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OGC® WaterML 2.0: Part 1- Timeseries

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i. Abstract

WaterML 2.0 is a standard information model for the representation of water observations data, with the intent of allowing the exchange of such data sets across information systems. Through the use of existing OGC standards, it aims at being an interoperable exchange format that may be re-used to address a range of exchange requirements, some of which are described later in this document.

ii. Preface

The primary goal of this profile is to capture the semantics of hydrological observational data for data exchange. This will allow hydrological information systems to communicate data between systems and to end users.

NOTE!! - Please note that 2.0.1 is a Corrigendum in which a number of errors have been corrected in the WaterML 2.0 schema. As such, please make sure that your application re-loads the schema from the OGC schema repository and that local copies are not being used.

iii. Submitting Organizations

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

- a) CSIRO
- b) San Diego Supercomputer Center
- c) Australian Bureau of Meteorology
- d) Geological Survey of Canada, Natural Resources Canada
- e) USGS
- f) KISTERS AG
- g) NOAA
- h) Deltares
- i) Federal Waterways Engineering and Research Institute
- j) disy Informationssysteme GmbH
- k) German Federal Institute of Hydrology

- l) International Office For Water - Sandre

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v. Future Work

- Specification of an ex-situ (e.g. water quality) profile
- Inclusion of further complex structures (e.g. rating curves, conversion tables etc.)
- Harmonizing time series structures with other standards (GML values vs. SWE Common vs. coverage types) and profiles (CSML, netCDF, SWE Common Profiles etc.)
- Harmonizing/adapting process model with SensorML and/or ISO19115

vi. Changes to the OGC® Abstract Specification

The OGC® Abstract Specification requires changes to accommodate this OGC® Standard.

1. TimeSeries needs to be added to Topic 6 (aka ISO 19123), and it needs to be in a way that supports both TVP and DR forms
2. ObservationCollection needs to be added to Topic 20/ISO 19156 (O&M)
3. The target of OM_Observation::metadata needs to be relaxed from MD_Metadata

Foreword

This work has, for the most part, been funded through a water information research and development alliance between CSIRO's Water for a Healthy Country Flagship and the Australian Bureau of Meteorology. The work has also been supported by The Consortium for the Advancement of Hydrological Sciences Inc. (CUAHSI). The work is operating under the joint World Meteorological Organisation (WMO) and 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.

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 specification set forth in this document, and to provide supporting documentation.

This document formalises work discussed in the existing discussion documents OGC 09-124r1 – Harmonising Standards for Water Observations Data and 07-041- WaterML.

Introduction

Motivation

The increasing global demand on fresh water supplies is putting increased pressure on the natural resource environment. This demand is leading nations to improve terrestrial water monitoring facilities to better understand the amount, and the quality, of fresh water resources.

Traditional water monitoring networks consist of regional monitoring programs that help to address issues of direct significance, such as flood warnings, providing water management guidelines (applying restrictions, setting allocations etc.), drought management and so on. More recently, nations are moving towards more holistic structuring of monitoring systems in order to provide an integrated national view on the state of water resources.

This has led to a requirement on monitoring programs to exchange their data with other organisations that may have an interest in the observational data collected. National monitoring programs that often aggregate smaller, locally maintained monitoring networks, are requesting data for the use in national reporting facilities.

In addition to this is the increased need for the exchange of data to improve our understanding of complex environmental processes, such as climate change. Terrestrial water movement can play a significant influencing role in such processes; cross-domain scientific enquiry and modelling requires access to increasing set of observational data, including hydrological observations.

A report from the Global Climate Observing System (GCOS) into data exchange problems in global hydrological and atmospheric networks identifies standards as a key challenge:

“There are no established international standards on the acquisition of river data, the set of required metadata, data formats, and transmission modes.”

And

“Common metadata standards are, even on national scales, the exception rather than the rule.”

WaterML 2.0 is a standard information model for the representation of water observations data, with the intent of allowing the exchange of such data sets across information systems. Through the use of existing OGC standards, it aims at being an interoperable exchange format that may be re-used to address a range of exchange requirements, some of which are described later in this document.

Historical background

A previous report [2] investigated and compared existing standards and initiatives from various countries being used for the exchange of hydrological observations. The report also suggested an approach to developing an OGC compliant conceptual information model and encoding that harmonises existing definitions with OGC standards. This document specifies such a model and encoding.

One of the existing standards that was investigated was WaterML1.0 (and 1.1), developed by CUAHSI for use in the U.S. As this was recognized in the community as a data exchange standard with significant traction, the name has been continued for use with the OGC standard

version. OGC WaterML2.0 is, however, a harmonized information model between a number of standards from various countries with existing OGC standards. OGC WaterML2.0 is based on the OGC Observations and Measurements standard (ISO 19156), and therefore is significantly different from CUAHSI WaterML1.0.

WaterML2.0: part 1 - timeseries

1 Scope

This document is an OpenGIS® Encoding Standard for the representation of hydrological observations data with a specific focus on time series structures. WaterML2.0 is implemented as an application schema of the Geography Markup Language version 3.2.1, making use of the OGC Observations & Measurements standards.

WaterML2.0 is designed as an extensible schema to allow encoding of data to be used in a variety of exchange scenarios. Example areas of usage are: exchange of data for operational hydrological monitoring programs; supporting operation of infrastructure (e.g. dams, supply systems); cross-border exchange of observational data; release of data for public dissemination; enhancing disaster management through data exchange; and exchange in support of national reporting.

The core aspect of the model is in the correct, precise description of time series. Interpretation of time series relies on understanding the nature of the process that generated them. This standard provides the framework under which time series can be exchanged with appropriate metadata to allow correct machine interpretation and thus correct use for further analysis. Existing systems should be able to use this model as a conceptual ‘bridge’ between existing schema or systems, allowing consistency of the data to be maintained.

2 Conformance

This standard 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 Modular Specification Policy.

Conformance with this standard shall be checked using all the relevant tests specified in Annex A. 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).

3 Normative 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 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

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

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]

Discharge

In its simplest concept discharge means outflow; therefore, the use of this term is not restricted as to course or location, and it can be applied to describe the flow of water from a pipe or from a drainage basin. If the discharge occurs in some course or channel, it is correct to speak of the discharge of a canal or of a river. It is also correct to speak of the discharge of a canal or stream into a lake, a stream, or an ocean.

[USGS, <http://water.usgs.gov/wsc/glossary.html#Discharge>]

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]

Feature

Abstraction of real-world phenomena

[ISO 19101:2002, definition 4.11]

Observation

Act of observing a property

[ISO19156, definition 4.10]

Observation procedure

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

[ISO19156, definition 4.11]

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

Sampling feature

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

[ISO19156, definition 4.16]

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.

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 Abbreviated terms

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

API	Application Program Interface
CSIRO	Commonwealth Scientific and Industrial Research Organization
CSML	Climate Science Modelling Language
CSV	Comma Separated Values
CUAHSI	Consortium of Universities for Advancement of Hydrologic Science Incorporated
GWML	Groundwater Markup Language
ISO	International Organization for Standardization
O&M	Observations and Measurements
OGC	Open Geospatial Consortium
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
XML	Extensible Markup Language

5.2 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.

Blue: Defined within this standard

Green: ISO19156 – Observations & Measurements

Red: Other (ISO or GML)

5.3 Finding requirements and recommendations

This standard is identified as <http://www.opengis.net/spec/waterml/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 Overview of WaterML2.0

WaterML2.0 is an open standard for encoding water observations data for exchange. It is based on the information model of Observations and Measurements version 2.0 (O&M) and implemented as an application schema according to the rules of Geography Markup Language version 3.2 (GML). GML is an extensible international standard for the exchange of spatial data. O&M is a conceptual model for describing observations and the relationships to various important aspects of the observation process.

O&M provides a conceptual model, with an associated implementation as a GML Application Schema in XML schema, for describing a wide range of observations from multiple domains; from observations made by satellites and sensors to manual procedures performed in laboratories. It is a flexible model. Section 7 provides a brief overview of O&M.

This profile restricts and extends the O&M conceptual model to define a conceptual model that is directly applicable to observations and derived data specific to the hydrology domain. This conceptual model is then used to define an XML schema that may be used for the exchange of hydrological observations, addressing needs previously identified [2].

This standard represents part 1 of WaterML2.0, with the focus on the description of time series resulting from direct observations and processed data, such as forecasts and derived results. Further parts will extend into other areas of hydrological data, such as the description of rating curves, gauging information, controlled vocabularies etc.

This standard is broken up into the following parts:

- A conceptual UML model for observational data as a profile as ISO19156 – Observations & Measurements;

- An implementation of the model in XML Schema, specifically a GML 3.2 conformant XML Schema.

This separation allows capturing the information model in an implementation-agnostic fashion, using UML, to allow multiple implementations to occur. In addition to GML, other implementations in future work may include JSON, NetCDF, non-GML conformant XML etc.

WaterML2.0 defines five main components for describing water observations. [Table 1](#) lists each component and its relationship with Observation and Measurements (ISO-19156). Collections are not defined within O&M and are thus an extension.

Table 1 - WaterML 2.0 components and equivalent concepts in O&M 2.0

WaterML 2.0 components	O & M 2.0 concepts
Time series	Result
Observation specialisations	Observation
Procedures used in measurement/analysis/processing	Procedure
Observation metadata	Observation (metadata)
Location description	Sampling features
Collections	-

The general characteristics of WaterML2.0:

1. Communicates the semantics of hydrological time series data;
2. An explicit time series model that supports encoding of information crucial to correct interpretation of time series, such as properties describing the nature of individual data values and their relationships;
3. A flexible exchange schema that can be re-used in a number of scenarios. Includes concepts to deal with common complexities in cross-system data exchange, such as multiple identifiers and names;
4. The schema is reusable across different transport technologies, including FTP, and a variety of web services etc.;
5. Ability to extend through use of external schema and soft-typing;
6. Ability to capture information relating to the provenance of a time series (i.e. how the time series was created). Allows for interpretation of 'data products' such as statistical summaries;

7 Observations and Measurements overview

ISO19156 – Observations and Measurements (O&M) is a generic information model for describing observations. 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.” This is described using UML in Figure 1.

