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OGC WaterML2.0: part 2 – Ratings, Gaugings and Sections

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i. Abstract

This standard defines an information model and XML encoding for exchanging the following three hydrological information resources:

1. *Conversion tables*, or *conversion curves*, that are used for the conversion of related hydrological phenomenon.
2. *Gauging observations* – the observations performed to develop *conversion table* relationships.
3. *Cross sections* - survey observations made of the geometric structure of features, such as river channels, storages etc.

Metadata and vocabularies are defined that together provide a means for parties to exchange these concepts using common semantics.

This standard is the second part of the WaterML2.0 suite of standards, building on part 1 that addresses the exchange of time series[1].

ii. Keywords

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

ogcdoc, waterml, ratings, gaugings, o&m, conversion, cross section

iii. Preface

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights.

Recipients of this document are requested to submit, with their comments, notification of any relevant patent claims or other intellectual property rights of which they may be aware that might be infringed by any implementation of the standard set forth in this document, and to provide supporting documentation.

iv. Submitting organizations

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

- CSIRO
- Australian Bureau of Meteorology
- Centre for Ecology and Hydrology, UK

[1] www.opengeospatial.org/standards/waterml

- KISTERS
- USGS
- Aquatic Informatics

v. Submitters

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1. Scope

This document defines an information model to describe hydrological ratings, gauging observations and survey observations. It is part 2 of the WaterML2.0 'suite' of standards; the first part covered time-series observations and monitoring points. This standard re-uses types from part 1.

This work has been conducted by members of the WaterML 2.0 Standards Working Group and the joint WMO/OGC Hydrology Domain Working Group.

2. Conformance

This standard defines a UML conceptual model and XML encoding schema for describing hydrological conversions, gauging observations and survey observations. Requirements for two standardization target types are considered:

- UML models

- XML instances (e.g. XML documents)

Conformance with this standard shall be checked using all the relevant tests specified in Annex A (normative) and Annex B (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies and Procedures and the OGC Compliance Testing web site[1].
In order to conform to this OGC™ interface standard, a software implementation shall choose to implement:

a) Any one of the conformance levels specified in Annex A (normative) or Annex B (normative).

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

3. References

The following normative documents contain provisions that, through referenced in this text, constitute provisions of this document. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. For undated references, the latest edition of the normative document referred to applies.

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

ISO 19103:2005 – Geographic information - Conceptual schema language

ISO 8601:2004 - Data elements and interchange formats – Information interchange – Representation of dates and times

OGC Abstract Specification Topic 1 – Feature geometry (aka ISO 19107)

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 19115:2014)

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

1. http://cite.opengeospatial.org/

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

OGC WaterML2.0 part 1 – timeseries. OGC 10-126r4.
http://www.opengeospatial.org/standards/waterml

OGC Observations and Measurements v2.0 XML OGC Document 10-025r1.
http://www.opengis.net/doc/IS/OMXML/2.0

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

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 standard.

For the purposes of this document, the following additional terms and definitions apply. There is some variation in the specific use of some technical terms within the hydrological domain. We have attempted to follow common usage, referring where possible to the WMO Glossary of hydrological concepts (http://webworld.unesco.org/water/ihp/db/glossary/glu/aglu.htm). English version: http://webworld.unesco.org/water/ihp/db/glossary/glu/HINDEN.HTM.

4.1
discharge
volume of liquid flowing through a cross-section in a unit time.

Synonym: flow.

4.2
stage
water level, typically measured at a stream-monitoring site.

Synonym: gauge height, level.

4.3
cross-section
profile of a stream normal to the mean direction of flow, usually bounded by the potential inundation extent of the stream.

4.4
control
physical properties of a channel which determine the relationship between stage and discharge at a location in the channel. (WMO)

NOTE 1 Physical properties refers to the shape of the natural or anthropogenic feature which is controlling the stream level at the monitoring station.

4.5
gauging observation
physical, paired, simultaneous measurement of two related phenomena for the purposes of developing or validating the relationship between them.

EXAMPLE Simultaneous measurements of streamflow and aggregate mean gauge height.

EXAMPLE Simultaneous measurements of velocity and flow.

NOTE 1 Also referred to as *Gauging,* often - depending on local usage - implying stage and discharge observations specifically.

NOTE 2 In some situations outside of this specification the term calibration, or even rating, is used to describe such a measurement.

4.6
monitoring point
primary location for conducting observations. (OGC WaterML2.0 part 1)

NOTE Also often referred to as *Station*, *Gauging Station* and *Site*.

4.7
property
physical phenomenon that may be directly measured or estimated.

EXAMPLE Stage, discharge, rainfall, evapotranspiration

NOTE 1 Phenomena are often associated with features, where they may be termed *property* or *property type.*

NOTE 2 Other domain synonyms or close matches include *variable, observed property* and *parameter.*

4.8
conversion
relationship between two phenomena at a moment in time as defined by an equation, table of paired values or other form.

EXAMPLE A stage to discharge conversion defined by a rating table describes the relationship between the water level and the volumetric flow rate of a stream.

4.9
rating conversion
specific Conversion that relates stage to discharge.

NOTE Within hydrology this is commonly referred to as a *Rating*. A plot of a Rating Conversion is often called a rating curve.

4.10
conversion table
table representation of a Conversion.

NOTE A conversion table is, most often, a discretised representation of a rating curve; hence there will be a 1:1 relation between a curve and its table. The tabular form of the rating curve facilitates use and exchange.

NOTE Within hydrology this is commonly referred to as a *Rating Table* when representing a stage to discharge conversion.

4.11
conversion equation
equation representation of a Conversion.

NOTE The equation may be presented as a curve, which within hydrology is termed a rating curve.

4.12
conversion group
A conversion group defines the applicable conversions for time periods at a specific location.

EXAMPLE A collection of stage to discharge conversion tables that have their period of application defined across time.

4.13
input property
property that is being measured to estimate another property using a Conversion.

EXAMPLE stage, velocity, turbidity

NOTE 1 Also known as the independent (or input) property

4.14
output property
property that is being estimated using a Conversion.

EXAMPLE discharge, cross-sectional velocity, total suspended sediment

NOTE 1 Also known as the dependent (or output) property

5. Conventions

5.1 Abbreviated terms

GML	Geography Markup Language
O&M	Observations and Measurements
OGC	Open Geospatial Consortium
SWE	Sensor Web Enablement
UML	Unified Modeling Language
WMO	World Meteorological Organisation
XML	Extensible Markup Language
XSD	W3C XML Schema Definition Language

5.2 Schema language

The XML implementation specified in this Standard is described using the XML Schema language (XSD) [XML Schema Part 1: Structures, XML Schema Part 2: Datatypes] and Schematron [ISO/IEC 19757-3, Information technology — Document Schema Definition Languages (DSDL) — Part 3: Rule-based validation — Schematron].

5.3 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 standard, the following color scheme is used to identify the package in which the class exists. This is just for informative purposes.

 Tan: Defined within this standard

 Blue: WaterML2.0 part 1 - timeseries

 Red: ISO19156 – Observations & Measurements

Green: ISO19115 – Metadata

6. Vocabularies

This standard defines a number of properties that require the use of codes/vocabulary items. In some cases, a list of terms is provided. Where no codes are provided, it is expected that a list will be developed in the future, or a local code list may be used. A summary of the vocabularies is shown in **Error! Reference source not found.**. The joint OGC/WMO Hydrology Domain Working Group (HydroDWG) is responsible for managing the content of these vocabularies. Once agreement is reached for definitions, the HydroDWG should submit updates to the OGC Naming Authority.

Table 1 – Summary of vocabularies within this standard

Code list	Package(s)	Code items defined
DevelopmentMethodCode	Conversions	Yes
DomainFeatureTypeCode	Conversions	No
PropertyCode	Conversions & Gaugings	No
StatusCode	Conversions & Gaugings	Yes
InputMethodCode	Gaugings	No
OutputMethodCode	Gaugings	No
RelativeDirectionCode	Gaugings	Yes
StreamStateCode	Gaugings	Yes
ControlConditionCode	Gaugings	No

Code list	Package(s)	Code items defined
RangeDefinitionCode	RangeValues	No
SectionPropertyCode	Sections	Yes
TerminationTypeCode	Sections	No

7. Non-Normative (Informative) Material

WaterML2.0 is an initiative of the OGC to develop international standards and address interoperability of hydrological information systems. The first part of WaterML2.0[1] focused on a standard information model for time series of hydrological observations. The scope was defined through identification of common requirements and priority areas for data hydrological data exchange[2]. The development involved a harmonisation process whereby existing formats were compared and contrasted with an aim of capturing the key elements for time series data exchange. Early versions of the standard were tested through a number of OGC Interoperability Experiments, each testing against a different set of use cases.

WaterML2.0 part 2 focuses on another key aspect of hydrological data: rating conversions, gauging observations and river cross-sections. These are part of most surface water monitoring programs and are used in daily operations, including reporting, analysis, modelling and forecasting. This type of data is becoming increasingly important to exchange and share outside the scope of single organisations. The full history of rating conversions through time, and the gauging observations used to develop ratings, is needed to judge their fitness for purpose, and increasingly for the quantification of uncertainty for risk-based modelling and analysis.

7.1 Conversions are a generalised concept

The practice of using an observed or theoretical relationship to make indirect observations through conversion of a more readily measured phenomenon has wide application within hydrology. The most prevalent usage of conversions within hydrology is the application of rating conversions.

This standard enables the definition of simple relationships between any phenomena, though the primary focus in its creation has been to ensure its appropriateness for stage to

1 www.opengeospatial.org/standards/waterml
2 Harmonising standards for water observations data, discussion paper. OGC 09-124r2,

discharge conversion. The following discussion describes stage to discharge relationships, their derivation, and their uncertainty in more detail in order to aid understanding of the use cases and the resulting data model.

Conversions may be applied in a compound manner with the sequential application of conversions being required to determine the final derived value, e.g. the North American practice of correcting stage data via a conversion prior to the derivation of discharge. This standard defines the method for the communication of the conversions but does not define the workflow process for compound conversion usage.

7.2 Key hydrological concepts

7.2.1 Overview

Hydrometry is the practice of measuring river flow, which is important to almost all areas of hydrology. River flows are generally measured indirectly – relying on the conversion of a record of stage to discharge using an often empirically derived rating conversion.

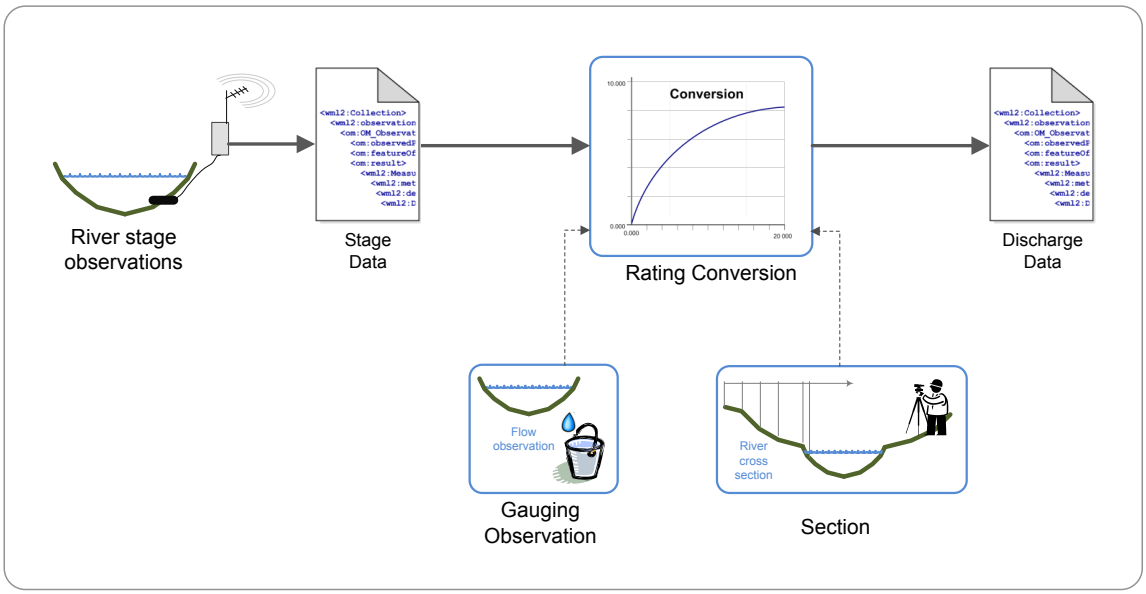

Figure 1 - Rating process

7.2.2 Rating-conversion

7.2.2.1 Purpose

A rating conversion contains the information needed to correctly derive the dependent phenomenon (output property) from the independent one (input property). The rating conversion has validity during one, or more, specified periods of duration. The rating conversion period of validity may overlap with the period of validity of another rating requiring a transition.

