologicConstituent

The characterisation of the biological composition of the groundwater, both natural and man-made.

Attribute	Type and Multiplicity	Definition
<i>gwOrganism</i>	<i>OrganismType</i>	Biological species.
<i>gwState</i>	<i>StateType solid</i>	Organisms are always solids.

Relation	Source	Target
<i>Generalization</i>	<i>Entity: GW_BiologicConstituent</i> <i>Role:</i>	<i>Entity: GW_Constituent</i> <i>Role:</i>

### 7.6.8 GW\_ChemicalConstituent

The characterisation of the chemical composition of the groundwater, both natural and man-made.

Attribute	Type and Multiplicity	Definition
<i>gwChemical</i>	<i>ChemicalType</i>	Chemical component type, e.g. arsenic.

Relation	Source	Target
<i>Generalization</i>	<i>Entity: GW_ChemicalConstituent</i>	<i>Entity: GW_Constituent</i>

### 7.6.9 GW\_ConfiningBed

A layer of rock having very low porosity and in consequence hydraulic conductivity that hampers the movement of water into and out of an aquifer (Heath 1983)

Attribute	Type and Multiplicity	Definition
<i>gwSpatialConfinement</i>	<i>SpatialConfinementType</i>	Degree of confinement (typically: "Unconfined-Confined", "Partially Confined").
<i>gwConductivityCo</i>	<i>ConductivityConfinemen</i>	Degree of confinement (e.g. aquiclude).

Attribute	Type and Multiplicity	Definition
<i>nfinement</i>	<i>tType</i>	

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_Aquifer</i> <i>Role: gwConfinedAquifer</i>	<i>Entity: GW_ConfiningBed</i> <i>Role: gwConfiningBed</i>
<i>Generalization</i>	<i>Entity: GW_ConfiningBed</i> <i>Role:</i>	<i>Entity: GW_AquiferUnit</i> <i>Role:</i>

#### 7.6.10 GW\_Constituent

General (abstract) entity denoting a material, chemical or biological constituent of a fluid body.

Attribute	Type and Multiplicity	Definition
<i>gwConcentration</i>	<i>Measurement</i>	The concentration (with uom) of the constituent in the fluid body.
<i>gwState</i>	<i>StateType</i>	The physical state of the constituent, i.e. solid, liquid, or gas.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_FluidBody</i> <i>Role:</i>	<i>Entity: GW_Constituent</i> <i>Role: gwBackgroundConstituent</i>
<i>AssociationClass</i>	<i>Entity: GW_Constituent</i> <i>Role: gwConstituent</i>	<i>Entity: GW_Constituent</i> <i>Role: gwConstitutedOf</i>
<i>Generalization</i>	<i>Entity: GW_BiologicConstituent</i>	<i>Entity: GW_Constituent</i>

<b>Relation</b>	<b>Source</b>	<b>Target</b>
	<i>Role:</i>	<i>Role:</i>
<i>Generalization</i>	<i>Entity: GW_ChemicalConstituent</i> <i>Role:</i>	<i>Entity: GW_Constituent</i> <i>Role:</i>
<i>Generalization</i>	<i>Entity: GW_MaterialConstituent</i> <i>Role:</i>	<i>Entity: GW_Constituent</i> <i>Role:</i>
<i>AssociationClass</i>	<i>Entity: GW_FluidBody</i> <i>Role:</i>	<i>Entity: GW_Constituent</i> <i>Role: gwBodyConstituent</i>

#### 7.6.11 GW\_ConstituentRelation

Relation between fluid body components, typically caused by a specific mechanism, e.g. coating (from adsorption), constitution (from chemical bonding forming a new material?), aggregation (from physical bonding, e.g. pressure), containment (from absorption, digestion).

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwConstituentRelationType</i>	<i>ConstituentRelationType</i>	Specific type of relation between fluid body components, typically caused by a specific mechanism, e.g. coating (from adsorption), constitution (from chemical bonding forming a new material?), aggregation (from physical bonding, e.g. pressure), containment (from absorption, digestion).
<i>gwConstitutionRelationMechanism</i>	<i>MechanismType</i>	Mechanisms by which materials (of various states) come into a relationship, e.g. sorption, precipitation, digestion, excretion, etc.

### 7.6.12 GW\_Discharge

An outflow of water from a stream, pipe, groundwater aquifer, or watershed; the opposite of recharge. (<http://www.groundwater.org/get-informed/basics/glossary.html>)

Relation	Source	Target
<i>Generalization</i>	<i>Entity: GW_Discharge</i> <i>Role:</i>	<i>Entity: GW_InterFlow</i> <i>Role:</i>

### 7.6.13 GW\_Divide

Line on a water table or piezometric surface on either side of which the groundwater flow diverges. IGH0556

Attribute	Type and Multiplicity	Definition
<i>gwDivideShape</i>	<i>Geometry</i>	Shape / position of the divide (line, plane or point)... intersecting a gw surface
<i>gwDivideFlow</i>	<i>GW_FlowSystem [2..*]</i>	Flow system on each side of the divide.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_Divide</i> <i>Role: gwSurfaceDivide</i>	<i>Entity: GW_FluidBodySurface</i> <i>Role: gwDivideSurface</i>
<i>Association</i>	<i>Entity: GW_FlowSystem</i> <i>Role: gwDivideFlow</i>	<i>Entity: GW_Divide</i> <i>Role:</i>

### 7.6.14 GW\_Flow

Process by which the fluid enters or exits a hydrogeologic unit or a void, or flows within a unit or a void. Can flow from/to other natural or man-made features such as rivers, filtration stations, etc.

Attribute	Type and Multiplicity	Definition
<i>gwFlowProcess</i>	<i>WaterFlowProcess</i>	E.g. evapotranspiration, evaporation,

Attribute	Type and Multiplicity	Definition
		transpiration, runoff, baseflow, pumping, infiltration, injection, etc.
<i>gwFlowTime</i>	<i>TemporalType</i>	Refers to duration or instant or interval of that flow (actual time, not observation time). E.g. "yearly", or "summer" or 2009 or 2009-2011.
<i>gwFlowVelocity</i>	<i>Measurement</i>	Measure of water volume per unit of time
<i>gwFlowVolumeRate</i>	<i>Measurement</i>	Measure of water quantity per time period with uom.
<i>gwFlowPersistence</i>	<i>FlowPersistenceType</i>	E.g. ephemeral, intermittent, perennial, seasonal; <a href="http://inspire.ec.europa.eu/codeList/WaterPersistenceValue/">http://inspire.ec.europa.eu/codeList/WaterPersistenceValue/</a> (INSPIRE v3.0).

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_WaterBudget</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role: gwBudgetRecharge</i>
<i>Association</i>	<i>Entity: GW_WaterBudget</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role: gwBudgetDischarge</i>
<i>Generalization</i>	<i>Entity: GW_IntraFlow</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role:</i>
<i>Aggregation</i>	<i>Entity: GW_FlowSystem</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role: gwFlow</i>
<i>Generalization</i>	<i>Entity: GW_InterFlow</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role:</i>



### 7.6.15 GW\_FlowSystem

Flow path from recharge to discharge location, through hydrogeological units, and related to a groundwater body. It is a collection or aggregation of specific flows.

Attribute	Type and Multiplicity	Definition
<i>gwFlowPath</i>	<i>Geometry [1..*]</i>	The path of flow of a fluid through a container.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_FlowSystem</i> <i>Role: gwDivideFlow</i>	<i>Entity: GW_Divide</i> <i>Role:</i>
<i>Association</i>	<i>Entity: GW_FlowSystem</i> <i>Role: gwFlowSystemPart</i>	<i>Entity: GW_FlowSystem</i> <i>Role: gwPartOfSystemFlow</i>
<i>Aggregation</i>	<i>Entity: GW_FlowSystem</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role: gwFlow</i>

### 7.6.16 GW\_FluidBody

A distinct body of some fluid (liquid, gas) that fills the voids of a container such as an aquifer, system of aquifers, water well, etc; in hydrogeology this body is usually constituted from groundwater, but the model allows for other types of fillers e.g. petroleum.

Attribute	Type and Multiplicity	Definition
<i>gwBodyDescription</i>	<i>char [1..*]</i>	Text description of the flow body
<i>gwBodyFlow</i>	<i>GW_Flow [1..*]</i>	Flow details for the gw body.
<i>gwBodyMetadata</i>	<i>GW_Metadata [1..*]</i>	Metadata about the flow body
<i>gwBodyQuality</i>	<i>BodyQualityType [1..*]</i>	Categorical assessment of fluid quality: e.g. saline, brackish, fresh, turbide, sulfurous, mixed, ... 1000-3000mg/l tds, etc.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
		A normative quality description is an assesment based upon some guideline edited by a government or a quality standard
<i>gwBodyShape</i>	<i>Geometry</i>	Shape and position of the groundwater body.
<i>gwBodyVolume</i>	<i>Measurement</i>	Description of the volume/quantity of water present in a container at a certain time.
<i>gwBodyVulnerability</i>	<i>GW_Vulnerability</i> <i>[0..*]</i>	The susceptibility of the fluid body to specific threats such as surface contamination, etc.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>AssociationClass</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role: gwFluidBodyUnit</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwUnitFluidBody</i>
<i>Association</i>	<i>Entity: GW_HydrogeoVoid</i> <i>Role: gwFluidBodyVoid</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwVoidFluidBody</i>
<i>Association</i>	<i>Entity: GW_ManagementArea</i> <i>Role:</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwAreaBody</i>
<i>Association</i>	<i>Entity: GW_FluidBodyChange</i> <i>Role:</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwBodyPriorState</i>
<i>Association</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwBodyCurrentState</i>	<i>Entity: GW_FluidBodyChange</i> <i>Role: gwBodyChange</i>
<i>Association</i>	<i>Entity: GW_FluidBodySurface</i>	<i>Entity: GW_FluidBody</i>

<b>Relation</b>	<b>Source</b>	<b>Target</b>
	<i>Role: gwBodySurface</i>	<i>Role: gwSurfaceBody</i>
<i>Aggregation</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwPartOfBody</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwBodyPartOf</i>
<i>Association</i>	<i>Entity: GW_FluidBody</i> <i>Role:</i>	<i>Entity: GW_FluidBodyProperty</i> <i>Role: gwBodyProperty</i>
<i>Association</i>	<i>Entity: GW_FluidBody</i> <i>Role:</i>	<i>Entity: GW_Constituent</i> <i>Role: gwBackgroundConstituent</i>
<i>AssociationClass</i>	<i>Entity: GW_FluidBody</i> <i>Role:</i>	<i>Entity: GW_Constituent</i> <i>Role: gwBodyConstituent</i>

### 7.6.17 GW\_FluidBodyChange

Represents the transition of a fluid body from a previous state to a new state.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwChangeAgent</i>	<i>ChangeAgentType</i>	The agent facilitating / causing / initiating the change.
<i>gwChangeDegree</i>	<i>ChangeDegreeType</i>	Corresponds to INSPIRE <b>ConditionOfGroundwaterValue</b> pg. 273 v D2.8.II.4_v3.0 rc3  The approximate degree of change to groundwater as a result of human activity (INSPIRE v3.0): e.g. natural, modified, lightly modified, etc
<i>gwChangeTime</i>	<i>TemporalType</i>	The duration over which the change occurred.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Association</i>	<i>Entity: GW_FluidBodyChange</i> <i>Role:</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwBodyPriorState</i>
<i>Association</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwBodyCurrentState</i>	<i>Entity: GW_FluidBodyChange</i> <i>Role: gwBodyChange</i>

#### 7.6.18 GW\_FluidBodyProperty

Properties that characterize the groundwater body.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwBodyProperty</i>	<i>gwBodyPropertyType</i>	Type of property, e.g. age, temperature, density, viscosity, turbidity, color, hardness, acidity, etc.
<i>gwBodyPropertyValue</i>	<i>Measurement</i>	Value of the property (with uom).

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Association</i>	<i>Entity: GW_FluidBody</i> <i>Role:</i>	<i>Entity: GW_FluidBodyProperty</i> <i>Role: gwBodyProperty</i>

#### 7.6.19 GW\_FluidBodySurface

A surface on a body of groundwater, for a local or regional area, e.g. piezometric, potentiometric, water table, salt wedge, etc.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwSurfaceShape</i>	<i>Surface</i>	Geometry / position of the surface.
<i>gwSurfaceType</i>	<i>SurfaceType</i>	Type of gw body surface, e.g. piezometric,

Attribute	Type and Multiplicity	Definition
		potentiometric, water table, salt wedge, etc.
<i>gwSurfaceMetadata</i>	<i>ObservationMetadata</i>	Date, time, method, etc., of the observation of the surface.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_Divide</i> <i>Role: gwSurfaceDivide</i>	<i>Entity: GW_FluidBodySurface</i> <i>Role: gwDivideSurface</i>
<i>Association</i>	<i>Entity: GW_FluidBodySurface</i> <i>Role: gwBodySurface</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwSurfaceBody</i>

#### 7.6.20 GW\_HydrogeoUnit

Hydrogeologic unit (1) Any soil or rock unit or zone which by virtue of its hydraulic properties has a distinct influence on the storage or movement of groundwater (after ANS, 1980).

Attribute	Type and Multiplicity	Definition
<i>gwUnitMedia</i>	<i>PorosityType</i>	Type of material or, by proximity, type of voids (granular, fracture, karstic, or mixed).
<i>gwUnitRecharge</i>	<i>GW_Interflow [1..*]</i>	Volumetric flow rate of water that enters an hydrogeologic unit, at potentially multiple locations.
<i>gwUnitDischarge</i>	<i>GW_Interflow [1..*]</i>	Volumetric flow rate of water that goes out of an hydrogeologic unit, at potentially multiple locations.  Also: british punk rock group.
<i>gwUnitWaterBudget</i>	<i>GW_WaterBudget</i>	Sum of water input and output of a hydrogeologic unit, at a particular point in time, with a description of inflows and outflows.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwUnitVulnerability</i>	<i>GW_Vulnerability</i> <i>[0..*]</i>	The susceptibility of the aquifer to specific threats such as various physical events (earthquakes), human processes (depletion), etc.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>AssociationClass</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role: gwFluidBodyUnit</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwUnitFluidBody</i>
<i>Generalization</i>	<i>Entity: GW_Basin</i> <i>Role:</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role:</i>
<i>Generalization</i>	<i>Entity: GW_AquiferUnit</i> <i>Role:</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role:</i>
<i>Generalization</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role:</i>	<i>Entity: GL_GeologicUnit</i> <i>Role:</i>
<i>AssociationClass</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role: gwVoidUnit</i>	<i>Entity: GW_HydrogeoVoid</i> <i>Role: gwUnitVoid</i>
<i>Association</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role:</i>	<i>Entity: GW_UnitProperties</i> <i>Role: gwUnitProperty</i>
<i>Aggregation</i>	<i>Entity: GW_Basin</i> <i>Role:</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role: gwBasinUnit</i>

Relation	Source	Target
Association	Entity: <i>GW_ManagementArea</i> Role: <i>gwManagementArea</i>	Entity: <i>GW_HydrogeoUnit</i> Role: <i>gwManagedUnit</i>

### 7.6.21 GW\_HydrogeoVoid

Voids represent the spaces inside (hosted by) a unit or its material. E.g. the pores in an aquifer, or in the sandstone of an aquifer. Voids are hosted by a container (e.g. an aquifer), and can contain water bodies. Voids are differentiated from 'porosity' in that porosity is the proportion of void volume to total volume (i.e. container + voids), while voids are the spaces themselves. Their delineation as a distinct entity is necessary, for example, to capture the volume of fractures in an aquifer.

Attribute	Type and Multiplicity	Definition
<i>gwVoidDescription</i>	<i>char</i>	Text description of the void
<i>gwVoidHostMaterial</i>	<i>EarthMaterial [0..*]</i>	The material that hosts the void. Note voids are always hosted by a unit (an aquifer), which is specified by the <i>gwVoidUnit</i> property. Voids can also be hosted by a material of the unit (e.g. sandstone) via this <i>gwVoidHostMaterial</i> property.
<i>gwVoidMetadata</i>	<i>GW_Metadata</i>	Metadata for the void.
<i>gwVoidShape</i>	<i>Geometry</i>	Shape of the void.
<i>gwVoidType</i>	<i>PorosityType</i>	Type of void e.g. fractured, intergranular, etc.
<i>gwVoidVolume</i>	<i>Measurement</i>	Volume of the void.

Relation	Source	Target
Association	Entity: <i>GW_HydrogeoVoid</i> Role: <i>gwFluidBodyVoid</i>	Entity: <i>GW_FluidBody</i> Role: <i>gwVoidFluidBody</i>

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>AssociationClass</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role: gwVoidUnit</i>	<i>Entity: GW_HydrogeoVoid</i> <i>Role: gwUnitVoid</i>
<i>Aggregation</i>	<i>Entity: GW_HydrogeoVoid</i> <i>Role: gwPartOfVoid</i>	<i>Entity: GW_HydrogeoVoid</i> <i>Role: gwVoidPartOf</i>

### 7.6.22 GW\_InterFlow

Water flow between features, out from one feature and into another. Features into which water is flowing are usually units, voids, or gw bodies, but can be natural surface water features such as rivers, or man-made features such as dams or canals. Likewise for features out of which water is flowing.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwFlowLocation</i>	<i>Geometry [1..*]</i>	The location at which water is being transferred from one feature into another.
<i>gwFlowSourceContainer</i>	<i>Feature</i>	The feature from which water is flowing.
<i>gwFlowDestinationContainer</i>	<i>Feature</i>	The feature into which water is flowing.
<i>gwFlowSourceBody</i>	<i>Feature</i>	The fluid body from which water is flowing.
<i>gwFlowDestinationBody</i>	<i>Feature</i>	The fluid body into which water is flowing.
<i>gwFlowInterfaceFeature</i>	<i>Feature [0..*]</i>	The feature that facilitates the interface between the groundwater and surface or between two aquifers, e.g. well, spring, seep, etc.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Generalization</i>	<i>Entity: GW_Recharge</i>	<i>Entity: GW_InterFlow</i>



<b>Relation</b>	<b>Source</b>	<b>Target</b>
	<i>Role:</i>	<i>Role:</i>
<i>Generalization</i>	<i>Entity: GW_Discharge</i> <i>Role:</i>	<i>Entity: GW_InterFlow</i> <i>Role:</i>
<i>Generalization</i>	<i>Entity: GW_InterFlow</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role:</i>

### 7.6.23 GW\_IntraFlow

Water flow within a feature such as a unit, void, gw body, or even a man-made feature such as a conduit of some kind.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwFlowLocation</i>	<i>Geometry</i>	The location where gw is flowing within a feature.
<i>gwFlowContainer</i>	<i>Feature</i>	The entity in which the gw is flowing. Typically a unit, void, or gw body, but also be a man made feature such as some conduit.
<i>gwFlowBody</i>	<i>Feature</i>	The flow body which is flowing.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Generalization</i>	<i>Entity: GW_IntraFlow</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role:</i>

### 7.6.24 GW\_ManagementArea

Area of ground identified for groundwater management purposes and can be delineated by human factors such as policy or regulation concerns, as well as hydrogeological or hydrological concerns. Does not necessarily align exactly with hydrogeological or hydrological boundaries.

Attribute	Type and Multiplicity	Definition
<i>gwAreaDescription</i>	<i>char</i>	General description of the management area.
<i>gwAreaFeature</i>	<i>Feature [1..*]</i>	The features being managed, e.g. aquifers, watersheds, etc.
<i>gwAreaMetadata</i>	<i>GW_Metadata [0..*]</i>	Metadata for the management area.
<i>gwAreaName</i>	<i>char [1..*]</i>	Name of the management area.
<i>gwAreaShape</i>	<i>Geometry</i>	Geometric shape and position of management area.
<i>gwAreaType</i>	<i>ManagementAreaType</i>	Type of management area, e.g. restricted use zone, irrigation area, consumption area, etc. TBD
<i>gwAreaWaterBudget</i>	<i>GW_WaterBudget [1..*]</i>	Water budget associated with the management area.
<i>gwAreaYield</i>	<i>GW_Yield</i>	

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_ManagementArea</i> <i>Role:</i>	<i>Entity: GW_FluidBody</i> <i>Role: gwAreaBody</i>
<i>Association</i>	<i>Entity: GW_ManagementArea</i> <i>Role: gwManagementArea</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role: gwManagedUnit</i>

#### 7.6.25 GW\_MaterialConstituent

Non-chemical or non-biological material in a fluid body, e.g sediment.

Attribute	Type and Multiplicity	Definition
<i>gwMaterial</i>	<i>EarthMaterial</i>	Description of the material.

Relation	Source	Target
<i>Generalization</i>	Entity: <i>GW_MaterialConstituent</i> Role:	Entity: <i>GW_Constituent</i> Role:

#### 7.6.26 GW\_Mixture

The nature of the inclusion of the constituent in the fluid body, e.g. suspension, emulsion, etc.

Attribute	Type and Multiplicity	Definition
<i>gwMixture</i>	<i>MixtureType</i>	E.g. solution, suspension, emulsion, precipitate, colloidal.

#### 7.6.27 GW\_MonitoringSite

Observation site (e.g. well) used to watch for the advent of an anticipated condition, generally undesirable, such as the advance of the salt-water front in a coastal area where salt-water encroachment is occurring, or the movement of a pollutant injected into a disposal well. IGH0806

Attribute	Type and Multiplicity	Definition
<i>gwSiteName</i>	<i>char [0..*]</i>	Name (or identifier) of the monitoring site.
<i>gwSiteLocation</i>	<i>Geometry</i>	Spatial location of the site.
<i>gwSiteReferenceElevation</i>	<i>ElevationType [1..*]</i>	Reference elevation for all observations at the site, e.g. ground elevation, casing elevation. This can differ from the host feature elevation, or be more specific.
<i>gwSiteType</i>	<i>SiteType</i>	Type of monitoring site, e.g. well, gauging station, etc.
<i>gwMonitoringHost</i>	<i>Feature</i>	The feature hosting the site, e.g. a well, spring, lake or stream.

### 7.6.28 GW\_Porosity

"Porosity or void fraction is a measure of the void (i.e. "empty") spaces in a material, and is a fraction of the volume of voids over the total volume (i.e. material + voids)" (after Wikipedia)  
Types of porosity include: specific, effective, etc.

Voids are differentiated from 'porosity' in that porosity is the proportion of void volume to total volume (i.e. container + voids), while voids are the spaces themselves.

Attribute	Type and Multiplicity	Definition
<i>gwPorosityType</i>	<i>PorosityType</i>	Type of porosity (primary, secondary, dual, specific, effective, granular, fractured, karstic, etc.)
<i>gwPorosity</i>	<i>Measurement</i>	Measure of the proportion of volume occupied by a void over the the total volume of material + voids (e.g. the material of an aquifer + its pores).

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_UnitVoidProperty</i> <i>Role:</i>	<i>Entity: GW_Porosity</i> <i>Role: gwPorosity</i>

### 7.6.29 GW\_Recharge

Water added to a groundwater aquifer. For example, when rainwater seeps into the ground. Recharge may occur naturally through precipitation or surface water or artificially through injection wells or by spreading water over groundwater reservoirs. (<http://www.groundwater.org/get-informed/basics/glossary.html>)

Relation	Source	Target
<i>Generalization</i>	<i>Entity: GW_Recharge</i> <i>Role:</i>	<i>Entity: GW_InterFlow</i> <i>Role:</i>

### 7.6.30 GW\_Spring

Any natural situation where groundwater flows to the surface of the earth.

Area where there is a concentrated discharge of ground water that flows at the ground surface. (<http://pubs.usgs.gov/gip/gw/glossary.html>)

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwSpringName</i>	<i>char [0..*]</i>	Name or ID (if any).
<i>gwSpringLocation</i>	<i>Geometry</i>	Geometry / position of the feature.
<i>gwSpringReferenceElevation</i>	<i>ElevationType [1..*]</i>	Reference elevation for all observations at the site, e.g. ground elevation, casing elevation.
<i>gwSpringType</i>	<i>SpringType</i>	Type of spring e.g. mineral, thermal, saline, etc.
<i>gwSpringCauseType</i>	<i>SpringCauseType</i>	The cause of the spring e.g. artesian, geyser, perched, etc.
<i>gwSpringPersistence</i>	<i>SpringPersistenceType</i>	The periodicity of the spring e.g. ephemeral, perennial, intermittent, seasonal, etc.
<i>gwSpringGeology</i>	<i>GL_GeologicUnit [0..*]</i>	Related borehole, including lithology log.
<i>gwSpringUnit</i>	<i>GW_HydrogeoUnit [1..*]</i>	The geological unit(s) hosting the spring.
<i>gwSpringBody</i>	<i>GW_FluidBody [0..*]</i>	The fluid body being depleted by the spring.
<i>gwSpringConstruction</i>	<i>SpringConstruction [0..1]</i>	Spring construction details, if any.

### 7.6.31 GW\_UnitFluidProperty

A measured or calculated physical or hydraulic property that can be inherent in either an aquifer or its material, and some fluid body, e.g. hydraulic conductivity, transmissivity, storativity, permeability, porosity.

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwHydraulicConductivity</i>	<i>Measurement</i>	Hydraulic conductivity describes how easily a fluid can move through the voids in a material. It can be measured by applying Darcy's law on the material. Such experiments can be conducted by creating a hydraulic gradient between two points, and measuring the flow rate (Oosterbaan and

Attribute	Type and Multiplicity	Definition
		Nijland[1]). (Wikipedia)
<i>gwTransmissivity</i>	<i>Measurement</i>	The rate which groundwater flows horizontally through an aquifer, based on hydraulic conductivity and container thickness. (Wikipedia)
<i>gwStorativity</i>	<i>Measurement</i>	Storativity is the volume of water released from storage per unit decline in hydraulic head in the aquifer, per unit area of the aquifer. (gwml1)

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_UnitFluidProperty</i> <i>Role:</i>	<i>Entity: GW_Yield</i> <i>Role: gwYield</i>

### 7.6.32 GW\_UnitProperties

Additional properties of an aquifer not included in the model.

Attribute	Type and Multiplicity	Definition
<i>gwUnitProperty</i>	<i>gwUnitPropertyType</i>	The type of property, e.g. average well depth.
<i>gwUnitPropertyValue</i>	<i>Any</i>	The value of the property.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_HydrogeoUnit</i> <i>Role:</i>	<i>Entity: GW_UnitProperties</i> <i>Role: gwUnitProperty</i>

### 7.6.33 GW\_UnitVoidProperty

Properties inherent in the relation between a hydrogeologic unit and a void, related to the proportion of voids to the unit (porosity) or to the connectivity / size of openings of the voids within the unit (intrinsic permeability).

Attribute	Type and Multiplicity	Definition
<i>gwPermeability</i>	<i>Measurement</i>	Refers to intrinsic permeability: a measure of a material's ability to allow fluid flow that is independent of fluid properties, and based on connectivity of pores and size of their openings.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_UnitVoidProperty</i> <i>Role:</i>	<i>Entity: GW_Porosity</i> <i>Role: gwPorosity</i>

### 7.6.34 GW\_Vulnerability

The susceptibility of a feature to specific threats such as various physical events (earthquakes), human processes (depletion), etc.

Attribute	Type and Multiplicity	Definition
<i>gwVulnerabilityType</i>	<i>VulnerabilityType</i>	The type of vulnerability.
<i>gwVulnerability</i>	<i>Measurement</i>	A quantitative estimate of the susceptibility to contamination, e.g. a DRASTIC value. Requires metadata about method of calculation.

### 7.6.35 GW\_WaterBudget

Sum of water input and output of a hydrogeologic unit, at a particular point in time, with a description of inflows and outflows.

An accounting of the inflow, outflow, and storage changes of water in a hydrologic unit. (<http://www.usgs.gov/science/science.php?term=1297&type=theme>)

Attribute	Type and Multiplicity	Definition
<i>gwBudgetAmount</i>	<i>Measurement</i>	Final quantity (sum) of the budget. If recharge = discharge, the sum is 0.
<i>gwBudgetValidTime</i>	<i>TemporalType</i>	Valid time of this budget (eg, 2010).
<i>gwBudgetRecharge</i>	<i>GW_Interflow [1..*]</i>	Recharge (inflows) considered by the budget.
<i>gwBudgetDischarge</i>	<i>GW_Interflow [1..*]</i>	Discharge (outflows) considered in the budget.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_WaterBudget</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role: gwBudgetRecharge</i>
<i>Association</i>	<i>Entity: GW_WaterBudget</i> <i>Role:</i>	<i>Entity: GW_Flow</i> <i>Role: gwBudgetDischarge</i>

### 7.6.36 GW\_Well

A shaft or hole sunk, dug or drilled into the Earth to extract water. IGH1379

A hole or shaft constructed in the earth intended to be used to locate, sample, or develop groundwater. The diameter of a well is typically much smaller than the depth. Wells can be used to recharge groundwater artificially. (Modified from USGS GWSI).

Attribute	Type and Multiplicity	Definition
<i>gwWellName</i>	<i>char [0..*]</i>	Name or ID (if any).
<i>gwWellLocation</i>	<i>Geometry</i>	Geometry / position of the feature.
<i>gwWellReferenceElevation</i>	<i>ElevationType [1..*]</i>	Reference elevation for all observations at the site, e.g. ground elevation, casing elevation.



<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>gwWellContributionZone</i>	<i>Geometry</i>	The area surrounding a pumping well or other discharge site that encompasses all areas and features that supply groundwater to the well or discharge site.
<i>gwWellGeology</i>	<i>GeologyLog [0..*]</i>	Related borehole, including lithology log.
<i>gwWellUnit</i>	<i>GW_HydrogeoUnit [1..*]</i>	The aquifers or confining beds intersecting the well.
<i>gwWellBody</i>	<i>GW_FluidBody [0..*]</i>	The fluid body occupying the well.
<i>gwWellPurpose</i>	<i>WellPurposeType [1..*]</i>	Purpose of well, e.g. extraction, injection, observation, dewatering, cathodic protection, decontamination, disposal, FlowingShot, Geotechnical, Mineral, MonitoringlevelHead, MonitoringQuality, Oil, OilExploratory, Seismic, WaterExploratory, etc.
<i>gwWellStatus</i>	<i>WellStatusType</i>	Status of the well, Can be new, unfinished, reconditioned, deepened, not in use, standby, unknown, abandoned dry, abandoned insufficient, abandoned quality. (gwml1)
<i>gwWellWaterUse</i>	<i>WellWaterUseType [1..*]</i>	E.g. Agricultural, Domestic, Industrial, Recreation.
<i>gwWellTotalLength</i>	<i>Measurement</i>	Total length of the well from reference elevation.
<i>gwWellConstructedDepth</i>	<i>Measurement [0..1]</i>	Constructed depth of the well.
<i>gwWellStaticWaterDepth</i>	<i>Measurement</i>	Depth of the groundwater (piezometric level).
<i>gwWellYield</i>	<i>GW_Yield</i>	Estimated or calculated yield from a well.
<i>gwWellConstruction</i>	<i>WellConstruction</i>	Construction details for a well.

### 7.6.37 GW\_Yield

Hydrogeological unit yield (aquifer yield) is the rate of withdrawal that can be sustained by a unit. Expressed as m3. There are several types of yield, that can be considered: specific yield, sustainable yield, safe yield, aquifer yield, etc.

Attribute	Type and Multiplicity	Definition
<i>gwYieldType</i>	<i>YieldType</i>	Type of yields (of the aquifer or management area): e.g. specific yield, safe yield, etc. but excludes well yield. TBD
<i>gwYield</i>	<i>Measurement</i>	Measurement of the yield in units of volume per unit of time.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_UnitFluidProperty</i> <i>Role:</i>	<i>Entity: GW_Yield</i> <i>Role: gwYield</i>

## 8 Logical Model

The logical model differs from the conceptual model via the introduction of technology-specific artifacts from the OGC General Reference Model, such as classes, relations, properties, and organizing principles. Another difference is the addition of a well construction package. However, the logical model is not a syntactical encoding, but is rather an OGC-compliant schema design that is syntax-neutral. Syntactical encoding is the next step, described in subsequent sections.

Practically speaking, the addition of OGC constructs to the conceptual model amounts to the integration of two OGC-compliant GML schemas, GeoSciML 3.2 and Observations & Measurements, using the following strategies:

- (1) HydrogeologicalUnit in GWML2 specializes GeologicUnit from GeoSciML, recognizing that in its most basic sense, a hydrogeological unit is a body of rock (a geologic unit) exhibiting some hydrogeological properties.
- (2) Water wells and boreholes (from well construction) specialize O&M:SF\_SamplingCurve, which allows them to have a shape described by 3D points at the start and end of each segment along the well or borehole. Wells and boreholes differ by purpose and use: boreholes are physical engineering artifacts consisting of a hole and potentially materials fitted inside the hole for some human use. Wells are in effect boreholes constructed for the extraction or injection of water from the ground, and have specific hydrogeological properties such as water yield and intended use. A well can thus be seen as a specific role played by a borehole. Note that as a consequence, well and its associated borehole lengths can differ for the same well.
- (3) Property values are assigned datatypes from O&M: numeric properties are assigned the OM\_Measurement datatype, and properties that can be either numeric or categorical are assigned the Observation datatype. Two reasons compel these choices: method metadata can be added to each value to describe determination of the value, and each property can be further soft-typed for greater precision. An example of the latter is the porosity property, which in practical situations could refer to any one of a wide range of porosity types such as effective porosity, primary porosity, or secondary porosity.
- (4) Fluid body constituent values are modeled as observations: for example, a chemical analysis of a groundwater sample might be represented in the following way:
  - Each measured value is the result of an observation.
  - The ObservedProperty would be e.g. “As\_Concentration”
  - The FeatureofInterest would be an instance of e.g. GW\_ChemicalConstituent with ChemicalTypeTerm = “As” and gwState = “solid”.

This approach is quite flexible: it allows for different mixture types (e.g. suspension, solution, emulsion), states (i.e. liquid, solid, gas), and measurement types (e.g. concentration) for a constituent type (e.g. “As”).

The logical model is organized into five application schema packages, as mentioned in Section 1:

- (1) GWML2-Nucleus: core items, e.g. aquifers, their pores, fluid bodies, management areas.
- (2) GWML2-Constituent: the biologic, chemical, and material elements of a fluid body.

- (3) GWML2-Flow: groundwater flow within and between containers, and water budgets.
- (4) GWML2-Well: water wells, springs, and monitoring sites.
- (5) GWML2-WellConstruction: the components used to construct a well.

Because most of the differences between the logical and conceptual models can be understood from the logical model UML diagrams, all diagrams are included below. Differences that cannot be read directly or easily from the UML diagrams are explicitly expressed in complete class descriptions following the diagrams.