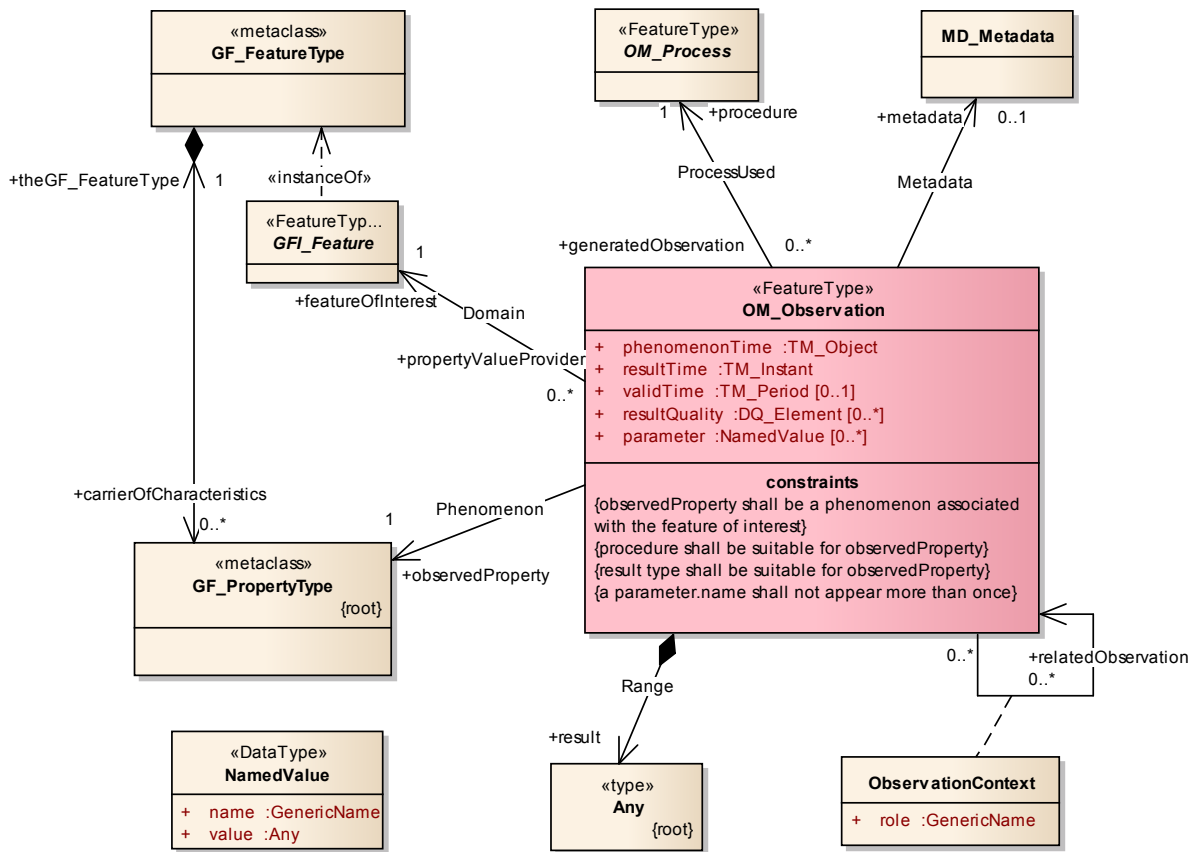


Figure 1 - Observation as defined by O&M

7.1 Sampling features

O&M defines the concept of sampling features as a “feature, such as a station, transect, section or specimen, which is involved in making observations concerning a domain feature.”

Sampling features are used in two circumstances:

1. The observation does not obtain values for the whole of a domain feature;

2. The observation procedure obtains values for properties that are not characteristic of the type of the ultimate feature (e.g. measuring electrical conductivity as a proxy for salinity)

These concepts are common within the hydrology domain, thus the sampling features concept is used in this profile. Section 9.19 describes the use further.

8 The nature of hydrological observations

“Water is found on Earth in significant amounts in all three of its physical phases: liquid, solid, and gaseous. It is also found in all three of Earth’s major environments that are readily accessible to humans: the atmosphere, the seas and oceans, and the land masses. Because water can readily move from one environment to another and can change from one phase to another in response to its environment, it is a dynamic medium in both space and time.” [3].

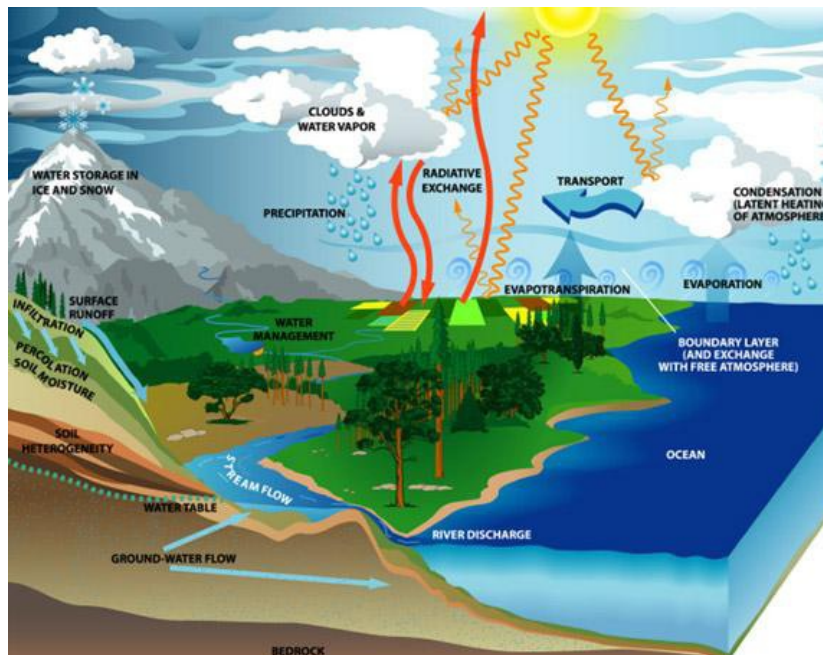


Figure 2 – The hydrologic cycle [4]

The field of hydrology focuses on the water cycle as it interacts with land; hydrological observations are performed in order for us to increase our understanding of this interaction. Observations can occur at any point within the hydrologic cycle, employing different techniques, and estimating phenomena related to water quantity or quality. The types of observations made in hydrology differ not just in the phenomena monitored, but also in the observation method.

The method or technique used has important implications affecting the frequency and location of observations. For example, water quality observations often require laboratory analysis in which a person may take a sample from a site and return it to a specialist for analysis; this implies a higher cost and will thus occur infrequently. Whereas a river level gauge connected to an automatic telemetry device can make measurements every 15 minutes and relay results

periodically to a central data repository. This provides greater temporal granularity but is restricted to a single location.

For the purpose of this profile, five broad observation styles are defined, detailed in Table 2.

Table 2 - Broad categories of water observations

#	Observation style	Description
1	In-situ, fixed observation style	Generally temporally dense, spatially sparse, small number of observed phenomena. Examples: river level or stage, river discharge, storage level, rainfall, pH, turbidity etc.
2	In-situ, manual observations	Temporally sparse (often associated with sites visits) but potentially spatially dense. E.g. groundwater observations made during pump tests at well sites.
3	Ex-situ, complex processing observations	Temporally sparse, spatially sparse, many observed phenomena. Examples: nutrients (nitrate, phosphorus etc.), pesticides (atrazine, glyphosate etc.), biologicals etc.
4	Remote-sensed observations	Observations that are collected by a sensor that is not in direct contact with the property being observed. These observations can be spatially and temporally dense.
5	Complex data products	These consist of processed or synthesised observational data, mainly created to provide estimation of not directly measurable phenomena or predictions of future values. Examples: outputs from models or algorithms, water storage estimates, calculation of complex physics-chemistry, biological indices etc.

These definitions are not clear-cut; it is possible to have water quality measurements that are made continuously by in-situ measurements (such as dissolved oxygen, turbidity etc.). Similarly, storage volume may be viewed as a complex data product as it often involves the integration of survey data and estimation algorithms. Exchange formats addressing category 1 may be capable of capturing data within category 3, but representation of the procedure used to generate the data set implies extra requirements on metadata (if it is to be supported through transfer). Generally, the more complex the process of making the measurement, the less likely it is to be available as a continuous observation.

This standard is capable of encoding data sets from the first and second categories from Table 2. Complex data products (category 5) can be accommodated, if they are structurally similar to in-situ observations. Ex-situ (e.g. water quality) data will be handled in future work.

8.1 Observations and forecasts

While Observations and Measurements (ISO19156) describes a conceptual information model for describing ‘observations’, this may include the description of outputs from simulations such as forecast models, where the ‘observations’ occur into the future, or within a simulated time period. Using the same base concepts for describing observations and simulations increases the ease of data integration.

9 UML Conceptual Models (normative)

This standard defines the conceptual models for the description of water observations, making use of ISO19156 as the base conceptual model. The standardization target for the UML conformance classes are:

- Encoding models derived from the conceptual models of this standard.

- Software implementations seeking compliance to this standard.

9.1 Structural overview of requirements classes

The requirements classes of the standard are structured as shown in Figure 3 (internal package dependencies). Below is a brief summary of the function of the requirements classes.

[Timeseries Observation \(abstract\)](#)

An abstract class that captures common restrictions of the ISO1956 OM_Observation class, for observations that have timeseries as their result. This class is not directly implemented but used as a basis to define the two types of timeseries observations.

[Timeseries Observation \(domain range\)](#)

An observation that returns a time series with the time and values represented separately. The two more specific classes (MeasurementTimeseriesDomainRangeObservation and CategoricalTimeseriesDomainRangeObservation) capture common specialized series types where the value-type is restricted.

[Timeseries Observation \(interleaved\)](#)

An observation that returns a timeseries with the time-value pair coupled (interleaved) representation. The two more specific classes (MeasurementTimeseriesTVPObservation and CategoricalTimeseriesTVPObservation) capture the specialized series types where the value-type is restricted.

[Timeseries \(core\)](#)

An abstract class that captures the common characteristics of timeseries (the result of the above observation types). This provides the basis for more specialized timeseries types and forms the core requirements class of the standard.

[Timeseries \(domain range\)](#)

This requirements class describes the structure of timeseries when the time and value components are separated and not explicitly represented as pairs. The two more specific classes (MeasurementDomainRangeTimeseries and CategoricalDomainRangeTimeseries) capture two specific types of timeseries where the value-type is restricted.

[Timeseries \(interleaved\)](#)

This requirements class describes the structure of interleaved timeseries (time-value pairs) and associated metadata classes. The two more specific classes (MeasurementTimeseriesTVP and CategoricalTimeseriesTVP) capture two specific types of timeseries where the value-type is restricted.

[Monitoring Points](#)

Implement this requirements class to describe monitoring points using ISO19156 sampling features. The requirements class defines a single specialization of a point spatial sampling feature.

[Monitoring point feature of interest](#)

For timeseries observations using in-situ monitoring points this conformance class should be used. It captures one of the more common continuous timeseries observations that occur using a monitoring point. It is a separate conformance class in order to allow timeseries observations using different sampling features (e.g. groundwater wells) or features with more complex geometries such as lines and polygons.

[Collections](#)

Implement this requirements class to provide collections of sampling features, timeseries and inline vocabularies.

[Observation Process](#)

Implement this requirements class to described processes involved in the generation of timeseries.