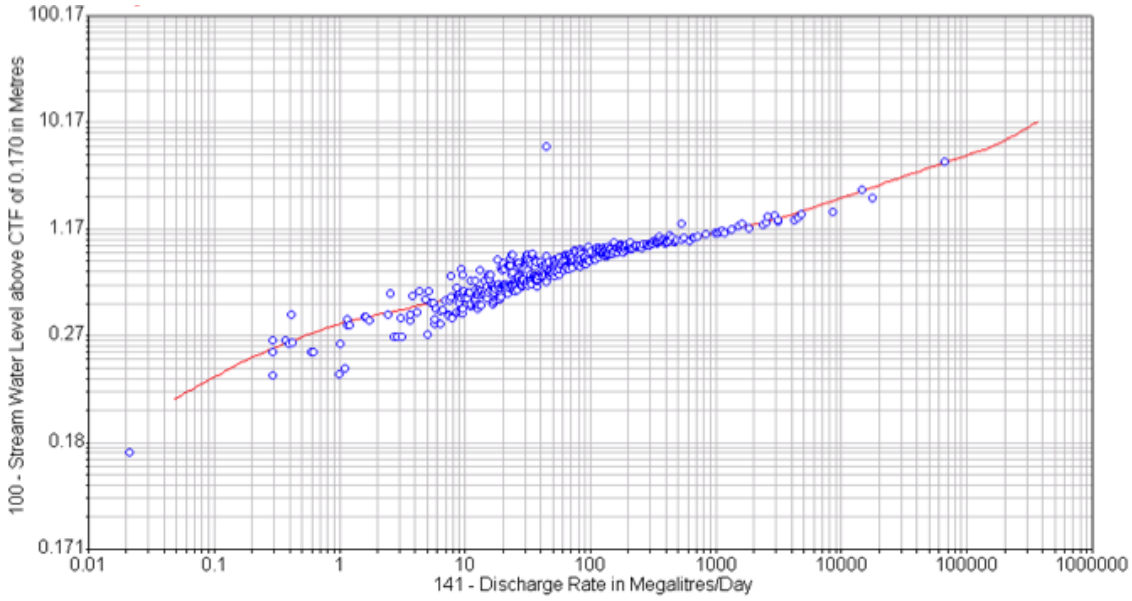

Figure 2 - Example stage to discharge rating relationship, showing gauging observations[2]

Figure 2 shows an example plot of a rating conversion curve (on a log-log scale) with the individual gauging points and rating period of application. WMO recommends a curve should "…include at least 12 to 15 measurements, all made during the period of analysis" and these should be "…well distributed over the range of gauge heights experienced."

7.2.2.2 Construction of a Rating-conversion

A rating conversion is an articulation of the complex physical relationship between stage and discharge. The shape, extent and form of a rating conversion are typically calibrated with gauging observations. Rating conversions are often extrapolated beyond the range of gauging observations.

Construction of a rating conversion requires consideration of factors such as the shape of the channel cross-section, the hydro-morphology of the channel, including the texture of the channel surfaces, and the hydraulics of the channel upstream and downstream of the monitoring point.

Some monitoring points implement an artificial structure to control the stage to discharge relationship over a limited range of stage e.g. a weir or flume. A control structure may be constructed to a specification for which the stage to discharge relationship is known. In this case gauging observations are commonly used to validate the theoretical relationship, and to define the relationship for the stage ranges where the theoretical relationship does not apply e.g. when the capacity of the control structure is exceeded.

7.2.2.3 Maintenance of a Rating-conversion

The stage to discharge relationship can change over time due to a large number of factors including erosion of the channel bed or banks, deposition of sediment either at, or up- and

[2] **Graph extracted from http://www.water.nsw.gov.au/. Identifiers and site details removed.**

downstream of, the cross-section, growth of weed or accumulation of algae. These changes can be sudden (e.g. erosion of the bed and banks during a flood event) or gradual, seasonal (e.g. weed growth) or irregular in time.

The changing nature of the relationship drives a need for ongoing review and re-definition of the relationship. Monitoring points generally have a history of rating conversions that have a time-limited period of validity; the latest rating conversion is used to define the current stage to discharge relationship.

7.2.2.4 Rating-conversion uncertainty

Uncertainty is an inherent aspect of rating conversion development and application. Some sources of rating conversion uncertainty at a monitoring point can be characterized by expert-knowledge, for example the quality of a structure, or the likelihood of weed-growth or erosion within a river section.

In most cases it is ultimately the quality of the fit of the rating to the gauging observations, and the ability of the gauging observations to represent the range of stage at a monitoring point, which is used to quantify the uncertainty.

Increased sharing of ratings and gaugings will assist data users to complete their own evaluation of uncertainty in any dataset.

7.2.2.5 WaterML2 Part 2 expresses the data as a points table

Rating conversions are defined in many different forms in hydrometric data systems. The two primary methods for defining rating conversions are a table of stage/discharge pairs and one or more equations. **Assessment of exchange standards to support equation-based conversions was out of scope for this work**. This standard is scoped to enable the interoperable exchange of rating conversions though the use of a linearly interpretable points table.

7.2.2.6 Gauging observation

A gauging observation is the simultaneous measurement of the independent and dependent properties that are the subject of a conversion. The observations are used in the development and validation of a conversion.

7.2.2.7 Stage-discharge gauging observation

Stage-discharge gauging observations are the simultaneous direct measurements of instantaneous stage and discharge.

The technique used for measuring both phenomena can vary. The most common method for determining an estimated discharge measurement is the velocity-area method, which is roughly described as follows:

- The velocity of water is measured in different segments of the river cross-section.
- The volume for each segment is calculated based on the segments measured area multiplied by the segments mean velocity, determined from multiple velocity observations.

- The volume of each segment is summed to give an estimate of total discharge.

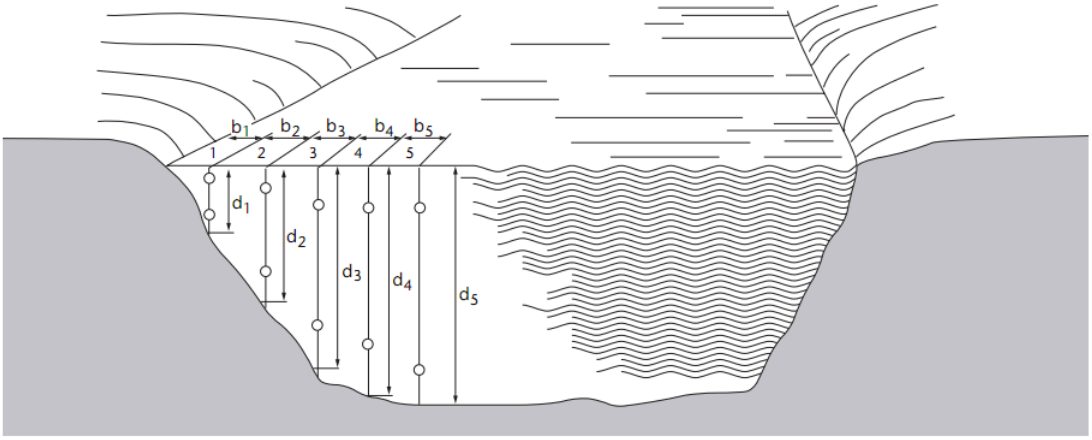

Figure 3 - View of a stream cross-section showing the location of points of observation[1]

Stream-discharge gauging observations are undertaken to quantify the discharge at the monitoring point. The location of the actual observation is likely to be up or downstream of the monitoring point. The observation location will be chosen based on the prevailing river conditions and assessment of the most appropriate place for conducting a stage-discharge gauging observation.

7.2.2.8 Changing technologies

The method used to determine the velocity at each point varies – more traditional techniques involve the use of an impeller driven current meter that is lowered into the river, sometimes from a boat or directly by an operator standing in the river.

The use of acoustic methods, such those provided by Doppler instruments, are increasing in use due to their practicality and availability of commercial instruments.

For example, Acoustic Doppler Current Profilers (ADCP) can simultaneously measure the velocity of suspended particles in the river, depth and the river cross section path to estimate discharge. Multiple transects can be taken to provide a more accurate estimate. The increased speed of the measurement technique allows for more precise recording of discharge, allowing for greater definition of the rating curve through an increased number of observations in the same time period compared to older methods.

7.2.3 Sections

River channel sections are used in the construction and maintenance of rating tables. The types of sections in common use are cross sections and long sections.

[1] **Extracted from WMO Guide to Hydrological Practices, Volume I.**

7.2.3.1 Cross section

Cross sections are taken to define the stage/area relationship and identify variation of riverbank profile.

Cross sections are usually taken to define the shape of stage to discharge relationship controlling features. As the stage to discharge relationship controlling feature may change with increasing stage, multiple section may be required e.g. at lower stages there may be an artificial weir, above the weir a downstream bend may be a controlling feature.

7.2.3.2 Long section

Long sections typically follow the riverbed along the thalweg. Long sections are used to understand the slope of the river channel and its contribution to the rivers kinetic energy.

7.2.3.3 Use of gauging observation cross sections

The process of completing a stage-discharge gauging observation involves the measurement of the river cross section at the gauging section. Whilst this information is useful, it has limited value to rating conversion construction and maintenance as it does not define a stage–discharge relationship at the controlling feature and it only defines the riverbank profile for the area of current inundation.

7.3 Use cases/scenarios

Sharing of rating curves is required in multiple scenarios, generally stemming from the need to perform the calculation of the derived phenomenon or to analyse the derived data with a view to understanding its inherent uncertainty or quality. The following use cases were used in the requirements analysis process and produced a set of requirements that are described later in this document.

7.3.1 Data scrutiny

A primary use case for exposing detailed descriptions of rating tables is for closer scrutiny of derived data sets. A number of regularly used hydrological time-series – the most obvious being river discharge/flow – are derived using techniques that are approximations of relationships between other more readily measurable phenomena. It is becoming increasingly important for these data to be treated carefully due to the inherent assumptions made in the conversion process[1].

Five scenarios were used when analyzing requirements from this perspective:

1. Uncertainty research;
2. Geomorphic process, cross sections;
3. Engineering design, e.g. designing a flood barrier;
4. Analysis and assessment of input data for hydrological models; and
5. Evaluation of fitness for purpose of data derived from ratings.

[1] Beven, K., & Westerberg, I. (2011). On red herrings and real herrings: disinformation and information in hydrological inference. Hydrological Processes, 25(10), 1676-1680.

7.3.2 Exchange of specific rating table

It is often desirable to have instant access to a specific rating table relationship for a specific purpose. Some indicative examples include:

1. Time sensitive (floods, events, emergencies);
2. Inundation modelling (reverse the conversion and get the input variable from the output variable, e.g., get state from discharge);
3. A site visit or comparing a gauging point against the curve;
4. Exchange of the most recent shift curve. (E.g. for reservoir optimization where the rating for inflow is subject to frequent shifts); and
5. Providing ratings to operational systems (such as SCADA).

7.3.3 Exchange of full rating history

Often a centralised repository or reporting agency requires access to a full history of rating tables to run derived calculations for specific sites at any point in time. This requires a full history of rating tables as they have evolved through time. This typically excludes development versions of rating tables that have not been approved for use or release.

7.3.4 Suspended sediment and load calculations

Sediment-transport relationships (for calculating concentration, loads etc.) are used in numerous scenarios requiring an understanding of expected sediment build up or effects on the general environment. These relationships are often required by hydraulic or civil engineers for particular analyses or case studies.

7.3.5 Transfer between disparate information systems

This use case covers exchange between systems that do not have a common information model/schema for representation rating conversion. While this is a generic use case that may occur within the above scenarios, it is an important one for operation and interoperability of distributed information systems. Examples include:

1. Exchange of ratings amongst databases using different schema;
2. Migration of ratings into a new database using a different schema; and
3. Archive of ratings in a form that will preserve information without dependence on any particular software.