### 8.1 Dependencies

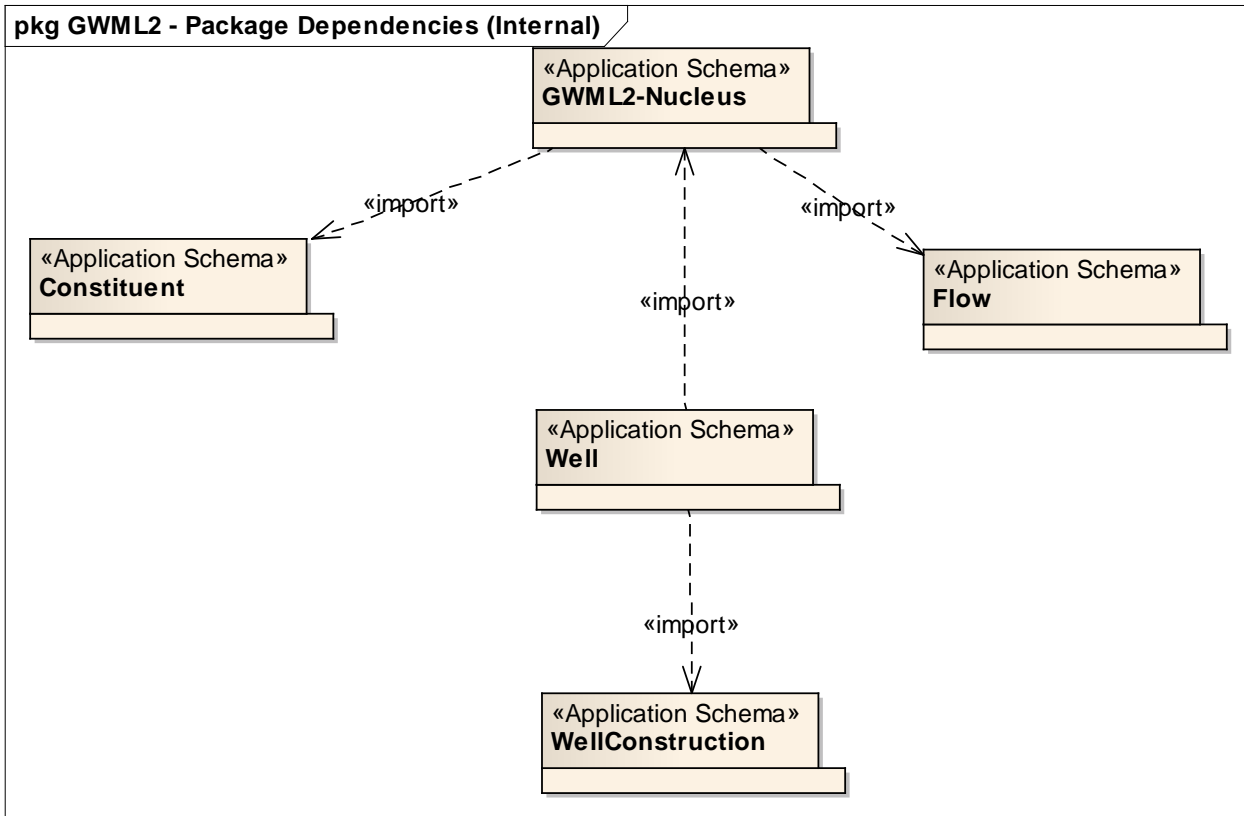
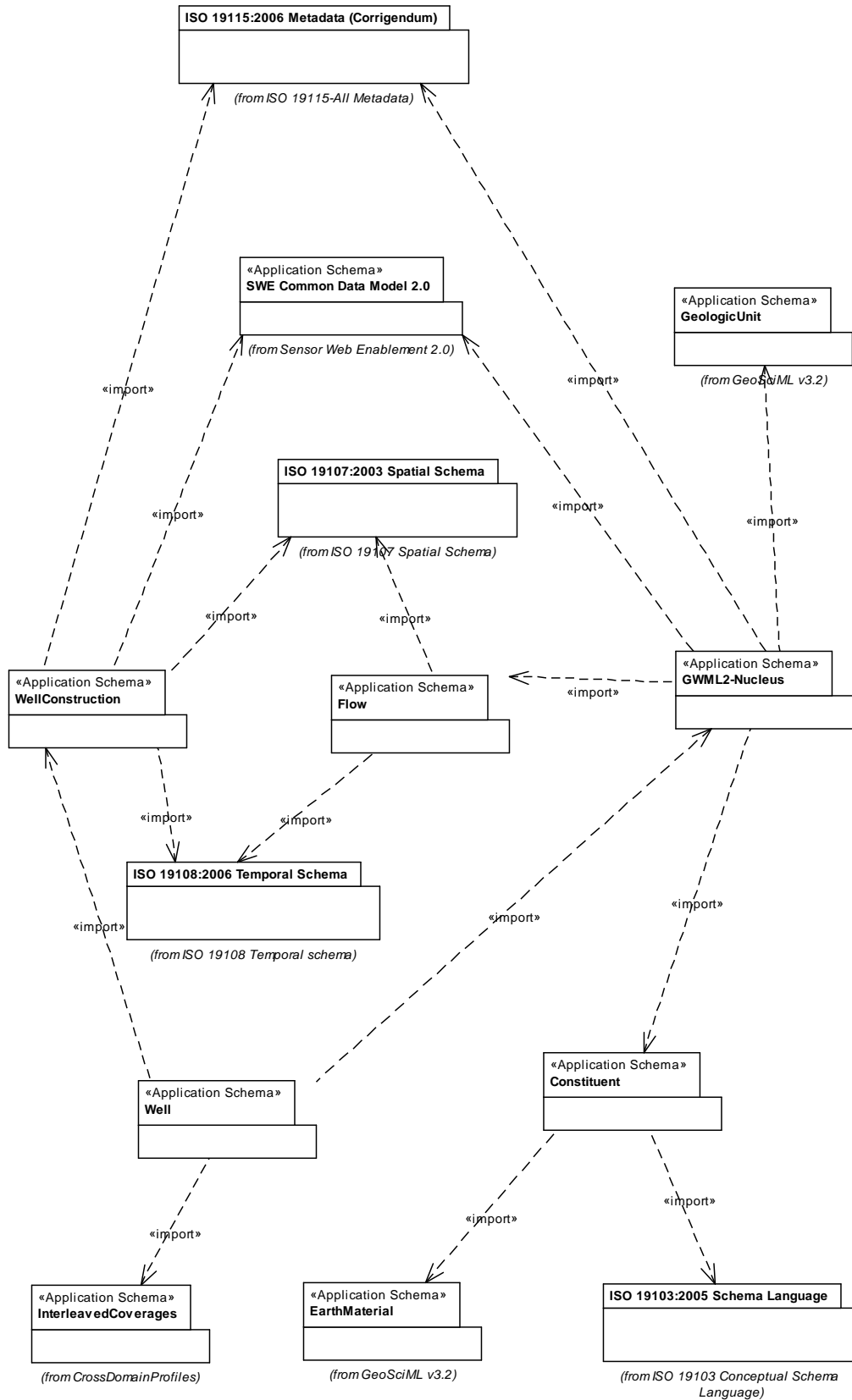


Figure 7: GWML2 LM - Package Dependencies (Internal)



**Figure 8: GWML2 external dependencies (indirect dependencies not shown)**

## 8.2 Logical Model Diagrams

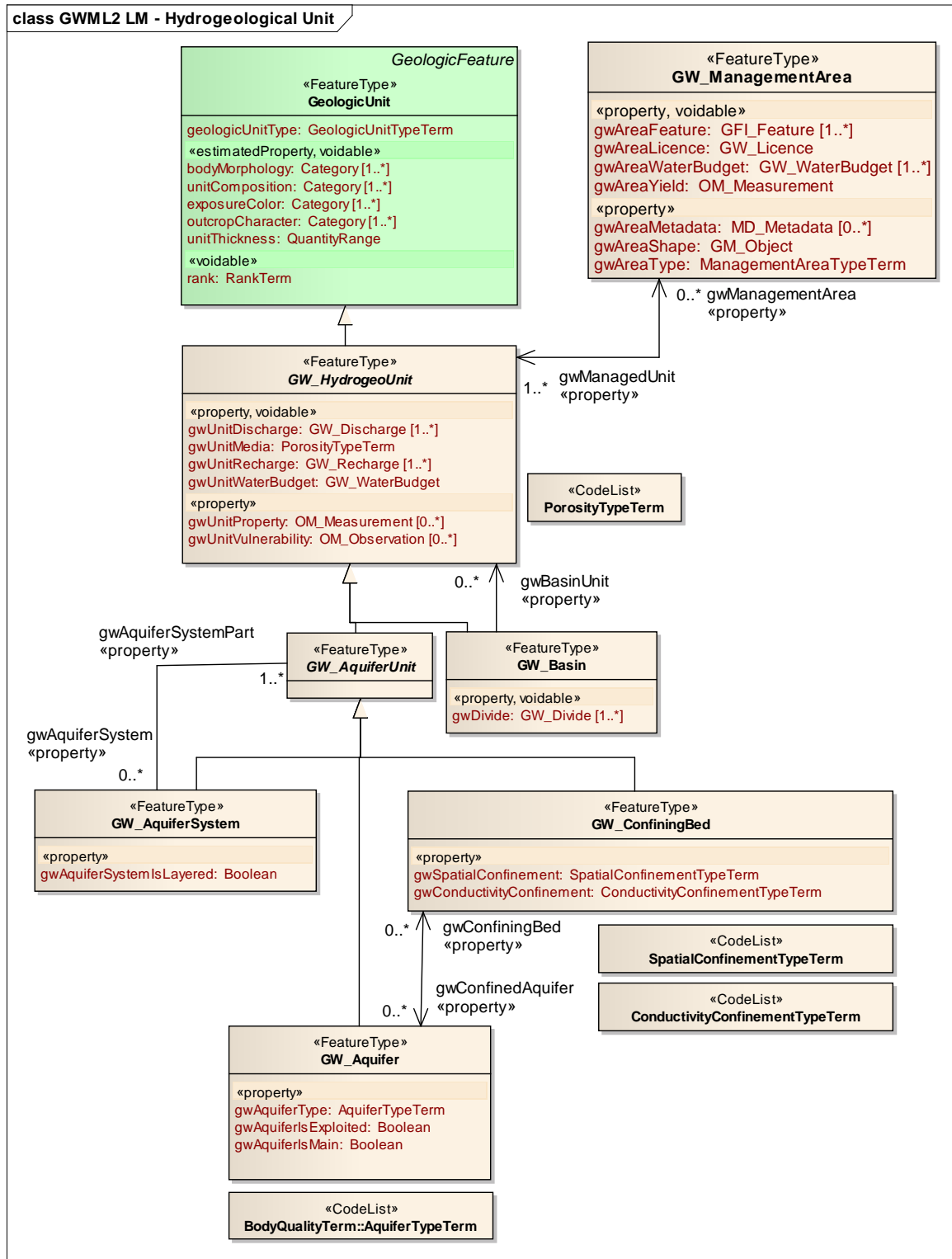


Figure 9: GWML2 LM - Hydrogeological Unit

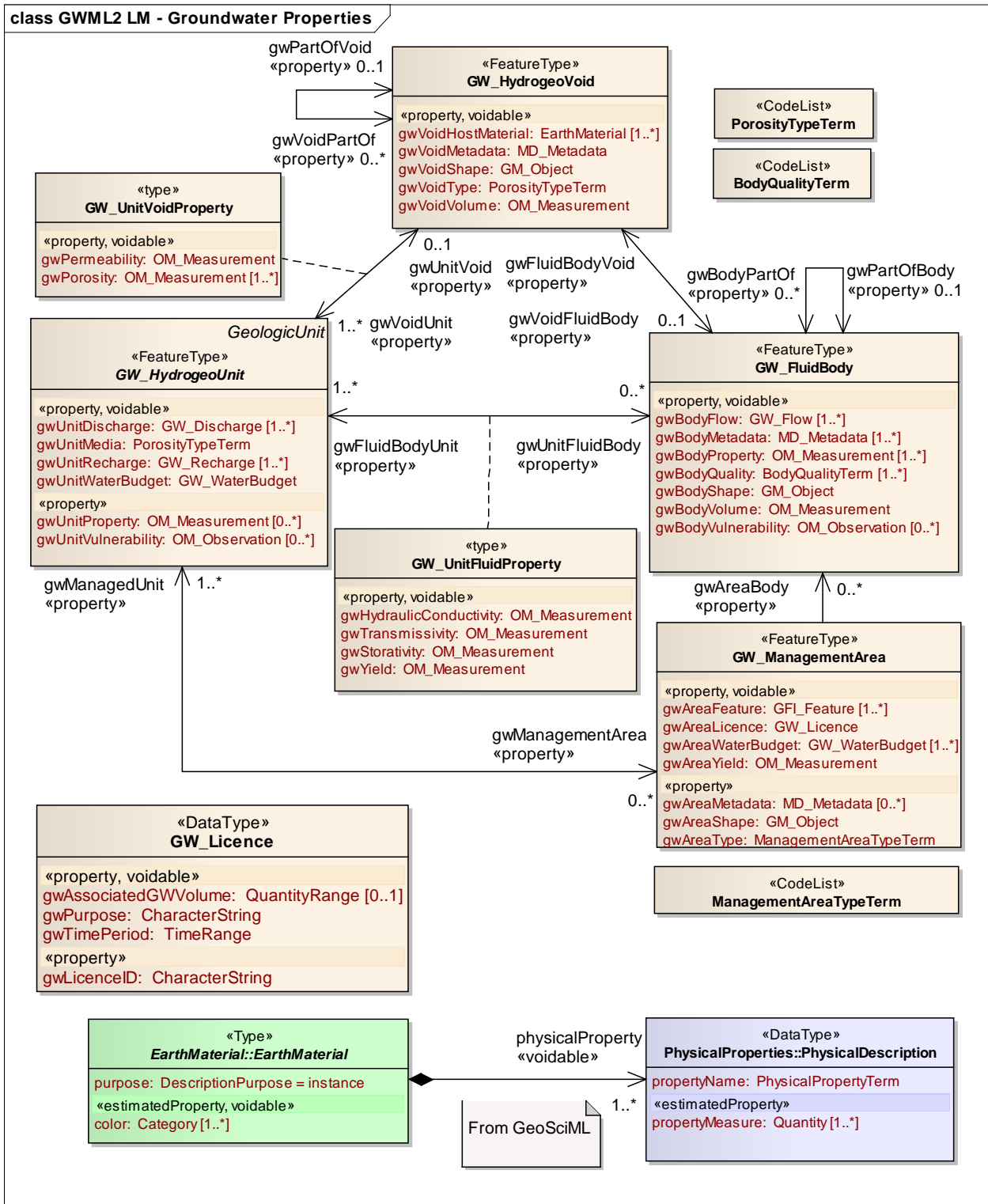


Figure 10: GWML2 LM - Groundwater Properties

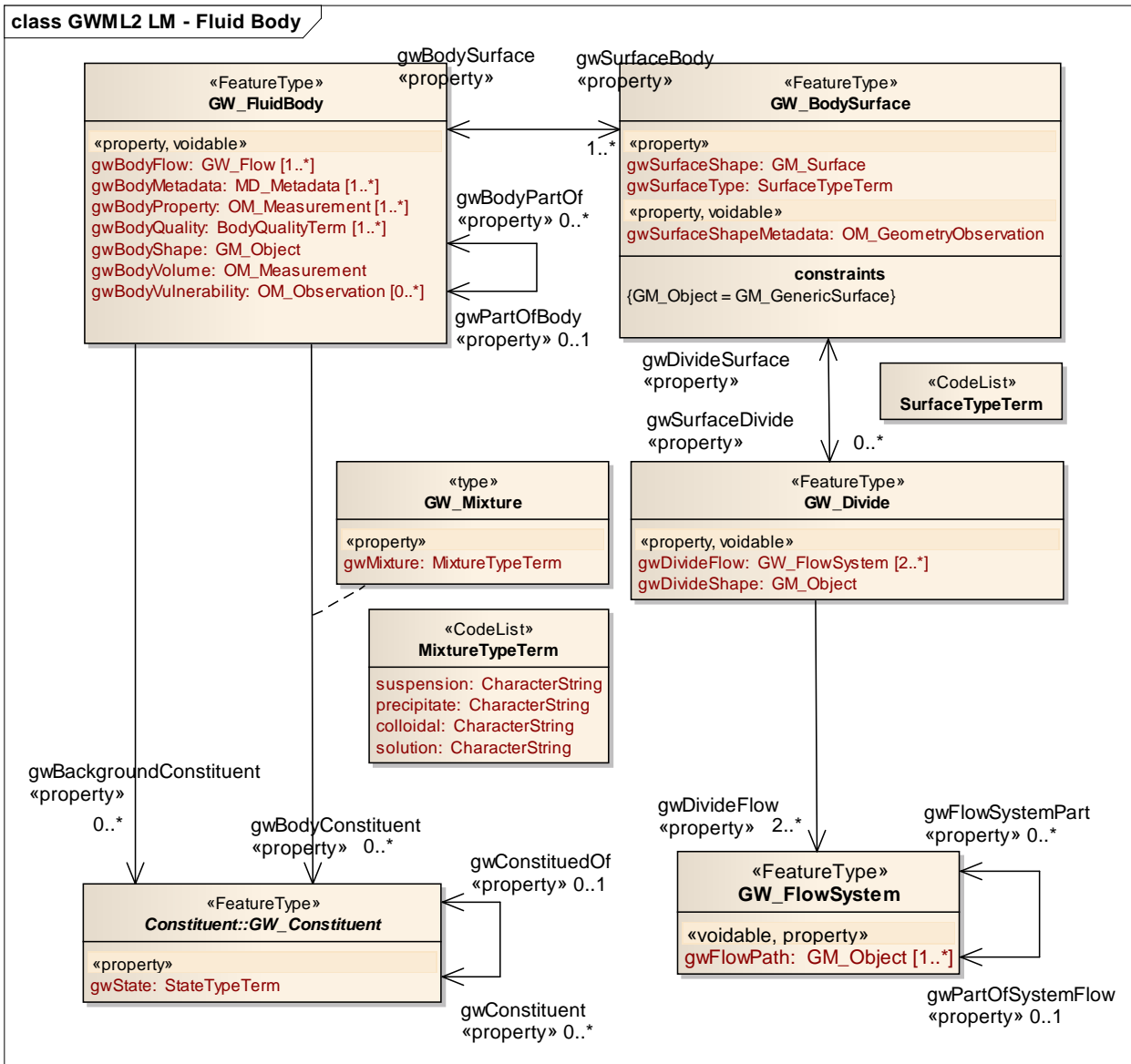


Figure 11: GWML2 LM - Fluid Body



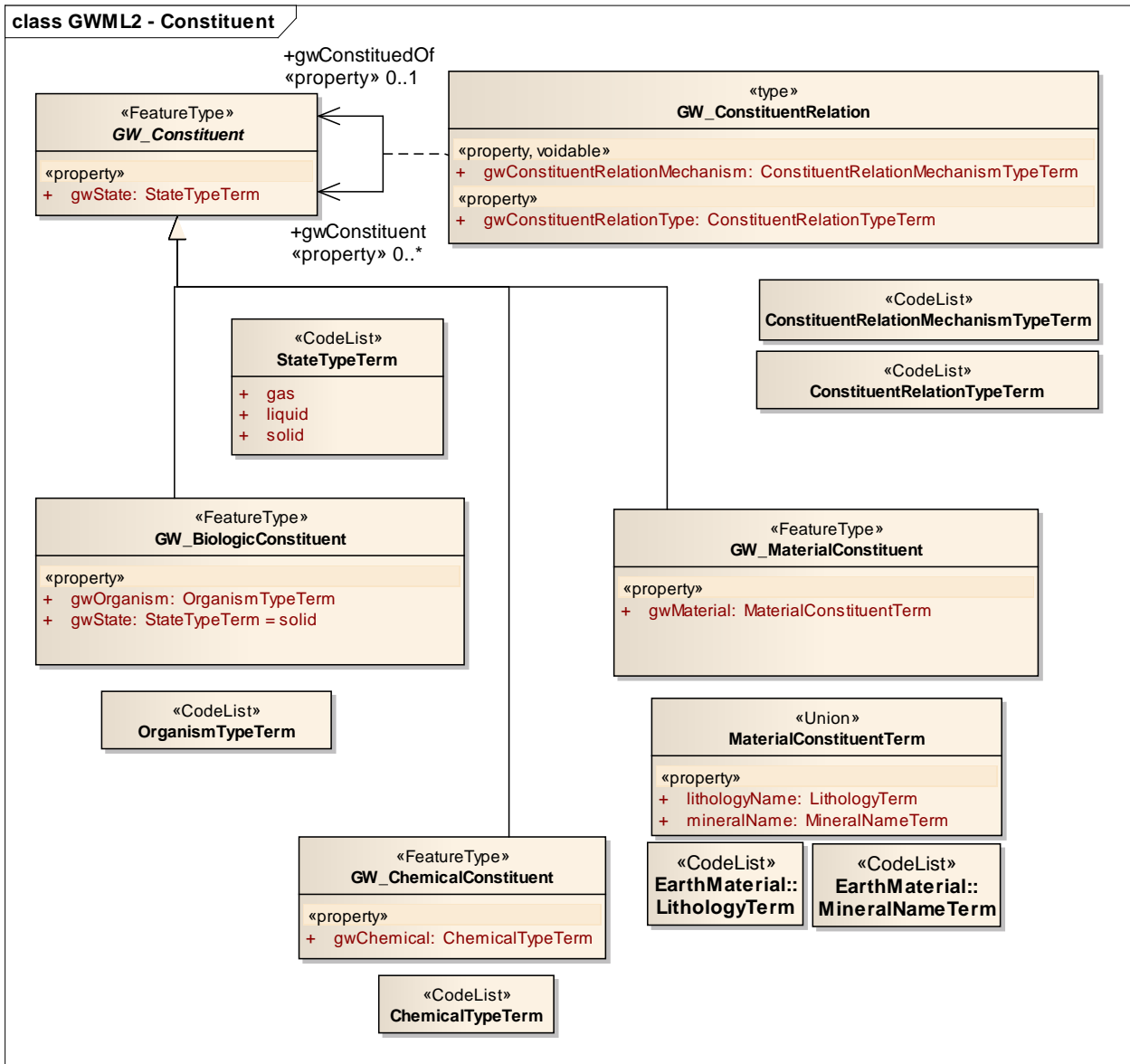
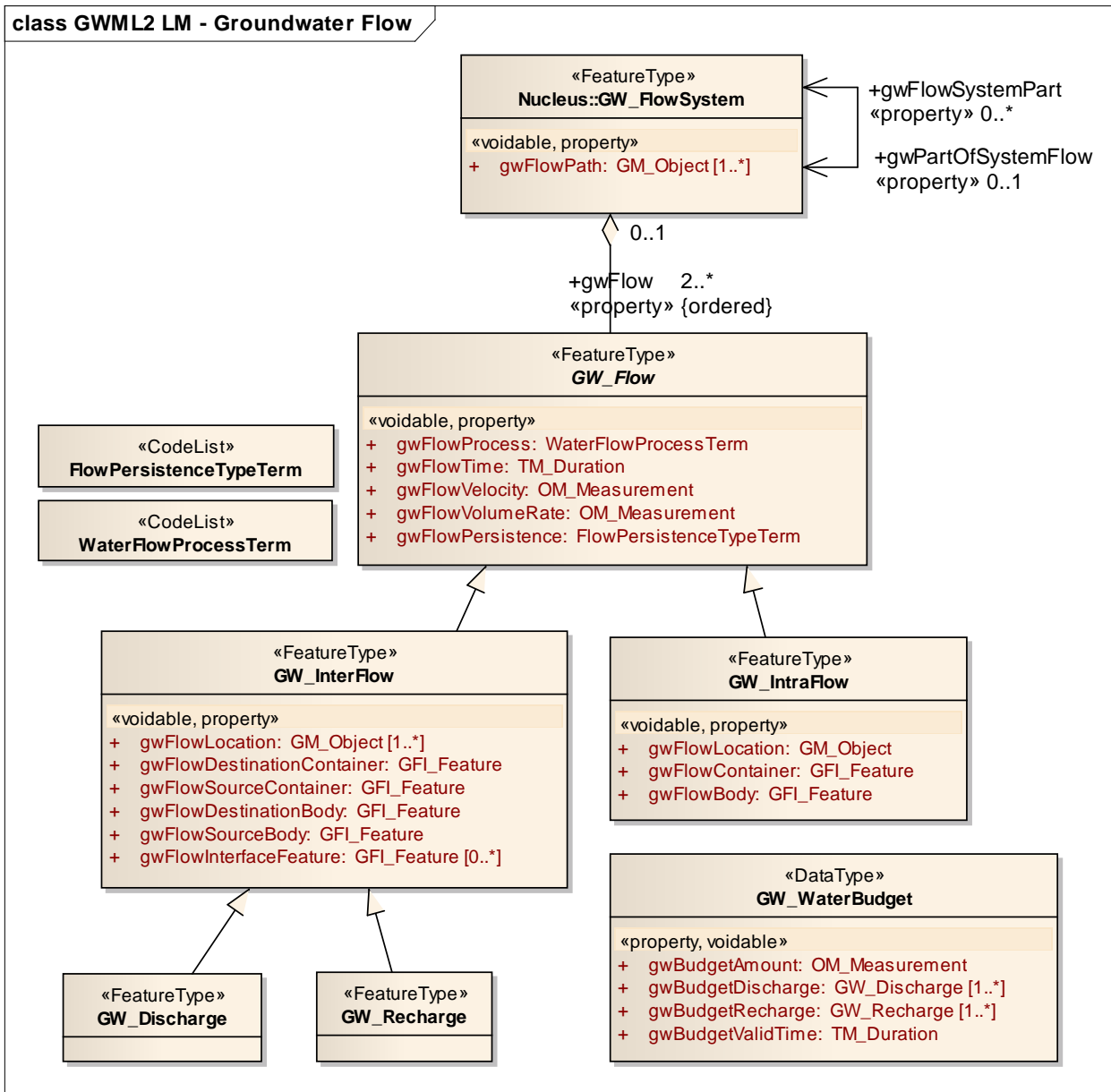


Figure 12: GWML2 LM - GroundWaterML2-Constituent



**Figure 13: GWML2 LM - Groundwater Flow**

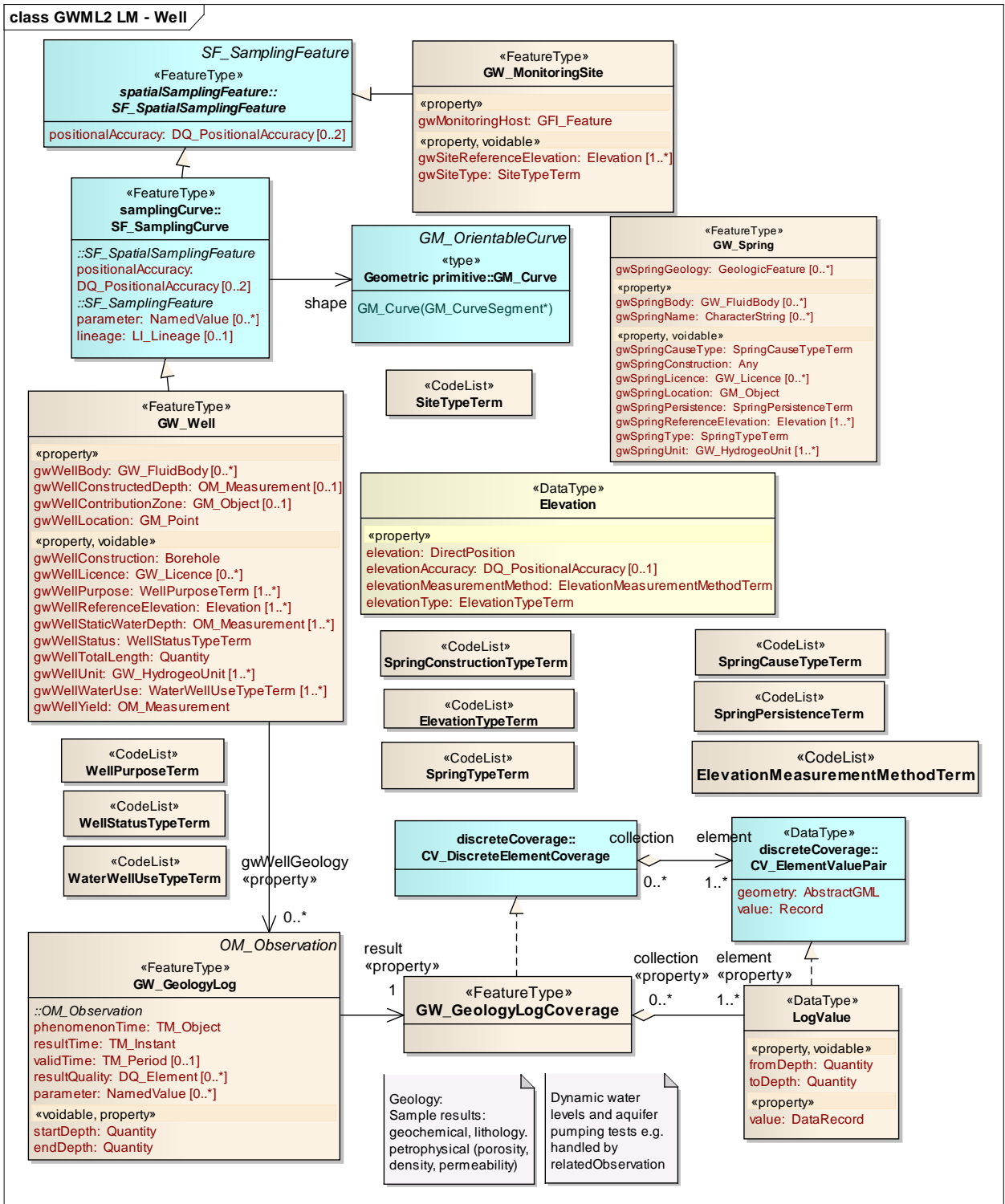


Figure 14: GWML2 LM - Well

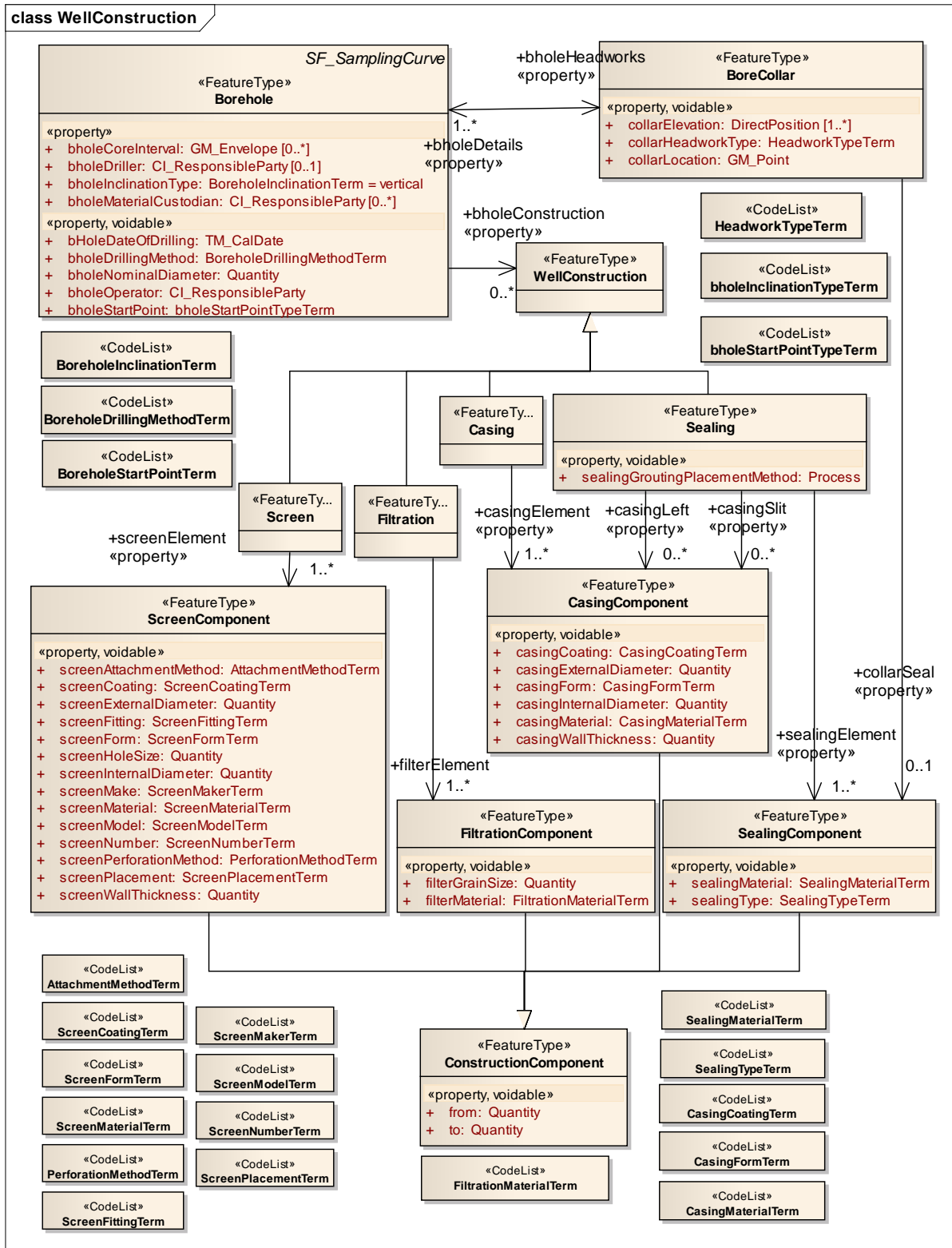


Figure 15: WellConstruction

## 8.3 Logical Model Classes and Relationships

### 8.3.1 Elevation

A class to capture the elevation information about a well to enable applications that can not handle 3D data.

Attribute	Type and Multiplicity	Definition
<i>elevation</i>	<i>DirectPosition</i>	<i>Numeric value and CRS and UoM for the elevation</i>
<i>elevationAccuracy</i>	<i>DQ_PositionalAccuracy [0..1]</i>	<i>Description of the accuracy of the elevation measurement</i>
<i>elevationMeasurementMethod</i>	<i>ElevationMeasurementMethodTerm</i>	<i>Method used to measure the elevation (GPS, Survey, DEM, etc..)</i>
<i>elevationType</i>	<i>ElevationTypeTerm</i>	<i>Type of reference elevation, defined as the element of the well that is considered the reference elevation (eg. Top of Casing, Ground Surface, etc.)</i>

### 8.3.2 GW\_GeologyLog

Specialization of the OM\_Observation class to allow defining the log start end depth for coverages.

For Stratigraphic logs the observedProperty will be a GeoSciML:GeologicUnit/classifier.

For Lithologic logs the observedProperty will be a GeoSciML:GeologicUnit/composition/CompositionPart/material.

Attribute	Type and Multiplicity	Definition
<i>startDepth</i>	<i>Quantity</i>	Begin log depth.
<i>endDepth</i>	<i>Quantity</i>	End log depth.

Relation	Source	Target
<i>Association</i>	<i>Entity: GW_Well</i>	<i>Entity: GW_GeologyLog</i>

<b>Relation</b>	<b>Source</b>	<b>Target</b>
	<i>Role:</i>	<i>Role: gwWellGeology</i>
<i>Generalization</i>	<i>Entity: GW_GeologyLog</i> <i>Role:</i>	<i>Entity: OM_Observation</i> <i>Role:</i>
<i>Association</i>	<i>Entity: GW_GeologyLog</i> <i>Role:</i>	<i>Entity: GW_GeologyLogCoverage</i> <i>Role: result</i>

### 8.3.3 GW\_GeologyLogCoverage

Overrides Discrete coverage to allow LogValues as elements.

<b>Relation</b>	<b>Source</b>	<b>Target</b>
<i>Aggregation</i>	<i>Entity: LogValue</i> <i>Role: element</i>	<i>Entity: GW_GeologyLogCoverage</i> <i>Role: collection</i>
<i>Realization</i>	<i>Entity: GW_GeologyLogCoverage</i> <i>Role:</i>	<i>Entity: CV_DiscreteElementCoverage</i> <i>Role:</i>
<i>Association</i>	<i>Entity: GW_GeologyLog</i> <i>Role:</i>	<i>Entity: GW_GeologyLogCoverage</i> <i>Role: result</i>

### 8.3.4 LogValue

<b>Attribute</b>	<b>Type and Multiplicity</b>	<b>Definition</b>
<i>fromDepth</i>	<i>Quantity</i>	Start interval depth.
<i>toDepth</i>	<i>Quantity</i>	End interval depth.

Attribute	Type and Multiplicity	Definition
<i>value</i>	<i>DataRecord</i>	Measured value for the interval, e.g. lithology, geophysical value, etc.

Relation	Source	Target
<i>Aggregation</i>	<i>Entity: LogValue</i> <i>Role: element</i>	<i>Entity: GW_GeologyLogCoverage</i> <i>Role: collection</i>
<i>Realization</i>	<i>Entity: LogValue</i> <i>Role:</i>	<i>Entity: CV_ElementValuePair</i> <i>Role:</i>

### 8.3.5 GW\_Licence

A licence giving permission to drill, extract or use groundwater.

Attribute	Type and Multiplicity	Definition
<i>gwAssociatedGWVolume</i>	<i>QuantityRange [0..1]</i>	<i>Groundwater volume associated with the licence.</i>
<i>gwLicenceID</i>	<i>CharacterString</i>	<i>Identifier of the licence</i>
<i>gwPurpose</i>	<i>CharacterString</i>	<i>Role of the licence</i>
<i>gwTimePeriod</i>	<i>TimeRange</i>	<i>The period of time for which the licence is valid</i>

## 9 Requirement classes (normative)

This section describes requirement classes for any target implementation conforming to GWML2. Target implementations must meet related conformance class tests for at least one **concrete** requirements class (in Sections 9.2 and greater). The core requirement class (Section 9.1) is **abstract**, therefore solely meeting the core requirements is insufficient to claim compliance with GWML2. Note, this section documents those requirements that cannot be read directly from the UML logical model, which denotes the first suite of canonical requirements.

### 9.1 Abstract requirements classes: GWML2 core logical model

This core requirement class describes requirements that must be met by all target implementations that claim compliance with GWML2 (this specification). It also sets common requirements for all extensions of this specification. Since this requirement class is abstract, a conformant target implementation **SHALL** also implement at least one concrete requirements class from Sections 9.2 and greater.

<b>Requirements class</b>	/req/gwml2-core
<b>Target type</b>	Encoding of logical models
<b>Name</b>	GWML2 core logical model
<b>Dependency</b>	urn:iso:dis:iso:19156:clause:6.2.2
<b>Dependency</b>	urn:iso:dis:iso:19156:clause:7
<b>Dependency</b>	http://www.opengis.net/doc/IS/GML/3.2/clause/2.4
<b>Dependency</b>	O&M Abstract model, OGC 10-004r3, clause D.3.4
<b>Dependency</b>	<a href="http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components">http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components</a>
<b>Requirement</b>	/req/gwml2-core/encoding
<b>Requirement</b>	/req/gwml2-core/quantities_uom
<b>Recommendation</b>	/req/gwml2-core/codelist
<b>Recommendation</b>	/req/gwml2-core/observed-property_foi

The properties, constraints, cardinalities and associations documented in the UML will be honoured by all the target implementations.

<b>/req/gwml2-core/encoding</b>	All target implementations SHALL conform to the appropriate GroundWaterML2 Logical Model UML as defined at <a href="http://www.opengis.net/def/groundwaterml/2.0/ftc">http://www.opengis.net/def/groundwaterml/2.0/ftc</a> and represented in Section 8.
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#### 9.1.1 Observations (OM\_Measurements)

When an OM\_Observation is used as a datatype for the value of a property of a GM\_Feature, it creates an implicit bidirectional link between the Observation (that can be by reference) and the



feature that exhibits that property. The inverse property is implicitly the om:featureOfInterest. There exist no rules in O&M to force a featureOfInterest to be the “owner” of that property, but having the ability to link back to the feature is useful, especially as OM\_Observation can be serialized offline. Because not all classifiers having an OM\_Observation property are GM\_Feature (e.g. GW\_WaterBudget is a DataType with a gwBudgetAmount property of type OM\_Observation), nothing prevents an OM\_Observation from being shared by several Features: we suggest that a featureOfInterest links back to its owner feature or a related feature when possible.

<b>/req/gwml2-core/observed-property_foi</b>	When a OM_Observation is the value of a non SamplingFeature, the featureOfInterest should be the feature that exhibits that property.
--	---

### 9.1.2 Quantities

Quantities and measurements shall have proper units of measurement.