9.2 Package dependencies

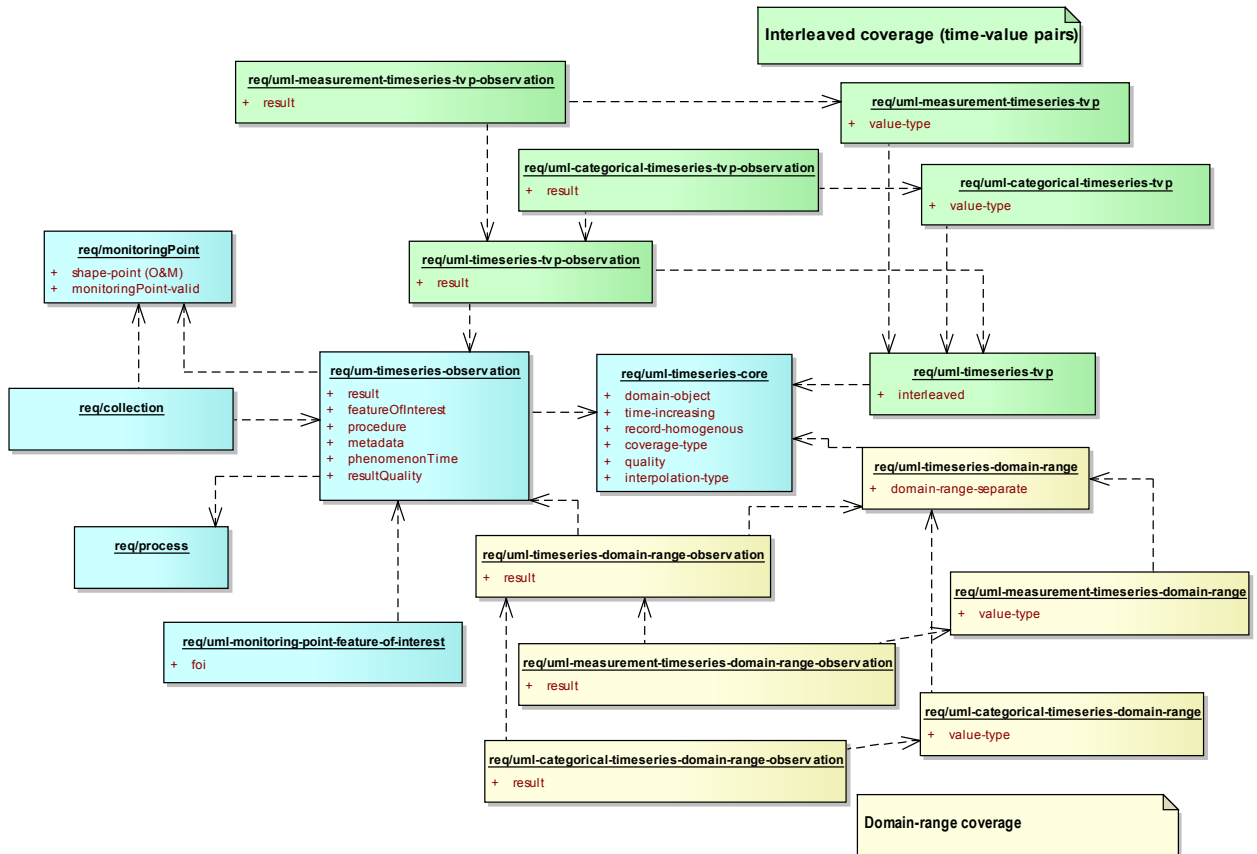


Figure 3 – Internal package dependencies

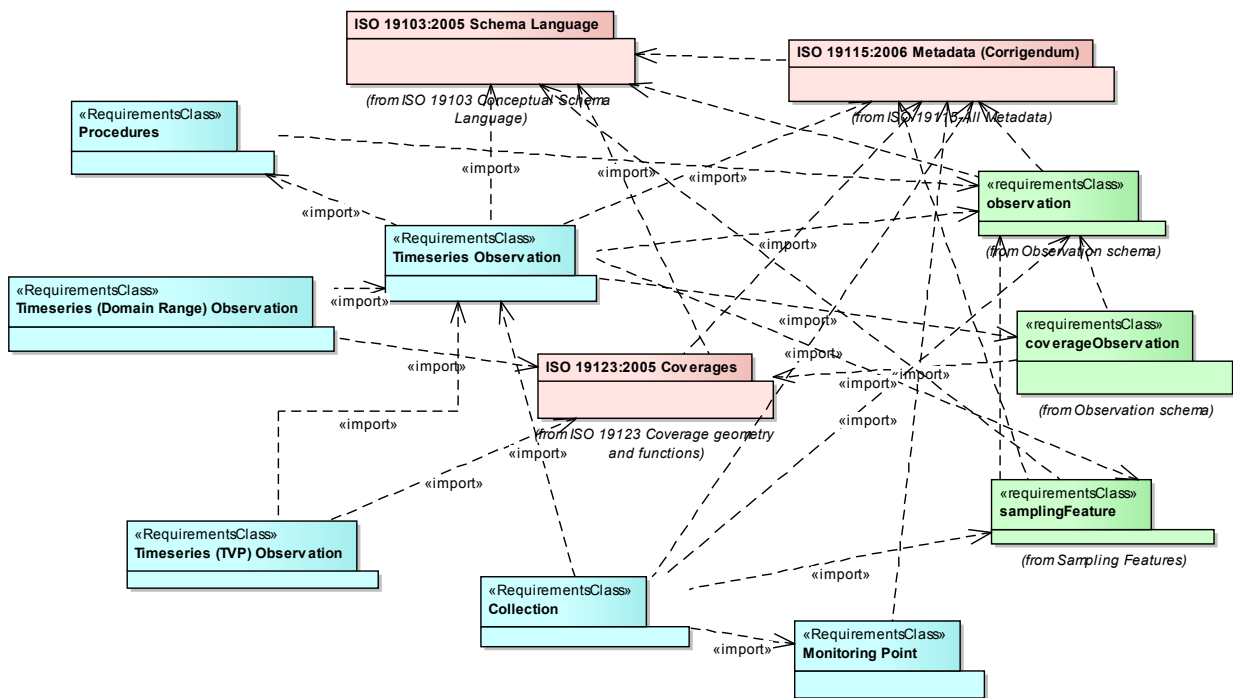


Figure 4 - External dependencies (timeseries observations)

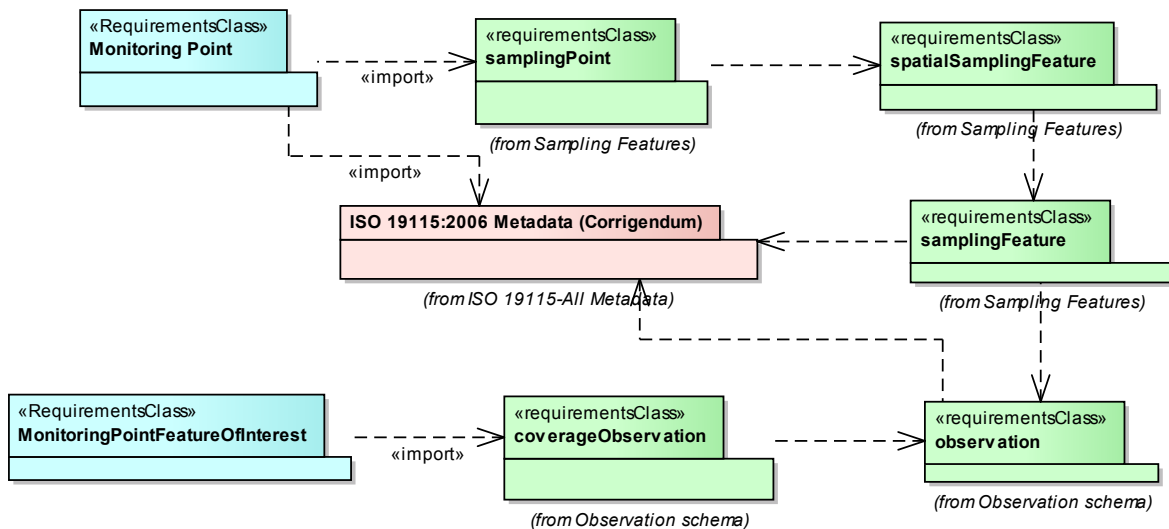


Figure 5 - External dependencies (monitoring points)

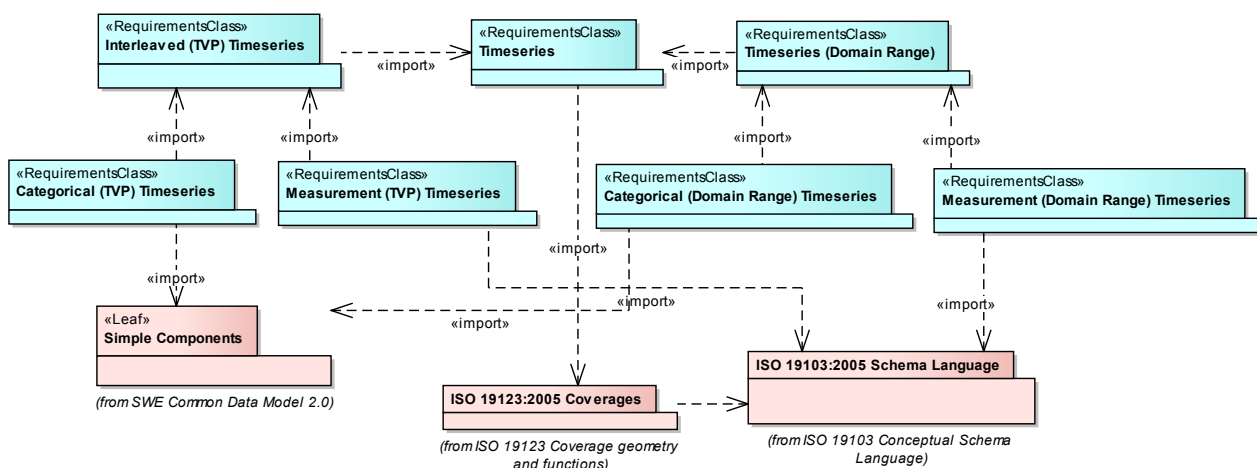


Figure 6 - External dependencies (timeseries)

9.3 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 in hierarchies or through other relationships such as equivalence (e.g. precipitation and rainfall refer to the same concept).

Part 1 of WaterML2.0 does not define a full set of vocabularies for data exchange; it does, however, define a number of vocabularies that were identified as providing a first step for data exchange of time series. This standard defines vocabularies for the following concepts:

- Quality assertions for data values of a broad, categorical type. See section 9.12.3.2.1.
- The medium that is being sampled as part of the observation process. See section 9.4.1.8.3.
- The general types of processes used in observation. See section 9.22.1.
- The interpolation type of the values of a time series. See section 9.15.3.2.

These vocabularies are defined within the OGC definition namespace (<http://opengis.net/def/>), 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).

It is envisaged that WaterML2.0 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 exchanged. Optimally a recognized body, such as WMO, would govern the vocabularies. Future work within the Hydrology Domain Working Group should address the area of controlled vocabularies for the hydrology domain. These vocabularies require a governance structure that allows changes to be made as definitions evolve.

9.4 Requirements class: Timeseries Observation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-observation	
Target Type	Encoding of the conceptual model
Name	Time series observation
Dependency	urn:iso:dis:iso:19156:clause:6.2.2
Dependency	urn:iso:dis:iso:19156:clause:7
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-core
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-observervation-process
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point-feature-of-interest
Requirement	<p>/req/uml-timeseries-observation/result</p> <p>A TimeseriesObservation shall have a result that is conformant with the Timeseries UML and Timeseries requirements class, as defined in Figure 16 and section 9.12 of this standard.</p>
Requirement	<p>/req/uml-timeseries-observation/resultDomain</p> <p>The spatial domain of the timeseries result shall be consistent with the featureOfInterest of the observation.</p>
Requirement	<p>/req/uml-timeseries-observation/featureOfInterest</p> <p>If the feature of interest of the observation is not a domain feature (e.g. river section, dam, lake) then the featureOfInterest shall be of type or subtype of SF_SpatialSamplingFeature, as defined by ISO19156, which includes MonitoringPoint defined in section 9.20 of this standard.</p>
Requirement	<p>/req/uml-timeseries-observation/procedure</p> <p>A TimeseriesObservation shall have a procedure property of type ObservationProcess, or a reference to such a type, as defined in section 9.22 of this standard.</p>
Requirement	<p>/req/uml-timeseries-observation/metadata</p> <p>A TimeseriesObservation shall have a metadata property of type ObservationMetadata, as defined in section 9.4.1.8 of this standard.</p>
Requirement	<p>/req/uml-timeseries-observation/observedProperty</p> <p>A TimeseriesObservation shall have an observedProperty of type</p>

	GFI_PropertyType, as described in ISO19156.
Requirement	<p>/req/uml-timeseries-observation/phenomenonTime</p> <p>The OM_Observation:phenomenonTime property shall be used to define the period over which the time series result applies for the given observed property.</p>

9.4.1 Timeseries Observation as a specialised OM_Observation

O&M groups observations into two types based on the nature of the result: observations whose result is static (e.g. a single measurement) and observations where the result varies as some function. It is thus possible to define a time series observations two ways using this model:

1. A collection of OM_Observations. Each observation represents a single sensor data point; the collection makes up a time series.
2. An OM_Observation whose result is a discrete coverage that varies in time (c.f. *OM_DiscreteCoverageObservation*). Here the OM_Observation feature type provides the spatio-temporal context for the series.

WaterML 2.0 *TimeseriesObservation* takes the second view of *OM_Observation* and defines *TimeseriesObservation*, *TimeseriesTVPObservation* and a *TimeseriesDomainRangeObservation* as shown in Figure 9.