7.3.6 Research services

General hydrological studies benefit from open access to hydrological data that may be used in educational scenarios. Rating tables and gauging observations are fundamental concepts within hydrological operations and having access to real world data in common formats supports learning these base concepts.

8. UML Model (normative)

8.1 Requirements class: Collection

Requirements Class	
http://www.opengis.net/spec/waterml/part2/1.0/req/uml-collection	
Requirement	/extends-part1 The WaterML2.0 part 2 Collection type shall specialize the WaterML2.0 part 1 Collection by adding support for rating, gauging and cross-section members.

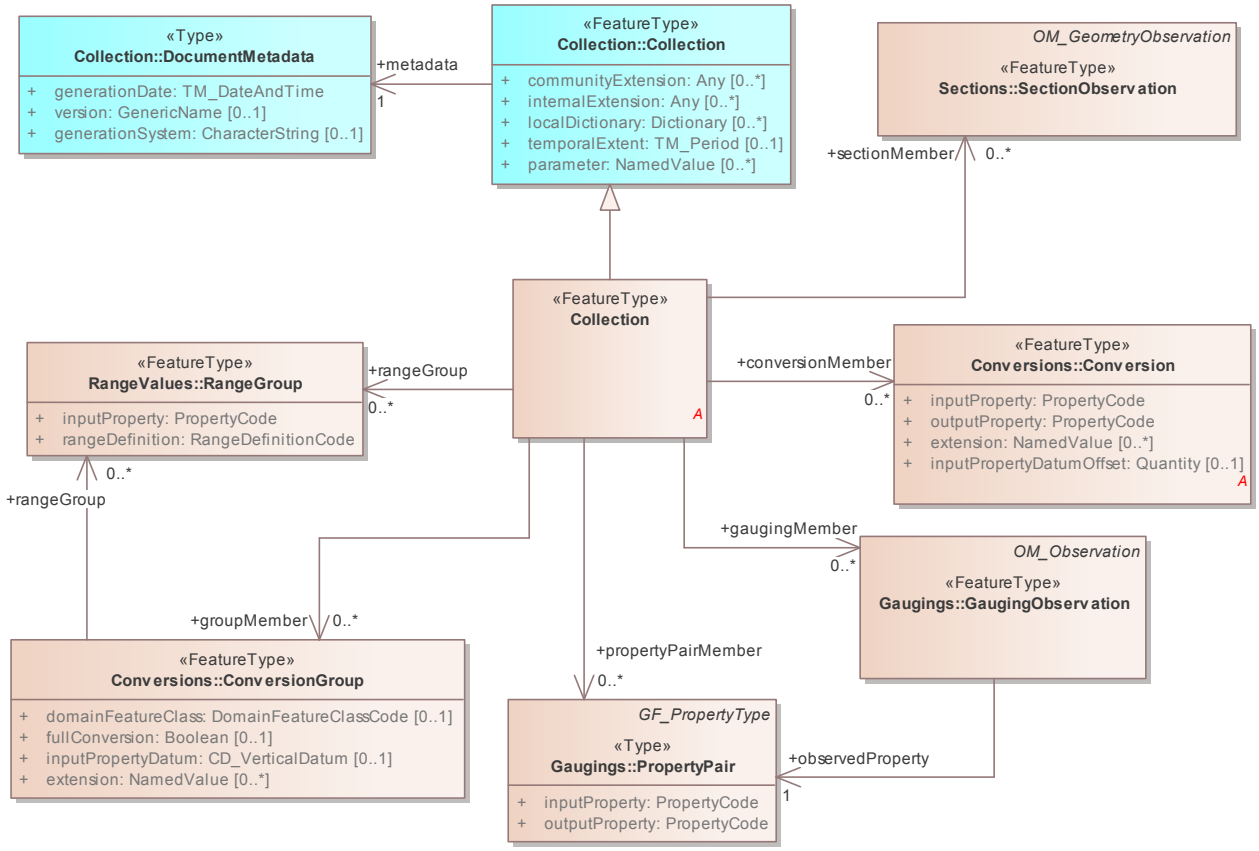

Figure 4 - Collection UML

8.1.1 Requirements class overview

The collection requirements class defines the top level collection that allows components of the part 2 model to be exchange together. It extends the WaterML2.0 part 1 collection type by adding support for conversions, gauging observations and cross-section observations.

8.1.2 Collection

The Collection type is an extension of the part 1 collection. It has been extended to allow members of type Conversion, GaugingObservation, ConversionGroups, and CrossSectionObservations.

Table 2 - Collection properties

Name	Definition	Data types and values	Multiplicity
groupMember	A member of the collection that contains a conversion group.	ConversionGroup	0..*
gaugingMember	A member of the collection that contains a specific gauging.	GaugingObservation	0..*
sectionMember	A member containing a cross-section instance.	SectionObservation	0..*
rangeGroup	A range group member of the collection.	RangeGroup	0..*
propertyPairMember	Members to allow local definition of property pairs, which group together two related properties. E.g. stage-flow. These can then be referenced for gauging observations.	PropertyPair (see 8.4.9)	0..*
conversionMember	A member of the collection that contains a specific conversion.	Conversion	0..*

8.2 Requirements class: Conversions

Requirements Class	
http://www.opengis.net/spec/waterml/part2/1.0/req/uml-conversions	
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point
Dependency	urn:iso:dis:iso:19156:clause:9
Requirement	/datums-for-stage A ConversionGroup that converts a level or stage property shall include a definition of the vertical datum used.
Requirement	/multiple-conversion-types Conversions shall support conversion between any properties, not just stage-flow conversions.
Requirement	/start-periods Within a ConversionGroup, each ConversionPeriod shall express the start date of a period of application for a Conversion. The end of the applicable period may be specified using the periodEnd. If no end is specified for the ConversionPeriod, the conversion applies to the start of the next applicable period, or indefinitely if no other ConversionPeriods exist in the ConversionGroup.
Requirement	/conversion-reuse Different ConversionPeriods shall be able to refer to the same Conversion.
Requirement	/conversion-gaps To express a gap in groups of Conversions, a ConversionPeriod with a periodEnd shall be used, followed by a ConversionPeriod with periodStart to express the end of the gap.
Requirement	/linear-interpolation A ConversionTable shall contain sufficient input/output values to allow linear interpolation between points. The data producer determines the resolution at which the values are created.
Requirement	/equation A Conversion shall support specification of the source equation of the conversion table. This shall be done using the sourceDefinition property to reference a ConversionEquation. The ConversionEquation supports a text-based equation description. There is no equation formatting specified.

Requirement	/transformation The definition of a Conversion shall be sufficient to allow calculation of derived values, without the need to specify the way the transformation should be run.
Requirement	/source-system A Conversion definition shall support additional information that describes how the source system stored the conversion table. This shall be done using the sourceDefinition property.
Requirement	/keys A ConversionGroup shall be uniquely identified by, at a minimum, the Monitoring Point, inputProperty and outputProperty. If additional key entries are required, these can be expressed using the 'name' property.
Requirement	/link-to-gaugings A Conversion shall allow referencing to the gauging observations that were used in construction of the conversion relationship through the ConversionMetadata type. This allows the following to be defined: - Gauging observations that were used and taken in the period of application; - Gauging observations that were not used in the period of application; - Gauging observation that were used but taken outside the application period, e.g. a high flow rating conversion.
Requirement	/phasing A ConversionGroup shall support the definition of a phased changed between Conversions. Each ConversionPeriod shall specify the period over which the applicable Conversion should be phased from the previous Conversion.
Requirement	/table-point-quality A ConversionTable shall support expression of the quality of each point within the table. A default shall be provided for the whole table, unless overridden by individual points. To override the default, the input and output values provide a SWE:Quantity type that allows a quality to be specified against a quantity.
Requirement	/review-process-metadata A Conversion shall contain metadata properties to support definition of whether the conversion is under review, approved or in development.
Requirement	/range-group A Conversion shall contain an associated with a RangeGroup, which describes metadata that varies according to the inputProperty.

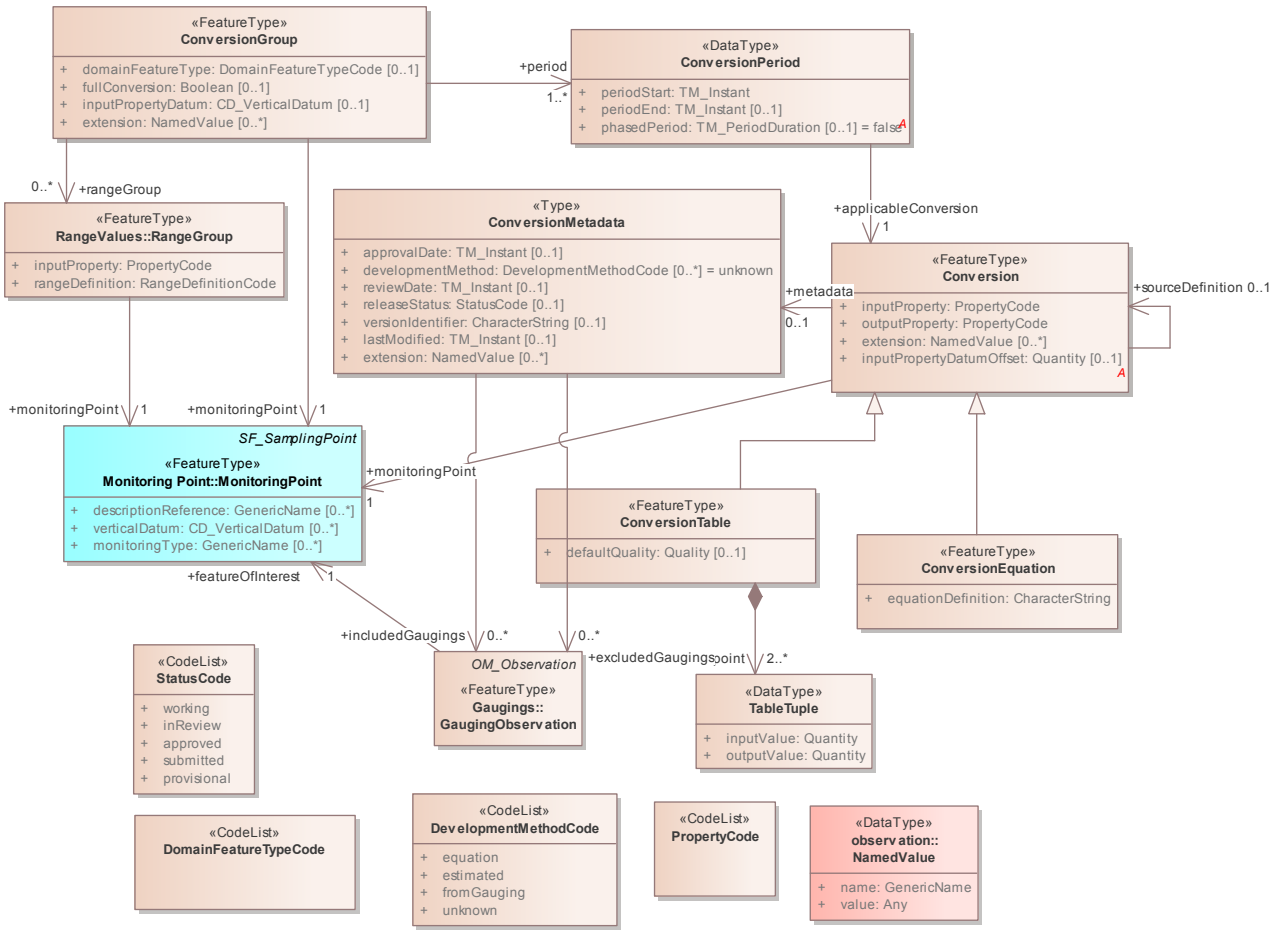

Figure 5 - Conversion UML

8.2.1 Requirements class overview

This requirements class provides a model and requirements to define conversions between input and output properties, e.g. a conversion table describing a stage to discharge relationship.

8.2.2 Conversion

A Conversion defines the relationship between two properties: the input property and the one being converted to (output property). A conversion applies to a specific monitoring point.