<b>/req/gwml2-core/quantities_uom</b>	Quantities and measurements SHALL have explicit units of measurement, governed as external ontologies.
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### 9.1.3 Code lists

All properties that require formal vocabularies are modelled in UML as classes having the stereotype <<CodeList>>. The list of valid terms should be managed externally.

<b>/req/gwml2-core/codelist</b>	Classes of stereotype <<CodeList>> SHOULD be managed as external vocabularies
---------------------------------	---

### 9.1.4 Identifier

All features that can be accessed through a resolvable HTTP URI must use this HTTP URI as its global unique identifier.

<b>/req/gwml2-core/identifier</b>	A feature that has a resolvable HTTP URI SHALL use this URI as its globally unique identifier
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## 9.2 Requirement class: GWML2-Nucleus

<b>Requirements class</b>	<b>req/gwml2-nucleus-uml</b>
<b>Target type</b>	Encoding of logical model
<b>Name</b>	Nucleus logical model
<b>Dependency</b>	ISO-19115
<b>Dependency</b>	gsml:GeologicUnit 3.2
<b>Dependency</b>	/req/gwml2-flow-uml

<b>Dependency</b>	/req/gwml2-constituent-uml
<b>Requirement</b>	/req/gwml2-nucleus/aquifer_type
<b>Requirement</b>	/req/gwml2-nucleus/aquifersystem_type
<b>Requirement</b>	/req/gwml2-nucleus/basin_type
<b>Requirement</b>	/req/gwml2-nucleus/confiningbed_type

### 9.2.1 Hydrogeologic units

A hydrogeologic unit is a subtype of a geologic unit. Then the GW\_HydrogeoUnit:geologicUnitType property inherited from GeoSciML GeologicUnit shall match the type of the hydrogeological unit (e.g. Aquifer, AquiferSystem, Basin).

Table 1 : Hydrogeologic unit types

<b>Unit class</b>	<b>Identifier</b>
GW_Aquifer	<a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifer_unit">http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifer_unit</a>
GW_AquiferSystem	<a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifersystem_unit">http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifersystem_unit</a>
GW_Basin	<a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/basin_unit">http://www.opengis.net/def/gwml/2.0/geologicunittype/basin_unit</a>
GW_ConfiningBed	<a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/confining_bed">http://www.opengis.net/def/gwml/2.0/geologicunittype/confining_bed</a>

<b>/req/gwml2-nucleus/aquifer_type</b>	geologicUnitType of instance of class GW_Aquifer SHALL be <a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifer_unit">http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifer_unit</a>
--	---

<b>/req/gwml2-nucleus/aquifersystem_type</b>	geologicUnitType of instance of class GW_AquiferSystem SHALL be <a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/aquiferSystem_unit">http://www.opengis.net/def/gwml/2.0/geologicunittype/aquiferSystem_unit</a>
--	---

<b>/req/gwml2-nucleus/basin_type</b>	geologicUnitType of instance of class GW_Basin SHALL be <a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/basin_unit">http://www.opengis.net/def/gwml/2.0/geologicunittype/basin_unit</a>
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### 9.3 Requirement class : GWML2-Constituent

<b>Requirements class</b>	<b>/req/gwml2_constituent</b>
<b>Target type</b>	Encoding of logical model
<b>Name</b>	Constituent logical model
<b>Dependency</b>	<b>/req/gwml2-core</b>

### 9.4 Requirement class : GWML2-Flow

<b>Requirements class</b>	<b>/req/gwml2_flow</b>
<b>Target type</b>	XML data document
<b>Name</b>	Flow logical model
<b>Dependency</b>	<b>/req/gwml2-core</b>
<b>Dependency</b>	<a href="http://www.opengis.net/doc/IS/GML/3.2/clause/2.4">http://www.opengis.net/doc/IS/GML/3.2/clause/2.4</a>
<b>Dependency</b>	<b>O&amp;M</b>

### 9.5 Requirement class : GWML2-Well

This sections describes groundwater abstraction and monitoring through artificial (water wells, monitoring stations) and natural (springs) features. Artificial features are considered O&M sampling features (by ISO-19156 definition) as they are used as support for observations.

#### 9.5.1 Water wells

<b>Requirements class</b>	<b>/req/gwml2_well</b>
<b>Target type</b>	XML data document
<b>Name</b>	Water well logical model
<b>Dependency</b>	<b>/req/gwml2-nucleus</b>
<b>Dependency</b>	/req/gwml2-construction
<b>Requirement</b>	/req/gwml2-well/origin_elevation
<b>Requirement</b>	/req/gwml2-well/waterwell_elevationCRS
<b>Requirement</b>	/req/gwml2-well/waterwell_shape
<b>Requirement</b>	/req/gwml2-well/waterwell_shape_origin
<b>Requirement</b>	/req/gwml2-well/waterwell_shape_crs
<b>Requirement</b>	/req/gwml2-well/waterwell_observation_foi
<b>Requirement</b>	/req/gwml2-well/waterwell_observation_fromParam
<b>Requirement</b>	/req/gwml2-well/waterwell_observation_toParam
<b>Requirement</b>	/req/gwml2-well/waterwell_sf_foi

<b>Requirement</b>	/req/gwml2-well/waterwell_sf_fromParam
<b>Requirement</b>	/req/gwml2-well/waterwell_sf_toParam
<b>Requirement</b>	/req/gwml2-well/well_geology
<b>Requirement</b>	/req/gwml2-well/log_coverage
<b>Requirement</b>	/req/gwml2-well/log_ref_samplingFeature
<b>Requirement</b>	/req/gwml2-well/log_geometry_origin
<b>Requirement</b>	/req/gwml2-well/log_depth
<b>Requirement</b>	/req/gwml2-well/log_depth_order
<b>Requirement</b>	/req/gwml2-well/log_observed_property
<b>Requirement</b>	/req/gwml2-well/geologicUnitLog
<b>Requirement</b>	/req/gwml2-well/earthMaterialLog
<b>Requirement</b>	/req/gwml2-well/monitoring_elevationCRS

The shape of the well is the 3D curve, in absolute coordinates, that represents the path of the hole in the ground. However, properties of the surrounding materials are traditionally located along this 3D path using a 1D coordinate system (straight line) relative to the beginning of the hole. This standard allows for the generic case, where the well path is not assumed to be a straight line, and therefore any such property or element needs to refer to the well path to calculate its absolute position.

This standard also provides alternative representations for commonly used origin elevations, such as the location of the well on the surface of the earth, the location and elevation of the well collar, the reference elevation for down hole properties, etc. Although some of these locations could be derived from the 3D well geometry, they are expressed as separate properties for convenience.

There are 3 distinct geometry properties:

- shape::GM\_Curve, inherited from SF\_SamplingCurve (3D)
- gwWellLocation, which is the well location at the surface of the earth (2D)
- gwWellReferenceElevation of type Elevation, having a GM\_DirectPosition

Several GW\_Well features need to be located relative to the well path:

- GW\_GeologyLog LogValue
- Construction elements
- Any related Observation
- Any related SamplingFeature

The following set of requirements set the constraints on how to report these values:

The origin of relative position shall be a combination of the location of the well and a reference elevation, therefore, the well location is a 2D Point and the elevation is a 1D point (z axis). The combination of x,y from location and z from Elevation forms a 3D point that is the origin of the relative coordinate system. This 3D point coincides with the first vertex of the well shape.

Each well must have an origin elevation.

/req/gwml2-well/origin_elevation	One of the Elevation instance of gwWellReferenceElevation SHALL have the elevationType = "http://www.opengis.net/req/gwml2-well/origin_elevation"
----------------------------------	---

The elevation CRS must be a relevant EPSG vertical (1 dimension) CRS. Example EPSG:5100 (Mean Sea Level : http://epsg.io/5100-datum).

/req/gwml2-well/waterwell_elevationCRS	CRS SHALL have a vertical datum.
--	----------------------------------

### 9.5.2 Well shape

/req/gwml2-well/waterwell_shape	GW_Well:shape SHALL be a 3D geometry that represents the complete well that includes any construction elements above the ground
/req/gwml2-well/waterwell_shape_origin	The first vertex of the shape SHALL match the x, y coordinates of gwWellLocation and the single coordinate of Elevation:elevation:DirectPosition where elevationType = "http://www.opengis.net/req/gwml2-well/origin_elevation"
/req/gwml2-well/waterwell_shape_crs	The coordinate reference system (CRS) of the shape SHALL be a coherent CRS of planar gwWellLocation and z axis from Elevation where elevationType = "http://www.opengis.net/req/gwml2-well/origin_elevation"

### 9.5.3 Relative position

The relative positions of all elements positioned relative to the bore shall be calculated from the origin point of the bore, which is either the first vertex of the shape or the combination of the well gwWellLocation and the z value from Elevation where elevationType = "http://www.opengis.net/req/gwml2-well/origin\_elevation".

The relative position is the linear distance along the bore path, expressed as a positive value, using the uom inferred from the CRS of the shape z axis (metres or feet in the vast majority of cases).

Different GW\_Well elements may have different ways to encode the relative positions.

#### 9.5.3.1 Observations

Any Observation that needs to be positioned along the well path must encode the relative position in om:parameter. The Observation must also identify the well as the featureOfInterest.

/req/gwml2-well/waterwell_observation_foi	The featureOfInterest of an Observation positioned along a GW_Well path SHALL identify
---	--

the well that is represented by this path as its featureOfInterest.
---

The relative position shall be encoded in a specially named NamedValue.

/req/gwml2-well/waterwell_observation_fromParam	The boundary of the interval closest to the well path origin, the “from” distance, SHALL be encoded in a om:NamedValue with the name <a href="http://www.opengis.net/req/gw_well/waterwell_observation_fromParam">http://www.opengis.net/req/gw_well/waterwell_observation_fromParam</a> and a value of type swe:Quantity
/req/gwml2-well/waterwell_observation_toParam	The boundary of the interval farthest from the well path origin, the “to” distance, shall be encoded in a om:NamedValue with the name <a href="http://www.opengis.net/req/gw_well/waterwell_observation_toParam">http://www.opengis.net/req/gw_well/waterwell_observation_toParam</a> and a value of type swe:Quantity

### 9.5.3.2 Related SamplingFeature

Any sampling feature that must be positioned along the well path shall encode relative position in sams:parameters and link to the well using sams:relatedSamplingFeature.

/req/gwml2-well/waterwell_sf_foi	SamplingFeature positioned along a well path SHALL identify the well that is represented by this path as its relatedSamplingFeature
----------------------------------	---

The relative position shall be encoded in specially labelled NamedValue.

/req/gwml2-well/waterwell_sf_fromParam	The boundary of the interval, closest to the well path origin, the “from” distance, shall be encoded in a om:NamedValue with the name <a href="http://www.opengis.net/req/gw_well/waterwell_observation_fromParam">http://www.opengis.net/req/gw_well/waterwell_observation_fromParam</a> and a value of type swe:Quantity
/req/gwml2-well/waterwell_sf_toParam	The boundary of the interval farthest from the well path origin, the “to” distance, shall be encoded in a om:NamedValue with the name <a href="http://www.opengis.net/req/gw_well/waterwell_observation_toParam">http://www.opengis.net/req/gw_well/waterwell_observation_toParam</a> and a value of type swe:Quantity

### 9.5.4 Geology Log

GW\_GeologyLog is an OM\_Observation, with a start and end depth, that shall capture down hole geological (including geophysical and geochemical) observations using the gwml:gwWellGeology property rather than other OM\_Observation properties.

/req/gwml2-well/well_geology	gwWellGeology SHALL associate GW_Well and any GW_GeologyLog
------------------------------	---

The geologic log is encoded as a GW\_GeologyLogCoverage.

/req/gwml2-well/log_coverage	The value of om:result of GW_GeologyLog SHALL be a GW_GeologyLogCoverage
------------------------------	--

The featureOfInterest of the GeologicLog must provide a linear geometry, as stated in OGC 10-004r3 clause D.3.4 .

/req/gwml2-well/log_ref_samplingFeature	The featureOfInterest of the GeologicLog SHALL be a SF_SamplingCurve or one of its subtypes.
---	--

The GW\_GeologyLogCoverage/LogValue is positioned at the origin of the support feature, which is a SF\_SamplingCurve.

/req/gwml2-well/log_geometry_origin	The origin of the GW_GeologyLogCoverage/LogValue location SHALL be the first vertex of the GW_Well shape
-------------------------------------	--

Depth shall be expressed as linear distance from the first vertex of the GM\_Curve. When the featureOfInterest is a GW\_Well, the origin is implicitly gwWellLocation + Elevation.

/req/gwml2-well/log_depth	The fromDepth and toDepth of a LogValue shall be the linear distance along the path from featureOfInterest's linear geometry
---------------------------	--

The fromDepth must be nearest the reference elevation.

/req/gwml2-well/log_depth_order	The fromDepth of a LogValue shall be the closest along the path to gw_WellReferenceElevation while the toDepth shall be the farthest.
---------------------------------	---

### 9.5.5 Monitoring Sites

Elevation CRS must be a relevant EPSG vertical (1 dimension) CRS. Example EPSG:5100 (Mean Sea Level : <http://epsg.io/5100-datum>)

/req/gwml2-well/monitoring_elevationCRS	CRS must be relevant vertical datum.
---	--------------------------------------

## 9.6 Requirement class : GWML2-WellConstruction

<b>Requirements class</b>	/req/gwml2-construction
<b>Target type</b>	XML data document
<b>Name</b>	Construction logical model
<b>Dependency</b>	/req/gwml2-core
<b>Requirement</b>	/req/gwml2-construction/collar_elevation_CRS
<b>Requirement</b>	/req/gwml2-construction/construction_geometry_origin
<b>Requirement</b>	/req/gwml2-construction/log_depth
<b>Requirement</b>	/req/gwml2-construction/log_depth_order

### 9.6.1 Borehole

BoreCollar collarElevation CRS must be a relevant vertical (1 dimension) CRS. Example EPSG:5100 (Mean Sea Level : <http://epsg.io/5100-datum>)

/req/gwml2- <b>construction/collar_elevation_CRS</b>	CRS must be relevant vertical datum.
---	--------------------------------------

### 9.6.2 Construction

The from and to positions of construction components must be expressed relative to the well reference elevation.

/req/gwml2- construction/construction_geometry_origin	The origin of the relative position shall be the first vertex of the Borehole shape.
--	--

Depth shall be expressed as linear distance from borehole's shape's first vertex.

/req/gwml2-construction/log_depth	The from and to of a construction element SHALL be the linear distance along the shape of the borehole.
-----------------------------------	---

The 'from' value must be closer to the Borehole origin than the 'to' value.

/req/gwml2-construction /log_depth_order	The 'from' value of a construction element SHALL be the closest along the path to first vertex of the Borehole shape while the 'to' value SHALL be the farthest.
--	--



### 9.7 Requirement class : Vertical Well (profile)

<b>Requirements class</b>	/req/gwml2-vertical-well
<b>Target type</b>	Model encoding
<b>Name</b>	Vertical well logical model
<b>Dependency</b>	/req/gwml2-well
<b>Requirement</b>	/req/gwml2-vertical-well /waterwell_shape
<b>Requirement</b>	/req/gwml2-vertical-well /end_vertex

A vertical well is a special case where the shape of the well is a straight line, usually downward. The rationale to create a special profile is to inform the data consumer that calculation of relative position into absolute position can be greatly simplified. It also gives the opportunity for the web client to identify services or data that are providing vertical GW\_Wells.

GW\_Well shape shall have only 2 vertices.

/req/gwml2-vertical-well/waterwell_shape	GW_Well shape SHALL only have 2 vertices
--	--

The second vertex shall have the same x and y as the first vertex.

/req/gwml2-vertical-well/end_vertex	The planar position (x,y) of the second vertex shall be the same as the first vertex
-------------------------------------	--

### 9.8 Requirement Class : geologicUnit log (profile)

This requirement class describes a common type of log where intervals along the bore are classified into Geologic Units.

<b>Requirements class</b>	/req/gwml2-well-gu
<b>Target type</b>	Model encoding
<b>Name</b>	Geologic Unit logs
<b>Dependency</b>	/req/gwml2-well
<b>Dependency</b>	GeoSciML 3.2 / GeologicUnit
<b>Requirement</b>	/req/gwml2-well-gu/log-category

The LogValue:value datatype is a record, which, according to the swe specification, is a collection of fields that can be of various type. Since GeoSciML:GeologicUnit/classifier is controlled in external vocabularies, this specification uses swe:Category to describe GeologicUnit/classifier log values.

/req/gwml2-well-gu/log-category	Where the GW_GeologyLog/observedProperty is " <a href="http://www.opengis.net/def/gwml/2.0/observ">http://www.opengis.net/def/gwml/2.0/observ</a>
---------------------------------	---

[edProperty/geologicUnit](#)”, the LogValue:value SHALL be a Record composed of a single Category

## 9.9 Requirement Class : earthMaterial log (profile)

This requirement class describes a common type of log where intervals along the well are classified into GeoSciML:EarthMaterials (lithologies).

<b>Requirements class</b>	/req/gwml2-well-em
<b>Target type</b>	Model encoding
<b>Name</b>	Earth Material logs
<b>Dependency</b>	/req/gwml2-well
<b>Dependency</b>	GeoSciML 3.2 / EarthMaterial
<b>Requirement</b>	/req/gwml2-well-em/log-category

As earth materials are normally controlled in external vocabularies, this specification opts to describe EarthMaterial log values as swe:Categories.

/req/gwml2-well-em/log-category	Where the GW_GeologyLog/observedProperty is “http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial” the LogValue:value SHALL be a Record composed of a single Category
---------------------------------	---

## 10 XML implementation (normative)

### 10.1 GWML2-XSD

Groundwater features and their properties will be encoded in XML using standard GML encoding rules.

<b>Requirements class</b>	/req/xsd-xml-rules
<b>Target type</b>	XML data document
<b>Name</b>	GML/XML encoding
<b>Dependency</b>	ISO-19118
<b>Dependency</b>	ISO/IEC 19757-3:2006 (Schematron)
<b>Dependency</b>	http://www.w3.org/TR/xmlschema-2
<b>Dependency</b>	http://www.opengis.net/doc/IS/GML/3.2/clause/2.4
<b>Dependency</b>	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components
<b>Dependency</b>	urn:iso:dis:iso:8601:2004:clause:4
<b>Dependency</b>	req/gwml2-core

<b>Dependency</b>	http://www.ietf.org/rfc/rfc2616
<b>Requirement</b>	/req/xsd-xml-rules/W3C_XSD
<b>Requirement</b>	/req/xsd-xml-rules/ISO-schematron
<b>Requirement</b>	/req/xsd-xml-rules/time-zone
<b>Requirement</b>	/req/xsd-xml-rules/swe-types
<b>Requirement</b>	/req/xsd-xml-rules/identifier
<b>Recommendation</b>	/req/xsd-xml-rules/byrefproperty
<b>Recommendation</b>	/req/xsd-xml-rules/xlink-title
<b>Recommendation</b>	/req/xsd-xml-rules/vocabulary-references

ISO-19136\_2007 provides a mapping between UML classifiers and XSD entities. All XSD types and elements must be created following those mapping rules. This specification considers the XSD files (the schema files) to be normative (they contain the official interpretation of 19136 conversion of the UML classifiers into XML).

<b>/req/xsd-xml-rules/W3C_XSD</b>	All elements and attributes in a namespace shall validate according to W3C XSD rules encoded in the xsd file associated with this namespace and its dependencies.
-----------------------------------	---

The date-time formats will conform to ISO standards. Although this is already a GML 3.2 encoding rule (clause 14.2.2.7), this format should also be used in any string that does not attempt to validate the date time structure.

<b>/req/xsd-xml-rules/iso8601-time</b>	All date-time elements SHALL be encoded using ISO8601 extended time format
--	--

Note that this precludes the use of time-coordinate systems such as UNIX time. This is specified in order to be maximally consistent with WML2 requirements. The time zone will be included in the time element.

<b>/req/xsd-xml-rules/time-zone</b>	The value of each time element SHALL include a time zone definition using a signed 4 digit character or a 'Z' to represent Zulu or Greenwich Mean Time (GMT). This is defined by the following regular expression: (Z[+][HH:MM])
-------------------------------------	---

Some SWE Common types are restricted to avoid ambiguity.

<b>/req/xsd-xml-rules/swe-types</b>	When using the SWE Common types, the following elements SHALL NOT be used: swe:quality ( <i>AbstractSimpleComponentType</i> ), swe:nilValues ( <i>AbstractSimpleComponentType</i> ), swe:constraint ( <i>QuantityType</i> , <i>QuantityRangeType</i> , <i>CategoryType</i> ). The attributes 'optional' and 'updatable' from the base type 'AbstractDataComponent' SHALL NOT be used.
-------------------------------------	---

Vocabulary references for all classes of stereotype «CodeList» must be implemented via xlink:href and ought to be a resolvable URI in the form of an HTTP URL.

<b>/req/xsd-xml-rules/vocabulary-references</b>	When specifying references to vocabulary (CodeList) items using an xlink:href, a resolvable HTTP URL SHOULD be used which, when resolved, SHOULD provide suitable description of the concept being referenced.
---	--

All property by reference using xlink:href should provide a human readable label in xlink:title

<b>/req/xsd-xml-rules/xlink-title</b>	If an xlink:href is used to reference a controlled vocabulary item, the element SHOULD encode the xlink:title attribute with a text label of the referenced item.
---------------------------------------	---

### 10.1.1 Identifier

A feature that can be accessed through Linked Data using a HTTP URI identifier must use this HTTP URI as it's global unique identifier. In GML, this is encoded as gml:identifier

<b>/req/xsd-xml-rules/identifier</b>	A resolvable resource SHALL expose it's resolvable HTTP URI as a gml:identifier AND use the codeSpace <a href="http://www.ietf.org/rfc/rfc2616">http://www.ietf.org/rfc/rfc2616</a>
--------------------------------------	---

Example of a feature that exposes its resolvable HTTP URI as a globally unique identifier

```
(...)  
<gml:description>Water well from Alberta water well database</gml:description>  
  <gml:identifier codeSpace="http://www.ietf.org/rfc/rfc2616">http://ngwd-  
bdnes.cits.nrcan.gc.ca/Reference/uri-  
cgi/feature/gsc/waterwell/ca.ab.gov.wells.402557</gml:identifier>  
  <gml:name codeSpace="urn:cgi:featureType:CA.AB:WaterWell">402557</gml:name>  
  <gml:name codeSpace="urn:x-gin">ca.ab.waterWell.402557</gml:name>
```

(...)

### 10.1.2 By-Reference properties

Properties can be inline or by-reference, or constrained to be by-reference only. When a by-reference property refers to an offline feature, the reference must be resolvable over the web. The reference can either be a resolvable HTTP URI that might also match the feature's globally unique identifier (see [/req/gwml-core/identifier](#)) or an HTTP request (for instance, a WFS GetFeature) to the a representation of the feature in GML.

<b>/req/xsd-xml-rules/byrefproperty</b>	A reference to an external (offline) feature SHOULD be resolvable to a GML representation of this feature
---	---

Note that elements under GWML2 namespaces can be mixed with other namespaces. For example, this specification does not have a dependency to WFS, but GWML can be serialised in a WFS document, along with features from other domains. Failure to validate such a document does not necessarily mean that GWML XML requirement is not met, as other external indirect instances might fail. Therefore, the requirement only addresses instance of GWML in an XML document.

## 10.2 Requirement class : GWML2-Nucleus XML encoding

<b>Requirements class</b>	<b>/req/xsd-nucleus</b>
<b>Target type</b>	XML data document
<b>Name</b>	Nucleus xml encoding
<b>Dependency</b>	<b>/req/xsd-xml-rules</b>
<b>Dependency</b>	<b>/req/xsd-flow</b>
<b>Dependency</b>	/req/xsd-constituent
<b>Dependency</b>	GeoSciML/GeologicUnit
<b>Dependency</b>	ISO-19115
<b>Requirement</b>	<b>/req/xsd-nucleus/xsd</b>

All xml elements under namespace <http://www.opengis.net/gwml-nucleus/2.0> must be valid with the schema encoded at <http://schemas.opengis.net/gwml/2.0/gwml-nucleus.xsd>.

<b>/req/xsd-nucleus/xsd</b>	All the elements and types under namespace " <a href="http://www.opengis.net/gwml-nucleus/2.0">http://www.opengis.net/gwml-nucleus/2.0</a> " SHALL validate with schema description at <a href="http://schemas.opengis.net/gwml/2.0/gwml-nucleus.xsd">http://schemas.opengis.net/gwml/2.0/gwml-nucleus.xsd</a>
-----------------------------	--

### 10.3 Requirement class : GWML2-Constituent XML encoding

<b>Requirements class</b>	<b>/req/xsd-constituent</b>
<b>Target type</b>	XML data document
<b>Name</b>	Constituent xml encoding
<b>Dependency</b>	<b>/req/xsd-xml-rules</b>
<b>Requirement</b>	<b>/req/xsd-constituent/xsd</b>

All xml elements under namespace <http://www.opengis.net/gwml-constituent/2.0> must be valid with the schema encoded at <http://schemas.opengis.net/gwml/2.0/gwml-constituent.xsd>.

<b>/req/xsd-constituent/xsd</b>	All the elements and types under namespace " <a href="http://www.opengis.net/gwml-constituent/2.0">http://www.opengis.net/gwml-constituent/2.0</a> " SHALL validate with schema description at <a href="http://schemas.opengis.net/gwml/2.0/gwml-constituent.xsd">http://schemas.opengis.net/gwml/2.0/gwml-constituent.xsd</a>
---------------------------------	--

### 10.4 Requirement class : GWML2-Flow XML encoding

<b>Requirements class</b>	<b>/req/xsd-flow</b>
<b>Target type</b>	XML data document
<b>Dependency</b>	<b>/req/xsd-xml-rules</b>
<b>Requirement</b>	<b>/req/xsd-flow/xsd</b>

All xml elements under namespace <http://www.opengis.net/gwml-flow/2.0> must be valid with the schema encoded at <http://schemas.opengis.net/gwml/2.0/gwml-flow.xsd>.

<b>/req/xsd-flow/xsd</b>	All the elements and types under namespace " <a href="http://www.opengis.net/gwml-flow/2.0">http://www.opengis.net/gwml-flow/2.0</a> " SHALL validate with schema description at <a href="http://schemas.opengis.net/gwml/2.0/gwml-flow.xsd">http://schemas.opengis.net/gwml/2.0/gwml-flow.xsd</a>
--------------------------	--

### 10.5 Requirement class : GWML2-Well XML encoding

<b>Requirements class</b>	<b>/req/xsd-gwml_well</b>
<b>Target type</b>	XML data document
<b>Dependency</b>	<b>/req/xsd-xml-rules</b>
<b>Dependency</b>	<b>/req/xsd-gwml_construction</b>

<b>Dependency</b>	/req/gwml-well
<b>Requirement</b>	/req/xsd-gwml-well/xsd
<b>Requirement</b>	/req/xsd-gwml-well/origin_elevation
<b>Requirement</b>	/req/xsd-gwml-well/waterwell_elevationCRS
<b>Requirement</b>	/req/gwml2-well/waterwell_shape_crs
<b>Requirement</b>	<b>/req/xsd-gwml_well/obs_relative_pos_foi</b>
<b>Requirement</b>	/req/xsd-gwml-well/waterwell_observation_fromParam
<b>Requirement</b>	/req/xsd-gwml-well/waterwell_observation_toParam
<b>Requirement</b>	/req/xsd-gwml-well/waterwell_sf_foi
<b>Requirement</b>	/req/xsd-gwml-well/waterwell_sf_fromParam
<b>Requirement</b>	/req/xsd-gwml-well/waterwell_sf_toParam
<b>Requirement</b>	/req/xsd-gwml-well/well_geology
<b>Requirement</b>	/req/xsd-gwml-well/log_coverage
<b>Requirement</b>	/req/gwml2-well/log_ref_samplingFeature
<b>Requirement</b>	<b>/req/xsd-gwml_well/log_depth_order</b>
<b>Requirement</b>	<b>/req/xsd-gwml_well/log_observed_property</b>
<b>Requirement</b>	<b>/req/xsd-gwml_well/geologicUnitLog</b>
<b>Requirement</b>	<b>/req/xsd-gwml_well/earthMaterialLog</b>
<b>Requirement</b>	/req/xsd-gwml-well/definition
<b>Requirement</b>	/req/xsd-gwml-well/monitoring_elevationCRS

All xml elements under namespace <http://www.opengis.net/gwml-well/2.0> must be valid with the schema encoded at <http://schemas.opengis.net/gwml/2.0/gwml-well.xsd>.

<b>/req/xsd-gwml-well/xsd</b>	All the elements and types under namespace " <a href="http://www.opengis.net/gwml-well/2.0">http://www.opengis.net/gwml-well/2.0</a> " SHALL validate with schema description at <a href="http://schemas.opengis.net/gwml/2.0/gwml-well.xsd">http://schemas.opengis.net/gwml/2.0/gwml-well.xsd</a>
-------------------------------	--

Well must provide an origin elevation as a reference for relative position along the borehole path.

<b>/req/xsd-gwml-well/origin_elevation</b>	There SHALL be a gwWellReferenceElevation: Elevation:elevationType with a xlink:href equal to " <a href="http://www.opengis.net/req/gwml2-well/origin_elevation">http://www.opengis.net/req/gwml2-well/origin_elevation</a> "
--	---

Elevation geometries must have a relevant vertical 1D srsName.

/req/xsd-gwml-well/waterwell_elevationCRS	gwWellReferenceElevation:Elevation:elevation @srsName SHALL contain a relevant vertical SRS.
---	--

Examples of reference elevations (measured using different methods); note, one of them is designated as the origin elevation for relative positions:

```

<gww:gwWellReferenceElevation>
  <!-- this entry is the one that should be used for relative positions -->
  <gww:Elevation>
    <gww:elevation srsName="urn:ogc:def:crs:EPSG:5100" uomLabels="m above sea level"
srsDimension="1">1737.36</gww:elevation>
    <gww:elevationType xlink:href="http://www.opengis.net/req/gwml2-well/origin_elevation"
xlink:title="origin"/>
    <gww:elevationMeasurementMethod xsi:nil="true" nilReason="unknown"/>
  </gww:Elevation>
</gww:gwWellReferenceElevation>
<gww:gwWellReferenceElevation>
  <gww:Elevation>
    <gww:elevation srsName="urn:ogc:def:crs:EPSG:5100" uomLabels="m above sea level"
srsDimension="1">1648</gww:elevation>
    <gww:elevationType xlink:href="http://www.opengis.net/req/gwml2-well/location_elevation"
xlink:title="dem site"/>
    <gww:elevationMeasurementMethod xlink:href="urn:gwml2:elevationMethod:DEM"
xlink:title="DEM"/>
  </gww:Elevation>
</gww:gwWellReferenceElevation>
<gww:gwWellReferenceElevation>
  <gww:Elevation>
    <gww:elevation srsName="urn:ogc:def:crs:EPSG:5100" uomLabels="m above sea level"
srsDimension="1">1658.633</gww:elevation>
    <gww:elevationType xlink:href="http://www.opengis.net/req/gwml2-well/location_elevation"
xlink:title="dem site"/>
    <gww:elevationMeasurementMethod xlink:href="urn:gwml2:elevationMethod:DEM"
xlink:title="DEM"/>
  </gww:Elevation>
</gww:gwWellReferenceElevation>

```

### 10.5.1 Well shape

The CRS of the shape must be a 3D CRS that is coherent with the planar CRS of gwWellLocation and the elevation CRS of origin Elevation.

/req/gwml2-well/waterwell_shape_crs	GW_Well:shape @srsName SHALL contain a relevant 3D SRS.
-------------------------------------	--

Example of a well shape represented as a vertical line, using a relevant srsName:

```

<sams:shape>
  <gml:Curve gml:id="ab.ww.402557.shape.1" srsDimension="3"
srsName="urn:ogc:def:crs:EPSG:4955">
    <gml:segments>
      <gml:LineStringSegment>
        <gml:posList>49.671622 -114.625045 0.00 49.671622 -114.625045 11.58</gml:posList>
      </gml:LineStringSegment>
    </gml:segments>
  </gml:Curve>

```



</sams:shape>

### 10.5.1.1 Observations

Any observation that is positioned relative to a well path must identify that well as its FeatureOfInterest.

**/req/xsd-gwml\_well/obs\_relative\_pos\_foi** Any OM\_Observation that is located relative to well path SHALL specify the SF\_SamplingCurve in om:featureOfInterest/@xlink:href

The relative position of the observation must be encoded in the om:parameter using a specific encoding.

/req/xsd-gwml-well/waterwell_observation_fromParam	The closest boundary of the interval , the “from” distance, SHALL be encoded in a om:NamedValue with the name <a href="http://www.opengis.net/req/gw_well/waterwell_observation_fromParam">http://www.opengis.net/req/gw_well/waterwell_observation_fromParam</a> and a value of type swe:Quantity
/req/xsd-gwml-well/waterwell_observation_toParam	The farthest boundary of the interval , the “to” distance, SHALL be encoded in a om:NamedValue with the name <a href="http://www.opengis.net/req/gw_well/waterwell_observation_toParam">http://www.opengis.net/req/gw_well/waterwell_observation_toParam</a> and a value of type swe:Quantity

Example of Observation positioned along the path of a bore:

```
<sam:relatedObservation>
  <om:OM_Observation gml:id="ab.ww.402557.flow.1">
    <gml:description>Fictive Flow measurement</gml:description>
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="ab.ww.402557.flow.1.pt">
        <gml:timePosition>2012-05-01</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <om:resultTime>
      <gml:TimeInstant gml:id="ab.ww.402557.flow.1.ti">
        <gml:timePosition>2012-05-01</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xlink:href="http://www.opengis.net/def/gwml/procedure/flowmeter"
xlink:title="flow meter"/>
    <!-- /req/gwml2-well/waterwell_observation_fromParam -->
    <om:parameter>
      <om:NamedValue>
        <om:name
xlink:href="http://www.opengis.net/req/gw_well/waterwell_observation_fromParam"
xlink:title="from"/>
          <om:value xsi:type="swe:QuantityPropertyType">
            <swe:Quantity>
```

```

        <swe:uom xlink:href="m" xlink:title="m from top"/>
        <swe:value>7.6</swe:value>
    </swe:Quantity>
</om:value>
</om:NamedValue>
</om:parameter>
<!-- /req/gwml2-well/waterwell_observation_toParam -->
<om:parameter>
    <om:NamedValue>
        <om:name
xlink:href="http://www.opengis.net/req/gw_well/waterwell_observation_toParam" xlink:title="to"/>
        <om:value xsi:type="swe:QuantityPropertyType">
            <swe:Quantity>
                <swe:uom xlink:href="m" xlink:title="m from top"/>
                <swe:value>7.7</swe:value>
            </swe:Quantity>
        </om:value>
    </om:NamedValue>
</om:parameter>
<om:observedProperty xlink:href="http://www.opengis.net/def/gwml/phenomenon/flowspeed"
xlink:title="groundwater flow speed"/>
<!--/req/gwml2-well/waterwell_observation_foi -->
<om:featureOfInterest xlink:href="#ab.ww.402557" xlink:title="ab.ww.402557"/>
<om:result xsi:type="gml:MeasureType" uom="m/s">0.0021</om:result>
</om:OM_Observation>
</sams:relatedObservation>

```

### 10.5.1.2 Related SamplingFeature

Any sampling feature that must be positioned along the bore path shall encode a relative position in sams:parameters and link to the well using sams:relatedSamplingFeature

/req/xsd-gwml-well/waterwell_sf_foi	A SamplingFeature positioned along a well path SHALL identify the well that is represented by this path as its sam:relatedSamplingFeature
-------------------------------------	---

The relative position shall be encoded using NamedValue.

/req/xsd-gwml-well/waterwell_sf_fromParam	The closest boundary of the interval , the “from” distance, SHALL be encoded in a om:NamedValue with the name <a href="http://www.opengis.net/req/gw_well/waterwell_sf_fromParam">http://www.opengis.net/req/gw_well/waterwell_sf_fromParam</a> and a value of type swe:Quantity
/req/xsd-gwml-well/waterwell_sf_toParam	The farthest boundary of the interval , the “to” distance, SHALL be encoded in a om:NamedValue with the name <a href="http://www.opengis.net/req/gw_well/waterwell_sf_toParam">http://www.opengis.net/req/gw_well/waterwell_sf_toParam</a> and a value of type swe:Quantity

Example of a related sampling feature:

```

<sam:relatedSamplingFeature>
  <spec:SF_Specimen gml:id="spc.1">
    <gml:description>Fictitious water sample taken in the well</gml:description>
    <gml:name>S.1</gml:name>
    <sam:sampledFeature xsi:nil="true" nilReason="unknown"/>
    <!-- /req/xsd-gwml-well/waterwell_sf_foi -->
    <sam:relatedSamplingFeature>
      <sam:SamplingFeatureComplex>
        <sam:role xlink:href="http://www.opengis.net/def/gwml/role/samplingFeature"/>
        <sam:relatedSamplingFeature xlink:href="#ab.ww.402557"
xlink:title="ab.ww.402557"/>
      </sam:SamplingFeatureComplex>
    </sam:relatedSamplingFeature>
    <!-- /req/gwml2-well/waterwell_sf_fromParam -->
    <sam:parameter>
      <om:NamedValue>
        <om:name
xlink:href="http://www.opengis.net/req/gw_well/waterwell_sf_fromParam" xlink:title="from"/>
        <om:value xsi:type="swe:QuantityPropertyType">
          <swe:Quantity>
            <swe:uom xlink:href="m" xlink:title="m from top"/>
            <swe:value>8.12</swe:value>
          </swe:Quantity>
        </om:value>
      </om:NamedValue>
    </sam:parameter>
    <!-- /req/gwml2-well/waterwell_sf_toParam -->
    <sam:parameter>
      <om:NamedValue>
        <om:name xlink:href="http://www.opengis.net/req/gw_well/waterwell_sf_toParam"
xlink:title="to"/>
        <om:value xsi:type="swe:QuantityPropertyType">
          <swe:Quantity>
            <swe:uom xlink:href="m" xlink:title="m from top"/>
            <swe:value>8.4</swe:value>
          </swe:Quantity>
        </om:value>
      </om:NamedValue>
    </sam:parameter>
    <spec:materialClass
xlink:href="http://www.opengis.net/def/waterml/2.0/medium/Groundwater" xlink:title="Groundwater"/>
    <spec:samplingTime>
      <gml:TimeInstant gml:id="spc.1.ts">
        <gml:timePosition>2012-06-24</gml:timePosition>
      </gml:TimeInstant>
    </spec:samplingTime>
    <spec:size uom="ml">150</spec:size>
  </spec:SF_Specimen>
</sam:relatedSamplingFeature>

```

### 10.5.1.3 Geology Log

This specification forbids the use of relatedObservation to link a GW\_Well to a GW\_GeologyLog, rather than relatedObservation.