The two subtypes of *TimeseriesObservation* offer two different structuring of the timeseries result: a time-value pair style structure where the time, value and associated metadata are encoded as coupled items (*TimeseriesTVPObservation*), and a separated structure where the time and values are represented as separate collections with metadata described separately to the time and values (*TimeseriesDomainRangeObservation*). The first style is most common within the hydrology domain; the second approach is common within communities that make use of coverages. The second approach will most often result in a more compact encoding due to a more efficient structuring. See section 9.12.2 for a detailed description of the relationship to coverages.

The *TimeseriesObservation* may be viewed as the spatiotemporal interoperability context that facilitates data exchange between parties through a common agreement (*OM_Observation*) of how observations may be conceptualised: i.e. the relationship between features, observed phenomena, procedure and the result generated (a time series). Traditional data exchange within the hydrology domain often occurs at the timeseries level, either with an explicit means to identify the monitoring site, sensor (procedure) and phenomenon or through use of internal identifiers where systems resolve the constituent parts internally. WaterML2.0 views the *TimeseriesObservation* as a type of *interoperability contract* that facilitates data exchange.

In the context of this profile, metadata at the Observation level is used as the carrier of first class elements required for data exchange and/or discovery (e.g. identifiers, spatiotemporal context, connections to features, procedures, phenomena and so on). Metadata at the Timeseries level is metadata that describes the structure and nature of the series, such as quality interpolation types, whether the series is cumulative etc. It should be noted that the Timeseries class is available for

use without the *TimeseriesObservation* feature type; this would be useful, for example, where existing systems are communicating that have previously agreed upon identifiers and/or context that allows sufficient context for exchange to occur.

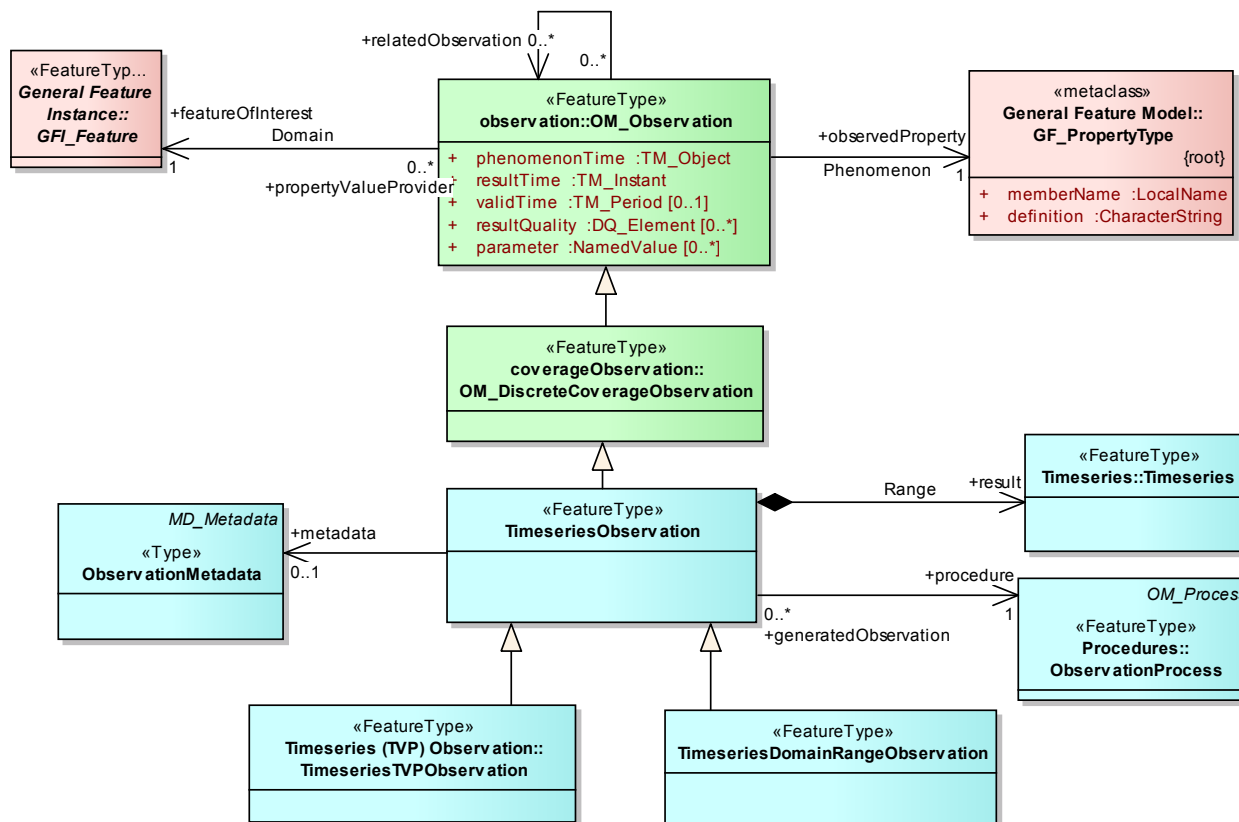


Figure 7 - Observation specialisation

The properties (attributes and associations) of the *TimeseriesObservation* are outlined in the following sections. This includes properties that are inherited from the base classes from O&M; the description of the use is adapted to the context of this profile, providing guidance on how they should be used in the context of hydrological observations.

9.4.1.1 observedProperty (OM_Observation)

This property is used to describe the phenomenon that is being observed, "...such as "temperature", "height", "colour", "material"" [ISO19156]. The definitions of such properties take the form of a controlled vocabulary, ontology or hierarchy of some form. Part 1 of WaterML2.0 does not define the available hydrological phenomena involved in exchange; it is envisaged that a governing body such as WMO or the OGC Hydro Domain Working Group will define and govern such vocabularies. This property should reference a code item that adequately describes the phenomenon. See the XML implementation for how this is done using XLink references. As a minimum the definition of a concept should contain a name and definition, as shown in the GF_PropertyType in Figure 7.

It is recommended that the observed phenomena be separated from the physical medium that is being sampled – see the sampled medium property in section 9.4.1.8.3 – and the units used for measurement (see MeasurementTimeseries in section 9.15.3).

9.4.1.2 **parameter (OM_Observation)**

This allows for arbitrary named value pairs to be specified for the observation. This is an extensible mechanism for adding (typically event-specific) information that may not be captured directly in the schema. The use of this property is described in ISO19156.

9.4.1.3 **phenomenonTime (OM_Observation)**

This property describes the temporal extent of the time series that is result of this observation. A TM_Object allows for multiple temporal objects defined by GML. WaterML2.0 restricts this to be a time period, defining the start and end times of the time series.

9.4.1.4 **resultTime (OM_Observation)**

O&M defines result time as the “...*the time when the result becomes available, typically when the procedure associated with the observation was completed.*” With a time series result, this will depend on the procedure used for the observation. For automated sensors producing continuous measurements, this will most likely be the time of the end of last point in the time series. For algorithms, sensors and manual methods, this will be time when the result time series becomes available, for example, when an algorithm or model has completed. The resultTime should be associated with the procedure producing the time series rather than generation of the encoded document (e.g. generation through a web service). The generationDate (see section 9.23) of the holding collection document should be used in this case.

9.4.1.5 **validTime (OM_Observation)**

This describes the time period for which the results are intended to be used. This is important for simulations (especially forecasts) that may only be applicable within a given window of time (often a newer data product will be available that supersedes the ‘observation’).

9.4.1.6 **resultQuality (OM_Observation)**

This is used to describe the overall quality of a time series. Time series often require per point quality information, which is provided by the specific timeseries types that are used (defined in section 9.12).

The resultQuality type is DQ_Element, which is defined by ISO19115 - Data quality information. This type allows for a detailed description of various qualitative aspects of data sets. It is possible to describe both the process used in determining the quality (*DQ_Element*) and the result of the process (i.e. the estimated quality – *DQ_Result*), which may be a quantitative result or a level of conformance.

9.4.1.7 featureOfInterest (OM_Observation)

The feature of interest describes the feature that is the target of the observation. ISO19156 makes the distinction between observations that make direct observations of feature properties and those that sample the feature and use the sample as a proxy for the value of a feature's property (often this step involves process, e.g. using an aggregation or interpolation method). Within hydrology sampling is the most common approach (e.g. making a measurement at a particular point on a river section to make inferences about the whole river). Example spatial sampling features within the hydrology domain are shown in Table 3 along with the associated type from ISO19156. All these sampling types exist for the purpose of making estimates of properties (phenomena) of a larger body.

Table 3 - Mapping of hydrological sampling features

Hydrological term	ISO19156 – Observations & Measurements
Monitoring station, gauging station, site	SF_SamplingPoint
Borehole, observation well, river profile	SF_SamplingCurve
River cross-section	SF_SamplingSurface

This profile defines one specialised sampling feature, a *MonitoringPoint*, which describes the characteristics of an in-situ point of observation (e.g. a monitoring station). This feature is recommended when describing such observations but it is recognised that more sampling features exist, thus the restriction of this property only extends to *SF_SpatialSamplingFeature*.

The core of WaterML2.0 does not restrict the feature of interest to be only point-based sampling features. It does, however, identify that this is a common pattern for in-situ monitoring and captures this in the “[monitoring point feature of interest](#)” requirements class. It is thus possible to use different sampling features as the target feature. For example, the timeseries observation may describe the average value of a polygon through time.

A separate OGC Discussion paper (11-039r2 HY_Features a Common Hydrologic Feature Model) provides a model for hydrologic features of interest and domain features. If exchanging detailed information on hydrologic features is required, this provides a framework for exchanging hydrologic features. As most timeseries data sources utilize monitoring points, the addition of a simple monitoring point feature is suitable for data exchange of this style.

9.4.1.8 metadata (OM_Observation)

The metadata property is restricted to type of *ObservationMetadata*, described in UML in Figure 8.

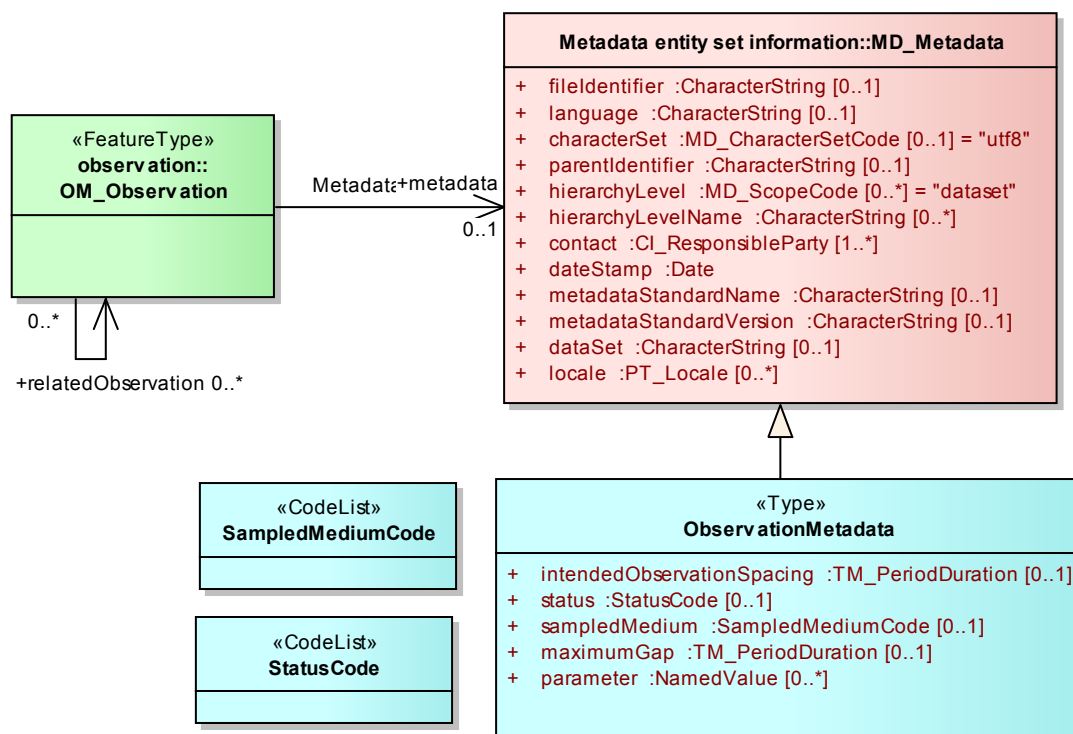


Figure 8 - Observation metadata

ObservationMetadata, defined as a specialisation of the ISO19115 *MD_Metadata* type, adds observation specific metadata; each property is described in the following sections.