Table 3 - Conversion properties

Name	Definition	Data types and values	Multiplicity
metadata	Association of a conversion with the Metadata of the conversion.	ConversionMetadata	0..1

Name	Definition	Data types and values	Multiplicity
sourceDefinition	This is an extension point to enable propriety systems to refer to an encoding of their systems definition of the conversion.	Conversion	0..1
monitoringPoint	Association of the conversion with a 'WaterML 2.0: Part 1-Timeseries' monitoring point.	MonitoringPoint (WaterML2.0 part 1)	1
inputProperty	The input property to the conversion. E.g. river level/stage.	PropertyCode (see 8.2.11)	1
outputProperty	The output of the conversion process. E.g. discharge.	PropertyCode (see 8.2.11)	1
extension	A point of extension to allow vendor/organization specific content.	NamedValue (ISO19156)	0..*
inputPropertyDatumOffset	Indicates that an offset from the specified datum (specified by the ConversionGroup) should be added to the input property. Positive upwards with respect to gravity.	Quantity (SWE Common 2.0)	0..1

8.2.3 ConversionEquation

A conversion may be defined by an equation. This type provides a simple free-form text description of the equation. Future work may specify particular equation types or forms. Where multiple equations are used to define conversion, the range values section of this standard should be considered for use.

Table 4 - ConversionEquation properties

Name	Definition	Data types and values	Multiplicity
equationDefinition	A string representation of the equation. No strict format is defined as many forms may exist.	CharacterString	1

8.2.4 ConversionGroup

A conversion group defines the association between conversion periods and specific conversions. This reflects the changing nature of a conversion through time. The group

may represent all conversions available at a site (see fullConversion attribute) or a subset for exchange.

Table 5 - ConversionGroup properties

Name	Definition	Data types and values	Multiplicity
rangeGroup	The available range tables for this conversion group (combination of inputProperty/outputProperty and monitoring point).	RangeGroup	0..*
monitoringPoint	Association of the conversion with a 'WaterML 2.0: Part 1-Timeseries' monitoring point.	MonitoringPoint (WaterML2.0 part 1)	1
period	Captures the conversion period members of the group. Each period defines a period of application that makes up the group.	ConversionPeriod	1..*
domainFeatureType	This describes the type of feature that the conversion is applicable to. This is likely to be a reference or code that describes a feature type. E.g. 'reservoir', 'river'.	DomainFeatureTypeCode (see 8.2.10)	0..1
fullConversion	Defines whether this group of conversions contains all the available conversions for a monitoring point, inputProperty and outputProperty combination. This would be false, for example, if the group contains only the latest conversions.	Boolean	0..1
inputPropertyDatum	The vertical datum that is associated with the input property.	CD_VerticalDatum (ISO19111)	0..1
extension	A point of extension, allowing named-value pairs, where the value is of type Any. E.g. you can name an extension point that can contain any application-specific metadata.	NamedValue (ISO19156)	0..*

8.2.5 ConversionMetadata

Describes metadata relating to the conversion. Generally, this is related to conversion development processes (review, development method etc.).

Table 6 - ConversionMetadata properties

Name	Definition	Data types and values	Multiplicity
includedGaugings	References to gaugings that were used in development of this conversion. Association properties (e.g. arcrole if an XML target) may be used to specify the reason for inclusion	GaugingObservation	0..*
excludedGaugings	References to gaugings that were excluded from this conversion in its development. Association properties (e.g. arcrole if an XML target) may be used to specify the reason for exclusion.	GaugingObservation	0..*
approvalDate	If the conversion has been approved for production use, this represents the date the conversion was approved for use. This is not related to the conversion period start date.	TM_Instant (ISO19108)	0..1
developmentMethod	A code that gives an indication of the method used to develop the conversion relationship. See DevelopmentMethodCode.	DevelopmentMethodCode (see 8.2.9)	0..*
reviewDate	Date of the last review of the conversion where the conversion was assessed for accuracy in relation to input data or observations such as gaugings.	TM_Instant (ISO19108)	0..1
releaseStatus	A code indicating the status of the conversion in relation to its development lifecycle.	StatusCode (see 8.2.12)	0..1
versionIdentifier	If a conversion has been through development of multiple versions, this version identifier allows reference to a specific	CharacterString	0..1

Name	Definition	Data types and values	Multiplicity
	version.		
lastModified	This defines that date when the conversion was last modified during the conversion maintenance process. If the conversion has been approved this represents the date the conversion was approved for use, this is not related to the conversion period start date.	TM_Instant (ISO19108)	0..1
extension	Extension point that allows extra metadata to be added to the Conversion. This can be used to exchange system specific metadata that is not defined in the standard model.	NamedValue (ISO19156)	0..*

8.2.6 ConversionPeriod

A conversion period defines the time period in which a particular conversion relationship should be used. Conversion periods may re-use conversions for different periods (e.g. the physical relationship is changed for a period of time due to some installation and reverts to the previous conversion once this is removed).

Table 7 - ConversionPeriod properties

Name	Definition	Data types and values	Multiplicity
applicableConversion	The applicable conversion for this period.	Conversion	1
periodStart	The start of the conversion period.	TM_Instant (ISO19108)	1
periodEnd	The end of the conversion period. This is used to define a gap between conversion periods or a period of validity for the current conversion table. Normal usage would involve a succession of conversion periods defined by only periodStart dates.	TM_Instant (ISO19108)	0..1

Name	Definition	Data types and values	Multiplicity
phasedPeriod	The phasedPeriod property specifies the period over which the conversion should be phased from the preceding table to the current table. Refer to requirement /phasing for further description.	TM_PeriodDuration (ISO19108)	0..1

8.2.7 Phasing between conversions

When two conversions are to be phased, the second conversion defines a period over which it should be phased into. This defines the transition period for moving between conversions. Two examples of phased transitions are show in the following diagrams.

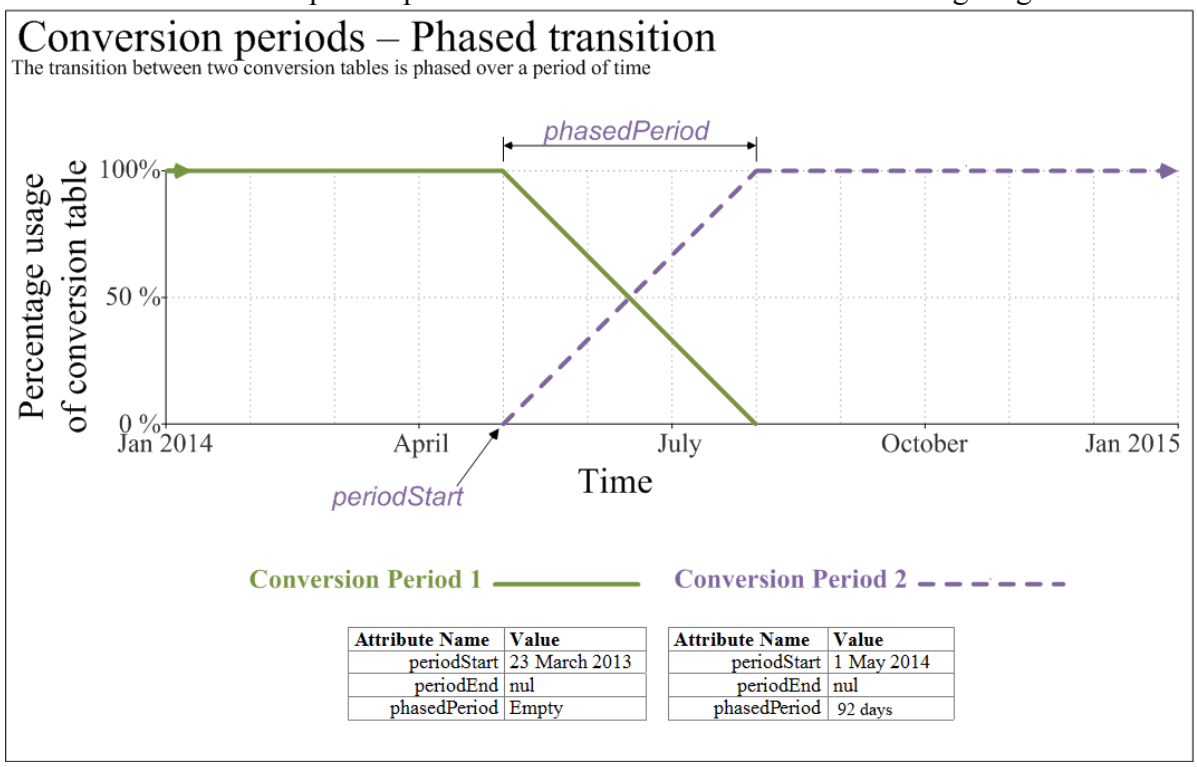

Figure 6 - An example phased conversion

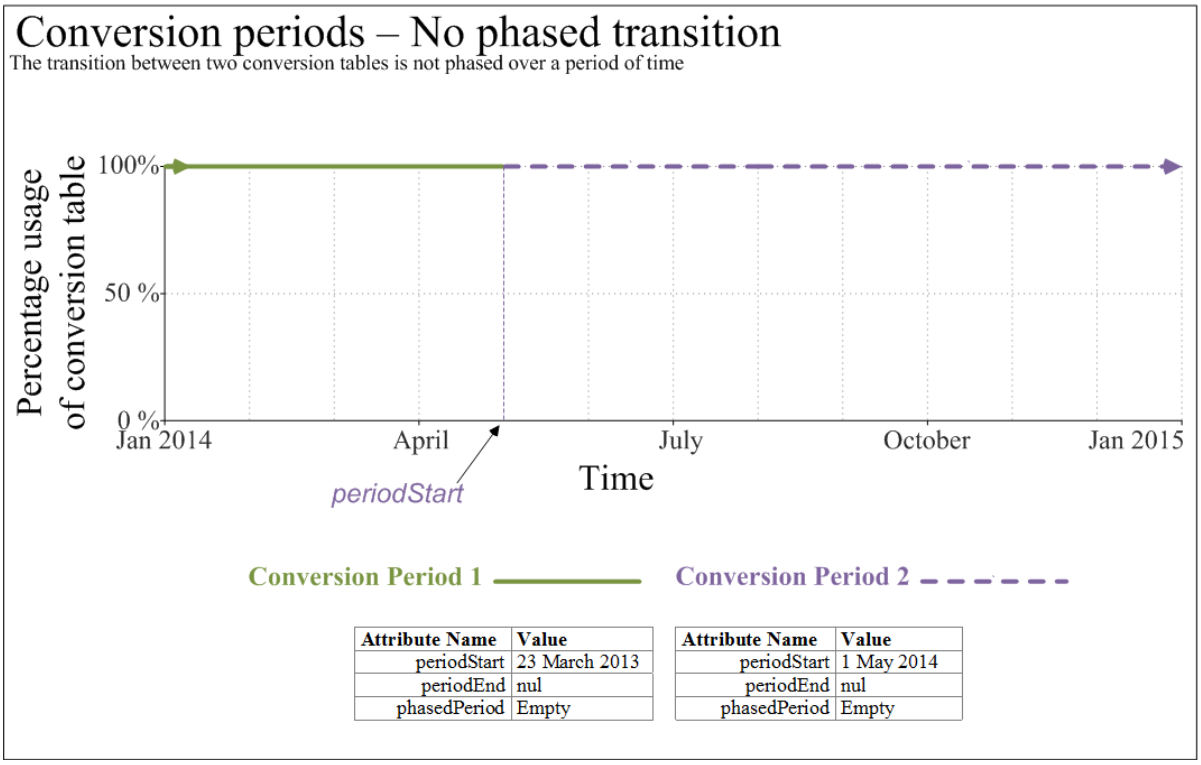

Figure 7 - An example conversion with no phasing

8.2.8 ConversionTable

A conversion table is the primary means for exchange of conversion relationships. It encodes the relationship between the input and output of the conversion using a table of tuples. This table shall be of sufficient resolution to allow linear interpolation between points.

Table 8 - ConversionTable properties

Name	Definition	Data types and values	Multiplicity
point	The points that make up the conversion table.	TableTuple	2..*
defaultQuality	Defines the default quality code for the output values of the table. Individual quality assertions override the default value. This property uses swe:Quality, which allows quality assertions using text, quantities, ranges, or a vocabulary entry.	Quality (SWE Common 2.0)	0..1

8.2.9 DevelopmentMethodCode

A code indicating the way the conversion was developed.