/req/xsd-gwml-well/well_geology	GW_Well SHALL be associated with GW_GeologyLog using gwWellGeology
---------------------------------	--

The geologic log is encoded as a GW\_GeologyLogCoverage.

/req/xsd-gwml-well/log_coverage	The XML element om:result of GW_GeologyLog SHALL have a data type GW_GeologyLogCoverage
---------------------------------	---

The featureOfInterest of the GW\_GeologyLog must refer to its associated well.

/req/gwml2-well/log_ref_samplingFeature	The om:featureOfInterest/@xlink:href of the GeologicLog SHALL be a SF_SamplingCurve or one of its subtypes.
---	---

The fromDepth value must be less than or equal to the toDepth value.

/req/gwml2-well/log_depth_order	For any given value where both fromDepth and toDepth are non-null, the value of gww:fromDepth/swe:Quantity/swe:Value SHALL be less than or equal to gww:toDepth/swe:Quantity/swe:Value
---------------------------------	--

Monitoring site elevation geometry must have a relevant vertical 1D srsName.

/req/xsd-gwml-well/monitoring_elevationCRS	GW_MonitoringSite elevation @srsName must contain a relevant vertical SRS.
--	--

## 10.6 Requirement class : GWML2-WellConstruction XML encoding

<b>Requirements class</b>	/req/xsd-gw_construction
<b>Target type</b>	XML data document
<b>Dependency</b>	/req/xsd-xml-rules
<b>Requirement</b>	/req/xsd-gw_construction/xsd
<b>Requirement</b>	/req/xsd-gw_construction/collar_elevation_CRS
<b>Requirement</b>	/req/xsd-gw_construction/depth_order

All xml elements under namespace <http://www.opengis.net/gwml-construction/2.0> must be valid with the schema encoded at <http://schemas.opengis.net/gwml/2.0/gwml-construction.xsd>.

<b>/req/xsd-gwml-construction/xsd</b>	All the elements and types under namespace " <a href="http://www.opengis.net/gwml-construction/2.0">http://www.opengis.net/gwml-construction/2.0</a> " SHALL validate with the schema description at <a href="http://schemas.opengis.net/gwml/2.0/gwml-construction.xsd">http://schemas.opengis.net/gwml/2.0/gwml-construction.xsd</a>
---------------------------------------	--

Monitoring site elevation geometry must have a relevant vertical 1D srsName.

<b>/req/xsd-gwml-construction/collar_elevation_CRS</b>	BoreCollar collarElevations SHALL had a relevant vertical srsName
--	---

Construction elements "from" value must be less than or equal to the "to" value.

<b>/req/xsd-gwml-construction/depth_order</b>	For any given value where both "from" and "to" are non-null, the value of bh:from/swe:Quantity/swe:Value must be less or equal to bh:to/swe:Quantity/swe:Value
---	--

### 10.7 Requirement class : GWML2-Well-Vertical XML encoding (profile)

<b>Requirements class</b>	<b>/req/xsd-gwml-vertical-well</b>
<b>Target type</b>	XML data document
<b>Dependency</b>	<b>/req/xsd-gwml_well</b>
<b>Dependency</b>	/req/gwml2-vertical-well
<b>Requirement</b>	<b>/req/xsd-gwml-vertical-well/waterwell-shape</b>

Vertical well are represented as simple gml:Curve, made of a single Segment having only 2 coordinates.

<b>/req/xsd-gwml-vertical-well/waterwell-shape</b>	The sams:shape value of a vertical GW_Well shall be of type gml:Curve, compose of a single segment of type LineStringSegment, composed itself of 2 3D vertices
--	--

Example of a 3D vertical curve:

```
<sams:shape>
  <gml:Curve gml:id="ab.ww.402557.shape.1" srsDimension="3"
srsName="urn:ogc:def:crs:EPSG:4955">
    <gml:segments>
      <gml:LineStringSegment>
        <gml:posList>49.671622 -114.625045 0.00 49.671622 -114.625045 11.58</gml:posList>
      </gml:LineStringSegment>
    </gml:segments>
  </gml:Curve>
```

</sams:shap

The first vertex (v0) of the LineStringSegment must have the same planar coordinate that the last vertex (v1).

<b>/req/xsd-gwml-vertical-well/endvertex</b>	The first vertex of the only LineStringSegment SHALL have the same planar (x,y) coordinate as the last vertex.
--	--

### 10.8 Requirement Class : GeologicUnit Log XML encoding

<b>Requirements class</b>	/req/xsd-gwml-well-gu
<b>Target type</b>	XML data document
<b>Dependency</b>	/req/xsd-gwml_well
<b>Dependency</b>	/req/gwml2-well-gu
<b>Requirement</b>	/req/xsd-gwml-well-gu/log_observed_property
<b>Requirement</b>	/req/xsd-gwml-well-gu/log-categories
<b>Requirement</b>	/req/xsd-gwml-well-gu/definition

The om:observedProperty shall be

["http://www.opengis.net/def/gwml/2.0/observedProperty/geologicUnit"](http://www.opengis.net/def/gwml/2.0/observedProperty/geologicUnit).

<b>/req/xsd-gwml-well-gu/log_observed_property</b>	The om:observedProperty/@xlink:href of the GeologicUnit GW_GeologyLog SHALL be <a href="http://www.opengis.net/def/gwml/2.0/observedProperty/geologicUnit">"http://www.opengis.net/def/gwml/2.0/observedProperty/geologicUnit"</a>
--	--

Log values are encoded as swe:DataRecord, which is an encoding of ISO 11404 Record. It is a composite datatype made of 1 to many fields that are defined along with the instance (not by the XSD). DataRecord allows any collection of fields of any Type. This specification constrains the encoding to a single field of type swe:Category.

<b>/req/xsd-gwml-well-gu/log-categories</b>	The LogValue's value of a GeologicUnit Log shall be a swe:DataRecord composed of a single swe:field of type swe:Category
---	--

The DataRecord definition URI defines the structure of the data record and the semantics of the fields. This specification requires that the definition points to <http://www.opengis.net/def/gwml/2.0/datarecord/geologicUnit>.

<b>/req/xsd-gwml-well-gu/definition</b>	The swe:DataRecord/@definition shall be <a href="http://www.opengis.net/def/gwml/2.0/datarecord/geologicUnit">"http://www.opengis.net/def/gwml/2.0/datarecord/geologicUnit"</a>
---	---

## 10.9 Requirement Class : EarthMaterial Log XML encoding

Requirements class	/req/xsd-gwml-well-em
Target type	XML data document
Dependency	/req/xsd-gwml_well
Dependency	/req/gwml2-well-em
Requirement	/req/xsd-gwml2-well-em/log_observed_property
Requirement	/req/xsd-gwml2-well-em/log-categories
Requirement	/req/xsd-gwml2-well-em/definition

The om:observedProperty shall be

<http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial>.

/req/xsd-gwml-well-em/log_observed_property	The om:observedProperty/@xlink:href of the GeologicUnit GW_GeologyLog SHALL be " <a href="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial">http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial</a> "
---	--

Log values are encoded as swe:DataRecord, which is an encoding of ISO 11404 Record. It is a composite datatype made of 1 to many fields that are defined along with the instance (not by the XSD). DataRecord allows any collection of fields of any Type. This specification constrains the encoding to a single fields of type swe:Category.

/req/xsd-gwml-well-em/log-categories	The LogValue's value of a EarthMaterial Log shall be a swe:DataRecord composed of a single swe:field of type swe:Category
--------------------------------------	---

The DataRecord definition URI defines the structure of the data record and the semantics of the fields. This specification requires that the definition points to <http://www.opengis.net/def/gwml/2.0/datarecord/earthMaterial>.

/req/xsd-gwml-well-em/definition	The swe:DataRecord/@definition shall be " <a href="http://www.opengis.net/def/gwml/2.0/datarecord/earthMaterial">http://www.opengis.net/def/gwml/2.0/datarecord/earthMaterial</a> "
----------------------------------	---

Example of a EarthMaterial Log:

```
<gww:gwWellGeology>
  <gww:GW_GeologyLog gml:id="ab.ww.402557.log.1">
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="ab.ww.402557.log.1.ph">
        <gml:timePosition>1981-09-12T00:00:00</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
  </gww:GW_GeologyLog>
</gww:gwWellGeology>
```

```

<om:resultTime>
  <gml:TimeInstant gml:id="ab.ww.402557.log.1.rs">
    <gml:timePosition>1981-09-12T00:00:00</gml:timePosition>
  </gml:TimeInstant>
</om:resultTime>
<om:procedure xsi:nil="true" nilReason="unknown"/>
<om:observedProperty
xlink:href="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial"
xlink:title="Lithology"/>
<om:featureOfInterest xsi:nil="true" nilReason="missing"/>
<om:result>
  <gww:GW_GeologyLogCoverage gml:id="ab.ww.402557.log.1.coverage">
    <gww:element>
      <gww:LogValue>
        <gww:fromDepth>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>0.00</swe:value>
          </swe:Quantity>
        </gww:fromDepth>
        <gww:toDepth>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>0.30</swe:value>
          </swe:Quantity>
        </gww:toDepth>
        <gww:value>
          <swe:DataRecord definition="
definition="http://www.opengis.net/def/gwml/2.0/datarecord/earthMaterial" id="le.1">
            <swe:field name="lithology">
              <swe:Category
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial">
                <swe:codeSpace
xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/simplelithology"/>
                  <swe:value>Soil</swe:value>
                </swe:Category>
              </swe:field>
            </swe:DataRecord>
          </gww:value>
        </gww:LogValue>
      </gww:element>
      <gww:element (more elements)>
      </gww:element>
    </gww:GW_GeologyLogCoverage>
  </om:result>
  <gww:startDepth>
    <swe:Quantity>
      <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
      <swe:value>0</swe:value>
    </swe:Quantity>
  </gww:startDepth>
  <gww:endDepth>
    <swe:Quantity>
      <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
      <swe:value>11.58</swe:value>
    </swe:Quantity>
  </gww:endDepth>
</gww:GW_GeologyLog>
</gww:gwWellGeology>

```



## Annex A : Abstract Test Suite (Normative)

### A.1 Introduction

This test suite contains 7 conformance classes, including one abstract conformance class. Each test relates to one or more specific requirements, which are explicitly indicated in the description of the test.

### A.2 Conformance classes – UML packages

#### A.2.1 Conformance class : GWML 2.0 core logical model (Abstract)

<b>Conformance Class</b>	/conf/gwml2-core	
<b>Requirements</b>	/req/gwml2-core	
<b>Test</b>	/conf/gwml2-core/encoding	
	<b>Requirement</b>	/conf/gwml2-core/encoding
	<b>Test purpose</b>	Ensure that all mandatory classes and properties are encoded
	<b>Test method</b>	Verify that the target implementation has all mandatory classes and properties implemented. If mandatory class or property are missing, the test fails
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-core/observed-property	
	<b>Requirement</b>	/req/gwml2-core/observed-property
	<b>Test purpose</b>	Ensure that the observed property reported in the target instance is a GWML 2.0 property
	<b>Test method</b>	Visually inspect the target implementation and validate that all observedProperty values represent a GWML 2.0 property
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-core/quantities_uom	
	<b>Requirement</b>	/req/gwml2-core/quantities_uom

	<b>Test purpose</b>	Ensure that all properties of type swe:Quantity or om:OM_Measurement report a valid unit of measurement
	<b>Test method</b>	Visually inspect the target implementation and validate that all properties of type Quantity or Measurement report a unit of measurement
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-core/ <b>codelist</b>	
	<b>Requirement</b>	/req/gwml2-core/codelist
	<b>Test purpose</b>	Ensure that vocabularies use in the target implementation are managed in an external
	<b>Test method</b>	Visually inspect the target implementation and validate that all properties that are identified as vocabularies use values that are managed in a subsystem independent from the target implementation
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-core/ <b>identifier</b>	
	<b>Requirement</b>	/req/gwml2-core/ <b>identifier</b>
	<b>Test purpose</b>	Ensure that the that HTTP URI use as a globally unique identifier actually resolves to an instance of the feature
	<b>Test method</b>	For each feature that has a HTTP URI as a globally unique identifier, resolve the URI and inspect the result to see if it matches the same instance. Note, this conformance class does not imply any specific format, nor a single format
	<b>Test type</b>	Capability

### A.2.2 Conformance class : GWML 2.0 nucleus logical model

<b>Conformance Class</b>	/conf/gwml2-nucleus-uml	
<b>Requirements</b>	req/gwml2-nucleus-uml	
<b>Dependency</b>	/conf/gwml2-core	
<b>Dependency</b>	/conf/gwml2_constituent	
<b>Dependency</b>	/conf/gwml2_flow	
<b>Test</b>	/conf/gwml2-nucleus-feature	
	<b>Requirement</b>	/req/gwml2-core
	<b>Test purpose</b>	Ensure that instance of GWML2-Nucleus contain an appropriate feature
	<b>Test method</b>	Check that at least one of GW_AquiferSystem, GW_Aquifer, GW_ConfiningBed, GW_Basin, GW_ManagementArea, GW_HydrogeoVoid or GW_FluidBody is present.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-nucleus/aquifer_type	
	<b>Requirement</b>	/req/gwml2-nucleus/aquifer_type
	<b>Test purpose</b>	Ensure that instance of aquifer units uses the correct unitType
	<b>Test method</b>	Checks that the property gsml::geologicUnitType of instances of GW_Aquifer uses the string <a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifer_unit">http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifer_unit</a>
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-nucleus/aquifersystem_type	
	<b>Requirement</b>	/req/gwml2-nucleus/aquifersystem_type
	<b>Test purpose</b>	Ensure that instance of aquifer system units uses the correct unitType
	<b>Test method</b>	Checks that the property gsml::geologicUnitType of instances of GW_AquiferSystem uses the string <a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifersyst">http://www.opengis.net/def/gwml/2.0/geologicunittype/aquifersyst</a>

		<a href="#">em_unit</a>
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-nucleus/basin_type	
	<b>Requirement</b>	/req/gwml2-nucleus/basin_type
	<b>Test purpose</b>	Ensure that instance of basin units uses the correct unitType.
	<b>Test method</b>	Checks that the property gsml::geologicUnitType of instances of GW_Basin uses the string <a href="http://www.opengis.net/def/gwml/2.0/geologicunittype/basin_unit">http://www.opengis.net/def/gwml/2.0/geologicunittype/basin_unit</a>
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-nucleus/confiningbed_type	
	<b>Requirement</b>	/req/gwml2-nucleus/confiningbed_type
	<b>Test purpose</b>	Ensure that instance of confining bed units uses the correct unitType.
	<b>Test method</b>	Checks that the property gsml::geologicUnitType of instances of GW_ConfiningBed uses a string coming from <a href="http://def.seegrid.csiro.au/sissvoc/cgi201211/resource?uri=http://resource.geosciml.org/classifierscheme/cgi/201211/geologicunittype">http://def.seegrid.csiro.au/sissvoc/cgi201211/resource?uri=http://resource.geosciml.org/classifierscheme/cgi/201211/geologicunittype</a>
	<b>Test type</b>	Capability

### A.2.3 Conformance class : GWML 2.0 constituent logical model

<b>Conformance Class</b>	/conf/gwml2_constituent	
<b>Requirements</b>	/req/gwml2_constituent	
<b>Dependency</b>	/conf/gwml2-core	
<b>Test</b>	/conf/gwml2-constituent-feature	
	Requirement	/req/gwml2-core
	<b>Test purpose</b>	Ensure that GWML2-Constituent contains a valid constituent feature
	Test Method	Check that at least one of GW_BiologicalConstituent, GW_ChemicalConstituent or GW_MaterialConstituent is present

	<b>Test type</b>	Capability
--	------------------	------------

#### A.2.4 Conformance class : GWML 2.0 flow logical model

<b>Conformance Class</b>	/conf/gwml2_flow	
<b>Requirements</b>	/req/gwml2_flow	
<b>Dependency</b>	/conf/gwml2-core	
<b>Test</b>	/conf/gwml2-flow-feature	
	<b>Requirement</b>	/req/gwml2-core
	<b>Test purpose</b>	Ensure that GWML2-Flow contains a valid flow feature
	<b>Test Method</b>	Check that at least one of GW_IntraFlow, GW_Interflow, GW_Discharge or GW_Recharge is present.
	<b>Test type</b>	Capability

#### A.2.5 Conformance class : GWML 2.0 Well logical model

<b>Conformance Class</b>	/conf/gwml2-well	
<b>Requirements</b>	/req/gwml2-well	
<b>Dependency</b>	/conf/gwml2-core	
<b>Test</b>	/conf/gwml2-well/feature	
	<b>Requirement</b>	/req/gwml2-core
	<b>Test purpose</b>	Ensure that GWML2-Well contains a valid well feature
	<b>Test method</b>	Check that at least one of GW_Well, GW_MonitoringSite or GW_Spring is present
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/origin_elevation	
	<b>Requirement</b>	/req/gwml2-well/origin_elevation
	<b>Test purpose</b>	Ensure that the well has at least one gwReferenceElevation value of type Elevation and this Elevation with elevationType property has value "origin" represented by the string "http://www.opengis.net/req/gwml2-well/origin_elevation"

	<b>Test method</b>	Check, for each well instance, that it has at least one instance of Elevation that has elevation type = "http://www.opengis.net/req/gwml2-well/origin_elevation" and no other Elevation has this elevation type
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/waterwell_elevationCRS	
	<b>Requirement</b>	/req/gwml2-well/waterwell_elevationCRS
	<b>Test purpose</b>	Ensure that the all Elevation elevation geometry has relevant coordinate reference system.
	<b>Test method</b>	Check, for each well, Elevation instance and check the elevation geometry CRS identifier. Check that this identifier is a valid EPSG code in the EPSG database ( <a href="http://epsg.io">http://epsg.io</a> )
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/waterwell_shape_origin	
	<b>Requirement</b>	/req/gwml2-well/waterwell_shape_origin
	<b>Test purpose</b>	Ensure that the first vertex of the shape corresponds to the x,y of the well position and the z of the origin elevation
	<b>Test method</b>	Check that x,y value of the first vertex of the GW_Well:shape matches the GW_Well:gwWellLocation coordinates and the z value matches the only coordinate of the Elevation::elevation that correspond to /req/gwml2-well/origin_elevation.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/waterwell_shape_crs	
	<b>Requirement</b>	/req/gwml2-well/waterwell_shape_crs
	<b>Test purpose</b>	Ensure that the coordinate system of the shape, that is derived from the well position and the origin elevation, is a coherent and accept CRS
	<b>Test method</b>	Check in the EPSG database that a CRS made of the planar CRS of the gwWellLocation and the Elevation::elevation CRS, that correspond to /req/gwml2-well/origin_elevation, exists. Check that this is indeed the CRS reported by the geometry
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/waterwell_observation_foi	
	<b>Requirement</b>	/req/gwml2-well/waterwell_observation_foi
	<b>Test purpose</b>	Ensure that the an OM_Observation that is located along the bore path identifies the well as its featureOfInterest
	<b>Test method</b>	Check, for each candidate observation, that the featureOfInterest property has a value that correspond to well identifier (local or global)
	<b>Test type</b>	Capability

<b>Test</b>	/conf/gwml2-well/waterwell_observation_fromParam	
	<b>Requirement</b>	/req/gwml2-well/waterwell_observation_fromParam
	<b>Test purpose</b>	Ensure that the “from” distance is encoded correctly in the NamedParameter of OM_Observation
	<b>Test method</b>	For each Observation that is positioned relative to bore path, check that the value of om:parameter has an instance of om::NamedParameter with two components; the name must be the string “ <a href="http://www.opengis.net/req/gw_well/waterwell_observation_fromParam">http://www.opengis.net/req/gw_well/waterwell_observation_fromParam</a> ” and the distance from the origin must a instance of swe::Quantity, properly encoded according to /conf/gwml2-core/quantities_uom
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/waterwell_observation_toParam	
	<b>Requirement</b>	/req/gwml2-well/waterwell_observation_toParam
	<b>Test purpose</b>	Ensure that the “to” distance is encoded correctly in the NamedParameter of OM_Observation
	<b>Test method</b>	For each Observation that is positioned relative to bore path, check that the value of om:parameter has an instance of om::NamedParameter with two components. the name must be the string “ <a href="http://www.opengis.net/req/gw_well/waterwell_observation_toParam">http://www.opengis.net/req/gw_well/waterwell_observation_toParam</a> ” and the distance from the origin must a instance of swe::Quantity, properly encoded according to /conf/gwml2-core/quantities_uom
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/waterwell_sf_foi	
	<b>Requirement</b>	/req/gwml2-well/waterwell_sf_foi
	<b>Test purpose</b>	Ensure that the an SF_SamplingFeature that is located along the bore path identifies the well as its relatedSamplingFeature
	<b>Test method</b>	Check, for each candidate sampling feature, that the relatedSamplingFeature property has a value that correspond to the well (either inline or byReference)
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/waterwell_sf_fromParam	
	<b>Requirement</b>	/req/gwml2-well/waterwell_sf_fromParam
	<b>Test purpose</b>	Ensure that the “from” distance is encoded correctly in the NamedParameter of SF_SamplingFeature
	<b>Test method</b>	For each SamplingFeature that is positioned relative to bore path, check that the value of om:parameter has an instance of om::NamedParameter with two components; the name must be the string “ <a href="http://www.opengis.net/req/gw_well/waterwell_observation_fromParam">http://www.opengis.net/req/gw_well/waterwell_observation_fromParam</a> ” and the distance from the

		origin must a instance of swe::Quantity, properly encoded according to /conf/gwml2-core/quantities_uom
	<b>Test type</b>	Capability
<b>Test</b>		/conf/gwml2-well/waterwell_sf_toParam
	<b>Requirement</b>	/req/gwml2-well/waterwell_sf_toParam
	<b>Test purpose</b>	Ensure that the “to” distance is encoded correctly in the NamedParameter of SF_SamplingFeature
	<b>Test method</b>	For each sampling feature that is positioned relative to bore path, check that the value of om:parameter has an instance of om:NamedParameter with two components. the name must be the string “ <a href="http://www.opengis.net/req/gw_well/waterwell_observation_toParam">http://www.opengis.net/req/gw_well/waterwell_observation_toParam</a> ” and the distance from the origin must a instance of swe::Quantity, properly encoded according to /conf/gwml2-core/quantities_uom
	<b>Test type</b>	Capability
<b>Test</b>		/conf/gwml2-well/well_geology
	<b>Requirement</b>	/req/gwml2-well/well_geology
	<b>Test purpose</b>	Ensure that an association between a GW_Well and a GW_GeologyLog is only made using a gwWellGeology.
	<b>Test method</b>	Check that there are no occurrences of GW_Well/om:relatedObservation/GW_GeologyLog
	<b>Test type</b>	Capability
<b>Test</b>		/conf/gwml2-well/log_coverage
	<b>Requirement</b>	/req/gwml2-well/log_coverage
	<b>Test purpose</b>	Ensure that the om:result of GeologyLog is an instance of GW_GeologyLogCoverage
	<b>Test method</b>	Check the om:result of GeologyLog and check if it's an instance of GW_GeologyLogCoverage or any of its subtypes.
	<b>Test type</b>	Capability
<b>Test</b>		/conf/gwml2-well/log_ref_samplingFeature
	<b>Requirement</b>	/req/gwml2-well/samplingFeature
	<b>Test purpose</b>	Ensure that the GeologyLog has a featureOfInterest that has a GM_Curve geometry usable as a reference geometry to translate relative positions of LogValue into absolute positions.
	<b>Test method</b>	Check the GeologyLog::featureOfInterest is a SF_SF_SamplingCurve or one of its subtypes.



	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/geometry_origin	
	<b>Requirement</b>	/req/gwml2-well/geometry_origin
	<b>Test purpose</b>	Ensure the LogValue are positioned relative to the first vertex of the SF_SamplingCurve of the feature identified by GW_GeologyLog's feature if interest
	<b>Test method</b>	Compare coherence with source data
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/log_depth	
	<b>Requirement</b>	/req/gwml2-well/log_depth
	<b>Test purpose</b>	Ensure the LogValue depth (fromDepth or toDepth) is the linear distance from the origin of the GM_Curve
	<b>Test method</b>	Compare with the source data that the distance is correctly calculated
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/log_depth_order	
	<b>Requirement</b>	/req/gwml2-well/log_depth_order
	<b>Test purpose</b>	Ensure the fromDepth and toDepth are ordered correctly
	<b>Test method</b>	Check , for each LogValue, where both fromDepth and toDepth are not nil, that the fromDepth is less or equal to toDepth.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/earthMaterialLog	
	<b>Requirement</b>	/req/gwml2-well/earthMaterialLog
	<b>Test purpose</b>	Ensure that LogValue::value are compose of Record of a single field of swe:Category type
	<b>Test method</b>	Check that the target implementation of LogValue's value is compose of a swe:DataRecord containing a single instance of swe:Category
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well/monitoring_elevationCRS	
	<b>Requirement</b>	/req/gwml2-well/monitoring_elevationCRS
	<b>Test purpose</b>	Ensure that reference elevations geometries have a relevant CRS

	<b>Test method</b>	Check in the EPSG database that CRS of Elevation::elevation exists and is an elevation CRS.
	<b>Test type</b>	Capability

#### A.2.6 Conformance class GWML 2.0 Construction logical model

<b>Conformance Class</b>	<b>/conf/gwml2-construction</b>	
<b>Requirements</b>	<b>/req/ gwml2-construction</b>	
<b>Test</b>	<b>/conf/gwml2-construction/feature</b>	
	<b>Requirement</b>	<b>/req/gwml2-core</b>
	<b>Test purpose</b>	Ensure that GWML2-WellConstruction contains a valid well construction feature.
	<b>Test method</b>	Check that at least one of Borehole is present
	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/gwml2-construction /collar_elevation_CRS</b>	
	<b>Requirement</b>	<b>/req/gwml2-construction /collar_elevation_CRS</b>
	<b>Test purpose</b>	Ensure that the collar elevation geometry has a relevant CRS
	<b>Test method</b>	Check in the EPSG database that CRS of collarElevation exists and is an elevation CRS.
	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/gwml2-construction /construction_geometry_origin</b>	
	<b>Requirement</b>	<b>/req/gwml2-construction /construction_geometry_origin</b>
	<b>Test purpose</b>	Ensure that the origin of the construction items is the first vertex of the bore shape
	<b>Test method</b>	Check with source data if the relative positions matche
	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/gwml2-construction/construction_geometry_well</b>	
	<b>Requirement</b>	<b>/req/gwml2-construction/construction_geometry_well</b>

	<b>Test purpose</b>	Ensure that when a borehole is actually a well, the shape of the well must be the same as the borehole, and therefore they should share the same shape
	<b>Test method</b>	Check if a borehole is the value of a GW_Well::gwWellConstruction, Borehole:shape must refer to the GW_Well::shape using a pointer OR, if the encoding does not support byReference value, the Borehole::shape must be an exact copy of the GW_Well:shape
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-construction /log_depth	
	<b>Requirement</b>	/req/gwml2-construction/log_depth
	<b>Test purpose</b>	Ensure that construction component are positioned linearly from the first vertex of the bore shape, along its path
	<b>Test method</b>	Check that each construction components has a “from” and “to” value is between 0 (zero) and the length of Borehole::shape. If a value is unknown, a “nil” value can be used
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-construction/log_depth_order	
	<b>Requirement</b>	/req/gwml2-well/log_depth_order
	<b>Test purpose</b>	Ensure that ConstructionComponent’s “from” value is always less (closer to origin) than “to” value
	<b>Test method</b>	When both “from” and “to” are non nil, check that “from” is less than or equal to “to” value
	<b>Test type</b>	Capability

#### A.2.7 Conformance class : GWML 2.0 Vertical Well logical model

<b>Conformance Class</b>	/conf/gwml2-vertical-well	
<b>Requirements</b>	/req/gwml2-vertical-well	
<b>Dependency</b>	/conf/gwml2-well	
<b>Test</b>	/conf/gwml2-vertical-well/waterwell_shape	
	<b>Requirement</b>	/req/gwml2-vertical-well/waterwell_shape
	<b>Test purpose</b>	Ensure that the shape of a vertical well is made of only one segment (two vertices)
	<b>Test method</b>	Check that GW_Well::shape geometry has 6 and only 6 coordinates

	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-vertical-well/endvertex	
	<b>Requirement</b>	/req/gwml2-vertical-well/endvertex
	<b>Test purpose</b>	Ensure that the shape of the GW_Well is vertical
	<b>Test method</b>	Considering that the GW_Well:shape is composed of two 3D points, [x0,y0,z0] and [x1,y1,z1]. Check coordinates x1 == x0 and y1 == y0
	<b>Test type</b>	Capability

#### A.2.8 Conformance class : GWML 2.0 Geologic unit logs

<b>Conformance Class</b>	/conf/gwml2-well-gu	
<b>Requirements</b>	/req/gwml2-well-gu	
<b>Dependency</b>	/conf/gwml2-well	
<b>Test</b>	/conf/gwml2-well-gu/log_observed_property	
	<b>Requirement</b>	/req/gwml2-well-gu/log_observed_property
	<b>Test purpose</b>	Ensure that GeologicUnit logs use specific observedProperty identifier
	<b>Test method</b>	Check that GW_GeologyLog::observedProperty has value equal to " <a href="http://www.opengis.net/def/gwml/2.0/observedProperty/geologicUnit">http://www.opengis.net/def/gwml/2.0/observedProperty/geologicUnit</a> "
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well-gu/log-categories	
	<b>Requirement</b>	/req/gwml2-well-gu log-categories
	<b>Test purpose</b>	Ensure that LogValue::value are compose of Record of a single field of swe:Category type
	<b>Test method</b>	Check that the target implementation of LogValue's value is compose of a swe:DataRecord containing a single instance of swe:Category
	<b>Test type</b>	Capability

#### A.2.9 Conformance class : GWML 2.0 Earth material logs

<b>Conformance Class</b>	/conf/gwml2-well-em	
<b>Requirements</b>	/req/gwml2-well-em	
<b>Dependency</b>	/conf/gwml2-well	

<b>Test</b>	/conf/gwml2-well-em/log_observed_property	
	<b>Requirement</b>	/req/gwml2-well-em/log_observed_property
	<b>Test purpose</b>	Ensure that EarthMaterial logs use specific observedProperty identifier
	<b>Test method</b>	Check that GW_GeologyLog::observedProperty has value equal to " <a href="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial">http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial</a> "
	<b>Test type</b>	Capability
<b>Test</b>	/conf/gwml2-well-em/log-categories	
	<b>Requirement</b>	/req/gwml2-well-em/log-categories
	<b>Test purpose</b>	Ensure that LogValue::value are compose of Record of a single field of swe:Category type
	<b>Test method</b>	Check that the target implementation of LogValue's value is compose of a swe:DataRecord containing a single instance of swe:Category
	<b>Test type</b>	Capability

## A.3 Conformance classes – XML encoding

### A.3.1 Conformance classes : xml-rules

<b>Conformance Class</b>	<b>/conf/xsd-xml-rules</b>	
<b>Requirements</b>	<b>/req/xsd-xml-rules</b>	
<b>Dependency</b>	<b>08-131r3 Req 39</b>	
<b>Dependency</b>	<b>08-131r3 Req 40</b>	
<b>Test</b>	<b>/conf/xsd-xml-rules/W3C_XSD</b>	
	<b>Requirement</b>	<b>/req/xsd-xml-rules/ W3C_XSD</b>
	<b>Test purpose</b>	Ensure that the xml element are valid with XSD
	<b>Test method</b>	Use a XSD validation tool and check that validation does not return any error
	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/xsd-xml-rules/W3C_XSD</b>	
	<b>Requirement</b>	<b>/req/xsd-xml-rules/ISO-schematron</b>
	<b>Test purpose</b>	Ensure that the xml element are valid with schematron
	<b>Test method</b>	Use a schematron validation tool and check that validation does not return any error
	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/xsd-xml-rules/iso8601-time</b>	
	<b>Requirement</b>	<b>/req/xsd-xml-rules/iso8601-time</b>
	<b>Test purpose</b>	Ensure that all instance of date time, even in free text string, use the iso8601 encoding
	<b>Test method</b>	Inspect instance where date-time instance appears and check if they are encoded as iso8601
	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/xsd-xml-rules/time-zone</b>	
	<b>Requirement</b>	<b>/req/xsd-xml-rules/time-zone</b>

	<b>Test purpose</b>	Ensure that all time are flagged with time zone
	<b>Test method</b>	Inspect occurrence of date-time and check if it has a 4 digit character or a Z (Zulu). If absent, test fails
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-xml-rules/ <b>unit-of-measure</b>	
	<b>Requirement</b>	/req/xsd-xml-rules/ <b>unit-of-measure</b>
	<b>Test purpose</b>	Ensure that all swe:Quantity and OM_Measurement have a uom
	<b>Test method</b>	Validate the XML document using the schematron document <a href="http://schemas.opengis.net/gwml/2.0/xml-rules.sch">http://schemas.opengis.net/gwml/2.0/xml-rules.sch</a> . Passes if no errors are reported for 'unit-of-measure' test. Fails otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-xml-rules/ <b>swe-types</b>	
	<b>Requirement</b>	/req/xsd-xml-rules/ <b>swe-types</b>
	<b>Test purpose</b>	Ensure that certain swe common types are not used
	<b>Test method</b>	Validate the XML document using the schematron document <a href="http://schemas.opengis.net/gwml/2.0/xml-rules.sch">http://schemas.opengis.net/gwml/2.0/xml-rules.sch</a> . Passes if no errors are reported for 'swe-types' test. Fails otherwise
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-xml-rules/ <b>xlink-title</b>	
	<b>Requirement</b>	/req/xsd-xml-rules/ <b>xlink-title</b>
	<b>Test purpose</b>	Ensure that when xlink:href is used, a xlink:title is provided
	<b>Test method</b>	Validate the XML document using the schematron document <a href="http://schemas.opengis.net/gwml/2.0/xml-rules.sch">http://schemas.opengis.net/gwml/2.0/xml-rules.sch</a> . Passes if no errors are reported for 'xlink-title' test. Fails otherwise
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-xml-rules/ <b>identifier</b>	
	<b>Requirement</b>	/req/xsd-xml-rules/ <b>identifier</b>
	<b>Test purpose</b>	Ensure that gml:identifiers with codeSpace == <a href="http://www.ietf.org/rfc/rfc2616">http://www.ietf.org/rfc/rfc2616</a> have http URI that resolve
	<b>Test method</b>	Check that HTTP URI, when invoked returns an HTTP code between 200 and 203, or 300 and 305

	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/xsd-xml-rules/byrefproperty</b>	
	<b>Requirement</b>	<b>/req/xsd-xml-rules/byrefproperty</b>
	<b>Test purpose</b>	Ensure that a xlink:href to an external resource can resolve (as one of the processable format)
	<b>Test method</b>	Check that HTTP URI, when invoked returns an HTTP code between 200 and 203, or 300 and 305
	<b>Test type</b>	Capability

### A.3.2 Conformance classes : GWML2-Nucleus xml encoding

<b>Conformance Class</b>	<b>/conf/xsd-nucleus</b>	
<b>Requirements</b>	<b>/req/xsd-nucleus</b>	
<b>Dependency</b>	<b>/conf/xsd-flow</b>	
<b>Dependency</b>	<b>/conf/xsd-constituent</b>	
<b>Test</b>	<b>/conf/xsd-nucleus/xsd</b>	
	<b>Requirement</b>	<b>/req/xsd-nucleus/xsd</b>
	<b>Test purpose</b>	Ensure that all element under the namespace <a href="http://www.opengis.net/gwml-nucleus/2.0">http://www.opengis.net/gwml-nucleus/2.0</a> validates with schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-nucleus.xsd">http://schemas.opengis.net/gwml/2.0/gwml-nucleus.xsd</a>
	<b>Test method</b>	Use a XSD validator to validate the XML instance against schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-nucleus.xsd">http://schemas.opengis.net/gwml/2.0/gwml-nucleus.xsd</a> and check that no error are generate for elements under namespace <a href="http://www.opengis.net/gwml-nucleus/2.0">http://www.opengis.net/gwml-nucleus/2.0</a> or its dependencies. Pass if no errors reported. Fail otherwise
	<b>Test type</b>	Capability