9.4.1.8.1 intendedObservationSpacing

This defines the expected duration between individual observations. It is common that observations will occur frequently (such as those performed by automated sensors or regular visits); this property allows specification of expected time between measurements. This is reflected in the individual points that make up the resulting time series, but there are cases where the observation interval does not match the intended observation interval. One example would be an increased observation interval intended to capture an event such as a peak in flood. Note there is also the *spacing* property for *Timeseries* that is a stricter definition, allowing regularly spaced (equidistant) time series to be encoded (see section 9.12.3.1.2 for a full description).

9.4.1.8.2 status

The status is used as a general categorisation of the state of an observation often relating to the level of validation that has occurred to the data. This property will most likely reference a term in code list (e.g. 'Validated', 'Provisional'). WaterML2.0 does not currently define a code list for the list of potential statuses. This will be addressed in future vocabulary work.

9.4.1.8.3 sampledMedium

Describes the medium that was sampled in order to make the observation (e.g. water). Table 4 lists some of the commonly represented mediums in hydrological monitoring. Note: future work on vocabularies harmonisation will investigate hierarchical and mapping related vocabulary items (see section 9.3 for further discussion). The URIs listed provide an initial step towards interoperability of code items.

Table 4 - Media for hydrological monitoring

Medium	OGC Name
Water	http://www.opengis.net/def/waterml/2.0/medium/Water
Ground Water	http://www.opengis.net/def/waterml/2.0/medium/GroundWater
Surface Water	http://www.opengis.net/def/waterml/2.0/medium/SurfaceWater
Sediment	http://www.opengis.net/def/waterml/2.0/medium/SedimentWater
Pore Water	http://www.opengis.net/def/waterml/2.0/medium/PoreWater
Pore Air	http://www.opengis.net/def/waterml/2.0/medium/PoreAir
Soil	http://www.opengis.net/def/waterml/2.0/medium/Soil
Soil Air	http://www.opengis.net/def/waterml/2.0/medium/SoilAir
Soil Water	http://www.opengis.net/def/waterml/2.0/medium/SoilWater
Atmosphere	http://www.opengis.net/def/waterml/2.0/medium/Atmosphere
Tissue	http://www.opengis.net/def/waterml/2.0/medium/Tissue
Ground snow	http://www.opengis.net/def/waterml/2.0/medium/GroundSnow
Unknown	http://www.opengis.net/def/nil/OGC/0/unknown

9.4.1.8.4 parameter

A soft-typed field for arbitrary name-value pairs, using the O&M NamedValue type. This may be used to extend the available metadata properties. The use is different than the OM_Observation:parameter property which contains observation-specific parameters. This property should be used where cataloguing of the ObservationMetadata element is expected and requires specific extension.

9.4.1.8.5 maximumGap

Maximum gap provides information on the joining of different observations into a larger series. See section 9.15.2.2 for more information.

9.5 Time series observation specialisations

The core *TimeseriesObservation* is restricted in two specialised types that represent the two possible timeseries result structures: domain-range and time-value pairs. See section 9.12 for details on the definition of the timeseries types.

Note: The *TimeseriesObservation* does not directly subclass the *OM_TimeseriesObservation* from ISO19156 as this type restricts the result to a *CVT_DiscreteTimeInstantCoverage*, which is a style of TVP timeseries and thus would not allow the domain-range style of timeseries. Future work will attempt to harmonise the definition of timeseries across the ISO/OGC standards.

Figure 10 shows the relationship between the time-value pair structuring of timeseries with the *CVT_DiscreteTimeInstantCoverage* type. The WaterML2.0 *TimeValuePair* type makes the specialisation of the *DomainObject* (to a temporal component) explicit through the *WML_DomainObject*.

The two types reflect different styles of representing timeseries observations.

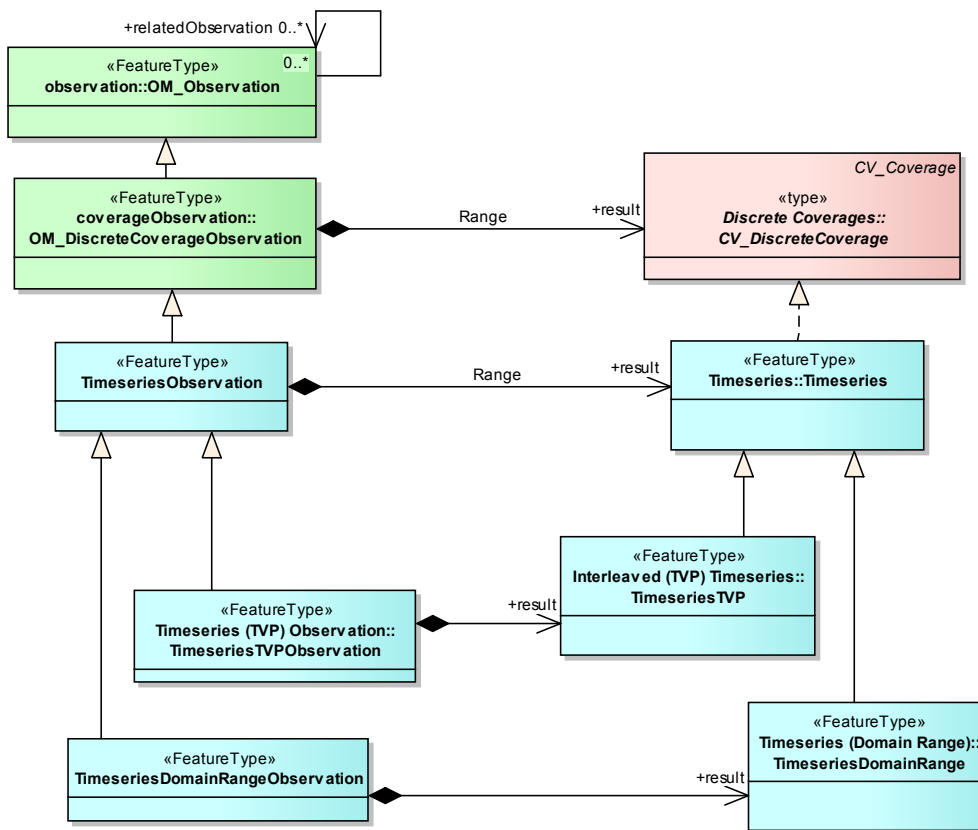


Figure 9 - Observation types as related to ISO19156 (green) and ISO19123 (red)

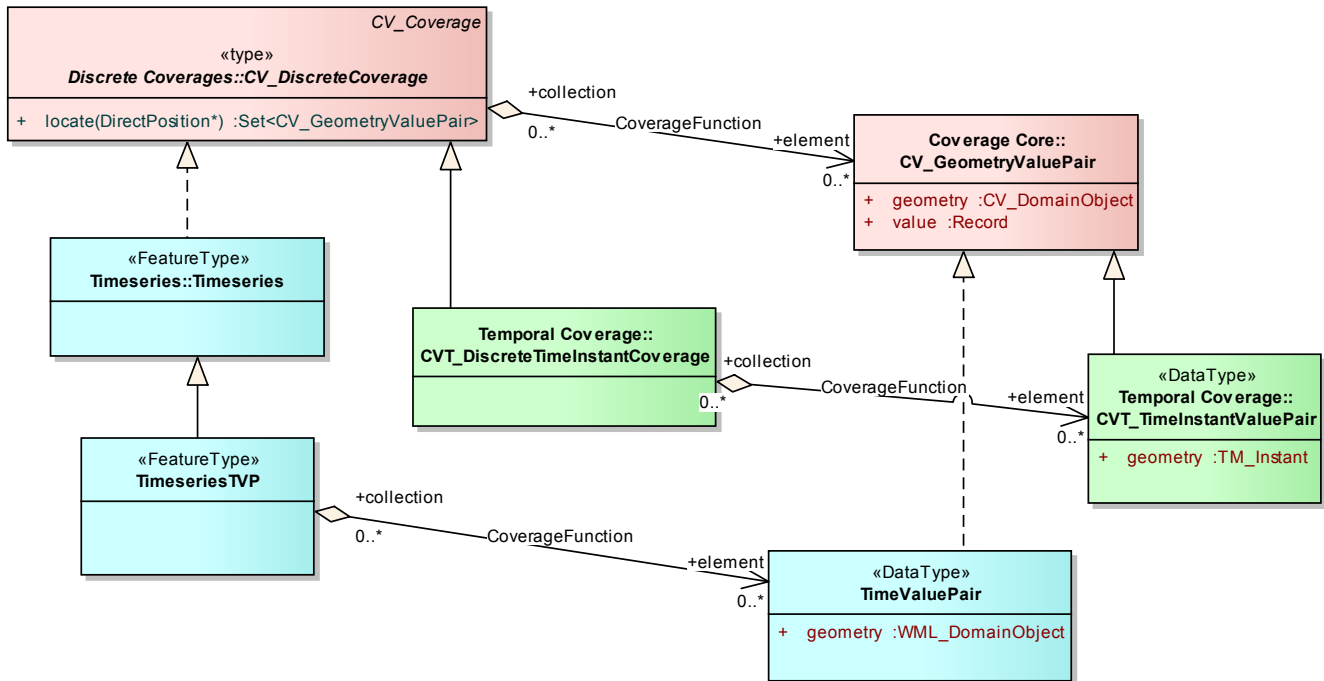


Figure 10 - Relationship to CVT_TimeInstantCoverage (ISO19156 – Annex C, green)

9.6 Requirements class – Timeseries (domain range) Observation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range-observation	
Target Type	Encoding of the conceptual model
Name	Time series (domain range) observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range
Requirement	<p>/req/uml-timeseries-domain-range-observation/result</p> <p>A <i>TimeseriesDomainRangeObservation</i> shall have a result of type <i>TimeseriesDomainRange</i>, as defined in section 9.13 of this standard. This is represented in the UML in Figure 9.</p>

9.6.1.1 result (OM_Observation)

The result of a *TimeseriesDomainRangeObservation* is restricted to be of type *TimeseriesDomainRange* as defined in section 9.13.