Table 9 - Development method code items

Code item	Definition	URL
equation	The conversion was developed using a standard equation (e.g. from a known control structure).	http://www.opengis.net/def/waterml/part2/1.0/DevelopmentMethodCode/equation
estimated	The relationship was estimated using modeling, mass balance or other quantifiable techniques	http://www.opengis.net/def/waterml/part2/1.0/DevelopmentMethodCode/estimated
fromGauging	The conversion was developed using regular gaugings.	http://www.opengis.net/def/waterml/part2/1.0/DevelopmentMethodCode/fromGauging
unknown	Unknown development method.	http://www.opengis.net/def/waterml/part2/1.0/DevelopmentMethodCode/unknown

8.2.10 DomainFeatureTypeCode

A code indicating the feature type that the conversion relates to. E.g. ‘River’, ‘Reservoir’. HY_Features[2] provides a potential high-level categorisation of relevant features.

8.2.11 PropertyCode

A code that defines an observable property. E.g. ‘river level’, ‘discharge’. This list has not been defined in this standard.

8.2.12 StatusCode

A proposed list of status codes to indicate where the conversion is in its development lifecycle.

Table 10 - Status code items

Code item	Definition	URL
working	The conversion relationship is the working version. This is the currently active conversion.	http://www.opengis.net/def/waterml/part2/1.0/StatusCode/working
inReview	The conversion is under review.	http://www.opengis.net/def/waterml/part2/1.0/StatusCode/inReview

2. OGC HY_Features: a Common Hydrologic Feature Model. https://portal.opengeospatial.org/files/?artifact_id=55157

Code item	Definition	URL
approved	The conversion has been approved for use.	http://www.opengis.net/def/waterml/part2/1.0/StatusCode/approved
submitted	The conversion has been reviewed and submitted for approval but has not yet been approved.	http://www.opengis.net/def/waterml/part2/1.0/StatusCode/submitted
provisional	The conversion has been modified to include the latest gauging information. It is released for real time purposes only.	http://www.opengis.net/def/waterml/part2/1.0/StatusCode/provisional

8.2.13 TableTuple

A tuple represents a pair of measured values: the input property and the output property.

Table 11 - TableTuple properties

Name	Definition	Data types and values	Multiplicity
inputValue	Individual value of the property being converted from.	Quantity (SWE Common 2.0)	1
outputValue	Individual value of the property being converted to.	Quantity (SWE Common 2.0)	1

8.3 Requirements class: RangeValues

Requirements Class	
http://www.opengis.net/spec/waterml/part2/1.0/req/uml-range-values	
Requirement	/range-values A range group shall contain multiple RangeTables, which define metadata that changes with the input property.
Requirement	/start-end-value Range tables shall contain a start and end value for which the specified metadata is valid.

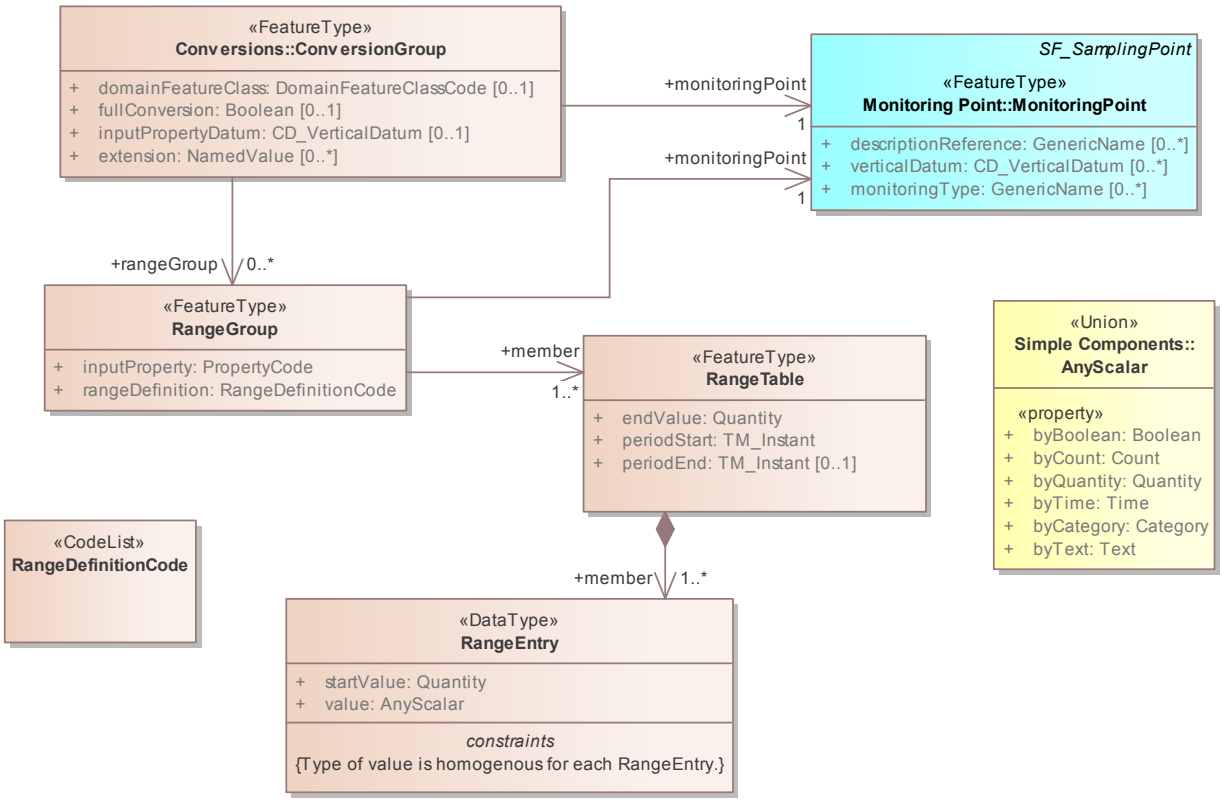

Figure 8 - RangeValue UML

8.3.1 Requirements class overview

Range tables are data structures that are similar to a conversion table except that the value applies across a broad input range and the content describes a state or condition that varies with the input range, rather than a conversion. Range tables may carry information that relates to, or adds value to, a conversion table. e.g. information describing the rating

construction method. A range table may carry information that is of value in its own right. e.g. stage vs. Flood condition (not in flood, minor flood, moderate flood, major flood).

8.3.2 RangeEntry

A single entry within the range values definition. A categorisation that defines the range of inputProperty values that are associated with a range value. The inputProperty start value is defined explicitly. The inputProperty end value is defined by the lower of the next rangeEntry startValue or the rangeTable endRangeValue.

Table 12 - RangeEntry properties

Name	Definition	Data types and values	Multiplicity
startValue	The value from which the range entry begins. Each entry holds until the next startValue, or to the endValue if it is the last entry in the definition.	Quantity (SWE Common 2.0)	1
value	The range value entry (i.e. the value for the property being described. e.g. flood level, controlling feature etc.).	AnyScalar (SWE Common 2.0)	1

8.3.3 RangeGroup

A group of range tables that have a period of application.

Table 13 - RangeGroup properties

Name	Definition	Data types and values	Multiplicity
monitoringPoint	The monitoringPoint associated with the rangeGroup.	MonitoringPoint (WaterML2.0 part 1)	1
member	The range table entry for this definition.	RangeTable	1..*
inputProperty	The property that the range group relates to.	PropertyCode (see 8.2.11)	1
rangeDefinition	The varying metadata property that the range group relates to. E.g. 'a vocabulary defining flood	RangeDefinitionCode	1

Name	Definition	Data types and values	Multiplicity
	levels'	(see 8.3.4)	

8.3.4 RangeDefinitionCode

A code that describes the nature of the range value, e.g. ‘a textual description of different flood levels’.

8.3.5 RangeTable

A RangeDefinition specifies metadata that is associated with a range of a quantity (e.g. from 2.3 to 3.5). For Conversions, this will most often relate to the input property (e.g. metadata for stage between 2.3 and 3.5 meters.). Ranges are specified by the start value and hold until the next range entry. The upper end of applicability is specified by the endValue attribute.

Table 14 - RangeTable properties

Name	Definition	Data types and values	Multiplicity
member	An entry within the range table.	RangeEntry	1..*
endRangeValue	The value at which the range entries end. Only the final end value is specified -- each range point holds from its start value until the next value or, if it is the last entry, to the endRangeValue.	Quantity (SWE Common 2.0)	1
periodStart	The start time from which this range table applies.	TM_Instant (ISO19108)	1
periodEnd	The end time until which the range value applies.	TM_Instant (ISO19108)	0..1

8.4 Requirements class: Gaugings

Requirements Class	
http://www.opengis.net/spec/waterml/part2/1.0/req/uml-gaugings	
Requirement	/observed-property The observed property of the OM_Observation type shall be a composite property that includes both the inputProperty and outputProperty. E.g. a stage to discharge definition.
Requirement	/result-type A GaugingObservation shall have a result property (from OM_Observation) that contains two scalar values: the observed inputProperty and outputProperty.
Requirement	/feature-of-interest The feature of interest of a Gauging Observation shall be a MonitoringPoint (from WaterML2.0 part 1).

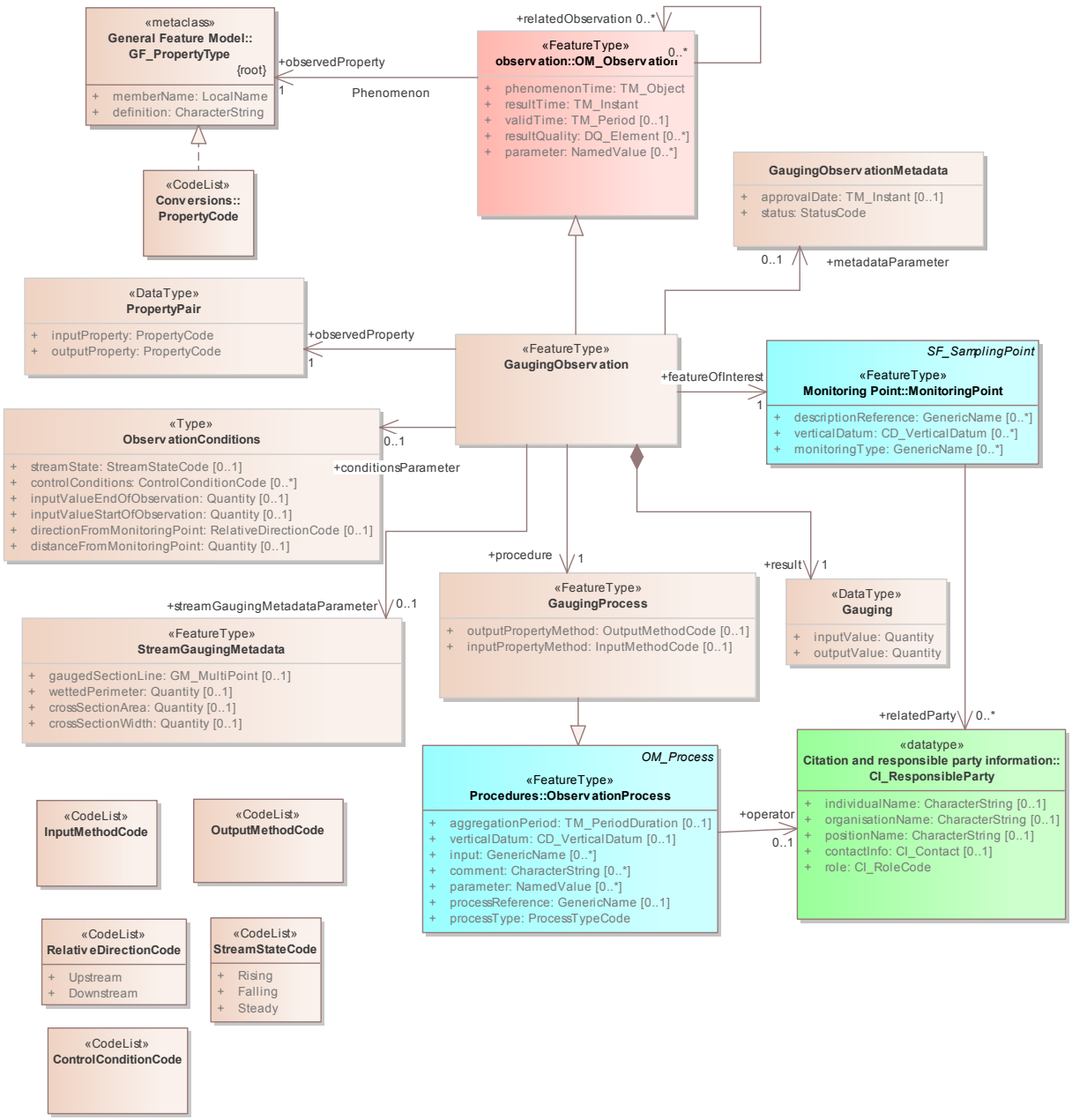

Figure 9 - Gauging UML

8.4.1 Requirements class overview

Gauging observations are the observations that are made to record the relationship between two properties at a specific point in time, influenced by the environmental conditions. These observations are used to either build an empirical conversion relationship or to verify a theoretically produced relationship between the properties.