### A.3.3 Conformance classes : GWML2-Constituent xml encoding

<b>Conformance Class</b>	<b>/conf/xsd-constituent</b>	
<b>Dependency</b>	<b>/conf/xsd-xml-rule</b>	
<b>Requirements</b>	<b>/req/xsd-constituent</b>	
<b>Test</b>	<b>/conf/xsd-constituent/xsd</b>	
	<b>Requirement</b>	<b>/req/xsd-constituent/xsd</b>



	<b>Test purpose</b>	Ensure that all element under the namespace <a href="http://www.opengis.net/gwml-constituent/2.0">http://www.opengis.net/gwml-constituent/2.0</a> validates with schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-constituent.xsd">http://schemas.opengis.net/gwml/2.0/gwml-constituent.xsd</a>
	<b>Test method</b>	Use a XSD validator to validate the XML instance against schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-constituent.xsd">http://schemas.opengis.net/gwml/2.0/gwml-constituent.xsd</a> and check that no error are generate for elements under namespace <a href="http://www.opengis.net/gwml-constituent/2.0">http://www.opengis.net/gwml-constituent/2.0</a> or its dependencies. Pass if no errors reported. Fail otherwise
	<b>Test type</b>	Capability

#### A.3.4 Conformance classes : GWML2-flow xml encoding

<b>Conformance Class</b>	<b>/conf/xsd-flow</b>	
<b>Dependency</b>	/conf/xsd-xml-rule	
<b>Requirements</b>	<b>/req/xsd-flow</b>	
<b>Test</b>	/conf/xsd-flow/xsd	
	<b>Requirement</b>	/req/xsd-flow/xsd
	<b>Test purpose</b>	Ensure that all element under the namespace <a href="http://www.opengis.net/gwml-flow/2.0">http://www.opengis.net/gwml-flow/2.0</a> validates with schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-flow.xsd">http://schemas.opengis.net/gwml/2.0/gwml-flow.xsd</a>
	<b>Test method</b>	Use a XSD validator to validate the XML instance against schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-flow.xsd">http://schemas.opengis.net/gwml/2.0/gwml-flow.xsd</a> and check that no error are generate for elements under namespace <a href="http://www.opengis.net/gwml-flow/2.0">http://www.opengis.net/gwml-flow/2.0</a> or its dependencies. Pass if no errors reported. Fail otherwise
	<b>Test type</b>	Capability

#### A.3.5 Conformance classes : GWML2-well xml encoding

<b>Conformance Class</b>	<b>/conf/xsd-well</b>	
<b>Dependency</b>	/conf/xsd-xml-rule	
<b>Dependency</b>	<b>/conf/xsd-construction</b>	
<b>Requirements</b>	<b>/req/xsd-well</b>	
<b>Test</b>	/conf/xsd-well/xsd	
	<b>Requirement</b>	/req/xsd-well/xsd
	<b>Test purpose</b>	Ensure that all element under the namespace <a href="http://www.opengis.net/gwml-well/2.0">http://www.opengis.net/gwml-well/2.0</a> validates with schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-well.xsd">http://schemas.opengis.net/gwml/2.0/gwml-well.xsd</a>

	<b>Test method</b>	Use a XSD validator to validate the XML instance against schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-well.xsd">http://schemas.opengis.net/gwml/2.0/gwml-well.xsd</a> and check that no error are generate for elements under namespace <a href="http://www.opengis.net/gwml-well/2.0">http://www.opengis.net/gwml-well/2.0</a> or its dependencies. Pass if no errors reported. Fail otherwise
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/origin_elevation	
	<b>Requirement</b>	/req/xsd-well/origin_elevation
	<b>Test purpose</b>	Ensure that the GW_Well instance has at least one origin Elevation
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well.sch">http://schema.opengis.net/gwml/2.0/gwml2-well.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/waterwell_elevationCRS	
	<b>Requirement</b>	/req/xsd-well/waterwell_elevationCRS
	<b>Test purpose</b>	Ensure that all Elevation have a relevant 1D vertical srsName
	<b>Test method</b>	Check the value of GW_Well/sam:gwWellReferenceElevation/Elevation/elevation/@srsName against EPSG database or CRS specification to Ensure it represents a 1D vertical SRS
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/obs_relative_pos_foi	
	<b>Requirement</b>	/req/xsd-well/obs_relative_pos_foi
	<b>Test purpose</b>	Ensure that all Observations that are located along the path of a bore shall refer to a SF_SamplingCurve as its featureOfInterest
	<b>Test method</b>	Check that om:OM_Observation/om:featureOfInterest/@xlink:href is a reference to a SF_SamplingCurve or one of its decendant.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/waterwell_observation_fromParam	
	<b>Requirement</b>	/req/xsd-well/waterwell_observation_fromParam
	<b>Test purpose</b>	Ensure that relative "from" position of an Observation is encoded in the om:parameter correctly.
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well.sch">http://schema.opengis.net/gwml/2.0/gwml2-well.sch</a> . Conformance passes if no error, fails otherwise

		Note, this is a partial test. It only tests that if a parameter having the correct URI is present, it must encode the distance as a Quantity
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/waterwell_observation_toParam	
	<b>Requirement</b>	/req/xsd-well/waterwell_observation_toParam
	<b>Test purpose</b>	Ensure that relative "to" position of an Observation is encoded in the om:parameter correctly
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well.sch">http://schema.opengis.net/gwml/2.0/gwml2-well.sch</a> . Conformance passes if no error, fails otherwise  Note, this is a partial test. It only tests that if a parameter having the correct URI is present, it must encode the distance as a Quantity
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/waterwell_sf_foi	
	<b>Requirement</b>	/req/xsd-well/waterwell_sf_foi
	<b>Test purpose</b>	Ensure that all SF_SamplingFeatures that are located along the path of a bore shall refer to a SF_SamplingCurve as its relatedSamplingFeature
	<b>Test method</b>	Check that sam:SF_SamplingFeature/sam:relatedSamplingFeature/sam:SamplingFeatureComplex/sam:relatedSamplingFeature/@xlink:href is a reference to a SF_SamplingCurve or one of its descendant
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/waterwell_sf_fromParam	
	<b>Requirement</b>	/req/xsd-well/waterwell_sf_fromParam
	<b>Test purpose</b>	Ensure that relative "from" position of an SF_SamplingFeature is encoded in the om:parameter correctly
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well.sch">http://schema.opengis.net/gwml/2.0/gwml2-well.sch</a> . Conformance passes if no error, fails otherwise  Note, this is a partial test. It only tests that if a parameter having the correct URI is present, it must encode the distance as a Quantity
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/waterwell_sf_toParam	
	<b>Requirement</b>	/req/xsd-well/waterwell_sf_toParam
	<b>Test purpose</b>	Ensure that relative "to" position of an Observation is encoded in the om:parameter correctly

	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well.sch">http://schema.opengis.net/gwml/2.0/gwml2-well.sch</a> . Conformance passes if no error, fails otherwise
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/well_geology	
	<b>Requirement</b>	/req/xsd-well/well_geology
	<b>Test purpose</b>	Ensure that GW_Well linkage to a GW_GeologyLog is done through a gwWellGeology
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well.sch">http://schema.opengis.net/gwml/2.0/gwml2-well.sch</a> . Conformance passes if no error, fails otherwise
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/log_coverage	
	<b>Requirement</b>	/req/xsd-well/log_coverage
	<b>Test purpose</b>	Ensure that the result of GW_GeologyLog is of type GW_GeologyLogCoverate
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well.sch">http://schema.opengis.net/gwml/2.0/gwml2-well.sch</a> . Conformance passes if no error, fails otherwise
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/log_ref_samplingFeature	
	<b>Requirement</b>	/req/xsd-well/log_ref_samplingFeature
	<b>Test purpose</b>	Ensure that the featureOfInterest of GW_GeologyLog must be a SF_SamplingCurve or one of its subtypes
	<b>Test method</b>	Check that the GW_GeologyLog/om:featureOfInterest/@xlink:href refers to an instance of GW_Well
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-well/log_depth_order	
	<b>Requirement</b>	/req/xsd-well/log_depth_order
	<b>Test purpose</b>	Ensure that "from" depth is less than "to" depth in LogValue
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well.sch">http://schema.opengis.net/gwml/2.0/gwml2-well.sch</a> . Conformance passes if no error, fails otherwise.

	<b>Test type</b>	Capability
<b>Test</b>		/conf/xsd-well/monitoring_elevationCRS
	<b>Requirement</b>	/req/xsd-well/monitoring_elevationCRS
	<b>Test purpose</b>	Ensure that the monitoring site elevation has relevant 1D vertical CRS
	<b>Test method</b>	Check the value of GW_Well/gwSiteReferenceElevation/Elevation/elevation/@srsName against EPSG database or CRS specification to Ensure it represents a 1D vertical SRS
	<b>Test type</b>	Capability

### A.3.6 Conformance classes : GWML2-construction xml encoding

<b>Conformance Class</b>	/conf/xsd-gwml-construction	
<b>Requirements</b>	/req/gwml2-construction	
<b>Dependency</b>	/conf/xsd-xml-rule	
<b>Test</b>	/conf/xsd-gwml-construction/xsd	
	<b>Requirement</b>	/req/xsd-gwml-construction/xsd
	<b>Test purpose</b>	Ensure that all element under the namespace <a href="http://www.opengis.net/gwml-construction/2.0">http://www.opengis.net/gwml-construction/2.0</a> validates with schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml2-construction.xsd">http://schemas.opengis.net/gwml/2.0/gwml2-construction.xsd</a>
	<b>Test method</b>	Use a XSD validator to validate the XML instance against schema located at <a href="http://schemas.opengis.net/gwml/2.0/gwml-well.xsd">http://schemas.opengis.net/gwml/2.0/gwml-well.xsd</a> and check that no error are generate for elements under namespace <a href="http://www.opengis.net/gwml-construction/2.0">http://www.opengis.net/gwml-construction/2.0</a> or its dependencies.  Pass if no errors reported. Fail otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-gw_construction/collar_elevation_CRS	
	<b>Requirement</b>	/req/xsd-gw_construction/collar_elevation_CRS
	<b>Test purpose</b>	Ensure that collar elevation uses a relevant 1D vertical CRS
	<b>Test method</b>	Check the values of BoreCollar/collarElevation/@srsName against EPSG database or CRS specification to Ensure it represents a 1D vertical SRS
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-gw_construction/depth_order	

	<b>Requirement</b>	<b>/req/xsd-gw_construction/depth_order</b>
	<b>Test purpose</b>	Ensure that “from” value are less than “to” values
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-construction.sch">http://schema.opengis.net/gwml/2.0/gwml2-construction.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability

### A.3.7 Conformance classes : GWML2-vertical well xml encoding

<b>Conformance Class</b>	<b>/conf/xsd-gwml-vertical-well</b>	
<b>Requirements</b>	<b>/req/gwml2-vertical-well</b>	
<b>Dependency</b>	<b>/conf/xsd-xml-rule</b>	
<b>Dependency</b>	<b>/conf/xsd-gwml-well</b>	
<b>Test</b>	<b>/conf/xsd-gwml-vertical-well/waterwell-shape</b>	
	<b>Requirement</b>	<b>/req/xsd-gwml-vertical-well/waterwell-shape</b>
	<b>Test purpose</b>	Ensure that the shape of the well is made of a single LineStringElement
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well-vertical.sch">http://schema.opengis.net/gwml/2.0/gwml2-well-vertical.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/xsd-gwml-vertical-well/endvertex</b>	
	<b>Requirement</b>	<b>/req/xsd-gwml-vertical-well/endvertex</b>
	<b>Test purpose</b>	Ensure that LineStringSegment is vertical (coincident x,y)
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well-vertical.sch">http://schema.opengis.net/gwml/2.0/gwml2-well-vertical.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	<b>/conf/xsd-gw_construction/depth_order</b>	
	<b>Requirement</b>	<b>/req/xsd-gw_construction/depth_order</b>
	<b>Test purpose</b>	Ensure that “from” value are less than “to” values
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-construction.sch">http://schema.opengis.net/gwml/2.0/gwml2-construction.sch</a> . Conformance passes if no error, fails otherwise.

	<b>Test type</b>	Capability
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### A.3.8 Conformance classes : GWML2 Geologic unit log xml encoding

<b>Conformance Class</b>	/conf/xsd-gwml-well-gu	
<b>Requirements</b>	/req/gwml2-well-gu	
<b>Dependency</b>	/conf/xsd-gwml-well	
<b>Test</b>	/conf/xsd-gwml-well-gu/log_observed_property	
	<b>Requirement</b>	/req/xsd-gwml-well-gu/log_observed_property
	<b>Test purpose</b>	Ensure that the GW_GeologyLog observedProperty is the correct value
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well-gu.sch">http://schema.opengis.net/gwml/2.0/gwml2-well-gu.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-gwml-well-gu/log-categories	
	<b>Requirement</b>	/req/xsd-gwml-well-gu/log-categories
	<b>Test purpose</b>	Ensure that the DataRecord is encoded correctly as single field of type Category
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well-gu.sch">http://schema.opengis.net/gwml/2.0/gwml2-well-gu.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-gwml-well-gu/definition	
	<b>Requirement</b>	/req/xsd-gwml-well-gu/definition
	<b>Test purpose</b>	Ensure that the swe:DataRecord definition is the correct value
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-gu.sch">http://schema.opengis.net/gwml/2.0/gwml2-gu.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability

### A.3.9 Conformance classes : GWML2 EarthMaterial log xml encoding

<b>Conformance Class</b>	/conf/xsd-gwml-well-em	
<b>Requirements</b>	/req/gwml2-well-em	
<b>Dependency</b>	/conf/xsd-gwml-well	
<b>Test</b>	/conf/xsd-gwml-well-em/log_observed_property	
	<b>Requirement</b>	/req/xsd-gwml-well-em/log_observed_property
	<b>Test purpose</b>	Ensure that the GW_GeologyLog observedProperty is the correct value
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well-em.sch">http://schema.opengis.net/gwml/2.0/gwml2-well-em.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-gwml-well-em/log-categories	
	<b>Requirement</b>	/req/xsd-gwml-well-em/log-categories
	<b>Test purpose</b>	Ensure that the DataRecord is encoded correctly as single field of type Category
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well-em.sch">http://schema.opengis.net/gwml/2.0/gwml2-well-em.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability
<b>Test</b>	/conf/xsd-gwml-well-em/definition	
	<b>Requirement</b>	/req/xsd-gwml-well-em/definition
	<b>Test purpose</b>	Ensure that the swe:DataRecord definition is the correct value
	<b>Test method</b>	Validate the XML document using the Schematron document <a href="http://schema.opengis.net/gwml/2.0/gwml2-well-em.sch">http://schema.opengis.net/gwml/2.0/gwml2-well-em.sch</a> . Conformance passes if no error, fails otherwise.
	<b>Test type</b>	Capability



## Annex B Use cases and requirements (informative)

<b>1. Commercial Use Case</b>	
<b>Summary</b>	<p>The commercial scenario involves serving data to allow water wells and springs to be found on a map, identified, and related information used to estimate the cost to complete a water supply well. For example, a consultant or water well driller could use a web client to investigate the local geology and inspect wells located near the target area. By investigating the the rock materials and water levels at each well in the web client, the consultant could infer the distance and materials to the water table, as well as the expected yield, and the driller could estimate the cost of drilling. The public is also impacted in this scenario, as they are able to assess online water well records and make independent estimates. This not only informs them about drilling potential, but it might also influence property purchases.</p> <p>Objective: serving water well and aquifer data so it can be used for commerical purposes such as to inform drilling.</p>
<b>Users/actors</b>	Public, Consultants, Drillers
<b>Information types</b>	<ul style="list-style-type: none"> <li>• water wells:             <ul style="list-style-type: none"> <li>○ <i>general</i>: id, source, location, elevation, length, water level, well purpope</li> <li>○ <i>logs</i>: depth interval, lithologies, porosity, hydraulic conductivity</li> </ul> </li> <li>• springs, etc.</li> <li>• aquifers:             <ul style="list-style-type: none"> <li>○ <i>general</i>: name, area,</li> <li>○ <i>geology</i>: formations, lithologies</li> <li>○ <i>properties</i>: confinement, media, water storage, sediment thickness, aquifer thickness, porosity,</li> </ul> </li> </ul>

	<p>conductivity</p> <ul style="list-style-type: none"> <li>○ <i>water balance</i>: aquifer recharge, aquifer discharge</li> <li>○ <i>water use</i>: yield, usage type, quality</li> <li>○ <i>risk</i>: physical vulnerability, threats</li> </ul>
<p><b>Actions</b></p>	<ul style="list-style-type: none"> <li>• A member of the public finds wells near their home.</li> <li>• A consultant examines the well-logs and aquifer info and determines there is groundwater potential.</li> <li>• A driller uses the well-logs and aquifer info to estimate depth to water for price estimate.</li> </ul>
<p><b>2. Policy Use Case</b></p>	
<p><b>Summary</b></p>	<p>The Water Framework Directive 2000/60/EC (WFD) requires all EU member states to achieve and preserve good status for all European waters, including groundwaters. Process to achieve WFD requirements includes definition and delineation of water bodies as management units, environmental monitoring, status assessment and finally developing river basin management plans.</p> <p>This use case describes process steps and interactions necessary for delivering data required to assess the groundwater bodies and thus fulfill the related EU reporting obligation. The activity includes: collection and evaluation of the geological and hydrogeological characteristics, as well as quantitative and qualitative monitoring of defined chemical and physical indicators and finally groundwater body overall status assessment.</p> <p>Delineation on WFD groundwater bodies, in many cases, is not done accordingly to their natural boundaries but usually follows administrative units.</p> <p>In order to better demonstrate interoperability the use case description covers also a cross border scenario. It defines the additional step of synchronizing of the collected information by two different member state water authorities. This integrating approach facilitates, promoted by WFD facilitates a coordinated assessment and planning</p>

	<p>of potential future measures.</p> <p>Objective: The provision of WFD required data and information on the trans-boundary groundwater body.</p>
<b>Users/actors</b>	Member state water authorities.
<b>Information types</b>	<ul style="list-style-type: none"> <li>• WFD River Basin District: <ul style="list-style-type: none"> <li>○ general: id, national code, parent river basin districts, name and area measurement</li> </ul> </li> <li>• WFD_Ground Water Body (GWB) <ul style="list-style-type: none"> <li>○ general: id (RBC-code), national code, name, location, protected area association</li> <li>○ pressures: pressure types</li> <li>○ impacts: impact types</li> <li>○ other impact: further pressure description, other impact description</li> <li>○ trend reversal: reversal trend, free text</li> <li>○ trend upward: upward trend, free text</li> <li>○ hydrogeological characteristics: GW layer, area, depth, thickness, depth range, geological formation, capacity, link surface water, link eco system</li> <li>○ quantitative status: quantitative status value, comment</li> <li>○ chemical status (qualitative): chemical status value, comment</li> <li>○ protected area status (optional): protected area code (unique), type of protection, Type of association, status value.</li> </ul> </li> </ul>
<b>Actions</b>	<ul style="list-style-type: none"> <li>• Step 1: Discovering and collecting initial information on hydrogeological, geological, chemical and physical data about the each groundwater body</li> <li>• Step 2: Preprocessing, syntactical and semantically transformation of the input information.</li> <li>• Step 3: Assessment of required output,</li> </ul>

	<ul style="list-style-type: none"> <li>• Step 4: Delivering of groundwater module for WFD reports</li> </ul>
<h3>3. Environmental Use Case</h3>	
<p><b>Summary</b></p>	<p>The role of groundwater in sustaining environmental values is of growing importance, particularly in arid countries such as Australia. Groundwater dependent ecosystems (GDE) include rivers, lakes, wetlands, estuaries, seeps, springs, <a href="#">phreatophytic vegetation</a>, <a href="#">cavernicolous</a> ecology and <a href="#">stygo fauna</a>. The key parameters are the depth to watertable, consistency of groundwater levels, groundwater fluxes to surface water, groundwater chemistry and groundwater biology.</p> <p>In many parts of Australia it is recognised that GDEs are vulnerable to the pressures on groundwater resources from activities such as mining, agriculture, urban and commercial developments. Within the Great Artesian Basin, the potential impacts of coal-seam gas extraction on groundwater and GDEs is of particular concern.</p> <p>An initial attempt at creating a national inventory of GDEs has recently been published as an interactive GDE Atlas on the Australian Bureau of Meteorology website <a href="http://www.bom.gov.au/water/groundwater/gde/map.shtml">http://www.bom.gov.au/water/groundwater/gde/map.shtml</a>.</p> <p>In some states, such as Victoria, proposed changes to legislation will provide a risk management framework to provide:</p> <ul style="list-style-type: none"> <li>• Protection of high-value GDEs when setting or adjusting permissible consumptive volumes,</li> <li>• The highest level of protection will be given to GDEs with high environmental values and a high risk of being affected by changes in groundwater levels,</li> <li>• GDEs with high environmental values that rely on regional and intermediate scale groundwater flow systems will be considered in groundwater management planning, and</li> <li>• GDEs with high environmental values that rely on the surface expression of local scale groundwater flow</li> </ul>

	<p>systems will be assessed on a site-by-site basis in the licensing regime.</p> <p>Objective: Serving the appropriate groundwater information to allow environmental managers, water managers and legislators to assess the risks to GDEs.</p>
<b>User communities/actors</b>	Water authorities, government departments, research organisations.
<b>Information types</b>	<ul style="list-style-type: none"> <li>• <i>Groundwater discharge feature</i>: point discharge (springs), line discharge (stream baseflow), areal discharge (seep, wetland, diffuse, biological) <ul style="list-style-type: none"> <li>○ <i>general</i>: id, type, name, location, length, area</li> <li>○ <i>environmental value</i>: status</li> </ul> </li> <li>• Groundwater levels (phreatic and potentiometric)</li> <li>• Groundwater chemistry: sample ID, date, method, field analyses (pH, EC, DO, etc.), laboratory analyses (major ions, minor ions, elements, etc.), isotopes, tracers.</li> <li>• Groundwater biology: microbiology, stygofauna</li> </ul>
<b>Actions</b>	<ul style="list-style-type: none"> <li>• A water authority assessing a groundwater licence application finds the nearest GDEs to investigate their types and environmental values.</li> <li>• A government department assesses the history of groundwater fluctuations around a GDE with high environmental values.</li> <li>• A research organisation investigates the groundwater heads, gradients and chemistry to determine the groundwater capture zone around a GDE at two points in time</li> </ul>
<b>4. Scientific Use Case</b>	
<b>Summary</b>	This use case involves the delivery of information required to help determine the flow of groundwater within a

	<p>particular terrain, likely for input into a computational flow modeling software, and model results. It involves the delivery of hydrogeologic and geophysical properties associated with hydrogeologic units (such as key aquifer properties), the delivery of observations related to those units, well characteristics (driller's log), information about the related water bodies and in some cases water use information.</p> <p>Objective:</p> <ul style="list-style-type: none"> <li>• Delivery of data for use in groundwater flow modeling software (e.g. MODFLOW, FEFLOW or ASPAR) <ul style="list-style-type: none"> <li>○ Data necessary for groundwater flow models: (May decide to incorporate only some of these data types) <ul style="list-style-type: none"> <li>▪ Data to complete Soil-Water Balance Model (hydrology &amp; terrestrial info: precipitation, temperature, land cover, land use, evapotranspiration, runoff)</li> <li>▪ Water body characteristics &amp; observations (stream flow, gw levels, sw levels)</li> <li>▪ Water use (pumping rates, diversion schedules)</li> <li>▪ Geophysical analysis (well construction, rock lithology and fractures, permeability and porosity, and water quality)</li> </ul> </li> </ul> </li> <li>• Delivery of groundwater flow model output <ul style="list-style-type: none"> <li>○ Coverage of heads &amp; fluxes</li> <li>○ Time series of flow and/or water level at points (wells &amp; springs)</li> </ul> </li> </ul>
<b>User communities/actors</b>	<ul style="list-style-type: none"> <li>• Groundwater modelers</li> <li>• Hydrogeologists</li> </ul>

<b>Actions</b>	<ul style="list-style-type: none"> <li>• Discovering, searching, displaying, analyzing and downloading characteristics for all groundwater bodies in a study area</li> <li>• Collecting geological, hydrogeological, physical and use/consumption data about each groundwater body</li> <li>• Completing a soil-water balance</li> <li>• Completing spatial and temporal analyses</li> <li>• Calculating heads &amp; fluxes in space and time</li> <li>• Calculating timeseries of flow or water level at points where data was collected (wells &amp; springs)</li> <li>• Visualization of gw flow and storage in time and space</li> </ul>
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<h2 style="text-align: center;">5. Technologic Use Case</h2>	
<b>Summary</b>	<p>Because of various technical and jurisdictional requirements, it is not possible, nor sought, to enforce a single physical model to all agencies managing groundwater related data. The international model developed in this IE is to meet interchange scenarios, not physical implementation. This implies that some sort of translation will happen between the existing models and the international model. The first step to achieve a translation is to identify the mapping between "private" models, those that are used by data providers, and the "public" model, which is used by the larger community.</p> <p>The objective of this use case is to document mappings between existing models: INSPIRE, GWML and HY_FEATURE and the international model. The objective of the UC is not to implement any working system but to identify and document in the most formally possible way how each feature and properties used by UC1 to UC4 can map to the international model. No formalism has been chosen at this point, but it is expected that part of the objective is to also evaluate the mapping methodology itself.</p>

	<p>The deliverable of this UC is a documentation, either as a human readable or machine readable format, that could potentially be used in the further implementation project. The mapping will be evaluation with regard to completeness, complexity , etc.. (parameters to be discussed)</p>
<b>User communities/actors</b>	<ul style="list-style-type: none"> <li>• Data providers: <ul style="list-style-type: none"> <li>○ INSPIRE GW model (EU)</li> <li>○ GWML (Groundwater Information Network)</li> <li>○ HY_Feature (WMO)</li> </ul> </li> </ul>
<b>Information types</b>	<p>Minimally:</p> <ul style="list-style-type: none"> <li>• Aquifer (including lithologic description and hydrogeologic properties)</li> <li>• Groundwater Body</li> <li>• Water Well, including water level</li> </ul>
<b>Actions</b>	<ul style="list-style-type: none"> <li>• Identify a mapping documentation method (ISO already propose, RDF / OWL is another possibility)</li> <li>• Identify a mapping evaluation method.</li> <li>• Flesh each model and map to international model.</li> </ul>



## Annex C XML Instance documents (informative)

### C.1 Introduction

This section illustrates Ground Water 2.0 using examples. Most examples are XML instances, but UML instance diagrams are also available as an alternative representation of some XML instances.

### C.2 GWML2-Nucleus

#### C.2.1 GW\_AquiferSystem

From NRCAN using a unit from GIN.

```
<?xml version="1.0" encoding="UTF-8"?>
<gwml2:GW_AquiferSystem xmlns:gu="http://xmlns.geosciml.org/GeologicUnit/3.2"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:gwml2="http://www.opengis.net/gwml-core/2.0"
xmlns:gwml2f="http://www.opengis.net/gwml-flow/2.0"
xmlns:gsmllem="http://xmlns.geosciml.org/EarthMaterial/3.2" xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-
Core/3.2" xmlns:gsmlpp="http://xmlns.geosciml.org/PhysicalProperties/3.2" gml:id="gin.1"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:swe="http://www.opengis.net/swe/2.0"
xmlns:gmd="http://www.isotc211.org/2005/gmd" xmlns:gco="http://www.isotc211.org/2005/gco"
xmlns:om="http://www.opengis.net/om/2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/gwml-core/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-core.xsd">
  <!-- Eric Boisvert, Geological Survey of Canada, 2014/06/05 *WORK IN PROGRESS* -->
  <gml:identifier codeSpace="http://gw-
info.net/identifiers">urn:db:ngwd:gw_data:hydrogeological_units:3</gml:identifier>
  <gml:name codeSpace="http://gw-info.net">Appalachian External Zone</gml:name>
  <gsml:observationMethod>
    <swe:Category>
      <swe:value>http://resource.geosciml.org/classifier/cgi/featureobservationmethod/synthesis_from_multiple_sour
ces</swe:value>
    </swe:Category>
  </gsml:observationMethod>
  <gsml:purpose>instance</gsml:purpose>
  <gsml:occurrence>
    <gsml:MappedFeature gml:id="gin.mf.1">
      <gsml:observationMethod>
        <swe:Category>
          <swe:value>http://resource.geosciml.org/classifier/cgi/featureobservationmethod/synthesis_from_multiple_sour
ces</swe:value>
        </swe:Category>
      </gsml:observationMethod>
      <gsml:positionalAccuracy>
        <swe:Quantity>
          <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>

```

```

        <swe:value>100</swe:value>
      </swe:Quantity>
    </gsml:positionalAccuracy>
    <gsml:resolutionScale>
      <gmd:MD_RepresentativeFraction>
        <gmd:denominator>
          <gco:Integer>100000</gco:Integer>
        </gmd:denominator>
      </gmd:MD_RepresentativeFraction>
    </gsml:resolutionScale>
    <gsml:samplingFrame xlink:href="http://resource.geosciml.org/feature/bgs/EarthBedrockSurface"/>
    <gsml:shape>
      <gml:Polygon gml:id="gin.mf.s.1">
        <gml:exterior>
          <gml:LinearRing>
            <gml:coordinates>-72.325447084382901,45.608588519094816 -
72.327301147319389,45.607134765361614 -...truncated </gml:coordinates>
          </gml:LinearRing>
        </gml:exterior>
      </gml:Polygon>
    </gsml:shape>
    <gsml:specification xlink:href="#gin.1"/>
    <gsml:metadata xsi:nil="true" gco:nilReason="missing"/>
  </gsml:MappedFeature>
</gsml:occurrence>
<gsml:relatedFeature nilReason="inapplicable"/>
<gsml:classifier nilReason="missing"/>
<gsml:metadata/>
<!-- we need to define our own hydrogeologic unit types -->
<gu:geologicUnitType xlink:href="http://resource.geosciml.org/classifier/cgi/geologicunittype/geologic_unit"
xlink:title="Hydrogeologic context"/>
<gu:bodyMorphology
xlink:href="http://resource.geosciml.org/classifier/cgi/geologicunitmorphology/layer_shape" xlink:title="Layers"/>
<gu:unitComposition>
  <swe:Category>
    <swe:value>Sedimentary</swe:value>
  </swe:Category>
</gu:unitComposition>
<gu:exposureColor xsi:nil="true" nilReason="inapplicable"/>
<gu:outcropCharacter xsi:nil="true" nilReason="unknown"/>
<gu:rank xsi:nil="true" nilReason="missing"/>
<gu:unitThickness xsi:nil="true" nilReason="unknown"/>
<!-- one detailed composition element -->
<gu:composition>
  <gu:CompositionPart>
    <gu:role nilReason="unknown"/>
    <gu:material>
      <gsmlem:RockMaterial gml:id="gin.1.rm.1">
        <gml:description>thin till unit followed by thin discontinuous sandy-gravelly coastal
sediments.</gml:description>
        <gml:name codeSpace="TB">Till</gml:name>
        <gsmlem:color xsi:nil="true" nilReason="unknown"/>
        <gsmlem:purpose>instance</gsmlem:purpose>
      </gsmlem:RockMaterial>
    </gu:material>
  </gu:CompositionPart>
</gu:composition>

```

```

    <gsmlem:physicalProperty xsi:nil="true" nilReason="missing"/>
    <gsmlem:geochemistry xsi:nil="true" nilReason="missing"/>
    <gsmlem:metadata/>
    <gsmlem:compositionCategory/>
    <gsmlem:geneticCategory/>
    <gsmlem:constituent/>
    <gsmlem:particleGeometry xsi:nil="true" nilReason="missing"/>
    <gsmlem:consolidationDegree/>
    <gsmlem:lithology/>
    <gsmlem:metamorphicProperties xsi:nil="true" nilReason="missing"/>
    <gsmlem:alterationProperties xsi:nil="true" nilReason="missing"/>
    <gsmlem:fabric xsi:nil="true" nilReason="missing"/>
  </gsmlem:RockMaterial>
</gu:material>
  <gu:proportion xsi:nil="true" nilReason="unknown"/>
</gu:CompositionPart>
</gu:composition>
<!-- generic, not sure it's legal to do this because the term that are referred don't provided explicitly the mandatory
properties, there should be a GeoSciML version of there guys -->
  <gu:composition>
    <gu:CompositionPart>
      <gu:role nilReason="unknown"/>
      <gu:material xlink:href="http://resource.geosciml.org/classifier/cgi/lithology/slate" xlink:title="Slate"/>
      <gu:proportion xsi:nil="true" nilReason="missing"/>
    </gu:CompositionPart>
  </gu:composition>
</gu:composition>
  <gu:CompositionPart>
    <gu:role nilReason="unknown"/>
    <gu:material xlink:href="http://resource.geosciml.org/classifier/cgi/lithology/shale" xlink:title="Shale"/>
    <gu:proportion xsi:nil="true" nilReason="missing"/>
  </gu:CompositionPart>
</gu:composition>
</gu:composition>
  <gu:CompositionPart>
    <gu:role nilReason="unknown"/>
    <gu:material xlink:href="http://resource.geosciml.org/classifier/cgi/lithology/sandstone"
xlink:title="Sandstone"/>
    <gu:proportion xsi:nil="true" nilReason="missing"/>
  </gu:CompositionPart>
</gu:composition>
</gu:composition>
  <gu:CompositionPart>
    <gu:role nilReason="unknown"/>
    <gu:material xlink:href="http://resource.geosciml.org/classifier/cgi/lithology/limestone"
xlink:title="Limestone"/>
    <gu:proportion xsi:nil="true" nilReason="missing"/>
  </gu:CompositionPart>
</gu:composition>
<!-- add more compositions -->
  <gu:metamorphicCharacter xsi:nil="true" nilReason="inapplicable"/>
</gu:part>
  <gu:GeologicUnitPart>

```

```

    <gu:role nilReason="unknown"/>
    <gu:proportion nilReason="unknown"/>
    <gu:containedUnit xlink:href="http://weblex.nrcan.gc.ca/html/013000/GSCC00053013643.html"
xlink:title="Shefford sandstone"/>
    </gu:GeologicUnitPart>
  </gu:part>
  <gu:part>
    <gu:GeologicUnitPart>
      <gu:role nilReason="unknown"/>
      <gu:proportion nilReason="unknown"/>
      <gu:containedUnit xlink:href="http://weblex.nrcan.gc.ca/html/011000/GSCC00053011797.html"
xlink:title="Philipsburg Group"/>
    </gu:GeologicUnitPart>
  </gu:part>
  <gu:part>
    <gu:GeologicUnitPart>
      <gu:role nilReason="unknown"/>
      <gu:proportion nilReason="unknown"/>
      <gu:containedUnit xlink:href="http://weblex.nrcan.gc.ca/html/016000/GSCC00053016984.html"
xlink:title="Stanbridge Group"/>
    </gu:GeologicUnitPart>
  </gu:part>
  <gu:part>
    <gu:GeologicUnitPart>
      <gu:role nilReason="unknown"/>
      <gu:proportion nilReason="unknown"/>
      <gu:containedUnit xlink:href="http://weblex.nrcan.gc.ca/html/008000/GSCC00053008289.html"
xlink:title="Laurier Group"/>
    </gu:GeologicUnitPart>
  </gu:part>
  <gu:part>
    <gu:GeologicUnitPart>
      <gu:role nilReason="unknown"/>
      <gu:proportion nilReason="unknown"/>
      <gu:containedUnit>
        <gu:GeologicUnit gml:id="gin.gu.drummyvilleOlitostrome">
          <gml:description>Dummondville Olitostrome or Drummyville Wildflysh lying at the base of
nappes</gml:description>
          <gml:name codeSpace="http://weblex.nrcan.gc.ca">unregistered</gml:name>
          <gsml:observationMethod>
            <swe:Category>
              <swe:value>http://resource.geosciml.org/classifier/cgi/featureobservationmethod/synthesis_from_multiple_sourc
es</swe:value>
            </swe:Category>
          </gsml:observationMethod>
          <gsml:purpose>typicalNorm</gsml:purpose>
          <gsml:relatedFeature xsi:nil="true" nilReason="inapplicable"/>
          <gsml:classifier xsi:nil="true" nilReason="unknown"/>
          <gsml:metadata xsi:nil="true"/>
        </gu:GeologicUnit>
      </gu:containedUnit>
    </gu:GeologicUnitPart>
  </gu:part>
</gu:GeologicUnitType
xlink:href="http://resource.geosciml.org/classifier/cgi/geologicunittype/lithostratigraphic_unit"
xlink:title="Lithostratigraphic unit"/>