9.7 Requirements class – Measurement Timeseries (domain range) Observation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-domain-range-observation	
Target Type	Encoding of the conceptual model
Name	Measurement timeseries (domain range) observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-domain-range
Requirement	<p>/req/uml-measurement-timeseries-domain-range-observation/result</p> <p>A <i>MeasurementTimeseriesDomainRangeObservation</i> shall have a result of type <i>MeasurementTimeseriesDomainRange</i>, as defined in section 9.17 of this standard. This is represented in the UML in Figure 11.</p>

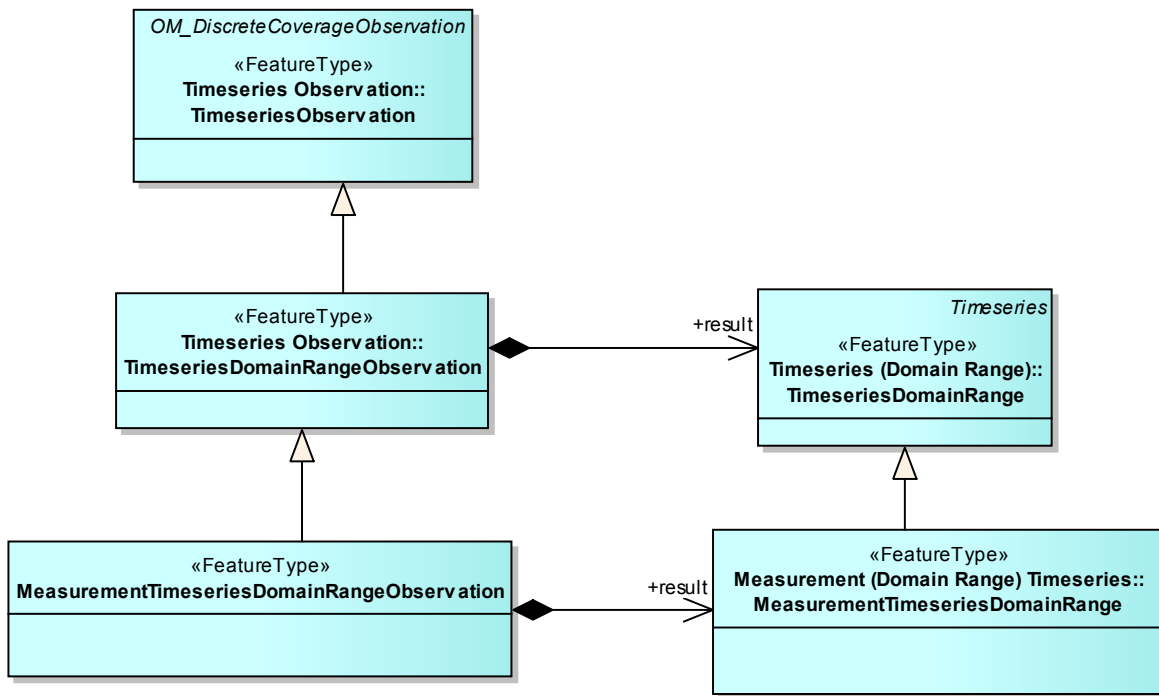


Figure 11 - Measurement timeseries (domain range) observation

9.7.1.1 result (OM_Observation)

The result of a *MeasurementTimeseriesDomainRangeObservation* is restricted to be of type *MeasurementTimeseriesDomainRange* as defined in section 9.17.

9.8 Requirements class – Categorical Timeseries (domain range) Observation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-domain-range-observation	
Target Type	Encoding of the conceptual model
Name	Categorical timeseries (domain range) observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-domain-range-observation
Requirement	<p>/req/uml-categorical-timeseries-domain-range-observation/result</p> <p>A <i>CategoricalTimeseriesDomainRangeObservation</i> shall have a result of type <i>CategoricalTimeseriesDomainRange</i>, as defined in section 9.8 of this standard. This is represented in the UML in Figure 12</p>

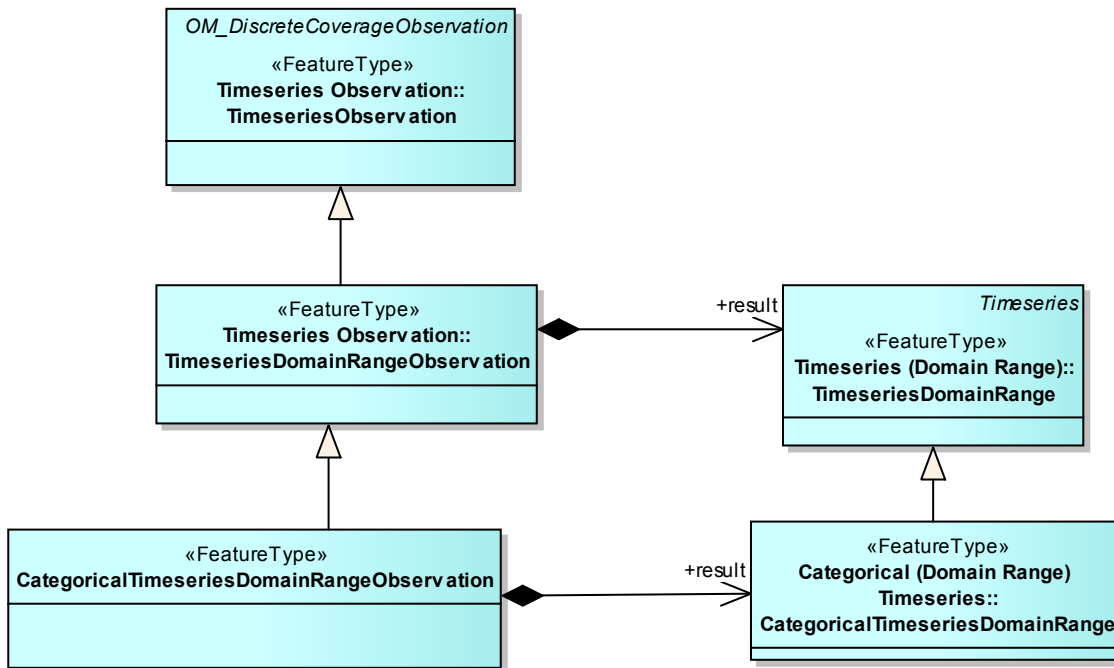


Figure 12 - categorical timeseries (domain range) observation

9.8.1.1 result (OM_Observation)

The result of a *CategoricalTimeseriesDomainRangeObservation* is restricted to be of type *CategoricalTimeseriesDomainRange* as defined in section 9.18.

9.9 Requirements class – Timeseries time-value pair (interleaved) Observation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tpv-observation	
Target Type	Encoding of the conceptual model
Name	TVP (interleaved) timeseries observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tpv
Requirement	<p>/req/uml-timeseries-tpv-observation/result</p> <p>A <i>TimeseriesTVPObservation</i> shall have a result of type <i>TVPTimeseries</i>, as defined in clause 9.14 of this standard. This is represented in the UML in Figure 13.</p>

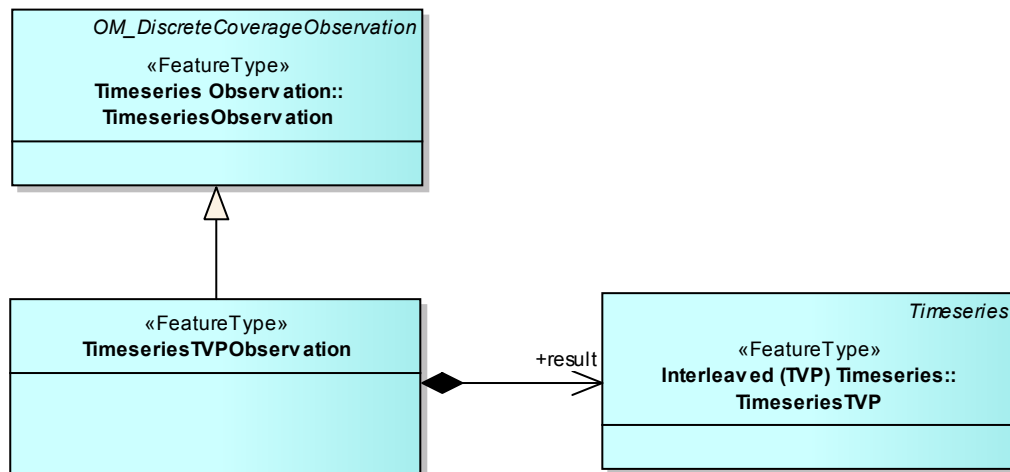


Figure 13 - Timeseries (TVP) Observation

9.9.1.1 result (OM_Observation)

The result of a *TVPTimeseriesObservation* is restricted to be of type *TVPTimeseries* as defined in section 9.14.

9.10 Requirements class – Measurement Timeseries time-value pair (interleaved) Observation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-tpv-observation	
Target Type	Encoding of the conceptual model

Name	Time-value pair (interleaved) timeseries observation - measurements
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-tvp
Requirement	<p>/req/uml-measurement-timeseries-tvp-observation/result</p> <p>A <i>MeasurementTimeseriesTVPObservation</i> shall have a result of type <i>MeasurementTimeseriesTVP</i>, as defined in clause 9.15 of this standard. This is represented in the UML in Figure 14.</p>

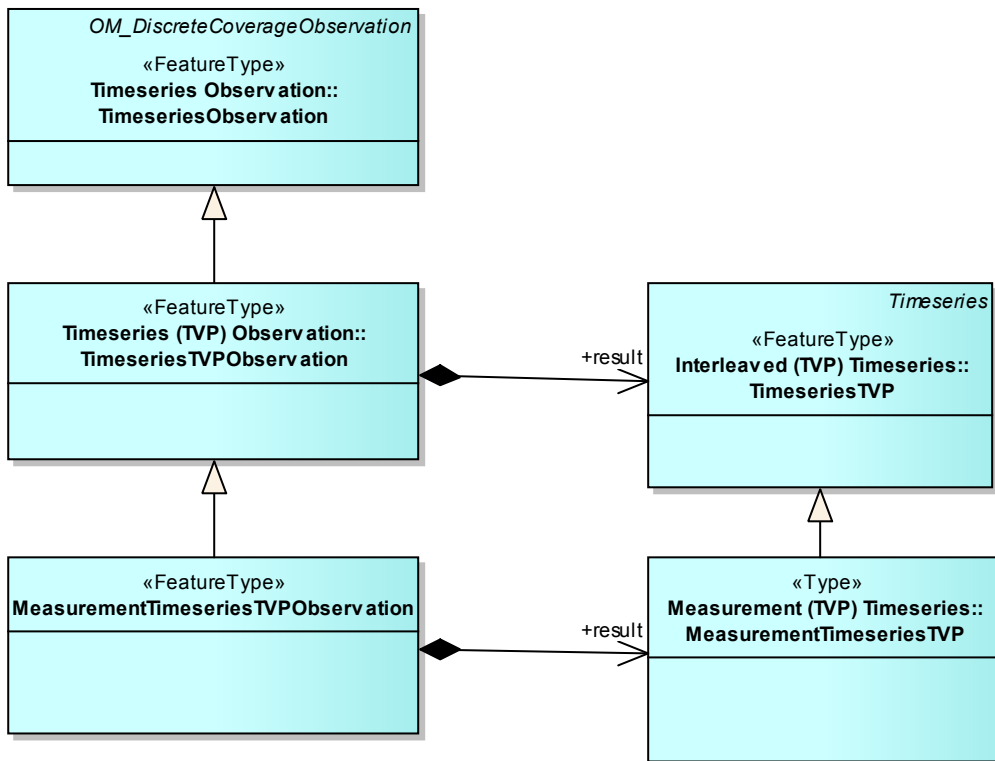


Figure 14 - Measurement timeseries (TVP) Observation

9.10.1.1 result (OM_Observation)

The result of a *MeasurementTimeseriesTVPObservation* is restricted to be of type *MeasurementTimeseriesTVP* as defined in section 9.15.