These observations are performed using a wide array of methods, procedures and types of hardware. The focus of this model is to capture the x-y value that results from (potentially many) observations that are made to estimate the relationship between two properties.

For example, to understand the stage to discharge relationship at a gauging station, many observations are made at different x-y-z locations within a watercourse. These results are generally used to calculate an aggregate a single stage to discharge estimate for the section of the river.

8.4.2 Gauging

The result of an individual gauging, comprising of two measurements of related properties.

Table 15 - Gauging properties

Name	Definition	Data types and values	Multiplicity
inputValue	The measurement of the input property.	Quantity (SWE Common 2.0)	1
outputValue	The measurement of the output property.	Quantity (SWE Common 2.0)	1

8.4.3 GaugingObservation

Gauging observations are defined as a specialised type OM_Observation from ISO19156, with the following restrictions:

- the feature of interest relates to the location to which the gauging observation is applied (a MonitoringPoint);
- the result is a measurement tuple of the input property (e.g. stage) and the output property (e.g. discharge) values;
- the observed property groups the two properties together into a property pair. The alternative is to model the gauging as two separate measurement observations, one each for the independent and dependent properties. It is common practice to combine the two; and
- the process is captured with a type categorisation and extensible metadata properties.

The variety of methods and metadata for gauging observations is extensive. Harmonisation of all the methods is not practical and would most likely rely on more fully standardised measurement methods. A metadata type captures common metadata relating to the observation, such as influencing environmental conditions, status of the observational data etc.

Table 16 - GaugingObservation properties

Name	Definition	Data types and values	Multiplicity
conditionsParameter	Captures conditions that influenced the measurement process during the period of observation. These are values that are not tightly bound to the definition of the process; they could vary across individual observations of the same feature/process.	ObservationConditions	0..1
monitoringPoint	Association of the conversion with a 'WaterML 2.0: Part 1-Timeseries' monitoring point.	MonitoringPoint (WaterML2.0 part 1)	1
metadataParameter	Metadata for the gauging observation.	GaugingObservationMetadata	0..1
streamGaugingMetadataParameter	Metadata specific to stream gauging style observations.	StreamGaugingMetadata	0..1
procedure	The procedure used in making the observation. A specialised type is provided to detail important aspects of the observation procedure. There is huge diversity in the available methods for gauging observations; the key aspects are captured here to provide useful metadata for result interpretation.	GaugingProcess	1
observedProperty	The observed property pair that is being observed and calculated. This will normally be an identifier that links to a vocabulary definition for the type of physical property being measured. The observed property is a tuple that captures the two properties that are being related.	PropertyPair (see 8.4.9)	1

Name	Definition	Data types and values	Multiplicity
result	The resulting measurements from the gauging.	Gauging	1

8.4.4 GaugingObservationMetadata

Captures metadata relating to the gauging observation.

Table 17 - GaugingObservationMetadata properties

Name	Definition	Data types and values	Multiplicity
approvalDate	Date that the gauging observation was approved.	TM_Instant (ISO19108)	0..1
status	Captures the status of the gauging in terms of its use in conversion relationships.	StatusCode (see 8.2.12)	1

8.4.5 GaugingProcess

A description of the observation process used for the gauging.

Table 18 - GaugingProcess properties

Name	Definition	Data types and values	Multiplicity
operator	The field operator (person/organisation/contact) for the gauging observation.	CI_ResponsibleParty (ISO19115)	0..1
outputPropertyMethod	Describes the method that was used for observing the output property. For example: area-velocity, ADCP, mechanical meter etc.	OutputMethodCode (see 8.4.6)	0..1
inputPropertyMethod	Describes the method that was used for observing the input property. For example: flow weighted mean gauge height.	InputMethodCode (see 8.4.7)	0..1

8.4.6 OutputMethodCode

A code that describes the method used when measuring the output value. E.g. code item that describes an acoustic Doppler current profiler.

8.4.7 InputMethodCode

A code that describes the method used when measuring the input value. E.g. manual staff gauge reading.

8.4.8 ObservationConditions

Captures conditions affecting the measurement being taken, these properties apply to stream gauging observations.

Table 19 - ObservationConditions properties

Name	Definition	Data types and values	Multiplicity
streamState	The state of the stream while the gauging was taking place (e.g. was the stream rising.). See also stageStart/EndOfObservation.	StreamStateCode (see 8.4.13)	0..1
controlConditions	Conditions adversely affecting the controls ability to function normally: e.g. weed growth, ice etc.	ControlConditionCode (see 8.4.10)	0..*
inputValueEndOfObservation	The observed input property (e.g. stage) at the end of the observation period.	Quantity (SWE Common 2.0)	0..1
inputValueStartOfObservation	The observed input property (e.g. stage) at the start of the observation period.	Quantity (SWE Common 2.0)	0..1
directionFromMonitoringPoint	A relative direction from the monitoring point to the location the measurement was made.	RelativeDirectionCode (see 8.4.11)	0..1
distanceFromMonitoringPoint	The distance to the monitoring point from the measurement location.	Quantity (SWE Common 2.0)	0..1

8.4.9 PropertyPair

The pair of related properties that are being measured by the gauging observation.

Table 20 - PropertyPair properties

Name	Definition	Data types and values	Multiplicity

Name	Definition	Data types and values	Multiplicity
inputProperty	The property that is being directly measured by the observation, e.g. stage.	PropertyCode (see 8.2.11)	1
outputProperty	The property that is being estimated, e.g. discharge.	PropertyCode (see 8.2.11)	1

8.4.10 ControlConditionCode

A code that describes the condition of the control. E.g. a code indicating 'control is affected by weed growth'. The code list is not defined in this standard.

8.4.11 RelativeDirectionCode

Provides codes to describe the location of the gauging measurement relative to the monitoring point.

Table 21 - RelativeDirectionCode code items

Code item	Definition	URL
Upstream	The measurement was performed upstream of the monitoring point.	http://www.opengis.net/def/waterml/part2/1.0/RelativeDirectionCode/Upstream
Downstream	The measurement was performed downstream of the monitoring point.	http://www.opengis.net/def/waterml/part2/1.0/RelativeDirectionCode/Downstream

8.4.12 StreamGaugingMetadata

A type capturing metadata typical for stream gauging.

Table 22 - StreamGaugingMetadata properties

Name	Definition	Data types and values	Multiplicity
gaugedSectionLine	The line (start coordinates, end coordinates) that describes the segment of the river that was measured.	GM_MultiPoint (ISO19107)	0..1
wettedPerimeter	The perimeter of the cross-section that is in contact with water flow.	Quantity (SWE Common 2.0)	0..1

Name	Definition	Data types and values	Multiplicity
crossSectionArea	The area of the cross-section that is being measured.	Quantity (SWE Common 2.0)	0..1
crossSectionWidth	The width of the cross-section that is being measured.	Quantity (SWE Common 2.0)	0..1

8.4.13 StreamStateCode

A controlled list for terms describing the stream state during the period of observation.

Table 23 - StreamState code items

Code item	Definition	URL
Rising	The level of the stream was rising during observation.	http://www.opengis.net/def/waterml/part2/1.0/StreamStateCode/Rising
Falling	The level of the stream was falling during observation.	http://www.opengis.net/def/waterml/part2/1.0/StreamStateCode/Falling
Steady	The level of the stream was steady during observation.	http://www.opengis.net/def/waterml/part2/1.0/StreamStateCode/Steady

8.5 Requirements class: Sections

Requirements Class	
http://www.opengis.net/spec/waterml/part2/1.0/req/uml-section-observations	
Requirement	/geometry-observation A section observation shall be an OM_GeometryObservation with a result type of that is a sub-class of GM_Object.
Requirement	/observed-property The observedProperty of the OM_GeometryObservation shall refer to the type of section that is being observed (e.g. river cross-section) using a controlled vocabulary.

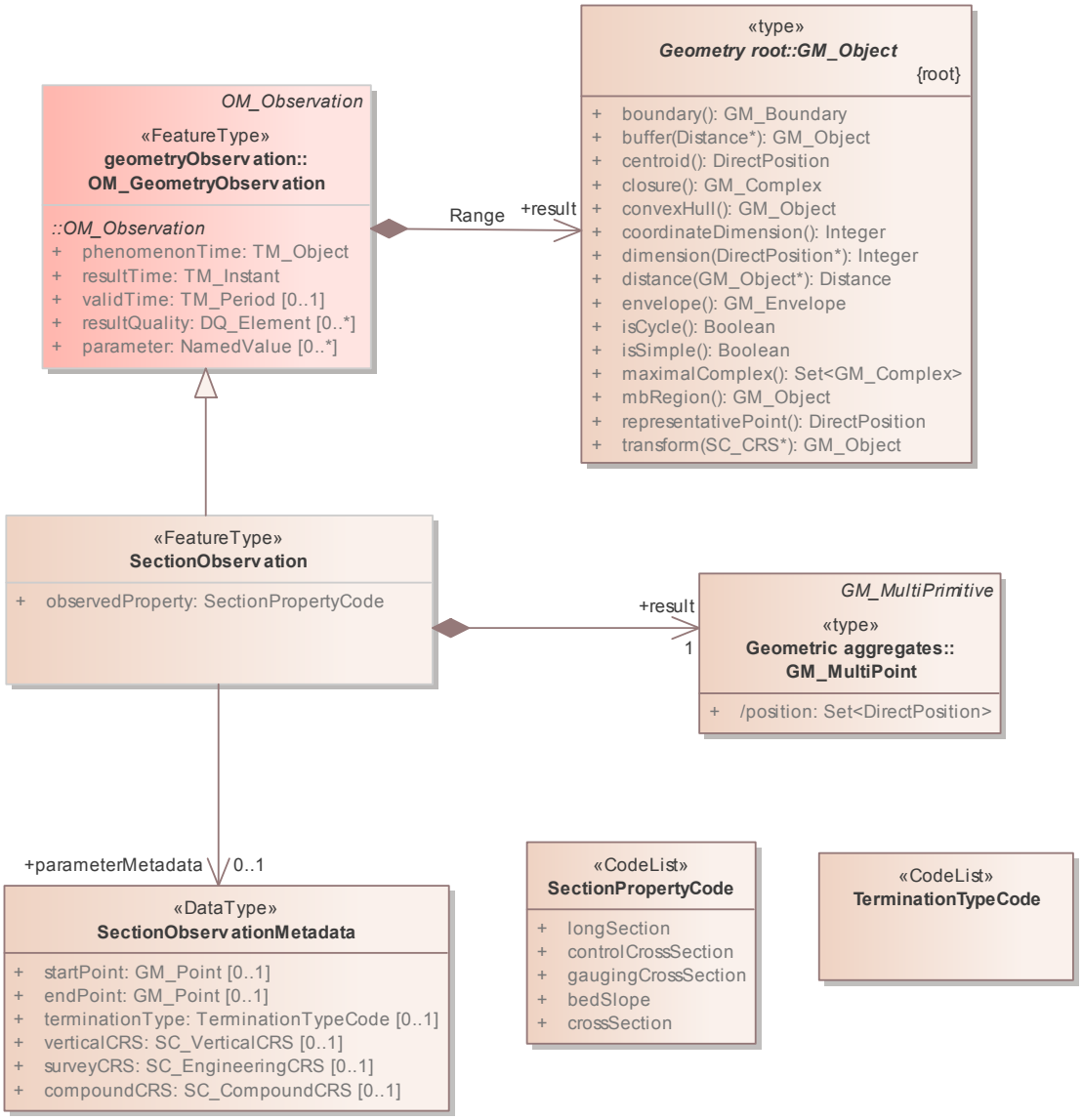

Figure 10 - Sections UML

8.5.1 Requirements class overview

Section observations are a type of geometric observation used to survey rivers sections, typically with the intention of understanding water flow.