```

```

    <gu:bodyMorphology>
      <swe:Category>

<swe:value>http://resource.geosciml.org/classifier/cgi/geologicunitmorphology/layer_shape</swe:value>
      </swe:Category>
    </gu:bodyMorphology>
    <gu:unitComposition xsi:nil="true" nilReason="missing"/>
    <gu:exposureColor xsi:nil="true" nilReason="missing"/>
    <gu:outcropCharacter xsi:nil="true" nilReason="missing"/>
    <gu:rank
xlink:href="http://resource.geosciml.org/classifier/cgi/stratigraphicrank/rank_not_specified" xlink:title="Rank not
specified"/>
      <gu:unitThickness xsi:nil="true" nilReason="missing"/>
      <gu:composition xsi:nil="true" nilReason="missing"/>
      <gu:metamorphicCharacter xsi:nil="true" nilReason="inapplicable"/>
      <gu:part xsi:nil="true" nilReason="inapplicable"/>
      <gu:physicalProperty xsi:nil="true" nilReason="missing"/>
      <gu:alterationCharacter xsi:nil="true" nilReason="missing"/>
      <gu:bedding xsi:nil="true" nilReason="missing"/>
      <gu:geochemistry xsi:nil="true" nilReason="unknown"/>
    </gu:GeologicUnit>
  </gu:containedUnit>
</gu:GeologicUnitPart>
</gu:part>
<gu:physicalProperty>
  <gsmllp:PhysicalDescription>
    <!-- definitively not the right SKOS entry, this is a THEME, not a observed property, must update our
SKOS dictionary -->
    <gsmllp:propertyName xlink:href="http://ngwd-bdnes.cits.nrcan.gc.ca/Reference/uri-
cgi/classifier/ca.gin/NRCanGroundWaterTopics/1404" xlink:title="Hydraulic Conductivity"/>
    <gsmllp:propertyMeasure>
      <swe:Quantity>
        <swe:description>Surficial units hydraulic conductivity</swe:description>
        <swe:quality>
          <swe:QuantityRange>
            <swe:uom xlink:href="http://sweet.jpl.nasa.gov/2.3/reprSciUnits.owl#meterPerSecond"
xlink:title="m/s"/>
              <swe:value>1.58 5.01</swe:value>
            </swe:QuantityRange>
          </swe:quality>
          <swe:uom xlink:href="http://sweet.jpl.nasa.gov/2.3/reprSciUnits.owl#meterPerSecond"
xlink:title="m/s"/>
            <swe:value>6.31</swe:value>
          </swe:Quantity>
        </gsmllp:propertyMeasure>
      </gsmllp:PhysicalDescription>
    </gu:physicalProperty>
  </gu:physicalProperty>
  <gsmllp:PhysicalDescription>
    <!-- definitively not the right SKOS entry, this is a THEME, not a observed property, must update our
SKOS dictionary -->
    <gsmllp:propertyName xlink:href="http://ngwd-bdnes.cits.nrcan.gc.ca/Reference/uri-
cgi/classifier/ca.gin/NRCanGroundWaterTopics/1404" xlink:title="Hydraulic Conductivity"/>

```

```

    <gsmlpp:propertyMeasure>
      <swe:Quantity>
        <swe:description>Hydraulic conductivity for the hydrogeological unit. The median value for
hydraulic conductivity is 10^-6.2 m/s, but it ranges from 10^-7.8 to 10^-4.8 m/s. Hydraulic regional conductivity
The decreasing trend of transmissivity with depth in the rock is observed in all contexts. The average hydraulic
conductivity is 10^-3.9 m/s near the top of bedrock (z = 1 m) which gradually loses an order of magnitude at a depth
of 10 m (10^-4.9 m/s), 25 m (10^-5.9 m/s), 60 m (10^-6.9 m/s) and 200 m (10^-7.9 m/s).</swe:description>
        <swe:uom xlink:href="http://sweet.jpl.nasa.gov/2.3/reprSciUnits.owl#meterPerSecond"
xlink:title="m/s"/>
        <swe:value>0.09</swe:value>
      </swe:Quantity>
    </gsmlpp:propertyMeasure>
  </gsmlpp:PhysicalDescription>
</gu:physicalProperty>
<gu:alterationCharacter xsi:nil="true" nilReason="unknown"/>
<gu:bedding xsi:nil="true" nilReason="missing"/>
<gu:geochemistry xsi:nil="true" nilReason="missing"/>
<gwml2:gwUnitMedia codeSpace="x">granular</gwml2:gwUnitMedia>
<gwml2:gwUnitWaterBudget xsi:nil="true"/>
<gwml2:gwUnitRecharge>
  <gwml2f:GW_Recharge gml:id="gin.richelieu.recharge.1">
    <gml:location>
      <gml:LocationString>Regional precipitation</gml:LocationString>
    </gml:location>
    <gwml2f:gwFlowPersistence nilReason="missing"/>
    <gwml2f:gwFlowProcess xlink:href="urn:Precipitation" xlink:title="Precipitation"/>
    <gwml2f:gwFlowTime><gml:TimePeriod
gml:id="gin.richelieu.recharge.1.ft"><gml:beginPosition>2012-04-01</gml:beginPosition><gml:endPosition>2013-
03-31</gml:endPosition></gml:TimePeriod></gwml2f:gwFlowTime>
    <gwml2f:gwFlowVelocity xsi:nil="true" nilReason="unknown"/>
    <gwml2f:gwFlowVolumeRate>
      <om:OM_Observation gml:id="gin.r.1">
        <gml:description>regional precipitation (not scope to this area)</gml:description>
        <om:phenomenonTime>
          <gml:TimePeriod gml:id="gin.r.1.tp">
            <gml:beginPosition>2012-04-01</gml:beginPosition>
            <gml:endPosition>2013-03-31</gml:endPosition>
          </gml:TimePeriod>
        </om:phenomenonTime>
        <om:resultTime>
          <gml:TimeInstant gml:id="gin.r.1.ti">
            <gml:timePosition>2013-03-31</gml:timePosition>
          </gml:TimeInstant>
        </om:resultTime>
        <om:validTime>
          <gml:TimePeriod gml:id="gin.r.1.tp2">
            <gml:beginPosition>2013-03-31</gml:beginPosition>
            <gml:endPosition indeterminatePosition="after"/>
          </gml:TimePeriod>
        </om:validTime>
        <om:procedure xsi:nil="true" nilReason="missing"/>
        <om:observedProperty xlink:href="http://dict.for/recharge" xlink:title="Precipitation"/>
        <om:featureOfInterest xlink:href="urn:geoscience.data.gc.ca:id:aquiferSystem:RichelieuYamaska"

```

```

xlink:title="Richelieu Yamaska Aquifer System"/>
  <om:result>
    <swe:Quantity>
      <swe:quality>
        <swe:QuantityRange>
          <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm-yr-1"/>
          <swe:value>1023.9 1306.5</swe:value>
        </swe:QuantityRange>
      </swe:quality>
      <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm-yr-1"/>
      <swe:value>1064.5</swe:value>
    </swe:Quantity>
  </om:result>
</om:OM_Observation>
</gwml2f:gwFlowVolumeRate>
<gwml2f:gwFlowDestinationBody xsi:nil="true" nilReason="missing"/>
<gwml2f:gwFlowDestinationContainer xsi:nil="true" nilReason="missing"/>
<!-- should point to an area ? the study area ? -->
<gwml2f:gwFlowLocation xsi:nil="true" nilReason="missing"/>
<gwml2f:gwFlowSourceBody xsi:nil="true" nilReason="inapplicable"/>
<gwml2f:gwFlowSourceContainer xsi:nil="true" nilReason="inapplicable"/>
</gwml2f:GW_Recharge>
</gwml2:gwUnitRecharge>
<gwml2:gwUnitRecharge>
  <gwml2f:GW_Recharge gml:id="gin.richelieu.recharge.2">
    <gml:location>
      <gml:LocationString>Noire River Valley</gml:LocationString>
    </gml:location>
    <gwml2f:gwFlowPersistence xsi:nil="true" nilReason="missing"/>
    <gwml2f:gwFlowProcess xlink:href="urn:Precipitation" xlink:title="Precipitation"/>
    <gwml2f:gwFlowTime><gml:TimePeriod
gml:id="gin.richelieu.recharge.2.ft"><gml:beginPosition>2012-04-01</gml:beginPosition><gml:endPosition>2013-
03-31</gml:endPosition></gml:TimePeriod></gwml2f:gwFlowTime>
    <gwml2f:gwFlowVelocity xsi:nil="true" nilReason="unknown"/>
    <gwml2f:gwFlowVolumeRate>
      <om:OM_Observation gml:id="gin.r.2">
        <gml:description>Region Recharge</gml:description>
        <om:phenomenonTime>
          <gml:TimePeriod gml:id="gin.r.2.tp">
            <gml:beginPosition>2012-04-01</gml:beginPosition>
            <gml:endPosition>2013-03-31</gml:endPosition>
          </gml:TimePeriod>
        </om:phenomenonTime>
        <om:resultTime>
          <gml:TimeInstant gml:id="gin.r.2.ti">
            <gml:timePosition>2013-03-31</gml:timePosition>
          </gml:TimeInstant>
        </om:resultTime>
        <om:validTime>
          <gml:TimePeriod gml:id="gin.r.2.tp2">
            <gml:beginPosition>2013-03-31</gml:beginPosition>
            <gml:endPosition indeterminatePosition="after"/>
          </gml:TimePeriod>

```

```

</om:validTime>
<om:procedure xsi:nil="true" nilReason="missing"/>
<om:observedProperty xlink:href="http://dict.for/recharge" xlink:title="Precipitation"/>
<om:featureOfInterest xlink:href="urn:geoscience.data.gc.ca:id:aquiferSystem:RichelieuYamaska"
xlink:title="Richelieu Yamaska Aquifer System"/>
<om:result>
  <swe:Quantity>
    <swe:quality>
      <swe:QuantityRange>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm-yr-1"/>
        <swe:value>0 417</swe:value>
      </swe:QuantityRange>
    </swe:quality>
    <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm-yr-1"/>
    <swe:value>114.7</swe:value>
  </swe:Quantity>
</om:result>
</om:OM_Observation>
</gwm2f:gwFlowVolumeRate>
<gwm2f:gwFlowDestinationBody xsi:nil="true" nilReason="missing"/>
<gwm2f:gwFlowDestinationContainer xsi:nil="true" nilReason="missing"/>
<!-- should point to an area ? the study area ? -->
<gwm2f:gwFlowLocation xsi:nil="true" nilReason="missing"/>
<gwm2f:gwFlowSourceBody xsi:nil="true" nilReason="inapplicable"/>
<gwm2f:gwFlowSourceContainer xsi:nil="true" nilReason="inapplicable"/>
</gwm2f:GW_Recharge>
</gwm2f:gwUnitRecharge>
<!-- UnitDischarge is of type interflow, that allows both Recharge and Discharge, because they are subtypes -->
<gwm2f:gwUnitDischarge>
  <gwm2f:GW_Discharge gml:id="gin.richelieu.discharge.1">
    <gml:name>Regional evapotranspiration</gml:name>
    <gml:location>
      <gml:LocationString>Yamaska study area</gml:LocationString>
    </gml:location>
    <gwm2f:gwFlowPersistence xsi:nil="true" nilReason="missing"/>
    <gwm2f:gwFlowProcess xlink:href="urn:Evapotranspiration" xlink:title="Evapotranspiration"/>
    <gwm2f:gwFlowTime><gml:TimePeriod gml:id="gin.richelieu.discharge.1.ft"><gml:beginPosition>2012-04-
01</gml:beginPosition><gml:endPosition>2013-03-
31</gml:endPosition></gml:TimePeriod></gwm2f:gwFlowTime>
    <gwm2f:gwFlowVelocity xsi:nil="true" nilReason="unknown"/>
    <gwm2f:gwFlowVolumeRate>
      <om:OM_Observation gml:id="gin.d.1">
        <gml:description>Region Recharge</gml:description>
        <om:phenomenonTime>
          <gml:TimePeriod gml:id="gin.d.1.tp">
            <gml:beginPosition>2012-04-01</gml:beginPosition>
            <gml:endPosition>2013-03-31</gml:endPosition>
          </gml:TimePeriod>
        </om:phenomenonTime>
        <om:resultTime>
          <gml:TimeInstant gml:id="gin.d.1.ti">
            <gml:timePosition>2013-03-31</gml:timePosition>
          </gml:TimeInstant>
        </om:resultTime>
      </om:OM_Observation>
    </gwm2f:gwFlowVolumeRate>
  </gwm2f:GW_Discharge>
</gwm2f:gwUnitDischarge>

```



```

</om:resultTime>
<om:validTime>
  <gml:TimePeriod gml:id="gin.d.1.tp2">
    <gml:beginPosition>2013-03-31</gml:beginPosition>
    <gml:endPosition indeterminatePosition="after"/>
  </gml:TimePeriod>
</om:validTime>
<om:procedure xsi:nil="true" nilReason="missing"/>
<om:observedProperty xlink:href="http://dict.for/evapotranspiration"
xlink:title="Evapotranspiration"/>
  <om:featureOfInterest xlink:href="urn:geoscience.data.gc.ca:id:aquiferSystem:RichelieuYamaska"
xlink:title="Richelieu Yamaska Aquifer System"/>
  <om:result>
    <swe:Quantity>
      <swe:quality>
        <swe:QuantityRange>
          <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm-yr-1"/>
          <swe:value>370 644.4</swe:value>
        </swe:QuantityRange>
      </swe:quality>
      <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm-yr-1"/>
      <swe:value>575</swe:value>
    </swe:Quantity>
  </om:result>
</om:OM_Observation>
</gwm12f:gwFlowVolumeRate>
<gwm12f:gwFlowDestinationBody xsi:nil="true" nilReason="missing"/>
<gwm12f:gwFlowDestinationContainer xsi:nil="true" nilReason="missing"/>
<!-- should point to an area ? the study area ? -->
<gwm12f:gwFlowLocation xsi:nil="true" nilReason="missing"/>
<gwm12f:gwFlowSourceBody xsi:nil="true" nilReason="inapplicable"/>
<gwm12f:gwFlowSourceContainer xsi:nil="true" nilReason="inapplicable"/>
</gwm12f:GW_Discharge>
</gwm12:gwUnitDischarge>
<gwm12:gwUnitDischarge>
  <gwm12f:GW_Discharge gml:id="gin.richelieu.discharge.2">
    <gml:name>Regional runoff</gml:name>
    <gml:location>
      <gml:LocationString>Yamaska study area</gml:LocationString>
    </gml:location>
    <gwm12f:gwFlowPersistence xsi:nil="true" nilReason="missing"/>
    <gwm12f:gwFlowProcess xlink:href="urn:Runoff" xlink:title="Runoff"/>
    <gwm12f:gwFlowTime><gml:TimePeriod
gml:id="gin.richelieu.discharge.2.ft"><gml:beginPosition>2012-04-
01</gml:beginPosition><gml:endPosition>2013-03-
31</gml:endPosition></gml:TimePeriod></gwm12f:gwFlowTime>
    <gwm12f:gwFlowVelocity xsi:nil="true" nilReason="unknown"/>
    <gwm12f:gwFlowVolumeRate>
      <om:OM_Observation gml:id="gin.d.2">
        <gml:description>Region Recharge</gml:description>
        <om:phenomenonTime>
          <gml:TimePeriod gml:id="gin.d.2.tp">
            <gml:beginPosition>2012-04-01</gml:beginPosition>

```

```

        <gml:endPosition>2013-03-31</gml:endPosition>
      </gml:TimePeriod>
    </om:phenomenonTime>
    <om:resultTime>
      <gml:TimeInstant gml:id="gin.d.2.ti">
        <gml:timePosition>2013-03-31</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:validTime>
      <gml:TimePeriod gml:id="gin.d.2.tp2">
        <gml:beginPosition>2013-03-31</gml:beginPosition>
        <gml:endPosition indeterminatePosition="after"/>
      </gml:TimePeriod>
    </om:validTime>
    <om:procedure xsi:nil="true" nilReason="missing"/>
    <om:observedProperty xlink:href="http://dict.for/runoff" xlink:title="Runoff"/>
    <om:featureOfInterest xlink:href="urn:geoscience.data.gc.ca:id:aquiferSystem:Richelieu Yamaska"
xlink:title="Richelieu Yamaska Aquifer System"/>
    <om:result>
      <swe:Quantity>
        <swe:quality>
          <swe:QuantityRange>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm-yr-1"/>
            <swe:value>79.2 1146.2</swe:value>
          </swe:QuantityRange>
        </swe:quality>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm-yr-1"/>
        <swe:value>460.2</swe:value>
      </swe:Quantity>
    </om:result>
  </om:OM_Observation>
</gwm12f:gwFlowVolumeRate>
<gwm12f:gwFlowDestinationBody xsi:nil="true" nilReason="missing"/>
<gwm12f:gwFlowDestinationContainer xsi:nil="true" nilReason="missing"/>
<!-- should point to an area ? the study area ? -->
<gwm12f:gwFlowLocation xsi:nil="true" nilReason="missing"/>
<gwm12f:gwFlowSourceBody xsi:nil="true" nilReason="inapplicable"/>
<gwm12f:gwFlowSourceContainer xsi:nil="true" nilReason="inapplicable"/>
</gwm12f:GW_Discharge>
</gwm12:gwUnitDischarge>

<gwm12:gwManagementArea>
  <gwm12:GW_ManagementArea gml:id="gin.mg.1">
    <gml:name>Yamaska Richelieu watershed</gml:name>
    <gwm12:gwAreaFeature xsi:nil="true" nilReason="missing"/>
    <gwm12:gwAreaShape nilReason="missing"/>
    <gwm12:gwAreaType>Watershed</gwm12:gwAreaType>
    <gwm12:gwAreaWaterBudget xsi:nil="true"/>
    <gwm12:gwAreaYield xsi:nil="true" nilReason="missing"/>
    <gwm12:gwManagedUnit xlink:href="#gin.1" xlink:title="Appalachian External Zone"/>
    <gwm12:gwManagedUnit xlink:href="urn:db.ngwd:gw_data:hydrogeological_units:1"
xlink:title="Southern St Lawrence Platform"/>
  </gwm12:GW_ManagementArea>
</gwm12:gwManagementArea>

```

```

    <gwm2:gwManagedUnit xlink:href="urn:db:ngwd:gw_data:hydrogeological_units:2"
xlink:title="Northern St Lawrence Platform"/>
    <gwm2:gwManagedUnit xlink:href="urn:db:ngwd:gw_data:hydrogeological_units:4"
xlink:title="Appalachian Internal zone"/>
    <gwm2:gwManagedUnit xlink:href="urn:db:ngwd:gw_data:hydrogeological_units:5"
xlink:title="Monteregian intrusions"/>
    <!-- I had to instanciate this guy to load the vulnerability info -->
    <gwm2:gwAreaBody>
      <gwm2:GW_FluidBody gml:id="gin.fb.1">
        <gml:description>General regional fluid body filling Richelieu Yamaska aquifer
</gml:description>
        <gwm2:gwBodyFlow xlink:href="#gin.richelieu.discharge.1" xlink:title="Evapotranspiration"/>
        <gwm2:gwBodyFlow xlink:href="#gin.richelieu.discharge.2" xlink:title="Runoff"/>
        <gwm2:gwBodyFlow xlink:href="#gin.richelieu.recharge.1" xlink:title="Precipitation"/>
        <gwm2:gwBodyFlow xlink:href="#gin.richelieu.recharge.2" xlink:title="Regional recharge"/>
        <gwm2:gwBodyMetadata xsi:nil="true" gco:nilReason="missing"/>
        <gwm2:gwBodyProperty xsi:nil="true" nilReason="unknown"/>
        <gwm2:gwBodyQuality>fresh-sulfurous</gwm2:gwBodyQuality>
        <gwm2:gwBodyShape xsi:nil="true" nilReason="unknown"/>
        <gwm2:gwBodyVolume xsi:nil="true" nilReason="missing"/>
        <gwm2:gwBodyVulnerability>
          <om:OM_Observation gml:id="gin.fb.1.1">
            <gml:description>Vulnerability</gml:description>
            <om:phenomenonTime>
              <gml:TimePeriod gml:id="gin.fb.1.1.tp">
                <gml:beginPosition>2012-04-01</gml:beginPosition>
                <gml:endPosition>2013-03-31</gml:endPosition>
              </gml:TimePeriod>
            </om:phenomenonTime>
            <om:resultTime>
              <gml:TimeInstant gml:id="gin.fb.1.1.ti">
                <gml:timePosition>2013-03-31</gml:timePosition>
              </gml:TimeInstant>
            </om:resultTime>
            <om:validTime>
              <gml:TimePeriod gml:id="gin.fb.1.1.tp2">
                <gml:beginPosition>2013-03-31</gml:beginPosition>
                <gml:endPosition indeterminatePosition="after"/>
              </gml:TimePeriod>
            </om:validTime>
            <!-- because drastic weighting can be tweaked, the procedure should point to a complete
SensorML description instead of a generic method identifier-->
            <om:procedure xlink:href="http://dict.for/drastic"/>
            <om:observedProperty xlink:href="http://dict.for/drasticvulnerability" xlink:title="Drastic
Vulnerability"/>
            <om:featureOfInterest xlink:href="#gin.fb.1" xlink:title="Yamaska Richelieu watershed"/>
            <om:result>
              <swe:Quantity>
                <swe:quality>
                  <swe:QuantityRange>
                    <!-- drastic is unit less -->
                    <swe:uom xlink:href="http://www.opengis.net/def/uom/nil"/>
                    <swe:value>77 187</swe:value>

```

```

        </swe:QuantityRange>
        </swe:quality>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/nil"/>
        <swe:value>142</swe:value>
    </swe:Quantity>
</om:result>
</om:OM_Observation>
</gwml2:gwBodyVulnerability>
<gwml2:gwFluidBodyUnit xlink:href="gin.1"/>
<gwml2:gwFluidBodyVoid xsi:nil="true" nilReason="missing"/>
<gwml2:gwBodySurface xsi:nil="true" nilReason="missing"/>
</gwml2:GW_FluidBody>
</gwml2:gwAreaBody>
<gwml2:gwAreaLicence xsi:nil="true"/>
</gwml2:GW_ManagementArea>
</gwml2:gwManagementArea>
<gwml2:gwAquiferSystemIsLayered>true</gwml2:gwAquiferSystemIsLayered>
<gwml2:gwAquiferSystemPart xsi:nil="true" nilReason="template"/>
</gwml2:GW_AquiferSystem>

```

## C.2.2 GW\_Aquifer

BRGM Aquifer from France's national BD LISA database (Base de Données des Limites des Systèmes Aquifères).

```

<?xml version="1.0" encoding="UTF-8"?>
<!--Sample XML file generated by XMLSpy v2007 rel. 3 sp1 (http://www.altova.com)-->
<gwml2:GW_Aquifer gml:id="BDLISA.139AF01" xsi:schemaLocation="http://www.opengis.net/gwml-nucleus/2.0
http://ngwd-bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-nucleus.xsd"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:gwml2f="http://www.opengis.net/gwml-flow/2.0"
xmlns:gwml2="http://www.opengis.net/gwml-nucleus/2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xmlns:gsmlm="http://xmlns.geosciml.org/EarthMaterial/3.2"
xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-Core/3.2"
xmlns:gsmlgu="http://xmlns.geosciml.org/GeologicUnit/3.2"
xmlns:gsmlpp="http://xmlns.geosciml.org/PhysicalProperties/3.2" xmlns:xlink="http://www.w3.org/1999/xlink">
<!-- Sylvain Grellet, BRGM (French Geological Survey), 2014/08/06 *WORK IN PROGRESS* -->
  <gml:description>Aquifer from national BD LISA (Base de Données des Limites des Systèmes Aquifères)
database </gml:description>
  <gml:identifiant
codeSpace="http://www.sandre.eaufrance.fr/urn.php?urn=urn:sandre:dictionnaire:SAQ::entite:EntiteHydroGeol:ress
ource:2::html">http://reseau.eaufrance.fr/geotraitements/bdlisa/files/entite/107AK01.pdf</gml:identifiant>
  <gml:name
codeSpace="http://www.sandre.eaufrance.fr/urn.php?urn=urn:sandre:dictionnaire:SAQ::entite:EntiteHydroGeol:ress
ource:2::html">Calcaires de Brie du Rupélien (Oligocène inf.) du Bassin Parisien (bassin Seine-Normandie et Loire-
Bretagne)</gml:name>
  <gsml:observationMethod/>
  <gsml:purpose>instance</gsml:purpose>
  <gsml:relatedFeature xlink:href="http://reseau.eaufrance.fr/geotraitements/bdlisa/files/entite/107.pdf"
xlink:title="Grand système multicouche de l'Oligo-Miocène du Bassin Parisien"><!-- NOTE SG : Should point by

```

```

reference to the service that provides the feature not the pdf --></gsml:relatedFeature>
  <gsml:classifier xsi:nil="true" nilReason="unknown"/>
  <gsml:metadata xsi:nil="true"/>
  <gsmlgu:geologicUnitType/>
  <gsmlgu:bodyMorphology xsi:nil="true" nilReason="unknown" />
  <gsmlgu:unitComposition xsi:nil="true" nilReason="unknown" />
  <gsmlgu:exposureColor xsi:nil="true" nilReason="inapplicable" />
  <gsmlgu:outcropCharacter xsi:nil="true" nilReason="inapplicable" />
  <gsmlgu:rank xsi:nil="true" nilReason="unknown" />
  <gsmlgu:unitThickness xsi:nil="true" nilReason="unknown" />
  <gsmlgu:composition> <!-- TODO SG : geol description here -->
    <gsmlgu:CompositionPart>
      <gsmlgu:role/>
      <gsmlgu:material/>
      <gsmlgu:proportion/>
    </gsmlgu:CompositionPart>
  </gsmlgu:composition>
  <gsmlgu:metamorphicCharacter xsi:nil="true" nilReason="unknown"/>
  <gsmlgu:part xsi:nil="true" nilReason="unknown"/>
  <gsmlgu:physicalProperty xsi:nil="true" nilReason="unknown"/>
  <gsmlgu:alterationCharacter xsi:nil="true" nilReason="unknown"/>
  <gsmlgu:bedding xsi:nil="true" nilReason="unknown" />
  <gsmlgu:geochemistry xsi:nil="true" nilReason="unknown"/>
  <gwml2:gwUnitMedia codeSpace="urn:ogc:PorosityTypeTerm">Mixed</gwml2:gwUnitMedia> <!-- NOTE SG
: Double porosité : matricielle et de fissures -->
  <!--<gwml2:gwUnitMedia xlink:href="http://www.opengis.net/req/gwml2-nucleus/PorosityTypeTerm"
xlink:title="Mixed"/>NOTE SG : in anticipation for the attribute to be typed gml:ReferenceType-->
  <gwml2:gwUnitWaterBudget xsi:nil="true"/>
  <gwml2:gwUnitRecharge xsi:nil="true" nilReason="unknown"/>
  <gwml2:gwUnitDischarge xsi:nil="true" nilReason="unknown"/>
  <gwml2:gwAquiferType codeSpace="urn:ogc:AquiferTypeTerm">Semi-confined</gwml2:gwAquiferType> <!--
- NOTE SG : Entité hydrogéologique à parties libres et captives -->
  <gwml2:gwAquiferIsExploited>>false</gwml2:gwAquiferIsExploited>
  <gwml2:gwAquiferIsMain>true</gwml2:gwAquiferIsMain>
</gwml2:GW_Aquifer>

```

### C.2.3 GW\_ManagementArea

From BRGM based on the EU Water Framework Directive Ground Water Body.

```
<?xml version="1.0" encoding="UTF-8"?>
<!--Sample XML file generated by XMLSpy v2007 rel. 3 sp1 (http://www.altova.com)-->
<gwml2:GW_ManagementArea gml:id="MasseDEauSouterraine.GG081"
xsi:schemaLocation="http://www.opengis.net/gwml-nucleus/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-nucleus.xsd" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:gwml2f="http://www.opengis.net/gwml-flow/2.0" xmlns:gwml2="http://www.opengis.net/gwml-nucleus/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xlink="http://www.w3.org/1999/xlink">
<!-- Sylvain Grellet, BRGM (French Geological Survey), 2014/08/06 *WORK IN PROGRESS* -->
  <gml:description>EU Water Framework Directive WaterBody</gml:description>
  <gml:identifier
codeSpace="http://www.sandre.eaufrance.fr/urn.php?urn=urn:sandre:dictionnaire:MDO::entite:MasseDEauSouterrai
ne:ressource:1.2::html#">http://www.adeseaufrance.fr/fmasseseau/2009/FRGG081.pdf</gml:identifier><!--TODO
SG : Mettre URL appel du point d'eau-->
  <gml:name
codeSpace="http://www.sandre.eaufrance.fr/urn.php?urn=urn:sandre:dictionnaire:MDO::entite:MasseDEauSouterrai
ne:ressource:1.2::htm#">Sables et grès du Cénomaniens sarthois</gml:name>
  <gwml2:gwAreaFeature xsi:nil="true" nilReason="unknown" />
  <gwml2:gwAreaShape>
    <gml:Polygon gml:id="MasseDEauSouterraine.GG081.geom"></gml:Polygon> <!-- TODO SG : dump the
geometry from the WFS request-->
  </gwml2:gwAreaShape>
  <gwml2:gwAreaType xlink:href="http://www.opengis.net/req/gwml2-well/WaterWellUseTypeTerm"
xlink:title="EU WFD Ground Water Body"/><!-- Filled as if was of type ReferenceType-->
  <gwml2:gwAreaWaterBudget xsi:nil="true" />
  <gwml2:gwAreaYield xsi:nil="true" nilReason="inapplicable"/>
  <gwml2:gwManagedUnit xsi:nil="true" nilReason="missing"/>
  <gwml2:gwAreaLicence xsi:nil="true"/>
</gwml2:GW_ManagementArea>
```

## C.3 GWML2-Constituent - empty

### C.4 GWML2-Flow

#### C.4.1 GW\_WaterBudget

From GNS New Zealand.

```
<xml-fragment xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:gwml2f="http://www.opengis.net/gwml-flow/2.0" xmlns:om="http://www.opengis.net/om/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gwml-flow/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-flow.xsd">
```

```

<gwml2f:GW_WaterBudget>
  <gwml2f:gwBudgetAmount>
    <om:OM_Observation gml:id="om_budget_1432124_1">
      <gml:description>estimated water budget in Horowhenua area</gml:description>
      <gml:name codeSpace="http://gns.cri.nz/client_reports">2010-22</gml:name>
      <om:phenomenonTime>
        <gml:TimePeriod gml:id="om_budget_1432124_ti_1">
          <gml:beginPosition>2009-01-01T00:00:00</gml:beginPosition>
          <gml:endPosition>2010-01-01T00:00:00</gml:endPosition>
        </gml:TimePeriod>
      </om:phenomenonTime>
      <om:resultTime>
        <gml:TimeInstant gml:id="om_budget_1432124_ti_2">
          <gml:timePosition>2010-06-30T12:00:00</gml:timePosition>
        </gml:TimeInstant>
      </om:resultTime>
      <om:procedure xlink:href="http://gns.cri.nz/consultancy" xlink:title="Commercial Research"/>
      <om:observedProperty xlink:href="http://some.vocab/water-budget" xlink:title="Water Budget"/>
      <om:featureOfInterest xlink:href="#om_budget_1432124_1"/>
      <om:result>
        <om:result xmlns:ns="http://www.opengis.net/swe/2.0" xsi:type="ns:QuantityType">
          <ns:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m3" xlink:title="cubic meters"/>
          <ns:value>0.0</ns:value>
        </om:result>
      </om:result>
    </om:OM_Observation>
  </gwml2f:gwBudgetAmount>
  <gwml2f:gwBudgetDischarge xsi:nil="true" nilReason="withheld"/>
  <gwml2f:gwBudgetRecharge>
    <gwml2f:GW_Recharge gml:id="qin_all_1">
      <gml:description>in-flow into study area, combined from prec, gw, surface</gml:description>
      <gwml2f:gwFlowPersistence xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="notspecified"/>
      <gwml2f:gwFlowProcess xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="infiltration"/>
      <gwml2f:gwFlowTime>
        <gml:TimePeriod gml:id="flowt_qin_all_1">
          <gml:beginPosition>2009-01-01T00:00:00</gml:beginPosition>
          <gml:endPosition>2010-01-01T00:00:00</gml:endPosition>
        </gml:TimePeriod>
      </gwml2f:gwFlowTime>
      <gwml2f:gwFlowVelocity xsi:nil="true"/>
      <gwml2f:gwFlowVolumeRate>
        <om:OM_Observation gml:id="om_flowt_qin_all_1">
          <gml:description>estimated water inflow over all</gml:description>
          <gml:name codeSpace="http://gns.cri.nz/">combined-inflow</gml:name>
          <om:phenomenonTime>
            <gml:TimePeriod gml:id="om_flowt_qin_all_1_ti_1">
              <gml:beginPosition>2009-01-01T00:00:00</gml:beginPosition>
              <gml:endPosition>2010-01-01T00:00:00</gml:endPosition>
            </gml:TimePeriod>
          </om:phenomenonTime>
          <om:resultTime>
            <gml:TimeInstant gml:id="om_flowt_qin_all_1_ti_2">
              <gml:timePosition>2010-06-30T12:00:00</gml:timePosition>
            </gml:TimeInstant>
          </om:resultTime>
        </om:OM_Observation>
      </gwml2f:gwFlowVolumeRate>
    </gwml2f:GW_Recharge>
  </gwml2f:gwBudgetRecharge>

```



```

    </gml:TimeInstant>
  </om:resultTime>
  <om:procedure xlink:href="http://gns.cri.nz/consultancy" xlink:title="Commercial Research"/>
  <om:observedProperty xlink:href="http://some.vocab/water-budget" xlink:title="Water Budget"/>
  <om:featureOfInterest xlink:href="http://the.gwhdrogeounit.x" xlink:title="Hydrogeological Unit"/>
  <om:result>
    <om:result xmlns:ns="http://www.opengis.net/swe/2.0" xsi:type="ns:QuantityType">
      <ns:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/million_cubic_metres_per_year"
xlink:title="Million Cubik Meters per Year"/>
      <ns:value>326.7</ns:value>
    </om:result>
  </om:result>
</om:OM_Observation>
</gwml2f:gwFlowVolumeRate>
<gwml2f:gwFlowDestinationBody xlink:href="http://the.gwwaterbody.x" xlink:title="Water body in
aquifersystem"/>
<gwml2f:gwFlowDestinationContainer xlink:href="http://the.gwhdrogeounit.x" xlink:title="Hydrogeological
Unit"/>
  <gwml2f:gwFlowLocation>
    <gml:Polygon gml:id="pol_study_horo1">
      <gml:interior>
        <gml:LinearRing>
          <gml:coordinates cs="," ts=" " decimal=".">175.2349,-40.4954 175.2382,-40.4962 175.2406,-40.496 ...
truncated </gml:coordinates>
        </gml:LinearRing>
      </gml:interior>
    </gml:Polygon>
  </gwml2f:gwFlowLocation>
  <gwml2f:gwFlowSourceBody xlink:href="http://the.environment" xlink:title="natural environment"/>
  <gwml2f:gwFlowSourceContainer xlink:href="http://the.environment" xlink:title="natural environment"/>
</gwml2f:GW_Recharge>
</gwml2f:gwBudgetRecharge>
<gwml2f:gwBudgetValidTime>
  <gml:TimePeriod gml:id="wbom_tp_1">
    <gml:beginPosition>2009-01-01T00:00:00</gml:beginPosition>
    <gml:endPosition>2010-01-01T00:00:00</gml:endPosition>
  </gml:TimePeriod>
</gwml2f:gwBudgetValidTime>
</gwml2f:GW_WaterBudget>
</xml-fragment>

```



## C.4.2 GW\_Recharge

From GNS NZ description of inflow to a groundwater catchment.

```
<gwml2f:GW_Recharge xmlns:gwml2f="http://www.opengis.net/gwml-flow/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:om="http://www.opengis.net/om/2.0"
xsi:schemaLocation="http://www.opengis.net/gwml-flow/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-flow.xsd" gml:id="qin_all_1">
  <gml:description>in-flow into study area, combined from prec, gw, surface</gml:description>
  <gwml2f:gwFlowPersistence xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="notspecified"/>
  <gwml2f:gwFlowProcess xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="infiltration"/>
  <gwml2f:gwFlowTime>
    <gml:TimePeriod gml:id="flowt_qin_all_1">
      <gml:beginPosition>2009-01-01T00:00:00</gml:beginPosition>
      <gml:endPosition>2010-01-01T00:00:00</gml:endPosition>
    </gml:TimePeriod>
  </gwml2f:gwFlowTime>
  <gwml2f:gwFlowVelocity xsi:nil="true"/>
  <gwml2f:gwFlowVolumeRate>
    <om:OM_Observation gml:id="om_flowt_qin_all_1">
      <gml:description>estimated water inflow over all</gml:description>
      <gml:name codeSpace="http://gns.cri.nz/">combined-inflow</gml:name>
      <om:phenomenonTime>
        <gml:TimePeriod gml:id="om_flowt_qin_all_1_ti_1">
          <gml:beginPosition>2009-01-01T00:00:00</gml:beginPosition>
          <gml:endPosition>2010-01-01T00:00:00</gml:endPosition>
        </gml:TimePeriod>
      </om:phenomenonTime>
      <om:resultTime>
        <gml:TimeInstant gml:id="om_flowt_qin_all_1_ti_2">
          <gml:timePosition>2010-06-30T12:00:00</gml:timePosition>
        </gml:TimeInstant>
      </om:resultTime>
      <om:procedure xlink:href="http://gns.cri.nz/consultancy" xlink:title="Commercial Research"/>
      <om:observedProperty xlink:href="http://some.vocab/water-budget" xlink:title="Water Budget"/>
      <om:featureOfInterest xlink:href="http://the.gwhdrogeounit.x" xlink:title="Hydrogeological Unit"/>
      <om:result>
        <om:result xmlns:ns="http://www.opengis.net/swe/2.0" xsi:type="ns:QuantityType">
          <ns:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/million_cubic_metres_per_year"
xlink:title="Million Cubik Meters per Year"/>
          <ns:value>326.7</ns:value>
        </om:result>
      </om:result>
    </om:OM_Observation>
  </gwml2f:gwFlowVolumeRate>
  <gwml2f:gwFlowDestinationBody xlink:href="http://the.gwaterbody.x" xlink:title="Water body in
aquifersystem"/>
  <gwml2f:gwFlowDestinationContainer xlink:href="http://the.gwhdrogeounit.x" xlink:title="Hydrogeological
Unit"/>
  <gwml2f:gwFlowLocation>
```

```
<gml:Polygon gml:id="pol_study_horo1">
  <gml:interior>
    <gml:LinearRing>
      <gml:coordinates cs="," ts=" " decimal=".">175.2349,-40.4954 175.2382,-40.4962 ...
truncated</gml:coordinates>
    </gml:LinearRing>
  </gml:interior>
</gml:Polygon>
</gwml2f:gwFlowLocation>
<gwml2f:gwFlowSourceBody xlink:href="http://the.environment" xlink:title="natural environment"/>
<gwml2f:gwFlowSourceContainer xlink:href="http://the.environment" xlink:title="natural environment"/>
</gwml2f:GW_Recharge>
```