9.11 Requirements class – Categorical Timeseries time-value pair (interleaved) Observation

Requirements Class
http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp-observation

Target Type	Encoding of the conceptual model
Name	Time-value pair (interleaved) timeseries observation - categorical
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp
Requirement	<p>/req/uml-categorical-timeseries-tvp-observation/result</p> <p>A <i>CategoricalTimeseriesTVPObservation</i> shall have a result of type <i>CategoricalTimeseriesTVP</i>, as defined in clause 9.16 of this standard. This is represented in the UML in Figure 15.</p>

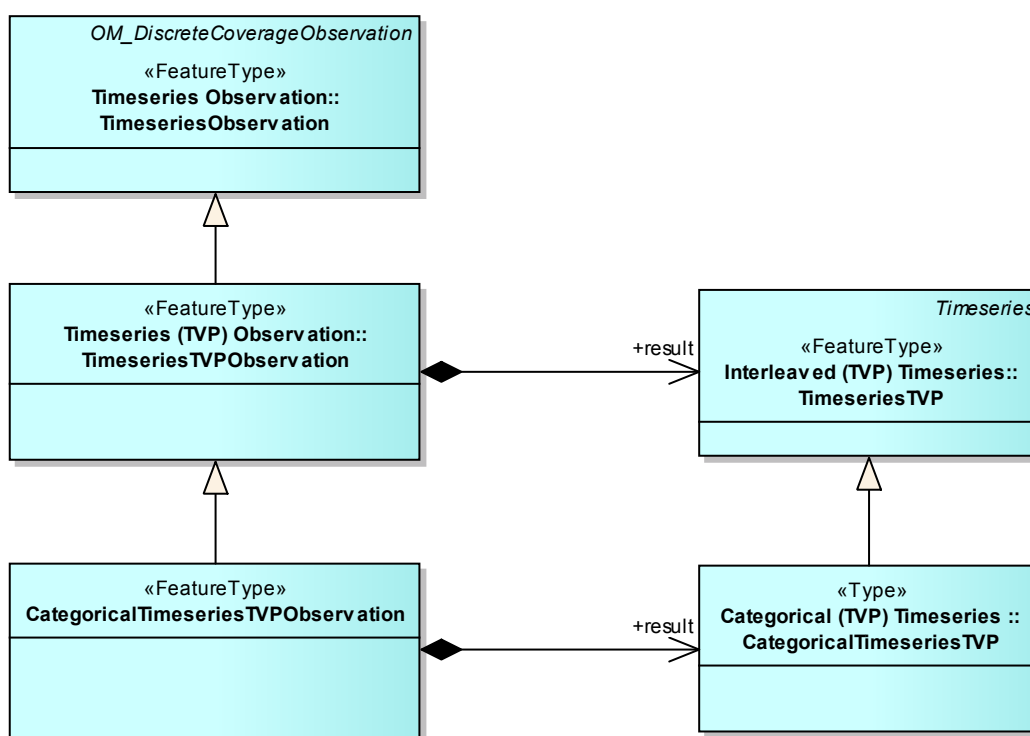


Figure 15 - Categorical timeseries (TVP) Observation

9.11.1.1 result (OM_Observation)

The result of a *CategoricalTVPTimeseriesObservation* is restricted to be of type *CategoricalTimeseriesTVP* as defined in clause 9.16.

9.12 Requirements class: Timeseries (Core)

Requirements Class
http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-core

Target Type	Encoding of the conceptual model
Name	Timeseries
Dependency	urn:iso:dis:iso:19123:clause:5.3 (CV_Coverage)
Requirement	<p>/req/uml-timeseries-core/domain-object</p> <p>A timeseries is a coverage whose domain shall consist of the temporal elements of the timeseries. If the series is spatially varying, the spatial elements shall describe each spatial element (empty for in-situ timeseries). This is shown in Figure 18.</p>
Requirement	<p>/req/uml-timeseries-core/time-increasing</p> <p>The time elements of the timeseries shall be ordered in increasing time.</p>
Requirement	<p>/req/uml-timeseries-core/record-homogenous</p> <p>The record-type for the values (range) of the timeseries shall be homogenous.</p>
Requirement	<p>/req/uml-timeseries-core/coverage-type</p> <p>A timeseries shall implement the domain-range or geometry-value (time-value pairs) coverage type. (This requirements class is abstract).</p>
Requirement	<p>/req/uml-timeseries-core/quality</p> <p>When specifying the quality of a data point using the quality property (section 9.12.3.2.1) an appropriate URI from Table 5 shall be used.</p>
Requirement	<p>/req/uml-timeseries-core/timeseries-metadata</p> <p>The timeseries shall support metadata for the series as shown in the UML in Figure 16 and Figure 19.</p>
Requirement	<p>/req/uml-timeseries-core/point-metadata</p> <p>The timeseries shall support point metadata for each value in the series as shown in the UML in Figure 20.</p>

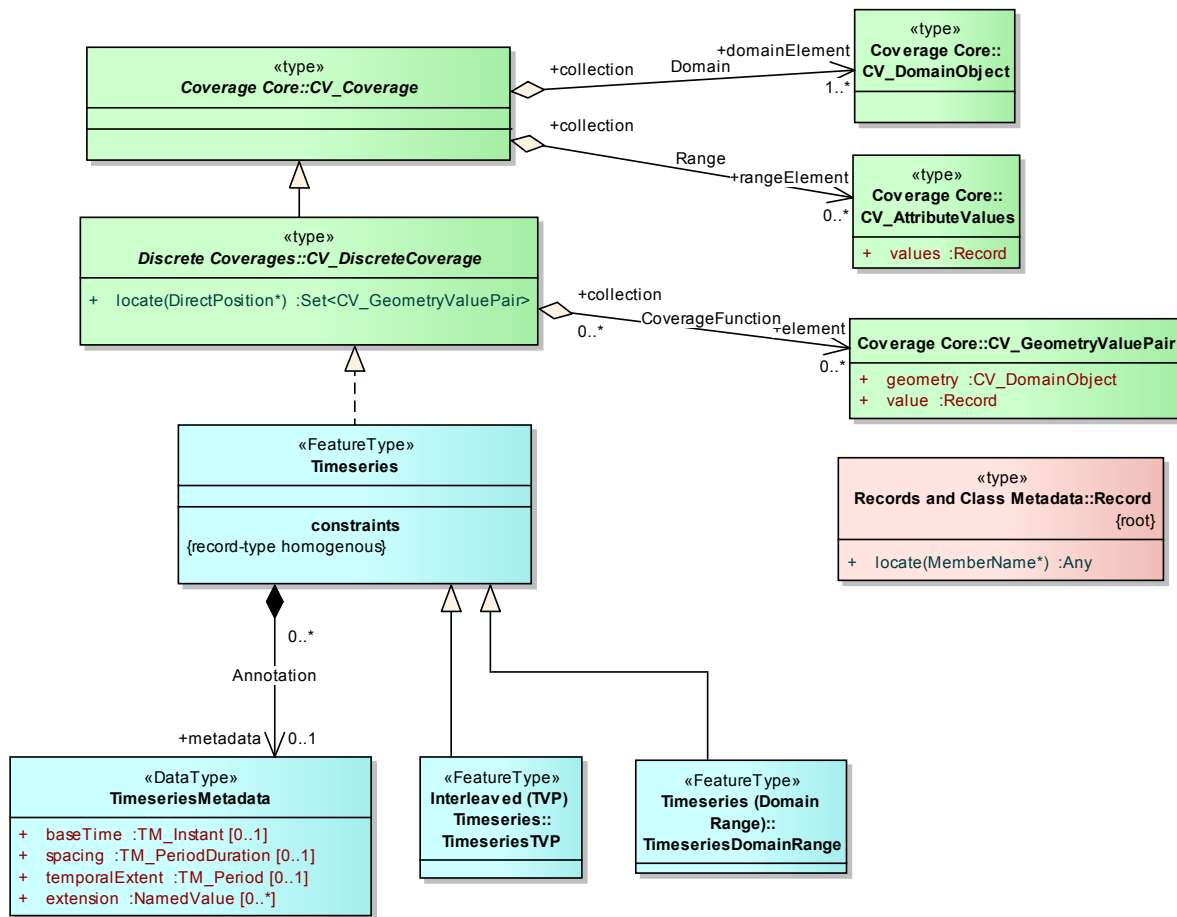


Figure 16 - Timeseries base type and relationship to coverages

Conceptually, WaterML2.0 captures the notion of timeseries as a low-level data management structure that contains an ordered set of related point observations. The point observations that make up a time series are often made by sensors, but may also be from manual observations, or a combination of both. For in-situ sensors, data loggers are often connected to sensors, store the individual observations, and will group them into time series for a particular phenomenon that is being measured. When data is processed from sensors and/or data loggers, particular metadata is associated with the collection of points that allow interpretation based on how the sensor is configured to measure (e.g. averaging periods, accumulation of values, value resets etc.).

A timeseries may not be the result of direct measurements but also derived from combinations of other series, processing and/or calculations. From an O&M perspective, such timeseries are still observations but are results from a different a process (e.g. a temporal aggregation process). This allows disambiguation of timeseries of directly sensed phenomena and those derived through other relationships. E.g. direct measurements of discharge vs. level-to-discharge calculation using a rating curve or table.

The value type of the individual observations is another axis of categorisation for time series. Potential types for measurement include:

- Measures (3.2 m/s)
- Vectors (e.g. wind speed and direction: 3.2 m/s North)
- Categorical (e.g. ‘cloudy’, ‘windy’ etc.)
- Composite (combination of phenomena, e.g. Conductivity, Temperature, Dissolved oxygen)

WaterML2.0 – part 1 focuses on timeseries with value types of measures and categories. These types capture the percentage of requirements for data exchange, while keeping a level of simplicity in the model and encodings, leading to simpler implementations. Composite timeseries (multiple phenomena) and other types will be addressed in future versions.

Within the hydrology domain, downstream processes often annotate timeseries using both manual and automatic methods. An example is quality assurance and control where a timeseries may be marked up to give an indication of quality of data; this may be done, for example, by a person manually looking at a plot, or by algorithms checking for abnormal deviations or other indicators. Such annotations come in many different forms and are important to persist for data exchange purposes.

9.12.1 Relationship to timeseries concepts in other domains

Timeseries are not specific to the hydrology domain, but the observation processes and use of data form a specific view of timeseries that represent the particular domains requirements. Other domains have information models for timeseries that reflect the needs of their domain; for example, financial timeseries, other environmental sciences or science domains making use of continuous observation. This standard, with a focus on assisting interoperability and the growing need for cross-domain exchange, attempts to relate key concepts to those in related domains. The most closely related concept within the spatial and observation community is that of coverages.

9.12.2 Relationship to ISO19123 – Coverages

ISO19123 defines a coverage as a:

“(a) feature that acts as a function to return values from its range for any direct position within its spatial, temporal or spatiotemporal domain”

Or,

“...a coverage is a feature that has multiple values for each attribute type, where each direct position within the geometric representation of the feature has a single value for each attribute type.”

A time series in the context of observational data can be seen as a *discrete coverage*, where the domain is a spatiotemporal axis and the range is all the possible values of the observed property. An instance of such a coverage would be a set of ordered time instances where each is associated with a single value from the attribute space. This association is often represented using time-value pairs.

The ISO coverages model describes two approaches to representing coverages: a ‘domain-range’ representation where the domain and range are encoded separately, with a mapping function that allows looking up of the range value for a given domain value; and a ‘geometry-value’, or interleaved, approach whereby the geometry and value are coupled together – the coupling explicitly represents the mapping.

GML 3.2.1 notes that the geometry-value approach “... is typically used during data collection where a set or properties relating to a single location are managed together, or update of a datastore where only a small number of features are manipulated at one time.”

And the domain-range approach is ‘...more suitable for analysis, where spatio-temporal patterns and anomalies within a specific property are of interest.’

Within hydrology this is often the case. For example, a grid showing the spatial distribution of rainfall is often generated from observations using interpolation techniques such as kriging. The surface may be generated using point observations from in-situ sensors. The point observations are often represented using a geometry-value structure with the generated surface being represented using the domain-range approach, with a spatial grid (domain) mapped to its range values (representing total rainfall in the grid cell, for example). This provides a more efficient representation.