8.5.2 SectionObservationMetadata

Metadata relating to the section observation.

Table 24 - SectionObservationMetadata properties

Name	Definition	Data types and values	Multiplicity
startPoint	The start point of which the section observation was made.	GM_Point (ISO19107)	1
endPoint	The end point of the section observation.	GM_Point (ISO19107)	0..1
terminationType	A vocabulary entry to indicate how the section observation was terminated.	TerminationTypeCode (see 8.5.4)	0..1
verticalCRS	The coordinate reference system used for the vertical component of the section observation.	SC_VerticalCRS (ISO19111)	0..1
surveyCRS	The coordinate reference system used when making the lateral component of the section observation.	SC_EngineeringCRS (ISO19111)	0..1
compoundCRS	The property that combines the vertical and engineering reference systems into a 2D reference system that can then be used in the observation result geometries.	SC_CompoundCRS (ISO19111)	0..1

8.5.3 SectionObservation

A SectionObservation is a more specialised GeometryObservation (as defined by O&M) that adds specific metadata and further refines the result to be an ordered list of geometric points.

Table 25 - SectionObseration properties

Name	Definition	Data types and values	Multiplicity
result	The geometric result of the observation. Overrides the O&M property by specialising to a Geometry.	GM_MultiPoint (ISO19107)	1
observedProperty	The type of section that is being observed. E.g. river cross section.	SectionPropertyCode (see 8.5.5)	1

Name	Definition	Data types and values	Multiplicity
parameterMetadata	Metadata of the observation.	SectionObservationMetadata	0..1

8.5.4 TerminationTypeCode

A code list to describe the way the section observation has been terminated.

8.5.5 SectionPropertyCode

A controlled list for observed properties of section observations.

Table 26 - SectionProperty code items

Code item	Definition	URL
longSection	An observation of a longitudinal section.	http://www.opengis.net/def/waterml/part2/1.0/SectionPropertyCode/longSection
gaugingCrossSection	An observation of a gauging cross section.	http://www.opengis.net/def/waterml/part2/1.0/SectionPropertyCode/gaugingCrossSection
crossSection	A cross section observation.	http://www.opengis.net/def/waterml/part2/1.0/SectionPropertyCode/crossSection
controlCrossSection	An observation of a control cross section.	http://www.opengis.net/def/waterml/part2/1.0/SectionPropertyCode/controlCrossSection
bedSlope	An observation of a section of bed slope.	http://www.opengis.net/def/waterml/part2/1.0/SectionPropertyCode/bedSlope

9. XML Encoding (normative)

Table 27 - Mapping of WaterML2.0 part 2 UML to XML

WaterML 2.0 part 2 UML	WaterML 2.0 part 2 XML
ConversionGroup	part2:ConversionGroup
Conversion	part2:Conversion
ConversionTable	part2:ConversionTable
TableTuple	part2:TableTuple
ConversionEquation	part2 ConversionEquation
ConversionPeriod	part2:ConversionPeriod
GaugingObservation	om:OM_Observation*
Gauging	part2:Gauging
ObservationProcess	part2:ObservationProcess
RangeGroup	part2:RangeGroup
RangeTable	part2:RangeTable
RangeEntry	part2:RangeEntry
Collection	part2:Collection
SectionObservation	om:OM_Observation*
* The specialisation of OM_Observation is provided through Schematron rather than a specialised XML type.	

10. This section defines an XML encoding of the WaterML2.0 part 2 mappings of the core types are show in XML Encoding (normative)

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10.1 Requirements class: XML encoding

Requirements Class	
http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-rules	
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules
Requirement	/part1-rules The XML encodings shall conform to the XML encoding rules specified in WaterML2.0 part 1.

10.2 Requirements class: Collections XML

Requirements Class	
http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-collection	
Dependency	http://www.opengis.net/spec/req/waterml/part2/1.0/xml-rules
Requirement	/extends-part1 The WaterML2.0 part 2 Collection type shall specialize the WaterML2.0 part 1 Collection (http://schemas.opengis.net/waterml/2.0/waterml2.xsd) by adding support for conversion, gauging and cross-section members.
Requirement	/valid The XML instance document shall be valid according to the XML grammar specified in http://schemas.opengis.net/waterml/part2/1.0/collection.xsd.

The following example instances show the use of the collection schema type:

- Collection with gauging members: http://schemas.opengis.net/waterml/part2/1.0/examples/gauging-collection-expanded-example.xml
- Collection with conversion members: http://schemas.opengis.net/waterml/part2/1.0/examples/collection-example.xml
- Collection with range-value members: http://schemas.opengis.net/waterml/part2/1.0/examples/conversion-group-example-with-datum.xml

10.3 Requirements class: Conversions XML

Requirements Class	
http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-conversions	
Dependency	http://www.opengis.net/spec/req/waterml/part2/1.0/xml-rules
Requirement	/valid The XML instance document shall be valid according to the XML grammar specified in http://schemas.opengis.net/waterml/part2/1.0/conversions.xsd.
Requirement	/monitoring-point All Conversion objects within a ConversionGroup shall inherit the monitoringPoint property. Additionally all Conversions within a ConversionGroup shall have the same monitoringPoint property.

Requirement	/inputProperty All Conversion objects within a ConversionGroup shall have the same inputProperty value. If a Conversion does not specify the inputProperty value, it is inherited from the ConversionGroup.
Requirement	/outputProperty All Conversion objects within a ConversionGroup shall have the same outputProperty value. If a Conversion does not specify the outputProperty value, it is inherited from the ConversionGroup.

The following example instances show the use of the conversion schema types:

- A conversion group with multiple applicable periods: http://schemas.opengis.net/waterml/part2/1.0/examples/conversion-group-linked-tables.xml
- A full conversion table: http://schemas.opengis.net/waterml/part2/1.0/examples/conversion-single-example.xml

10.4 Requirements class: RangeValues XML

Requirements Class	
http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-range-values	
Requirement	/valid The XML instance document shall be valid according to the XML grammar specified in http://schemas.opengis.net/waterml/part2/1.0/rangeValues.xsd.
Requirement	/range-definition The rangeDefinition xlink:href attribute shall use an HTTP URL that links to a vocabulary term indicating the type of range value that is being encoded. E.g. ‘percent of time height exceeded’ or ‘flood levels’.

The following example shows how a range value may be used to encode the precent of time height exceeded for ranges of stream height:
http://schemas.opengis.net/waterml/part2/1.0/examples/range-groups-example.xml

10.5 Requirements class: Gaugings XML

Requirements Class	
http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-gaugings	
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-feature-of-interest-monitoring-point

Requirement	/observation-type A Gauging Observation shall be encoded using the OM_Observation type, with restrictions defined in this requirements class.
Requirement	/result The 'result' property of the OM_Observation element shall be a 'Gauging' type.
Requirement	/observed-property The 'observedProperty' property of the OM_Observation element shall be reference a vocabulary term that defines both the input and the outputProperties that are being observed.
Requirement	/feature-of-interest The 'featureOfInterest' property of the OM_Observation element shall be reference a MonitoringPoint (WaterML2.0 part 1) or reference one using xlink.
Requirement	/observation-conditions The conditionsParameter property shall be encoded using the om:parameter property of OM_Observation. The 'name' element (of om:NamedValue) shall have an xlink:href value of 'http://www.opengis.net/def/waterml/part2/1.0/gauging-conditions', with the 'value' element containing the ObservationConditions value or a reference to one.
Requirement	/observation-metadata The metadataParameter property shall be encoded using the om:parameter property of OM_Observation. The 'name' element (of om:NamedValue) shall have an xlink:href value of 'http://www.opengis.net/def/waterml/part2/1.0/gauging-metadata', with the 'value' element containing the ObservationMetadata value or a reference to one.
Requirement	/stream-gauging-metadata The streamGaugingMetadataParameter type shall be encoded using the om:parameter property of OM_Observation. The 'name' element (of om:NamedValue) shall have an xlink:href value of 'http://www.opengis.net/def/waterml/part2/1.0/stream-gauging-metadata', with the 'value' element containing the StreamGaugingMetadatad value or a reference to one.

The following example instances show the use of the gauging observation schema types:

- http://schemas.opengis.net/waterml/part2/1.0/examples/gauging-example-extended.xml

- http://schemas.opengis.net/waterml/part2/1.0/examples/gauging-example-service-output.xml
- http://schemas.opengis.net/waterml/part2/1.0/examples/gauging-example-with-conditions.xml

10.6 Requirements class: Section Observation

Requirements Class	
http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-section-observation	
Requirement	/observation-type A SectionObservation shall be encoded using the OM_Observation type, with restrictions defined in this requirements class.
Requirement	/observed-property A observedProperty of the OM_Observation shall indicate the type of cross-section observed using a term from the vocabulary at: 'http://www.opengis.net/def/waterml/part2/1.0/SectionPropertyCode'
Requirement	/observation-metadata The parameterMetadata shall be encoded using the om:parameter property of OM_Observation, with 'name' element (of om:NamedValue) having an xlink:href value of 'http://www.opengis.net/def/waterml/part2/1.0/section-metadata'. The 'value' element shall contain the SectionObservationMetadata type.

The following instances show some example use of the section observation schema:

- A local coordinate system section observation: http://schemas.opengis.net/waterml/part2/1.0/examples/cross-section-example-line-string.xml.
- A 3D geo-referenced section observation: http://schemas.opengis.net/waterml/part2/1.0/examples/cross-section-example-georeferenced.xml.

11. Media Types for any data encoding(s)

WaterML2.0 part 2 data conforming to this standard 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'.

Annex A UML Conformance Class Abstract Test Suite (normative)

A.1 Conformance class: Collection

Conformance Class		
http://www.opengis.net/spec/waterml/part2/1.0/conf/uml-collection		
	/extends-part1	
	Requirement	/req/uml-collection/extends-part1
	Test purpose	Test that the collection extends the WaterML2.0 part 1 Collection type.
	Test method	Inspect the Collection type's base class and ensure if is either the WaterML2.0 part 1 Collection type, or a sub-class of it.
	Test type	Conformance

A.2 Conformance class: Conversions

Conformance Class		
http://www.opengis.net/spec/waterml/part2/1.0/conf/uml-conversions		
Dependency	**http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point**	
Dependency	**urn:iso:dis:iso:19156:clause:9**	
	/datums-for-stage	
	Requirement	/req/uml-conversions/datums-for-stage
	Test purpose	Test that the conversion supports the specification of a vertical datum
	Test method	Inspect the conversion model element to ensure a vertical datum is supported.
	Test type	Conformance
	/multiple-conversion-types	
	Requirement	/req/uml-conversions/multiple-conversion-types

	Test purpose	Check whether the conversion supports properties other than stage and discharge.
	Test method	Inspect the inputProperty and outputProperty attributes and ensure any vocabulary terms are allowed.
	Test type	Conformance
	/start-periods	
	Requirement	/req/uml-conversions/start-periods
	Test purpose	Check whether the model supports conversions with open ended applicable periods unless specified by an end time property.
	Test method	Inspect the ConversionPeriod type and check it has a start and end specified, with the end optional.
	Test type	Conformance
	/conversion-gaps	
	Requirement	/req/uml-conversions/conversion-gaps
	Test purpose	Check the model supports gaps in conversion periods.
	Test method	Inspect the model to ensure that it is possible to have gaps in periods of conversion application.
	Test type	Conformance
	/conversion-reuse	
	Requirement	/req/uml-conversions/conversion-reuse
	Test purpose	Ensure that a conversion period (applicableConversion) is able to refer to the same conversion.
	Test method	Check that Conversions are of a type that allows reference by its identity, rather than only contained within.
	Test type	Conformance.
	/linear-interpolation	

	Requirement	/req/uml-conversions/linear-interpolation
	Test purpose	Ensure that a conversion is able to represent sufficient points to enable linear interopolation.
	Test method	Check that Conversions has an unbounded number of input/output pairs.
	Test type	Conformance.
	/equation	
	Requirement	/req/uml-conversions/equation
	Test purpose	Ensure that a Conversion is able to refer to the source equation from which the conversion has been derived. Text-based equations are only supported.
	Test method	Check that Conversions allows a reference to a ConversionEquation.
	Test type	Conformance.
	/transformation	
	Requirement	/req/uml-conversions/transformation
	Test purpose	Ensure that a Conversion definition is sufficient to enable transformation of output data.
	Test method	Check that Conversion contains sufficient points and metadata to allow a transformation to be run, without requiring addition transformation information.
	Test type	Conformance.
	/source-system	
	Requirement	/req/uml-conversions/source-system
	Test purpose	Ensure that a Conversion is able to express how it was originally stored.
	Test method	Inspect the Conversion type and pass if a property allows specifying the source system of the conversion, fail otherwise.
	Test type	Conformance.