### C.4.3 GW\_Discharge, GW\_Recharge

From FedUni AU: GW\_Discharge, GW\_Recharge based on January 1993 Lake Murdeduke data.

```
<?xml version="1.0" encoding="UTF-8"?>
<gml:FeatureCollection gml:id="feduni.GW_InterFlow" xmlns:gww="http://www.opengis.net/gwml-well/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:sam="http://www.opengis.net/sampling/2.0"
xmlns:sams="http://www.opengis.net/samplingSpatial/2.0" xmlns:gu="http://xmlns.geosciml.org/GeologicUnit/3.2"
xmlns:gwml2="http://www.opengis.net/gwml-nucleus/2.0" xmlns:gwml2f="http://www.opengis.net/gwml-
flow/2.0" xmlns:gwml2wc="http://www.opengis.net/gwml-wellconstruction/2.0"
xmlns:gsmlem="http://xmlns.geosciml.org/EarthMaterial/3.2" xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-
Core/3.2" xmlns:gsmlpp="http://xmlns.geosciml.org/PhysicalProperties/3.2"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:swe="http://www.opengis.net/swe/2.0"
xmlns:gmd="http://www.isotc211.org/2005/gmd" xmlns:gco="http://www.isotc211.org/2005/gco"
xmlns:cv="http://www.opengis.net/cv/0.2/gml32" xmlns:om="http://www.opengis.net/om/2.0"
xmlns:spec="http://www.opengis.net/samplingSpecimen/2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation="http://www.opengis.net/gwml/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2.xsd http://www.opengis.net/samplingSpecimen/2.0
http://schemas.opengis.net/samplingSpecimen/2.0/specimen.xsd">
  <gml:featureMember>
    <!-- First featureMember is an example of GW_Discharge -->
    <gwml2f:GW_Discharge gml:id="lake-murdeduke-discharge-zone_19930101">
      <gml:description>Example Interflow instance of fluid flow from Tertiary-Quaternary Basalt Aquifer to
Lake Murdeduke based on data from Jane Coram MSc 1996</gml:description>
      <gml:identifier
codeSpace="http://www.ietf.org/rfc/rfc2616">http://groundwater.feduni.edu/flowsystem/feduni/lake-murdeduke-
discharge-zone_19930101</gml:identifier>
      <gml:name>Lake Murdeduke western discharge zone January 1993</gml:name>
      <gwml2f:gwFlowPersistence xlink:title="perennial"/>
      <gwml2f:gwFlowProcess xlink:title="baseflow"/>
      <gwml2f:gwFlowTime>
        <gml:TimePeriod gml:id="January1993">
          <gml:beginPosition xmlns="http://www.opengis.net/gml/3.2">1993-01-01</gml:beginPosition>
          <gml:endPosition xmlns="http://www.opengis.net/gml/3.2">1993-01-31</gml:endPosition>
        </gml:TimePeriod>
      </gwml2f:gwFlowTime>
      <gwml2f:gwFlowVelocity>
        <om:OM_Observation gml:id="lake-murdeduke-discharge-zone_19930101-FlowVelocity">
          <om:phenomenonTime xlink:href="#January1993"/>
          <om:resultTime xlink:href="#January1993"/>
          <om:procedure xlink:title="V=Ki/n"/>
          <om:observedProperty xlink:title="flow velocity"/>
          <om:featureOfInterest/>
          <om:result>
            <swe:Quantity>
              <swe:uom xlink:title="metres per month" code="m/mth"/>
              <swe:value>2.2</swe:value>
            </swe:Quantity>
          </om:result>
        </om:OM_Observation>
      </gwml2f:gwFlowVelocity>
    </gml:featureMember>
  </gml:FeatureCollection>
```

```

<gwml2f:gwFlowVolumeRate>
  <om:OM_Observation gml:id="lake-murdeduke-discharge-zone_19930101_FlowVolumeRate">
    <om:phenomenonTime xlink:href="January1993"/>
    <om:resultTime xlink:title="#January1993"/>
    <om:procedure xlink:title="flow net calculation"/>
    <om:observedProperty xlink:href="" xlink:title="GWML2-Flow:gwFlowVolumeRate"/>
    <om:featureOfInterest xlink:href="#"/>
    <om:result>
      <swe:Quantity>
        <swe:uom xlink:title="cubic metres per month" code="m3/mth"/>
        <swe:value>80427</swe:value>
      </swe:Quantity>
    </om:result>
  </om:OM_Observation>
</gwml2f:gwFlowVolumeRate>
<gwml2f:gwFlowDestinationBody xlink:title="Lake Murdeduke water body"/>
<gwml2f:gwFlowDestinationContainer xlink:title="Lake Murdeduke"/>
<gwml2f:gwFlowInterfaceFeature xlink:title="Lake Murdeduke western discharge zone"/>
<gwml2f:gwFlowLocation>
  <!-- Fill in some geometry -->
</gwml2f:gwFlowLocation>
<gwml2f:gwFlowSourceBody xlink:title="Upper Tertiary-Quaternary Basalt Fluid Body"/>
<gwml2f:gwFlowSourceContainer xlink:title="Upper Tertiary-Quaternary Basalt Aquifer"/>
</gwml2f:GW_Discharge>
</gml:featureMember>
<gml:featureMember>
  <!-- Second featureMember is an example of GW_Recharge -->
  <gwml2f:GW_Recharge gml:id="lake-murdeduke-recharge-zone_19930101">
    <gml:description>Example Interflow instance of fluid flow from Lake Murdeduke to Upper Tertiary-
Quaternary Basalt Aquifer based on data from Jane Coram MSc 1996</gml:description>
    <gml:identifier
codeSpace="http://www.ietf.org/rfc/rfc2616">http://groundwater.feduni.edu/flowsystem/feduni/lake-
murdeduke</gml:identifier>
    <gml:name>Lake Murdeduke outflow</gml:name>
    <gwml2f:gwFlowPersistence xlink:title="perennial"/>
    <gwml2f:gwFlowProcess xlink:title="constant head"/>
    <gwml2f:gwFlowTime xlink:href="#January1993">
</gwml2f:gwFlowTime>
    <gwml2f:gwFlowVelocity>
      <om:OM_Observation gml:id="lake-murdeduke-recharge-zone_19930101_FlowVelocity">
        <om:phenomenonTime xlink:href="#January1993"/>
        <om:resultTime xlink:href="#January1993"/>
        <om:procedure xlink:title="V=Ki/n"/>
        <om:observedProperty xlink:title="flow velocity"/>
        <om:featureOfInterest/>
        <om:result>
          <swe:Quantity>
            <swe:uom xlink:title="metres per month" code="m/mth"/>
            <swe:value>2.9</swe:value>
          </swe:Quantity>
        </om:result>
      </om:OM_Observation>

```

```

</gwml2f:gwFlowVelocity>
<gwml2f:gwFlowVolumeRate>
  <om:OM_Observation gml:id="lake-murdeduke-recharge-zone_19930101_FlowVolumeRate">
    <om:phenomenonTime xlink:href="#January1993"/>
    <om:resultTime xlink:href="#January1993"/>
    <om:procedure xlink:title="flow net calculation"/>
    <om:observedProperty xlink:href="" xlink:title="GWML2-Flow:gwFlowVolumeRate"/>
    <om:featureOfInterest xlink:href="#"/>
    <om:result>
      <swe:Quantity>
        <swe:uom xlink:title="cubic metres per month" code="m3/mth"/>
        <swe:value>88706</swe:value>
      </swe:Quantity>
    </om:result>
  </om:OM_Observation>
</gwml2f:gwFlowVolumeRate>
<gwml2f:gwFlowDestinationBody xlink:title="Upper Tertiary-Quaternary Basalt Fluid Body"/>
<gwml2f:gwFlowDestinationContainer xlink:title="Upper Tertiary-Quaternary Basalt Aquifer"/>
<gwml2f:gwFlowInterfaceFeature xlink:title="Lake Murdeduke eastern recharge zone"/>
<gwml2f:gwFlowLocation>
  <!-- Fill in some geometry -->
</gwml2f:gwFlowLocation>
<gwml2f:gwFlowSourceBody xlink:title="Lake Murdeduke water body"/>
<gwml2f:gwFlowSourceContainer xlink:title="Lake Murdeduke"/>
</gwml2f:GW_Recharge>
</gml:featureMember>
</gml:FeatureCollection>

```

## C.5 GWML2-Well & GWML2-WellConstruction

### C.5.1 GW\_Well

From NRCAN using [ab.w.ww.402557](http://ab.w.ww.402557) ( [GWML 1](#)); includes construction details.

```
<?xml version="1.0" encoding="UTF-8"?>
<gww:GW_Well xmlns:gww="http://www.opengis.net/gwml-well/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:sam="http://www.opengis.net/sampling/2.0"
xmlns:sams="http://www.opengis.net/samplingSpatial/2.0" xmlns:gu="http://xmlns.geosciml.org/GeologicUnit/3.2"
xmlns:gwml2="http://www.opengis.net/gwml-core/2.0" xmlns:gwml2f="http://www.opengis.net/gwml-flow/2.0"
xmlns:gsmlem="http://xmlns.geosciml.org/EarthMaterial/3.2" xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-
Core/3.2" xmlns:gsmhpp="http://xmlns.geosciml.org/PhysicalProperties/3.2"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:swe="http://www.opengis.net/swe/2.0"
xmlns:gmd="http://www.isotc211.org/2005/gmd" xmlns:gco="http://www.isotc211.org/2005/gco"
xmlns:bh="http://www.opengis.net/gwml-wellconstruction/2.0" xmlns:cv="http://www.opengis.net/cv/0.2/gml32"
xmlns:om="http://www.opengis.net/om/2.0" xmlns:spec="http://www.opengis.net/samplingSpecimen/2.0"
gml:id="ab.w.ww.402557" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation="http://www.opengis.net/gwml-well/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-well.xsd http://www.opengis.net/samplingSpecimen/2.0
http://schemas.opengis.net/samplingSpecimen/2.0/specimen.xsd">
  <!-- based on http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gin/wfs/gin?REQUEST=GetFeature&INFO_FORMAT=text/xml&FID=ab.w.ww.40255
7 -->
  <gml:description>Water well from Alberta water well database</gml:description>
  <gml:identifier codeSpace="http://www.ietf.org/rfc/rfc2616">http://ngwd-bdnes.cits.nrcan.gc.ca/Reference/uri-
cgi/feature/gsc/waterwell/ca.ab.gov.wells.402557</gml:identifier>
  <gml:name codeSpace="urn:cgi:featureType:CA.AB:WaterWell">402557</gml:name>
  <gml:name codeSpace="urn:x-gin">ca.ab.waterWell.402557</gml:name>
  <gml:boundedBy>
    <gml:Envelope srsName="urn:ogc:def:crs:EPSG:4326">
      <gml:pos srsDimension="2">-114.625045 49.671622</gml:pos>
      <gml:pos srsDimension="2">-114.625045 49.671622</gml:pos>
    </gml:Envelope>
  </gml:boundedBy>
  <!-- wells in Alberta are located by townships, their geographic locations is estimated as the center of the
township -->
  <gml:location>
    <!-- deprecated -->
    <gml:LocationString xlink:title="DLS well location">03-28-008-05-5</gml:LocationString>
  </gml:location>
  <sam:sampledFeature xsi:nil="true" nilReason="unknown"/>
  <sam:relatedObservation>
    <om:OM_Observation gml:id="ab.w.ww.402557.flow.1">
      <gml:description>Fictive Flow measurement</gml:description>
      <om:phenomenonTime>
        <gml:TimeInstant gml:id="ab.w.ww.402557.flow.1.pt">
          <gml:timePosition>2012-05-01</gml:timePosition>
        </gml:TimeInstant>
      </om:phenomenonTime>
    </om:OM_Observation>
  </sam:relatedObservation>

```

```

    <om:resultTime>
      <gml:TimeInstant gml:id="ab.ww.402557.flow.1.ti">
        <gml:timePosition>2012-05-01</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xlink:href="http://www.opengis.net/def/gwml/procedure/flowmeter" xlink:title="flow
meter"/>
    <!-- /req/gwml2-well/waterwell_observation_fromParam -->
    <om:parameter>
      <om:NamedValue>
        <om:name xlink:href="http://www.opengis.net/req/gw_well/waterwell_observation_fromParam"
xlink:title="from"/>
        <om:value xsi:type="swe:QuantityPropertyType">
          <swe:Quantity>
            <swe:uom xlink:href="m" xlink:title="m from top"/>
            <swe:value>7.6</swe:value>
          </swe:Quantity>
        </om:value>
      </om:NamedValue>
    </om:parameter>
    <!-- /req/gwml2-well/waterwell_observation_toParam -->
    <om:parameter>
      <om:NamedValue>
        <om:name xlink:href="http://www.opengis.net/req/gw_well/waterwell_observation_toParam"
xlink:title="to"/>
        <om:value xsi:type="swe:QuantityPropertyType">
          <swe:Quantity>
            <swe:uom xlink:href="m" xlink:title="m from top"/>
            <swe:value>7.7</swe:value>
          </swe:Quantity>
        </om:value>
      </om:NamedValue>
    </om:parameter>
    <om:observedProperty xlink:href="http://www.opengis.net/def/gwml/phenomenon/flowspeed"
xlink:title="groundwater flow speed"/>
    <!-- /req/gwml2-well/waterwell_observation_foi -->
    <om:featureOfInterest xlink:href="#ab.ww.402557" xlink:title="ab.ww.402557"/>
    <om:result xsi:type="gml:MeasureType" uom="m/s">0.0021</om:result>
  </om:OM_Observation>
</sam:relatedObservation>
<!-- positionned sampling feature -->
<sam:relatedSamplingFeature>
  <sam:SamplingFeatureComplex>
    <sam:role xlink:href="http://www.opengis.net/def/gwml/role/waterSample" xlink:title="Water sample"/>
    <sam:relatedSamplingFeature>
      <spec:SF_Specimen gml:id="spc.1">
        <gml:description>Fictitious water sample taken in the well</gml:description>
        <gml:name>S.1</gml:name>
        <sam:sampledFeature xsi:nil="true" nilReason="unknown"/>
        <!-- /req/xsd-gwml-well/waterwell_sf_foi -->
        <sam:relatedSamplingFeature>
          <sam:SamplingFeatureComplex>
            <sam:role xlink:href="http://www.opengis.net/def/gwml/role/samplingFeature"/>

```

```

        <sam:relatedSamplingFeature xlink:href="#ab.ww.402557" xlink:title="ab.ww.402557"/>
    </sam:SamplingFeatureComplex>
</sam:relatedSamplingFeature>
<!-- /req/gwml2-well/waterwell_sf_fromParam -->
<sam:parameter>
    <om:NamedValue>
        <om:name xlink:href="http://www.opengis.net/req/gw_well/waterwell_sf_fromParam"
xlink:title="from"/>
        <om:value xsi:type="swe:QuantityPropertyType">
            <swe:Quantity>
                <swe:uom xlink:href="m" xlink:title="m from top"/>
                <swe:value>8.12</swe:value>
            </swe:Quantity>
        </om:value>
    </om:NamedValue>
</sam:parameter>
<!-- /req/gwml2-well/waterwell_sf_toParam -->
<sam:parameter>
    <om:NamedValue>
        <om:name xlink:href="http://www.opengis.net/req/gw_well/waterwell_sf_toParam"
xlink:title="to"/>
        <om:value xsi:type="swe:QuantityPropertyType">
            <swe:Quantity>
                <swe:uom xlink:href="m" xlink:title="m from top"/>
                <swe:value>8.4</swe:value>
            </swe:Quantity>
        </om:value>
    </om:NamedValue>
</sam:parameter>
<spec:materialClass xlink:href="http://www.opengis.net/def/waterml/2.0/medium/Groundwater"
xlink:title="Groundwater"/>
    <spec:samplingTime>
        <gml:TimeInstant gml:id="spc.1.ts">
            <gml:timePosition>2012-06-24</gml:timePosition>
        </gml:TimeInstant>
    </spec:samplingTime>
    <spec:size uom="ml">150</spec:size>
</spec:SF_Specimen>
</sam:relatedSamplingFeature>
</sam:SamplingFeatureComplex>
</sam:relatedSamplingFeature>
<sams:shape>
    <gml:Curve gml:id="ab.ww.402557.shape.1" srsDimension="3" srsName="urn:ogc:def:crs:EPSG:4955">
        <gml:segments>
            <gml:LineStringSegment>
                <gml:posList>49.671622 -114.625045 0.00 49.671622 -114.625045 11.58</gml:posList>
            </gml:LineStringSegment>
        </gml:segments>
    </gml:Curve>
</sams:shape>
<gww:gwWellConstruction>
    <bh:Borehole gml:id="ab.ww.402557.bore.1">
        <sam:sampledFeature nilReason="unknown"/>

```



```

<!-- reuse the same bore shape -->
<sams:shape xlink:href="#ab.ww.402557" xlink:title="ab.ww.402557"/>
<bh:bHoleDateOfDrilling>1981-09-12</bh:bHoleDateOfDrilling>
<bh:bholeDrillingMethod xsi:nil="true"/>
<bh:bholeInclinationType xsi:nil="true"/>
<bh:bholeNominalDiameter xsi:nil="true"/>
<bh:bholeOperator gco:nilReason="missing" xsi:nil="true"/>
<bh:bholeStartPoint xsi:nil="true"/>
<bh:bholeConstruction>
  <bh:Casing gml:id="ab.ww.402557.bore.1.casing">
    <bh:casingElement>
      <bh:CasingComponent gml:id="ab.ww.402557.bore.1.casing.1">
        <gml:description>Well Casing</gml:description>
        <gml:name codeSpace="urn:x-gin">ca.ab.wellCasing.402557</gml:name>
        <bh:from>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>0.0</swe:value>
          </swe:Quantity>
        </bh:from>
        <bh:to>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>7.62</swe:value>
          </swe:Quantity>
        </bh:to>
        <!-- these guys should be nillable -->
        <bh:casingMaterial xlink:href="http://www.opengis.net/def/gwml/casingMaterial/Steel"
xlink:title="Steel"/>
        <bh:casingCoating xsi:nil="true" nilReason="unknown"/>
        <bh:casingForm nilReason="unknown" xsi:nil="true"/>
        <bh:casingInternalDiameter xlink:href="nil"/>
        <bh:casingExternalDiameter xlink:href="nil"/>
        <bh:casingWallThickness xlink:href="nil"/>
      </bh:CasingComponent>
    </bh:casingElement>
  </bh:Casing>
</bh:bholeConstruction>
<bh:bholeConstruction>
  <bh:Sealing gml:id="ab.ww.402557.bore.1.sealing">
    <gml:description>Well Sealing</gml:description>
    <gml:name codeSpace="urn:x-gin">ca.ab.Sealing.402557</gml:name>
    <bh:sealingGroutingPlacementMethod xsi:nil="true" nilReason="unknown"/>
    <bh:sealingElement>
      <bh:SealingComponent gml:id="ab.ww.402557.bore.1.sealing.1">
        <bh:from>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>0.0</swe:value>
          </swe:Quantity>
        </bh:from>
        <bh:to>
          <swe:Quantity>

```

```

                <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
                <swe:value>7.62</swe:value>
            </swe:Quantity>
            </bh:to>
            <bh:sealingMaterial xlink:href="http://www.opengis.net/def/gwml/sealingMaterial/Mixed"
xlink:title="Cement Grout"/>
            <bh:sealingType xsi:nil="true" nilReason="unknown"/>
            </bh:SealingComponent>
        </bh:sealingElement>
    </bh:Sealing>
</bh:boreholeConstruction>
<bh:boreholeHeadworks nilReason="missing" xsi:nil="true"/>
</bh:Borehole>
</gww:gwWellConstruction>
<gww:gwWellLocation>
    <gml:Point gml:id="w_well.pos.ab.ww.402557.w" srsName="urn:ogc:def:crs:EPSG:4326">
        <gml:pos srsDimension="2">49.671622 -114.625045</gml:pos>
    </gml:Point>
</gww:gwWellLocation>
<gww:gwWellPurpose xsi:nil="true"/>
<gww:gwWellReferenceElevation>
    <!-- this entry is the one that should be used for relative positions -->
    <gww:Elevation>
        <gww:elevation srsName="urn:ogc:def:crs:EPSG:5100" uomLabels="m above sea level"
srsDimension="1">1737.36</gww:elevation>
        <gww:elevationType xlink:href="http://www.opengis.net/req/gwml2-well/origin_elevation"
xlink:title="origin"/>
        <gww:elevationMeasurementMethod xsi:nil="true" nilReason="unknown"/>
    </gww:Elevation>
</gww:gwWellReferenceElevation>
<gww:gwWellReferenceElevation>
    <gww:Elevation>
        <gww:elevation srsName="urn:ogc:def:crs:EPSG:5100" uomLabels="m above sea level"
srsDimension="1">1648</gww:elevation>
        <gww:elevationType xlink:href="http://www.opengis.net/req/gwml2-well/location_elevation"
xlink:title="dem site"/>
        <gww:elevationMeasurementMethod xlink:href="urn:gwml2:elevationMethod:DEM"
xlink:title="DEM"/>
    </gww:Elevation>
</gww:gwWellReferenceElevation>
<gww:gwWellReferenceElevation>
    <gww:Elevation>
        <gww:elevation srsName="urn:ogc:def:crs:EPSG:5100" uomLabels="m above sea level"
srsDimension="1">1658.633</gww:elevation>
        <gww:elevationType xlink:href="http://www.opengis.net/req/gwml2-well/location_elevation"
xlink:title="dem site"/>
        <gww:elevationMeasurementMethod xlink:href="urn:gwml2:elevationMethod:DEM"
xlink:title="DEM"/>
    </gww:Elevation>
</gww:gwWellReferenceElevation>
<gww:gwWellStaticWaterDepth>
    <om:OM_Observation gml:id="ab.ww.402557.wl.1">
        <gml:description>Static Water Level</gml:description>
    </om:OM_Observation>
</gww:gwWellStaticWaterDepth>

```

```

<gml:name codeSpace="urn:cgi:featuretype:CA.AB:WaterLevel">10341338</gml:name>
<gml:name codeSpace="urn:x-gin">ca.ab.waterLevel.10341338</gml:name>
<om:phenomenonTime>
  <gml:TimeInstant gml:id="ab.ww.402557.wl.1.ti.1">
    <gml:timePosition>1981-09-12T00:00:00</gml:timePosition>
  </gml:TimeInstant>
</om:phenomenonTime>
<om:resultTime>
  <gml:TimeInstant gml:id="ab.ww.402557.wl.1.ti.2">
    <gml:timePosition>2014-06-09T00:00:00</gml:timePosition>
  </gml:TimeInstant>
</om:resultTime>
<om:procedure xlink:href="urn:ogc:def:procedure:GIN:unknown"/>
<om:observedProperty xlink:href="urn:ogc:def:phenomenon:GIN:StaticWaterLevel"/>
<om:featureOfInterest xlink:href="#ab.ww.402557"/>
<om:result>
  <swe:Quantity>
    <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
    <swe:value>9.75</swe:value>
  </swe:Quantity>
</om:result>
</om:OM_Observation>
</gww:gwWellStaticWaterDepth>
<gww:gwWellStatus nilReason="missing" xsi:nil="true"/>
<gww:gwWellTotalLength>
  <swe:Quantity>
    <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
    <swe:value>11.58</swe:value>
  </swe:Quantity>
</gww:gwWellTotalLength>
<gww:gwWellUnit xsi:nil="true" nilReason="unknown"/>
<gww:gwWellWaterUse xlink:href="urn:cgi:classifier:CA.AB:waterUseCode:Domestic"
xlink:title="Domestic"/>
<gww:gwWellYield nilReason="unknown" xsi:nil="true"/>
<gww:gwWellLicence xsi:nil="true"/>
<gww:gwWellGeology>
  <gww:GW_GeologyLog gml:id="ab.ww.402557.log.1">
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="ab.ww.402557.log.1.ph">
        <gml:timePosition>1981-09-12T00:00:00</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <om:resultTime>
      <gml:TimeInstant gml:id="ab.ww.402557.log.1.rs">
        <gml:timePosition>1981-09-12T00:00:00</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xsi:nil="true" nilReason="unknown"/>
    <om:observedProperty xlink:href="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial"
xlink:title="Lithology"/>
    <om:featureOfInterest xsi:nil="true" nilReason="missing"/>
    <om:result>
      <gww:GW_GeologyLogCoverage gml:id="ab.ww.402557.log.1.coverage">

```

```

    <gww:element>
      <gww:Log Value>
        <gww:fromDepth>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>0.00</swe:value>
          </swe:Quantity>
        </gww:fromDepth>
        <gww:toDepth>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>0.30</swe:value>
          </swe:Quantity>
        </gww:toDepth>
        <gww:value>
          <swe:DataRecord
definition="http://www.opengis.net/def/gwml/2.0/datarecord/earthMaterial" id="le.1">
          <swe:field name="lithology">
            <swe:Category
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial">
            <swe:codeSpace
xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/simplelithology"/>
            <swe:value>Soil</swe:value>
          </swe:Category>
        </swe:field>
      </swe:DataRecord>
    </gww:value>
  </gww:Log Value>
</gww:element>
<gww:element>
  <gww:Log Value>
    <gww:fromDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>0.30</swe:value>
      </swe:Quantity>
    </gww:fromDepth>
    <gww:toDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>4.27</swe:value>
      </swe:Quantity>
    </gww:toDepth>
    <gww:value>
      <swe:DataRecord
definition="http://www.opengis.net/def/gwml/2.0/datarecord/earthMaterial" id="le.2">
      <swe:field name="lithology">
        <swe:Category
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial">
        <swe:codeSpace
xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/simplelithology"/>
        <swe:value>Clay</swe:value>
      </swe:Category>

```

```

        </swe:field>
      </swe:DataRecord>
    </gww:value>
  </gww:LogValue>
</gww:element>
<gww:element>
  <gww:LogValue>
    <gww:fromDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>4.27</swe:value>
      </swe:Quantity>
    </gww:fromDepth>
    <gww:toDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>9.14</swe:value>
      </swe:Quantity>
    </gww:toDepth>
    <gww:value>
      <swe:DataRecord
definition="http://www.opengis.net/def/gwml/2.0/datarecord/earthMaterial" id="le.3">
        <swe:field name="lithology">
          <swe:Category
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial">
            <swe:codeSpace
xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/simplelithology"/>
              <swe:value>Till</swe:value>
            </swe:Category>
          </swe:field>
        </swe:DataRecord>
      </gww:value>
    </gww:LogValue>
  </gww:element>
</gww:element>
  <gww:LogValue>
    <gww:fromDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>9.14</swe:value>
      </swe:Quantity>
    </gww:fromDepth>
    <gww:toDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>11.58</swe:value>
      </swe:Quantity>
    </gww:toDepth>
    <gww:value>
      <swe:DataRecord
definition="http://www.opengis.net/def/gwml/2.0/datarecord/earthMaterial" id="le.4">
        <swe:field name="lithology">
          <swe:Category

```

```

definition="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial">
  <swe:codeSpace
xlink:href="http://resource.geosciml.org/classifierscheme/cgi/201211/simplelithology"/>
  <swe:value>Gravel</swe:value>
  </swe:Category>
  </swe:field>
  </swe:DataRecord>
  </gww:value>
  </gww:LogValue>
  </gww:element>
  </gww:GW_GeologyLogCoverage>
</om:result>
<gww:startDepth>
  <swe:Quantity>
    <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
    <swe:value>0</swe:value>
  </swe:Quantity>
</gww:startDepth>
<gww:endDepth>
  <swe:Quantity>
    <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
    <swe:value>11.58</swe:value>
  </swe:Quantity>
</gww:endDepth>
</gww:GW_GeologyLog>
</gww:gwWellGeology>
</gww:GW_Well>

```

### C.5.2 GW\_Well

From GNS NZ in the Horowhenua area, Horizons Regional Council (with borehole).

```

<gwml2w:GW_Well xmlns:gwml2w="http://www.opengis.net/gwml-well/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:sf="http://www.opengis.net/sampling/2.0" xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
xmlns:gwml2wc="http://www.opengis.net/gwml-wellconstruction/2.0"
xmlns:gmd="http://www.isotc211.org/2005/gmd" xmlns:gco="http://www.isotc211.org/2005/gco"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:swe="http://www.opengis.net/swe/2.0"
xmlns:om="http://www.opengis.net/om/2.0" gml:id="gwml_w_1432124"
xsi:schemaLocation="http://www.opengis.net/gwml-well/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-well.xsd">
  <gml:description>Ohau at u/s Levin water supply</gml:description>
  <gml:identifier codeSpace="http://horizons.govt.nz/assets/wells/siteid">1432124</gml:identifier>
  <gml:name codeSpace="http://horizons.govt.nz/assets/wells/siteid">1432124</gml:name>
  <gml:boundedBy>
    <gml:Envelope srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
      <gml:lowerCorner>175.26375 -40.80284</gml:lowerCorner>
      <gml:upperCorner>175.26375 -40.80284</gml:upperCorner>
    </gml:Envelope>
  </gml:boundedBy>
  <sf:sampledFeature xsi:nil="true" nilReason="unknown"/>
  <sams:shape>
    <gml:LineString srsName="http://www.opengis.net/gml/srs/epsg.xml#4440" srsDimension="1"

```

```

gml:id="wshp_1432124" axisLabels="depth">
  <gml:coordinates cs="," ts=" " decimal=".">42.2,-35.5</gml:coordinates>
  </gml:LineString>
</sams:shape>
<gwml2w:gwWellBody xsi:nil="true" nilReason="unknown"/>
<gwml2w:gwWellConstructedDepth xsi:nil="true" nilReason="template"/>
<gwml2w:gwWellConstruction>
  <gwml2wc:Borehole xsi:schemaLocation="http://www.opengis.net/gwml-wellconstruction/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-wellconstruction.xsd" gml:id="wbh_1432124">
  <gml:identifier codeSpace="http://horizons.govt.nz/assets/wells/siteid">1432124</gml:identifier>
  <gml:name codeSpace="http://horizons.govt.nz/assets/wellconstruction">concrete casing</gml:name>
  <gml:location>
  <gml:LocationString>Ohau at u/s Levin water supply, green shed</gml:LocationString>
  </gml:location>
  <sf:sampledFeature xsi:nil="true" nilReason="unknown"/>
  <sams:shape>
  <gml:LineString srsName="http://www.opengis.net/gml/srs/epsg.xml#4440" srsDimension="1"
gml:id="bh_shp_1432124" axisLabels="depth">
  <gml:coordinates cs="," ts=" " decimal=".">42.2,-35.5</gml:coordinates>
  </gml:LineString>
</sams:shape>
<gwml2wc:bholeMaterialCustodian>
  <gmd:CI_ResponsibleParty>
  <gmd:individualName>
  <gco:CharacterString>Brent Watson</gco:CharacterString>
  </gmd:individualName>
  <gmd:organisationName>
  <gco:CharacterString>Horizons Regional Council</gco:CharacterString>
  </gmd:organisationName>
  <gmd:role>
  <gmd:CI_RoleCode codeList="#ANZIC_ISO_CODELIST" codeListValue="custodian"
codeSpace="http://anzlic.."/>
  </gmd:role>
  </gmd:CI_ResponsibleParty>
</gwml2wc:bholeMaterialCustodian>
<gwml2wc:bholeCoreInterval xsi:nil="true" nilReason="unknown"/>
<gwml2wc:bHoleDateOfDrilling>1963-03-07</gwml2wc:bHoleDateOfDrilling>
<gwml2wc:bholeDriller>
  <gmd:CI_ResponsibleParty>
  <gmd:individualName>
  <gco:CharacterString>Mokahine Jones</gco:CharacterString>
  </gmd:individualName>
  <gmd:organisationName>
  <gco:CharacterString>Manawatu Drillers Ltd</gco:CharacterString>
  </gmd:organisationName>
  <gmd:role>
  <gmd:CI_RoleCode codeList="#ANZIC_ISO_CODELIST" codeListValue="driller"
codeSpace="http://anzlic.."/>
  </gmd:role>
  </gmd:CI_ResponsibleParty>
</gwml2wc:bholeDriller>
<gwml2wc:bholeDrillingMethod xlink:href="http://somevocab.org/drillingmethods" xlink:title="rotary"/>
<gwml2wc:bholeInclinationType xlink:href="http://somevocab.org/inclinationtypes" xlink:title="vertical"/>

```

```

<gwml2wc:bholeNominalDiameter>
  <swe:Quantity>
    <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m" xlink:title="meter"/>
    <swe:value>0.6</swe:value>
  </swe:Quantity>
</gwml2wc:bholeNominalDiameter>
<gwml2wc:bholeOperator xlink:href="http://horizons.govt.nz/" xlink:title="Horizons Regional Council"/>
<gwml2wc:bholeStartPoint xsi:nil="true" nilReason="unknown"/>
<gwml2wc:bholeConstruction>
  <gwml2wc:WellConstruction gml:id="bhconst_1432124">
    <gml:description>here should be list of construction details like sealing, casing, screen?</gml:description>
  </gwml2wc:WellConstruction>
</gwml2wc:bholeConstruction>
<gwml2wc:bholeHeadworks xsi:nil="true" nilReason="unknown"/>
<gwml2wc:Borehole>
</gwml2w:gwWellConstruction>
<gwml2w:gwWellContributionZone xsi:nil="true" nilReason="unknown"/>
<gwml2w:gwWellLocation>
  <gml:Point srsName="http://www.opengis.net/gml/srs/epsg.xml#4326" gml:id="wloc_1432124">
    <gml:coordinates cs="," ts=" " decimal=".">175.26375,-40.80284</gml:coordinates>
  </gml:Point>
</gwml2w:gwWellLocation>
<gwml2w:gwWellPurpose xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="extraction"/>
<gwml2w:gwWellReferenceElevation>
  <gwml2w:Elevation>
    <gwml2w:elevation srsName="http://www.opengis.net/gml/srs/epsg.xml#4440" srsDimension="1"
uomLabels="m above sea level">42.2</gwml2w:elevation>
    <gwml2w:elevationAccuracy xsi:nil="true" gco:nilReason="unknown"/>
    <gwml2w:elevationType xlink:href="http://some.vocab.org/MeasuredInSitu" xlink:title="in situ"/>
    <gwml2w:elevationMeasurementMethod xlink:href="http://some.vocab/some-gps-gear" xlink:title="D-GPS
method"/>
  </gwml2w:Elevation>
</gwml2w:gwWellReferenceElevation>
<gwml2w:gwWellStaticWaterDepth>
  <om:OM_Observation gml:id="om_swl_1432124_1">
    <gml:description>static water level</gml:description>
    <gml:name codeSpace="http://ggwdata.gns.cri.nz/ggw/properties">1679</gml:name>
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="om_swl_1432124_ti_1">
        <gml:timePosition>2011-05-21T12:00:00</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <om:resultTime xlink:href="#om_swl_1432124_ti_1"/>
    <om:procedure xlink:href="http://mfe.govt.nz/nems/protocols/soe-sampling" xlink:title="State of the
Environment / NEMS Protocols"/>
    <om:observedProperty xlink:href="http://ggwdata.gns.cri.nz/ggw/properties/1679" xlink:title="Static Water
Level"/>
    <om:featureOfInterest xlink:href="#gwml_w_1432124"/>
    <om:result>
      <om:result xmlns:ns="http://www.opengis.net/swe/2.0" xsi:type="ns:QuantityType">
        <ns:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m" xlink:title="meters"/>
        <ns:value>10.0</ns:value>
      </om:result>

```



```

    </om:result>
    </om:OM_Observation>
  </gwm12w:gwWellStaticWaterDepth>
  <gwm12w:gwWellStatus xlink:href="http://somevocab.org/gwm12w/notes" xlink:title="active"/>
  <gwm12w:gwWellTotalLength>
    <swe:Quantity>
      <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m" xlink:title="meters"/>
      <swe:value>78.5</swe:value>
    </swe:Quantity>
  </gwm12w:gwWellTotalLength>
  <gwm12w:gwWellUnit xsi:nil="true" nilReason="unknown"/>
  <gwm12w:gwWellWaterUse xlink:href="http://somevocab.org/gwm12w/notes" xlink:title="Domestic"/>
  <gwm12w:gwWellYield>
    <om:OM_Observation gml:id="om_yield_1432124_1">
      <gml:description>well mean yield</gml:description>
      <gml:name codeSpace="http://ggwdata.gns.cri.nz/ggw/properties">1077</gml:name>
      <om:phenomenonTime xlink:href="#om_sw1_1432124_ti_1"/>
      <om:resultTime xlink:href="#om_sw1_1432124_ti_1"/>
      <om:procedure xlink:href="http://mfe.govt.nz/nems/protocols/soe-sampling" xlink:title="State of the Environment / NEMS Protocols"/>
      <om:observedProperty xlink:href="http://ggwdata.gns.cri.nz/ggw/properties/1077" xlink:title="Well Yield"/>
      <om:featureOfInterest xlink:href="#gwm12w_1432124"/>
      <om:result>
        <om:result xmlns:ns="http://www.opengis.net/swe/2.0" xsi:type="ns:QuantityType">
          <ns:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/l.s-1" xlink:title="liters per second"/>
          <ns:value>148.0</ns:value>
        </om:result>
      </om:result>
    </om:OM_Observation>
  </gwm12w:gwWellYield>
  <gwm12w:gwWellLicence xsi:nil="true"/>
</gwm12w:GW_Well>

```

### C.5.3 GW\_Well

BRGM from France's national BSS (Banque Nationale du Sous-Sol) includes piezometry, construction, and a link to the Aquifer described above.

**pkg Well**

**01846X0361/P1 :GW\_Well**

identifier = <http://www.ades.eaufrance.fr/FichePtEau.aspx?code=01846X0361/P1>  
 name = PIEZOMETRE DU COLLEGE DELACROIX (ROISSY - 77)  
 gwWellLocation = [2.66531 48.79364]  
 gwWellPurpose = <http://www.opengis.net/req/gwm12-well/WellPurposeTerm/GroundWaterLevelMonitoring>  
 gwWellReferenceElevation = elevation : 110 m NGFI / elevationMeasurementMethod :estimated on a 1/25 000 scale map  
 gwWellStatus = <http://www.opengis.net/req/gwm12-well/WellStatusTypeTerm/InUse>  
 gwWellTotalLength = 62.15 m

```

<?xml version="1.0" encoding="UTF-8"?>
<!--Sample XML file generated by XMLSpy v2007 rel. 3 sp1 (http://www.altova.com)-->
<gwm12w:GW_Well gml:id="PointEau.01846X0361" xsi:schemaLocation="http://www.opengis.net/gwml-well/2.0
http://ngwd-bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-well.xsd"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:gwm12w="http://www.opengis.net/gwml-well/2.0"
xmlns:sam="http://www.opengis.net/sampling/2.0" xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:swe="http://www.opengis.net/swe/2.0" xmlns:gwm12="http://www.opengis.net/gwml-nucleus/2.0"
xmlns:om="http://www.opengis.net/om/2.0" xmlns:bh="http://www.opengis.net/gwml-wellconstruction/2.0"
xmlns:gco="http://www.isotc211.org/2005/gco">
<!-- Sylvain Grellet, BRGM (French Geological Survey), 2014/08/06 *WORK IN PROGRESS* -->
<!-- based on http://fichebseau.brgm.fr/bss_eau/fiche.jsf?code=01846X0361/P1 -->
<!-- based on http://www.ades.eaufrance.fr/FichePtEau.aspx?code=01846X0361/P1&type_pt_eau=2 -->
<!-- based on http://ficheinfoterre.brgm.fr/InfoterreFiche/ficheBss.action?id=01846X0361/P1 -->
<!-- based on http://bss-menu.brgm.fr/bssmenu/bssmenu.html#indice:01846X0361/P1 -->
  <gml:description>Water well from national BSS (Banque du Sous-Sol) Data database </gml:description>
  <gml:identifier
codeSpace="http://www.sandre.eaufrance.fr/urn.php?urn=urn:sandre:dictionnaire:PTE::entite:PointEau:ressource:2.1
::html">http://www.ades.eaufrance.fr/FichePtEau.aspx?code=01846X0361/P1</gml:identifier>
  <gml:name
codeSpace="http://www.sandre.eaufrance.fr/urn.php?urn=urn:sandre:dictionnaire:PTE::entite:PointEau:ressource:2.1
::html">PIEZOMETRE DU COLLEGE DELACROIX (ROISSY - 77)</gml:name>
  <sam:sampledFeature/>
  <sams:shape><!-- TODO SG : do we necessary have to dump a 3D shape ?-->
</sams:shape>
  <gwm12w:gwWellBody xsi:nil="true" nilReason="unknown"/>
  <gwm12w:gwWellConstructedDepth xsi:nil="true" nilReason="unknown" /><!-- TODO SG : voir avec Anette si
on a l'information -->
  <gwm12w:gwWellConstruction><!--TODO SG : voir avec Anette pour les éléments de Borehole construction --
>
    <bh:Borehole gml:id="PointEau.01846X0361.bore.1">
      <sam:sampledFeature nilReason="unknown"/>
      <!-- reuse the same bore shape -->
      <sams:shape xlink:href="#PointEau.01846X0361" xlink:title="PointEau.01846X0361"/>
      <bh:bHoleDateOfDrilling>2000-02-08</bh:bHoleDateOfDrilling>
      <bh:bholeDrillingMethod xlink:href="http://www.opengis.net/req/gwml2-
wellconstruction/BoreholeDrillingMethodTerm/RotaryWithMud" xlink:title="Foration ROTARY à la boue"/>
      <bh:bholeInclinationType xlink:href="http://www.opengis.net/req/gwml2-
wellconstruction/BoreholeInclinationTerm/vertical" xlink:title="vertical"/>
      <bh:bholeNominalDiameter>
        <swe:Quantity>
          <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/mm"/>
          <swe:value>254</swe:value>
        </swe:Quantity>
      </bh:bholeNominalDiameter>
      <bh:bholeOperator xsi:nil="true" gco:nilReason="withheld" />
      <bh:bholeStartPoint xsi:nil="true"/>
      <bh:bholeConstruction>
        <bh:Casing gml:id="PointEau.01846X0361.bore.1.casing">
          <bh:casingElement>
            <bh:CasingComponent gml:id="PointEau.01846X0361.bore.1.casing.1">

```

```

    <gml:description>Well Casing</gml:description>
    <gml:name codeSpace="urn:x-gin">PointEau.wellCasing.01846X0361</gml:name>
    <bh:from>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>0</swe:value>
      </swe:Quantity>
    </bh:from>
    <bh:to>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>41</swe:value>
      </swe:Quantity>
    </bh:to>
    <bh:casingMaterial xlink:href="http://www.opengis.net/def/gwml/casingMaterial/PVC"
xlink:title="PVC"/>
    <bh:casingCoating xsi:nil="true" nilReason="unknown"/>
    <bh:casingForm nilReason="unknown" xsi:nil="true"/>
    <bh:casingInternalDiameter xlink:href="nil"/>
    <bh:casingExternalDiameter xlink:href="nil"/>
    <bh:casingWallThickness xlink:href="nil"/>
  </bh:CasingComponent>
</bh:casingElement>
</bh:Casing>
</bh:bholeConstruction>
<bh:bholeConstruction>
  <bh:Sealing gml:id="ab.ww.402557.bore.1.sealing">
    <gml:description>Well Sealing</gml:description>
    <gml:name codeSpace="urn:x-gin">PointEau.Sealing.01846X0361</gml:name>
    <bh:sealingGroutingPlacementMethod xsi:nil="true" nilReason="unknown"/>
    <bh:sealingElement>
      <bh:SealingComponent gml:id="ab.ww.402557.bore.1.sealing.1">
        <bh:from>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>41</swe:value>
          </swe:Quantity>
        </bh:from>
        <bh:to>
          <swe:Quantity>
            <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
            <swe:value>62</swe:value>
          </swe:Quantity>
        </bh:to>
        <bh:sealingMaterial xlink:href="http://www.opengis.net/def/gwml/sealingMaterial/Mixed"
xlink:title="PVC crépiné"/>
        <bh:sealingType xsi:nil="true" nilReason="unknown"/>
      </bh:SealingComponent>
    </bh:sealingElement>
  </bh:Sealing>
</bh:bholeConstruction>
<bh:bholeHeadworks nilReason="missing" xsi:nil="true"/>
</bh:Borehole>

```

```

</gwm2w:gwWellConstruction>
<gwm2w:gwWellContributionZone xsi:nil="true" nilReason="inapplicable"/>
<gwm2w:gwWellLocation>
  <gml:Point gml:id="PointEau.01846X0361.pos" srsName="urn:ogc:def:crs:EPSG:4326" axisLabels="x y">
    <gml:pos srsDimension="2">2.66531 48.79364</gml:pos>
  </gml:Point>
</gwm2w:gwWellLocation>
<gwm2w:gwWellPurpose xlink:href="http://www.opengis.net/req/gwm2-
well/WellPurposeTerm/GroundWaterLevelMonitoring" xlink:title="Ground Water Level Monitoring"/>
<gwm2w:gwWellReferenceElevation>
  <gwm2w:Elevation>
    <gwm2w:elevation srsName="urn:ogc:def:crs:EPSG:5100" uomLabels="m NGF"
srsDimension="1">110</gwm2w:elevation>
    <gwm2w:elevationType xlink:href="http://www.opengis.net/req/gwm2-well/elevationTypeTerm/origin"
xlink:title="origin"/>
    <gwm2w:elevationMeasurementMethod xlink:href="http://www.opengis.net/req/gwm2-
well/elevationMeasurementMethodTerm/25000ScaleMap" xlink:title="estimated on a 1/25 000 scale map"/>
  </gwm2w:Elevation>
</gwm2w:gwWellReferenceElevation>
<gwm2w:gwWellStaticWaterDepth><!-- NOTE SG : water level value from
http://www.ad.es.eaufrance.fr/FicheMesuresPiezo.aspx?code=01846X0361/P1&profdeb=30,70&proffin=62,15&date
deb=02/09/2003&datefin=22/05/2014&position=->
  <om:OM_Observation gml:id="ADES.01846X0361.level1">
    <gml:description>Static Water Level</gml:description>
    <gml:name codeSpace="urn:cgi:featuretype:ADES:WaterLevel">01846X0361</gml:name>
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="ADES.01846X0361.level1.t1">
        <gml:timePosition>2014-05-22T00:00:00</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <om:resultTime>
      <gml:TimeInstant gml:id="ADES.01846X0361.level1.t2">
        <gml:timePosition>2014-05-22T00:00:00</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure xlink:href="urn:ogc:def:procedure:groundWaterLevelMonitoring:automatedSampling"/>
    <om:observedProperty xlink:href="urn:ogc:def:phenomenon:groundwater:StaticWaterLevel"/>
    <om:featureOfInterest xlink:href="#PointEau.01846X0361"/>
    <om:result>
      <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>52.08</swe:value>
      </swe:Quantity>
    </om:result>
  </om:OM_Observation>
</gwm2w:gwWellStaticWaterDepth>
<gwm2w:gwWellStatus xlink:href="http://www.opengis.net/req/gwm2-well/WellStatusTypeTerm/InUse"
xlink:title="InUse"/>
<gwm2w:gwWellTotalLength>
  <swe:Quantity>
    <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
    <swe:value>62.15</swe:value>
  </swe:Quantity>

```

```

    </gwml2w:gwWellTotalLength>
    <gwml2w:gwWellUnit
xlink:href="http://www.sandre.eaufrance.fr/?urn=urn:sandre:donnees:EntiteHydrogeol::CdEntiteHydrogeol:107AK0
1:::html" xlink:title="Calcaires de Brie du Rupélien (Oligocène inf.) du Bassin Parisien (bassin Seine-Normandie et
Loire-Bretagne)"><!-- Should normally point to a URL that provides GW_Aquifer--></gwml2w:gwWellUnit>
    <gwml2w:gwWellWaterUse xsi:nil="true" nilReason="inapplicable"/>
    <gwml2w:gwWellYield xsi:nil="true" nilReason="unknown"/>
    <gwml2w:gwWellGeology/> <!-- TODO SG : add information from
http://ficheinfoterre.brgm.fr/InfoterreFiche/logBss.action?_sourcePage=%2FficheBss.jsp&detail=false&profMax=62
.0&reference=01846X0361%2FP1&profMin=0.0 -->
</gwml2w:GW_Well>

```

### C.5.4 GW\_Well

From FedUni AU: Water well including lithology, stratigraphy, geologic age, logs and pH, eC, Temperature observations based on Federation University, Ballarat

```

<?xml version="1.0" encoding="UTF-8"?>
<gww:GW_Well gml:id="feduni.borehole.51409" xmlns:gww="http://www.opengis.net/gwml-well/2.0"
xmlns:gml="http://www.opengis.net/gml/3.2" xmlns:sam="http://www.opengis.net/sampling/2.0"
xmlns:sams="http://www.opengis.net/samplingSpatial/2.0" xmlns:gu="http://xmlns.geosciml.org/GeologicUnit/3.2"
xmlns:gwml2="http://www.opengis.net/gwml-nucleus/2.0" xmlns:gwml2f="http://www.opengis.net/gwml-flow/2.0"
xmlns:gwml2wc="http://www.opengis.net/gwml-wellconstruction/2.0"
xmlns:gsml="http://xmlns.geosciml.org/EarthMaterial/3.2" xmlns:gsml="http://xmlns.geosciml.org/GeoSciML-
Core/3.2" xmlns:gsmlpp="http://xmlns.geosciml.org/PhysicalProperties/3.2"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:swe="http://www.opengis.net/swe/2.0"
xmlns:gmd="http://www.isotc211.org/2005/gmd" xmlns:gco="http://www.isotc211.org/2005/gco"
xmlns:cv="http://www.opengis.net/cv/0.2/gml32" xmlns:om="http://www.opengis.net/om/2.0"
xmlns:spec="http://www.opengis.net/samplingSpecimen/2.0" xmlns:xsi="http://www.w3.org/2001/XMLSchema-
instance" xsi:schemaLocation="http://www.opengis.net/gwml/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2.xsd http://www.opengis.net/samplingSpecimen/2.0
http://schemas.opengis.net/samplingSpecimen/2.0/specimen.xsd">
  <!-- Federation University GWML2 GW_Well example -->
  <gml:description>Water well from Federation University groundwater well database</gml:description>
  <gml:identifier
codeSpace="http://www.ietf.org/rfc/rfc2616">http://groundwater.feduni.edu/borehole/feduni/51409</gml:identifier>
  <gml:name codeSpace="http://groundwater.feduni.edu/waterwell/oldboreid">{bore:oldid}</gml:name>
  <gml:name
codeSpace="http://groundwater.feduni.edu/waterwell/localborename">{bore:local_bore_name}</gml:name>
  <gml:boundedBy>
    <gml:Envelope srsName="EPSG:4939">
      <gml:pos srsDimension="2">139 -32</gml:pos>
      <gml:pos srsDimension="2">143 -37</gml:pos>
    </gml:Envelope>
  </gml:boundedBy>
  <!-- sam:sampledFeature is 1..*. It allows specifying the GeologicUnits intersected in the WaterWell. -->
  <sam:sampledFeature
xlink:href="http://groundwater.feduni.edu/hydrogeologicunit/feduni/feduni.hydrogeologicunit.newervolcanics"
xlink:title="Newer Volcanics" xlink:role="stratigraphic name"/>
  <!-- sam:relatedObservation to capture observations down the well -->
  <!-- pH observation -->

```

```

<sam:relatedObservation>
  <om:OM_Observation gml:id="feduni.ph.51409.1996-10-02">
    <!-- FedUni - gml:description from [swl:comments] -->
    <gml:description>free text description from [swl:comments]</gml:description>
    <om:phenomenonTime>
      <gml:TimeInstant gml:id="feduni.ph.51409.1996-10-02.pt">
        <gml:timePosition>1996-10-02T00:00:00</gml:timePosition>
      </gml:TimeInstant>
    </om:phenomenonTime>
    <om:resultTime xlink:href="#feduni.ph.51409.1996-10-02.pt"/>
    <om:procedure xlink:href="http://www.opengis.net/def/nil/OGC/0/unknown" xlink:role="unknown"
xlink:title="unknown"/>
    <!-- /req/gwml2-well/waterwell_observation_fromParam -->
    <!-- waterwell_observation_fromParam is the upper depth of the observation -->
    <om:parameter>
      <om:NamedValue>
        <om:name xlink:href="http://www.opengis.net/req/gw_well/waterwell_observation_fromParam"
xlink:title="from"/>
        <om:value xsi:type="swe:QuantityPropertyType">
          <swe:Quantity>
            <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"/>
            <swe:value>7.6</swe:value>
          </swe:Quantity>
        </om:value>
      </om:NamedValue>
    </om:parameter>
    <!-- /req/gwml2-well/waterwell_observation_toParam -->
    <om:parameter>
      <om:NamedValue>
        <om:name xlink:href="http://www.opengis.net/req/gw_well/waterwell_observation_toParam"
xlink:title="to"/>
        <om:value xsi:type="swe:QuantityPropertyType">
          <swe:Quantity>
            <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"/>
            <swe:value>7.7</swe:value>
          </swe:Quantity>
        </om:value>
      </om:NamedValue>
    </om:parameter>
    <om:observedProperty xlink:href="http://environment.data.gov.au/def/property/pH_water"
xlink:title="pH"/>
    <om:featureOfInterest xlink:href="http://www.opengis.net/def/nil/OGC/0/unknown"
xlink:role="unknown" xlink:title="unknown"/>
    <om:result xsi:type="gml:MeasureType"
uom="http://environment.data.gov.au/def/unit/pH">7.1</om:result>
  </om:OM_Observation>
</sam:relatedObservation>
<sams:shape>
  <gml:Curve gml:id="feduni.borehole.51409.shape.1" srsDimension="3"
srsName="http://www.opengis.net/def/crs/EPSG/0/4283">
    <gml:segments>
      <gml:LineStringSegment>
        <gml:posList>141.79256 -37.85769 11.857 141.79256 -37.85769 460.249</gml:posList>
      </gml:LineStringSegment>
    </gml:segments>
  </gml:Curve>
</sams:shape>

```

```

        </gml:LineStringSegment>
      </gml:segments>
    </gml:Curve>
  </sams:shape>
  <gww:gwWellConstructedDepth>
    <om:OM_Observation gml:id="feduni.borehole.51409.constructed-depth">
      <!-- om:phenomenomTime is the time the observation of the depth of the well was made -->
      <om:phenomenonTime>
        <gml:TimeInstant gml:id="feduni.borehole.51409.cdt">
          <gml:timePosition>1968-06-18</gml:timePosition>
        </gml:TimeInstant>
      </om:phenomenonTime>
      <om:resultTime xlink:href="#feduni.borehole.51409.cdt"/>
      <om:procedure xsi:nil="true" nilReason="missing"/>
      <om:observedProperty xlink:href="http://www.opengis.net/gwml-well/2.0/gwWellConstructedDepth"
xlink:title="gwWellConstructedDepth"/>
      <om:featureOfInterest xlink:href="#feduni.borehole.51409"/>
      <om:result>
        <swe:Quantity>
          <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre" code="m"/>
          <swe:value>61.00</swe:value>
        </swe:Quantity>
      </om:result>
    </om:OM_Observation>
  </gww:gwWellConstructedDepth>
  <gww:gwWellConstruction>
    <gwml2wc:Borehole gml:id="feduni.borehole.51409.bore">
      <sam:sampledFeature/>
      <sams:shape xlink:href="#feduni.borehole.51409.shape.1"/>
      <gwml2wc:bHoleDateOfDrilling>1968-06-18</gwml2wc:bHoleDateOfDrilling>
      <gwml2wc:bHoleDrillingMethod xlink:title="hydraulic rotary"/>
      <gwml2wc:bHoleInclinationType xlink:title="vertical"/>
      <gwml2wc:bHoleNominalDiameter xsi:nil="true"/>
      <gwml2wc:bHoleOperator xlink:title="DEPI"/>
      <gwml2wc:bHoleStartPoint xlink:title="natural ground surface"/>
      <!-- gwml2wc:bHoleHeadworks captures BoreCollar information. This will, largely be a duplicate of
GW_Well:gwWellLocation for collarLocation and GW_Well:gwWellReferenceElevation for collarElevation.
collarHeadworkType is the third BoreCollar property -->
      <gwml2wc:bHoleHeadworks>
        <gwml2wc:BoreCollar gml:id="feduni.borehole.51409.collar">
          <gwml2wc:collarElevation/>
          <gwml2wc:collarHeadworkType/>
          <gwml2wc:collarLocation/>
          <gwml2wc:bHoleDetails/>
        </gwml2wc:BoreCollar>
      </gwml2wc:bHoleHeadworks>
    </gwml2wc:Borehole>
  </gww:gwWellConstruction>
  <!-- gww:gwWellContributionZone is the area surrounding a pumping well or other discharge site that
encompasses all areas and features that supply groundwater to the well or discharge site. -->
  <gww:gwWellLocation>
    <!-- gml:Point gml:id is the identifier for the GW_Well:gwWellLocation. If it is defined elsewhere use
<gww:gwWellLocation xlink:href="#{gml:id}"/> -->

```



```

    <gml:Point gml:id="feduni.borehole.51409.location" srsName="EPSG:4939">
      <gml:pos>141.79256 -37.85769</gml:pos>
    </gml:Point>
  </gww:gwWellLocation>
  <gww:gwWellPurpose xsi:nil="true"/>
  <gww:gwWellReferenceElevation>
    <gww:Elevation>
      <gww:elevation srsName="http://www.opengis.net/def/crs/EPSSG/0/5711" uomLabels="m AHD"
srsDimension="1">120</gww:elevation>
      <gww:elevationType xlink:href="http://www.ga.gov.au/scientific-topics/positioning-
navigation/geodesy/geodetic-datums/australian-height-datum-ahd" xlink:title="AHD"/>
      <gww:elevationMeasurementMethod xlink:href="URI for method"/>
    </gww:Elevation>
  </gww:gwWellReferenceElevation>
  <gww:gwWellStaticWaterDepth>
    <om:OM_Observation gml:id="feduni.borehole.51409.static-wd">
      <om:phenomenonTime>
        <gml:TimeInstant gml:id="feduni.borehole.51409.static-wdt">
          <gml:timePosition>1996-10-02T00:00:00</gml:timePosition>
        </gml:TimeInstant>
      </om:phenomenonTime>
      <om:resultTime xlink:href="#feduni.borehole.51409.static-wdt"/>
      <om:procedure xsi:nil="true" nilReason="unknown"/>
      <om:observedProperty xlink:href="http://www.opengis.net/gwml-well/2.0/gwWellStaticWaterDepth"
xlink:title="gwWellStaticWaterDepth"/>
      <om:featureOfInterest xlink:href="#feduni.borehole.51409"/>
      <om:result>
        <swe:Quantity>
          <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre" code="m"/>
          <swe:value>10.12</swe:value>
        </swe:Quantity>
      </om:result>
    </om:OM_Observation>
  </gww:gwWellStaticWaterDepth>
  <!-- gwWellStatusType should allow nilReason -->
  <gww:gwWellStatus xsi:nil="true"/>
  <gww:gwWellTotalLength>
    <swe:Quantity>
      <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre" code="m"/>
      <swe:value>448.392</swe:value>
    </swe:Quantity>
  </gww:gwWellTotalLength>
  <!-- gwWellUnit specifies the GW_HydrogeoUnit. This duplicates the sampledFeature property -->
  <gww:gwWellUnit xsi:nil="true" nilReason="unknown"/>
  <gww:gwWellWaterUse xlink:href="urn:cgi:classifier:CA.AB:waterUseCode" xlink:title="Domestic"/>
  <gww:gwWellYield xsi:nil="true" nilReason="unknown"/>
  <!-- gwWellLicence Licence for relating to the drilling of the well or to the extraction of groundwater. -->
  <gww:gwWellLicence>
    <gwml2:GW_Licence>
      <gwml2:gwLicenceID/>
      <gwml2:gwPurpose xsi:nil="true"/>
      <gwml2:gwTimePeriod xsi:nil="true"/>
    </gwml2:GW_Licence>
  </gww:gwWellLicence>

```



```

</gww:gwWellLicence>
<gww:gwWellGeology>
  <gww:GW_GeologyLog gml:id="feduni.borehole.51409.lithology.D.1">
    <om:phenomenonTime nilReason="unknown"/>
    <om:resultTime nilReason="unknown"/>
    <om:procedure xlink:href="http://??" xlink:title="driller's log"/>
    <om:observedProperty
xlink:href="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial" xlink:title="lithology"/>
    <!-- The ultimate om:featureOfInterest could be considered the GeologicUnit the lithology describes. I
suggest the sampling FoI, i.e. the Borehole -->
    <om:featureOfInterest xlink:href="#feduni.borehole.51409"/>
    <om:result>
      <gww:GW_GeologyLogCoverage gml:id="feduni.borehole.51409.lithology.D.1.coverage">
        <gww:element>
          <gww:LogValue>
            <gww:fromDepth>
              <swe:Quantity>
                <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
                <swe:value>0.00</swe:value>
              </swe:Quantity>
            </gww:fromDepth>
            <gww:toDepth>
              <swe:Quantity>
                <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
                <swe:value>0.30</swe:value>
              </swe:Quantity>
            </gww:toDepth>
            <gww:value>
              <!-- swe:DataRecord needs defining for free text record -->
              <swe:DataRecord definition="http://www.opengis.net/def/gwml/2.0/data-record/free-
text">
                <swe:field name="lithology">
                  <swe:Text>
                    <swe:value>some text describing the lithology from FedUni database =
[lithology:lithology_description]</swe:value>
                  </swe:Text>
                </swe:field>
              </swe:DataRecord>
            </gww:value>
          </gww:LogValue>
        </gww:element>
      </gww:element>
      <gww:LogValue>
        <gww:fromDepth>
          <swe:Quantity>
            <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
            <swe:value>0.30</swe:value>
          </swe:Quantity>
        </gww:fromDepth>
        <gww:toDepth>

```

```

                <swe:Quantity>
                <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
                <swe:value>4.27</swe:value>
                </swe:Quantity>
            </gww:toDepth>
            <gww:value>
                <swe:DataRecord
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial">
                <swe:field name="lithology">
                <swe:Text>
                <swe:value>some text describing the lithology from
[lithology:lithology_description]</swe:value>
                </swe:Text>
                </swe:field>
                </swe:DataRecord>
            </gww:value>
            </gww:LogValue>
            </gww:element>
            </gww:GW_GeologyLogCoverage>
        </om:result>
        <gww:startDepth>
        <swe:Quantity>
        <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre" code="m"/>
        <swe:value>0</swe:value>
        </swe:Quantity>
        </gww:startDepth>
        <gww:endDepth>
        <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>11.58</swe:value>
        </swe:Quantity>
        </gww:endDepth>
    </gww:GW_GeologyLog>
</gww:gwWellGeology>
<gww:gwWellGeology>
    <gww:GW_GeologyLog gml:id="feduni.borehole.51409.stratigraphy.1">
        <om:phenomenonTime nilReason="unknown"/>
        <om:resultTime nilReason="unknown"/>
        <om:procedure xsi:nil="true" nilReason="unknown"/>
        <om:observedProperty xlink:href="http://www.opengis.net/def/gwml/2.0/observedProperty/stratigraphy"
xlink:title="stratigraphy"/>
        <!-- The ultimate om:featureOfInterest could be considered the GeologicUnit the stratigraphy describes. I
suggest the sampling FoI, i.e. the Borehole -->
        <om:featureOfInterest xlink:href="#feduni.borehole.51409"/>
        <om:result>
            <gww:GW_GeologyLogCoverage gml:id="feduni.borehole.51409.stratigraphy.1.coverage">
                <gww:element>
                <gww:LogValue>
                <gww:fromDepth>
                <swe:Quantity>
                <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>

```

```

        <swe:value>0.00</swe:value>
      </swe:Quantity>
    </gww:fromDepth>
    <gww:toDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
        <swe:value>0.30</swe:value>
      </swe:Quantity>
    </gww:toDepth>
    <gww:value>
      <swe:DataRecord
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/stratigraphy">
        <swe:field name="stratigraphy">
          <!-- Following is for categorical example to be used for stratigraphic log -->
          <swe:Category
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/stratigraphy">
            <swe:description>Some geological description</swe:description>
            <swe:codeSpace
xlink:href="http://geology.data.gov.vic.au/stratigraphicunit"/>
              <swe:value>To</swe:value>
            </swe:Category>
          </swe:field>
        </swe:DataRecord>
      </gww:value>
    </gww:LogValue>
  </gww:element>
</gww:element>
  <gww:LogValue>
    <gww:fromDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
        <swe:value>0.30</swe:value>
      </swe:Quantity>
    </gww:fromDepth>
    <gww:toDepth>
      <swe:Quantity>
        <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
        <swe:value>4.27</swe:value>
      </swe:Quantity>
    </gww:toDepth>
    <gww:value>
      <swe:DataRecord
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/earthMaterial" id="le.2">
        <swe:field name="stratigraphy">
          <swe:Category
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/stratigraphy">
            <swe:description>Some geological description</swe:description>
            <swe:codeSpace
xlink:href="http://geology.data.gov.vic.au/stratigraphicunit"/>
              <swe:value>Oap</swe:value>
            </swe:Category>
          </swe:field>
        </swe:DataRecord>
      </gww:value>
    </gww:LogValue>
  </gww:element>
</gww:element>

```

```

        </swe:Category>
        </swe:field>
        </swe:DataRecord>
        </gww:value>
        </gww:LogValue>
        </gww:element>
        </gww:GW_GeologyLogCoverage>
</om:result>
<gww:startDepth>
  <swe:Quantity>
    <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre" code="m"/>
    <swe:value>0</swe:value>
  </swe:Quantity>
</gww:startDepth>
<gww:endDepth>
  <swe:Quantity>
    <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
    <swe:value>11.58</swe:value>
  </swe:Quantity>
</gww:endDepth>
</gww:GW_GeologyLog>
</gww:gwWellGeology>
<gww:gwWellGeology>
  <gww:GW_GeologyLog gml:id="feduni.borehole.51409.age.1">
    <om:phenomenonTime nilReason="unknown"/>
    <om:resultTime nilReason="unknown"/>
    <om:procedure xsi:nil="true" nilReason="unknown"/>
    <om:observedProperty xlink:href="http://www.opengis.net/def/gwml/2.0/observedProperty/geologicAge"
xlink:title="geologic age"/>
    <!-- The ultimate om:featureOfInterest could be considered the GeologicUnit the stratigraphy describes. I
suggest the sampling FoI, i.e. the Borehole -->
    <om:featureOfInterest xlink:href="#feduni.borehole.51409"/>
    <om:result>
      <gww:GW_GeologyLogCoverage gml:id="feduni.borehole.51409.age.1.coverage">
        <gww:element>
          <gww:LogValue>
            <gww:fromDepth>
              <swe:Quantity>
                <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
                <swe:value>0.00</swe:value>
              </swe:Quantity>
            </gww:fromDepth>
            <gww:toDepth>
              <swe:Quantity>
                <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre"
code="m"/>
                <swe:value>0.30</swe:value>
              </swe:Quantity>
            </gww:toDepth>
            <gww:value>
              <!-- swe:DataRecord needs defining for age record -->
              <swe:DataRecord

```

```

definition="http://www.opengis.net/def/gwml/2.0/observedProperty/geologicAge">
    <swe:field name="geologicAge">
        <!-- Following is for categorical example to be used for geologic age log -->
        <swe:Category
definition="http://www.opengis.net/def/gwml/2.0/observedProperty/chronostratigraphy">
    <swe:identifier>xlink:href="http://resource.geosciml.org/classifier/ics/ischart/Quaternary"</swe:identifier>
        <swe:description>Some geological description</swe:description>
        <swe:codeSpace
xlink:href="http://resource.geosciml.org/classifier/ics/ischart/Quaternary"/>
        <swe:value>Quaternary</swe:value>
        </swe:Category>
    </swe:field>
</swe:DataRecord>
</gww:value>
</gww:LogValue>
</gww:element>
</gww:GW_GeologyLogCoverage>
</om:result>
<gww:startDepth>
    <swe:Quantity>
        <swe:uom xlink:href="http://qudt.org/vocab/unit#Meter" xlink:title="metre" code="m"/>
        <swe:value>0</swe:value>
    </swe:Quantity>
</gww:startDepth>
<gww:endDepth>
    <swe:Quantity>
        <swe:uom xlink:href="http://www.opengis.net/def/uom/UCUM/0/m"/>
        <swe:value>11.58</swe:value>
    </swe:Quantity>
</gww:endDepth>
</gww:GW_GeologyLog>
</gww:gwWellGeology>
</gww:GW_Well>

```

### C.5.5 GW\_MonitoringSite

From GNS NZ: Pupu Springs NGMP site.

```

<gwml2w:GW_MonitoringSite xmlns:gwml2w="http://www.opengis.net/gwml-well/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:sf="http://www.opengis.net/sampling/2.0" xmlns:sams="http://www.opengis.net/samplingSpatial/2.0"
xmlns:xlink="http://www.w3.org/1999/xlink" xmlns:gco="http://www.isotc211.org/2005/gco"
xsi:schemaLocation="http://www.opengis.net/gwml-well/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-well.xsd" gml:id="ngmp_pub_7">
    <gml:description>NGMP Site Pupu Springs</gml:description>
    <gml:name codeSpace="http://ggwdata.gns.cri.nz/ngmp">Pupu Springs</gml:name>
    <gml:boundedBy>
        <gml:Envelope srsName="http://www.opengis.net/gml/srs/epsg.xml#4326">
            <gml:lowerCorner>172.768 -40.849</gml:lowerCorner>
            <gml:upperCorner>172.768 -40.849</gml:upperCorner>
        </gml:Envelope>
    </gml:boundedBy>

```

```

<gml:location>
  <gml:Point srsName="http://www.opengis.net/gml/srs/epsg.xml#4326" gml:id="loc_ngmp_7">
    <gml:coordinates cs="," ts=" " decimal=".">172.768,-40.849</gml:coordinates>
  </gml:Point>
</gml:location>
<sf:sampledFeature xsi:nil="true" nilReason="unknown"/>
<sams:shape>
  <gml:Point srsName="http://www.opengis.net/gml/srs/epsg.xml#4326" gml:id="shape_point_ngmp_7">
    <gml:coordinates cs="," ts=" " decimal=".">172.768,-40.849</gml:coordinates>
  </gml:Point>
</sams:shape>
<gwml2w:gwMonitoringHost xlink:href="http://ggwdata.gns.cri.nz/ngmp/sites/pupu-springs-7" xlink:title="Pupu Springs"/>
<gwml2w:gwSiteReferenceElevation>
  <gwml2w:Elevation>
    <gwml2w:elevation srsName="http://www.opengis.net/gml/srs/epsg.xml#4440" srsDimension="1" uomLabels="m above sea level">3.7</gwml2w:elevation>
    <gwml2w:elevationAccuracy xsi:nil="true" gco:nilReason="unknown"/>
    <gwml2w:elevationType xlink:href="http://some.vocab.org/MeasuredInSitu" xlink:title="in situ"/>
    <gwml2w:elevationMeasurementMethod xlink:href="http://some.vocab/some-gps-gear" xlink:title="D-GPS method"/>
  </gwml2w:Elevation>
</gwml2w:gwSiteReferenceElevation>
<gwml2w:gwSiteType xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="spring"/>
</gwml2w:GW_MonitoringSite>

```

### C.5.6 GW\_Spring

#### GNS NZ : Te Waikoropupu Springs (Pupu Springs)

```

<gwml2w:GW_Spring xmlns:gwml2w="http://www.opengis.net/gwml-well/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance" xmlns:gml="http://www.opengis.net/gml/3.2"
xmlns:gco="http://www.isotc211.org/2005/gco" xmlns:xlink="http://www.w3.org/1999/xlink"
xsi:schemaLocation="http://www.opengis.net/gwml-well/2.0 http://ngwd-
bdnes.cits.nrcan.gc.ca/service/gwml/schemas/gwml2-well.xsd" gml:id="pupu-springs-7">
  <gwml2w:gwSpringName>Te Waikoropupu Springs (Pupu Springs)</gwml2w:gwSpringName>
  <gwml2w:gwSpringLocation>
    <gml:Point srsName="http://www.opengis.net/gml/srs/epsg.xml#4326" gml:id="loc_ngmp_7">
      <gml:coordinates cs="," ts=" " decimal=".">172.768,-40.849</gml:coordinates>
    </gml:Point>
  </gwml2w:gwSpringLocation>
  <gwml2w:gwSpringReferenceElevation>
    <gwml2w:Elevation>
      <gwml2w:elevation srsName="http://www.opengis.net/gml/srs/epsg.xml#4440" srsDimension="1" uomLabels="m above sea level">3.7</gwml2w:elevation>
      <gwml2w:elevationAccuracy xsi:nil="true" gco:nilReason="unknown"/>
      <gwml2w:elevationType xlink:href="http://some.vocab.org/MeasuredInSitu" xlink:title="in situ"/>
      <gwml2w:elevationMeasurementMethod xlink:href="http://some.vocab/some-gps-gear" xlink:title="D-GPS method"/>
    </gwml2w:Elevation>
  </gwml2w:gwSpringReferenceElevation>

```

```
</gwml2w:gwSpringReferenceElevation>
<gwml2w:gwSpringType xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="mineral"/>
<gwml2w:gwSpringCauseType xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="artesian"/>
<gwml2w:gwSpringGeology xlink:href="http://maps.gns.cri.nz/geology/wfs?" xlink:title="QMAP NZ Geology"/>
<gwml2w:gwSpringBody xsi:nil="true" nilReason="unknown"/>
<gwml2w:gwSpringUnit xsi:nil="true" nilReason="unknown"/>
<gwml2w:gwSpringConstruction xsi:nil="true"/>
<gwml2w:gwSpringPersistence xlink:href="http://somevocab.org/gwml/2.0/notes" xlink:title="permanent"/>
<gwml2w:gwSpringLicence xsi:nil="true"/>
</gwml2w:GW_Spring>
```

## Annex D Revision history

Date	Release	Author	Paragraph modified	Description
2014-05-20	0.1.0	Bruce Simons	All	Initial internal version
2014-06-04	0.2.0	Boyan Brodaric	All	More complete internal version
2014-08-04	0.3.0	Sylvain Grellet	All	Initial XML instance examples added
2014-08-11	0.3.1	Boyan Brodaric	All	Minor wording changes



## **Annex E Bibliography**

- [1] Boisvert, B., Brodaric, B. (2012) GroundWater Markup Language (GWML) – Enabling Groundwater Data Interoperability in Spatial Data Infrastructures. *Journal of Hydroinformatics*, 14(1):93–107, 2012.
- [2] INSPIRE ( 2009) Data Specification on Geology (D2.8.II.4). European Commission.