	/keys	
	Requirement	/req/uml-conversions/keys
	Test purpose	Ensure that a Conversion provides the core keys required to identify instances.
	Test method	Inspect the Conversion type and pass if associations are provided to monitoring point, inputProperty and outputPropety.
	Test type	Conformance.
	/link-to-gaugings	
	Requirement	/req/uml-conversions/link-to-gaugings
	Test purpose	Ensure that a Conversion can express which gauging observations were used in conversion development. This should include used and/or excluded gaugings.
	Test method	Inspect the Conversion type and check whether an association with GaugingObservation exists for both included and excluded observations.
	Test type	Conformance.
	/phasing	
	Requirement	/req/uml-conversions/phasing
	Test purpose	Ensure that a Conversion provides sufficient metadata to describe phasing between conversions.
	Test method	Inspect the ConversionGroup type and pass if a phase period can be specified within each ConversionPeriod definition.
	Test type	Conformance.
	/table-point-quality	
	Requirement	/req/uml-conversions/table-point-quality
	Test purpose	Ensure that a ConversionTable can express the quality of each table point individually or as a default for the whole table.
	Test method	Inspect the ConversionTable type and pass if a default quality is provided, along with a quality for each point within the

		ConversionTable.
	Test type	Conformance.
	/review-process-metadata	
	Requirement	/req/uml-conversions/review-process-metadata
	Test purpose	Ensure that a Conversion provides metadata properties relating to the status of its development.
	Test method	Inspect the Conversion object and pass if it is possible to described the state of the conversion development using a vocabulary.
	Test type	Conformance.
	/range-group	
	Requirement	/req/uml-conversions/range-group
	Test purpose	Ensure that a Conversion provides a RangeGroup type to describe metadata that varies according to the inputProperty.
	Test method	Inspect the Conversion object and pass if it has a property that is of type RangeGroup.
	Test type	Conformance.

A.3 Conformance class: RangeValues

Conformance Class		
http://www.opengis.net/spec/waterml/part2/1.0/conf/uml-range-values		
	/range-values	
	Requirement	/req/uml-range-values/range-values
	Test purpose	Ensure that a RangeGroup is associated with a ConversionGroup and defines sufficient metadata to described varying metadata for the inputProperty.
	Test method	Inspect the RangeGroup and ensure it is associated with an inputProperty and provides a range definition.
	Test type	Conformance.

	/start-end-value	
	Requirement	/req/uml-range-values/start-end-value
	Test purpose	Ensure that a RangeTable contains a start and end value, describing the period for which this range value is valid.
	Test method	Inspect the RangeTable type and pass if it provides both period start and end times, with the start being mandatory.
	Test type	Conformance.

A.4 Conformance class: Gaugings

Conformance Class		
http://www.opengis.net/spec/waterml/part2/1.0/conf/uml-gaugings		
	/observed-property	
	Requirement	/req/uml-gaugings/observed-property
	Test purpose	Ensure that the GaugingObservation supports an observed property containing an input and output property.
	Test method	Inspect the model and pass if a type is available that defines a property tuple containing an input and output property.
	Test type	Conformance.
	/result-type	
	Requirement	/req/uml-gaugings/result-type
	Test purpose	Ensure that a GaugingObservation has a result of two scalar values (input and output measurements).
	Test method	Inspect the GaugingObservation type and pass if the OM_Observation:result property is restricted to a type that supports two measurement values.
	Test type	Conformance.
	/feature-of-interest	

	Requirement	/req/uml-gaugings/feature-of-interest
	Test purpose	Ensure that a GaugingObservation has a feature of interest of a MonitoringPoint from WaterML2.0 part 1.
	Test method	Inspect the OM_Observation:featureOfInterest property and pass if it is restricted to be a MonitoringPoint type.
	Test type	Conformance.

A.5 Conformance class: Sections

Conformance Class		
http://www.opengis.net/spec/waterml/part2/1.0/conf/uml-sections		
	/geometry-observation	
	Requirement	/req/uml-sections/geometry-observation
	Test purpose	Ensure that a SectionObservation has an appropriate geometric result type
	Test method	Inspect the OM_Observation:result property and pass if it is restricted to be a GM_Object type.
	Test type	Conformance.
	/geometry-observation	
	Requirement	/req/uml-sections/observed-property
	Test purpose	Ensure that a SectionObservation has an appropriate observed property type.
	Test method	Inspect the OM_Observation:observedProperty type – pass if the property has been restricted to an appropriated vocabulary (preferably from http://www.opengis.net/def/waterml/part2/1.0/SectionPropertyCode)
	Test type	Conformance.

Annex B XML Conformance Class Abstract Test Suite (normative)

B.1 Conformance Class: XML Encoding

Conformance Class		
http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-rules		
Requirements	http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-rules	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/xsd-xml-rules	
Test	/part1-rules	
	Requirement	/req/xml-rules/part1-rules
	Test purpose	Verify that the XML instance conforms to the common XML encoding rules as specified by WaterML2.0 part 1 XML encoding.
	Test method	Execute all conformance tests specified by http://www.opengis.net/spec/waterml/2.0/conf/xsd-xml-rules.

B.2 Conformance Class: Collections XML

Conformance Class		
http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-collection		
Requirements	http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-collection	
Dependency	http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-rules	
Test	/extends-part1	
	Requirement	/req/xml-collection/extends-part1
	Test purpose	Verify that the XML Collection type extends the WaterML2.0 part 1 collection type.
	Test method	Inspect XML Schema to ensure Collection type extends the CollectionType specified by http://schemas.opengis.net/waterml/2.0/collection.xsd.
Test	/valid	
	Requirement	/req/xml-collection/valid
	Test purpose	Verify that the XML instance document is a valid collection.

	Test method	Validate the XML instance document using the XML Schema document: http://schemas.opengis.net/waterml/part2/1.0/collection.xsd.

B.3 Conformance Class: Conversions XML

Conformance Class		
http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-conversions		
Requirements	http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-conversions	
Dependency	http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-rules	
Test	/valid	
	Requirement	/req/xml-conversion/valid
	Test purpose	Verify that the XML instance is valid.
	Test method	Validate the XML instance document using the XML Schema document: http://schemas.opengis.net/waterml/part2/1.0/conversions.xsd.
Test	/monitoring-point	
	Requirement	/req/xml-conversion/monitoring-point
	Test purpose	Verify that all the Conversions within a ConversionGroup have the same monitoringPoint property.
	Test method	Inspect the value of the monitoringPoint property of each Conversion object. If they are the same then pass, fail otherwise, with the following rule: If no monitoringPoint is specified for a conversion then it inherits its value from the ConversionGroup.
Test	/inputProperty	
	Requirement	/req/xml-conversion/inputProperty
	Test purpose	Verify that all the Conversions within a ConversionGroup have the same inputProperty value.
	Test method	Inspect the value of the inputProperty property of each Conversion object. If they are the same then pass, fail otherwise, with the following rule:

		If no inputProperty is specified for a conversion then it inherits its value from the ConversionGroup.
Test	/conf/xml-conversion/outputProperty	
	Requirement	/req/xml-conversion/outputProperty
	Test purpose	Verify that all the Conversions within a ConversionGroup have the same outputProperty value.
	Test method	Inspect the value of the outputProperty property of each Conversion object. If they are the same then pass, fail otherwise, with the following rule: If no outputProperty is specified for a conversion then it inherits its value from the ConversionGroup.

B.4 Conformance Class: Range Values XML

Conformance Class		
http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-range-values		
Requirements	http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-range-values	
Dependency	http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-rules	
Test	/valid	
	Requirement	/req/xml-range-values/valid
	Test purpose	Verify that the XML instance is valid.
	Test method	Validate the XML instance document using the XML Schema document: http://schemas.opengis.net/waterml/part2/1.0/rangeValues.xsd.
Test	/range-definition	
	Requirement	/req/xml-range-values/range-definition
	Test purpose	Verify that the definition of the range values is specified in the range group.
	Test method	Verify the RangeGroup/rangeDefinition/@xlink:href value is a valid vocabulary term.

B.5 Conformance Class: Gaugings XML

Conformance Class		
http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-gaugings		
Requirements	http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-gaugings	
Dependency	http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-rules	
Test	/observation-type	
	Requirement	/req/xml-gaugings/observation-type
	Test purpose	Verify that the XML instance is a valid OM_Observation type.
	Test method	Validate the XML instance document using the O&M XML Schema document: http://schemas.opengis.net/om/2.0/observation.xsd
Test	/result	
	Requirement	/req/xml-gaugings/result
	Test purpose	Verify that the child element of the OM_Observation result property is a 'Gauging'.
	Test method	Validate the XML instance document the 'result' test in the Schematron file at gauging-observation.sch.
Test	/observed-property	
	Requirement	/req/xml-gaugings/observed-property
	Test purpose	Verify that the input and output property have been defined using the observedProperty xlink:href attribute.
	Test method	Inspect the vocabulary after resolving the HTTP URL in the OM_Observation/observedProperty/@xlink:href attribute. Ensure sufficient definition is provided to define both the input and output properties.
Test	/feature-of-interest	
	Requirement	/req/xml-gaugings/feature-of-interest
	Test purpose	Verify that a Monitoring Point has been specified as the feature of interest of the OM_Observation.

	Test method	Validate the XML instance document the 'featureOfInterest test in the Schematron file at gauging-observation.sch.
Test	/observation-conditions	
	Requirement	/req/xml-gaugings/observation-conditions
	Test purpose	Verify observation conditions are being encoded using the om:parameter property with the specified vocabulary term 'http://www.opengis.net/def/waterml/part2/1.0/gauging-conditions'.
	Test method	Inspect the om:parameter entries and ensure that any entries using the ObservationConditions type has set the om:name/@xlink:href to 'http://www.opengis.net/def/waterml/part2/1.0/gauging-conditions'.
Test	/observation-metadata	
	Requirement	/req/xml-gaugings/observation-metadata
	Test purpose	Verify observation metadata are being encoded using the om:parameter property with the specified vocabulary term 'http://www.opengis.net/def/waterml/part2/1.0/gauging-metadata.
	Test method	Inspect the om:parameter entries and ensure that any entries using the GaugingObservationMetadata type has set the om:name/@xlink:href to 'http://www.opengis.net/def/waterml/part2/1.0/gauging-metadata.

B.6 Conformance Class: Section Observation XML

Conformance Class	
http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-section-observation	
Requirements	http://www.opengis.net/spec/req/waterml/part2/1.0/req/xml-section-observation
Dependency	http://www.opengis.net/spec/req/waterml/part2/1.0/conf/xml-rules
Test	/observation-type
	Requirement	/req/xml-section-observation/observation-type

	Test purpose	Verify that the XML instance uses a valid OM_Observation type to encod a section observation.
	Test method	Validate the XML instance document using the O&M XML Schema document: http://schemas.opengis.net/om/2.0/observation.xsd
Test	/observed-property	
	Requirement	/req/xml-section-observation/observed-property
	Test purpose	Verify that the XML instance uses a valid vocabulary term for the observedProperty element.
	Test method	Inspect the om:observedProperty element and ensure it's xlink:href attribute refers to a code within the http://www.opengis.net/def/waterml/part2/1.0/SectionPropertyCode vocabulary.

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