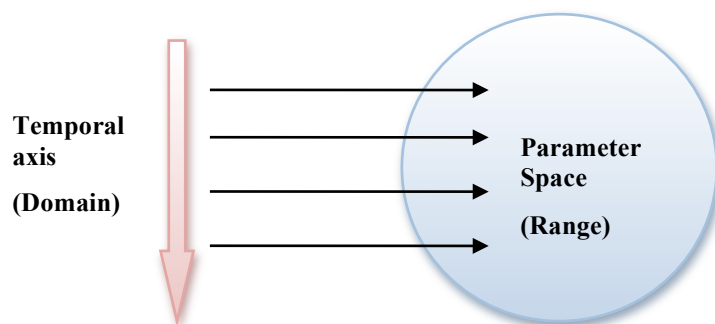


Figure 17 - Timeseries as a coverage

WaterML2.0 defines a timeseries as a coverage whose domain consists of collection of ordered temporal elements and the spatial component relates to the feature of interest of the observation. For in-situ timeseries the spatial element will be fixed and need not be directly represented in the timeseries domain. The core coverage elements and the relationship to timeseries are shown in Figure 16 and Figure 18.

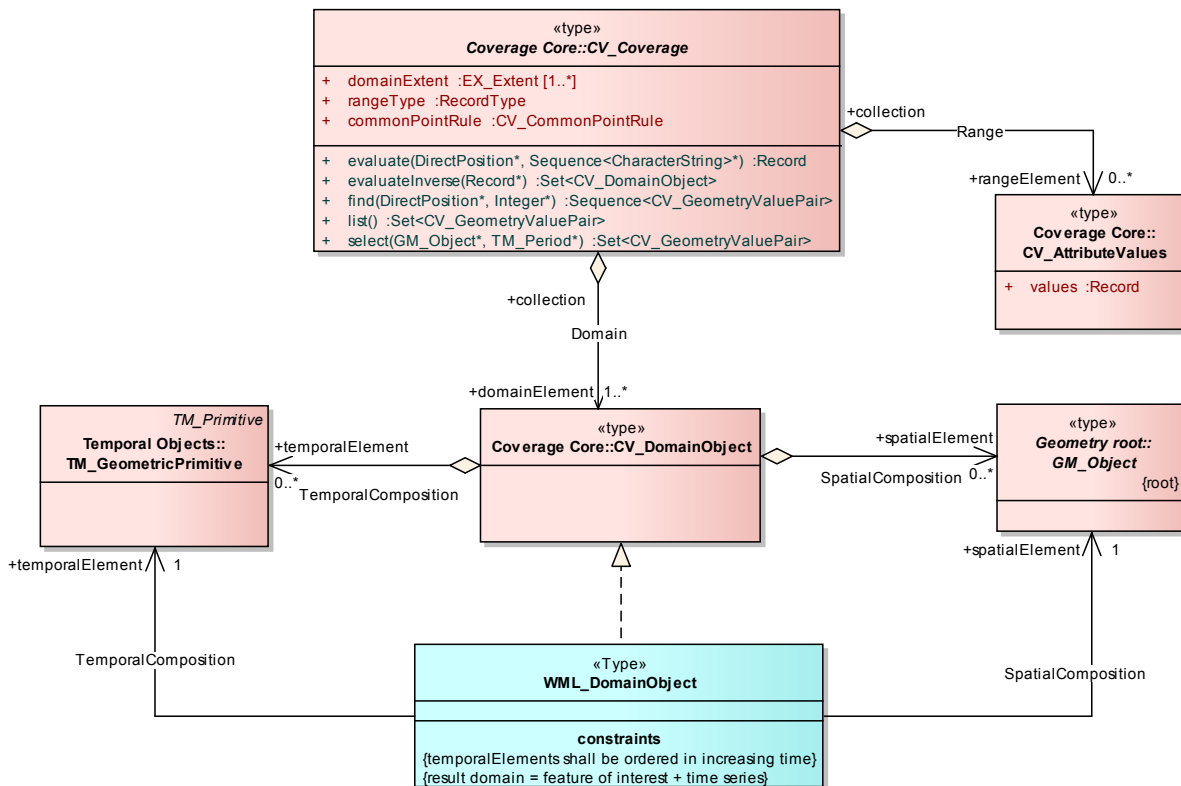


Figure 18 - Timeseries as a coverage

A timeseries may then be viewed in two ways from a coverage perspective: using the ‘domain-range’ view or the ‘geometry-value’ or interleaved view. Note that the term ‘geometry’ holds the domain object and is composed of varying spatial and temporal components (e.g. time instants). The two types are shown in Figure 21 and Figure 22 respectively.

The geometry-value view is consistent with the most common structuring in the hydrology domain: time and values are coupled together and represent discrete observations at time instants. The use of the term geometry is based on the coverage viewpoint; time-value will be used in place for clarity.

9.12.3 Timeseries and point metadata

Associating metadata with timeseries as a whole and at each individual point is a common requirement in hydrological data. Data is annotated with various types of qualifying information such as quality assertions, affecting environmental conditions, description of processing and so on. These annotations are important when processing and analysing timeseries to ensure correct interpretation.

At a generic level it is possible to associate any metadata with timeseries and timeseries points, this is shown with Annotation associations in Figure 21 and Figure 22. Using a soft-typed approach, this is simply a collection of named value pairs. Whilst flexible, this approach doesn’t

capture semantics specific to the metadata elements. WaterML2.0 thus defines two specialisations for timeseries and point-based metadata as shown in Figure 19 and Figure 20.

Using the interleaved structuring, metadata is associated with a time-value pair explicitly, with the metadata directly associated with a pair.

Using the domain-range structuring, metadata is associated to the timeseries through an AnnotationCoverage. This is a coverage that describes the temporally ranging metadata for the series. The domain of the coverage is the time that the annotation is valid; the range captures the values of the annotation (e.g. a quality assertion). In ISO19123 the values of range are described using a Record, which is a generic set of typed values. Each annotation that is required would need an associate record type. For example, quality may be a string record type that allows for simple categorical representations of quality.

The core elements of annotation for timeseries and timeseries points are shown in Figure 19 and Figure 20. These types are further extended for specific series types (e.g. measurement series.)

Each of the metadata elements is described in the following sections.

9.12.3.1 Timeseries metadata

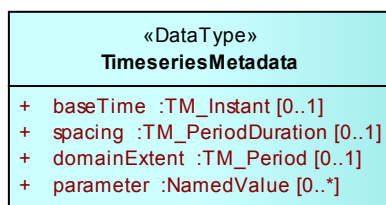


Figure 19 - Timeseries metadata

The following sections define the available metadata properties for timeseries.

9.12.3.1.1 domainExtent

The domain extent is the temporal extent of the timeseries. The concept is inherited from the coverage model as shown in Figure 18. As the domain of the timeseries is temporal, the domainExtent is a time period defining the start and end of its temporal domain (i.e. the start and end of the timeseries). Note that this often the same as the phenomenon time as specified in the OM_Observation; it is still useful here for timeseries that are described separately from an OM_Observation header.

9.12.3.1.2 Equidistant time series (baseTime and spacing)

Time series that are regularly spaced, such as those that are generated from automatic sensors, can be represented without specifying the individual time instant for each point. The *spacing* property of the time series is used to specify the time between points. This is then used as the spacing for each point encountered, starting from the time set by *baseTime*. See requirement req/xsd-timeseries-tvp/equidistant-encoding in section 10.8 for details on how this is implemented in XML. If the spacing between the timeseries values differs then the time instants

should be directly represented. For such cases (non-equidistant times), the intendedObservationSpacing (section 9.4.1.8.1) may be used to indicate the expected spacing. This allows for discovery based on the intended spacing, even there are some values that are not exactly equidistant (e.g. the frequency was increased through an important event).

9.12.3.1.3 parameter

This is a named value extension point that allows extra metadata to be added at the timeseries level. The parameters here are soft-typed (i.e. this standard does not define the properties semantics). Commonly used parameters here would be future candidates for definition within later versions or community extensions.

9.12.3.2 Point metadata

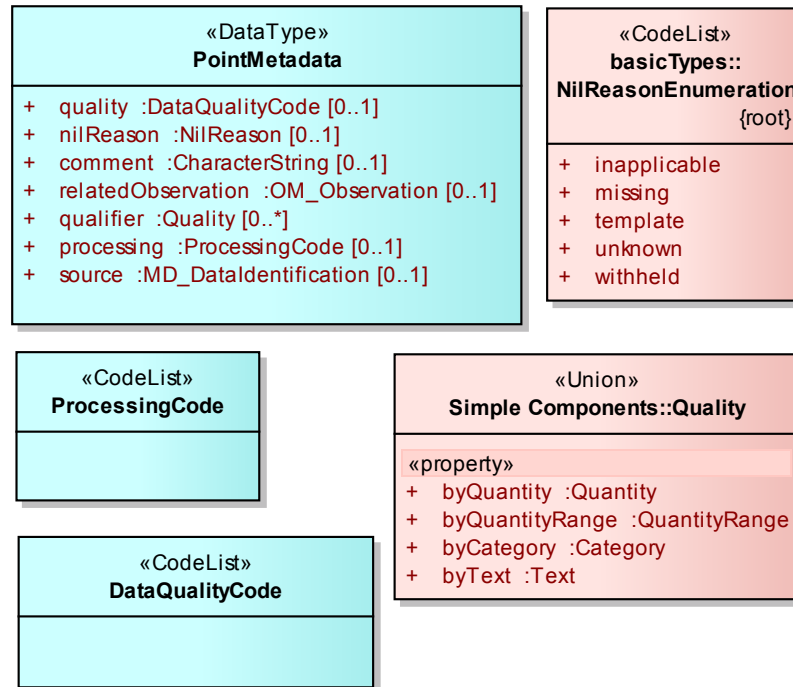


Figure 20 – Timeseries point metadata

9.12.3.2.1 quality

This property is for specifying a quality assertion using the WaterML2.0 defined concepts of quality as described below. When a non-standard quality code is required the qualifier property shall be used as described in section 9.12.3.2.5.

WaterML2.0 defines a set of high-level categories for quality to enhance interpretation and interoperability of data exchange, shown in Table 5. The categories defined in table allow for software and/or users to get an idea of the nature of a data series (or point). The URIs from this list shall be used for this property.

Table 5 - Quality categories

Quality	OGC Name	Description
Good	http://www.opengis.net/def/waterml/2.0/quality/good	The data has been examined and represents a reliable measurement.
Suspect	http://www.opengis.net/def/waterml/2.0/quality/suspect	The data should be treated as suspect.
Estimate	http://www.opengis.net/def/waterml/2.0/quality/estimate	The data is an estimate only, not a direct measurement.
Poor	http://www.opengis.net/def/waterml/2.0/quality/poor	The data should be considered as low quality and may have been rejected.
Unchecked	http://www.opengis.net/def/waterml/2.0/quality/unchecked	The data has not been checked by any qualitative method.
Missing	http://www.opengis.net/def/nil/OGC/0/missing	The data is missing.

9.12.3.2.2 nilReason

This property describes the reason that a point has been identified as null. This provides context for interpreting null points (e.g. missing, withheld etc.).

9.12.3.2.3 comment

Context information that does not fit into a controlled list of qualifiers, processing or quality information is often provided in free text per point. The comment property provides a placeholder for such textual information.

9.12.3.2.4 relatedObservation

This property allows individual points to be associated with related observations. This is used when a timeseries consists of interleaved observations from different sources and understanding the relationship to existing observation(s) is important.

9.12.3.2.5 qualifier

The qualifier property is used for qualifying information that is broader in nature than the quality property. These often include indicators or flags that provide further context for the value. Wide ranges of these are in use and harmonisation of the available types will be addressed in future work.

Quality information often aggregates these elements, but qualifiers allow for deeper interpretation and capture of useful information on a per point basis. The qualifier uses the SWE Common ‘Quality’ union that allows a qualifier to be specified using a Quantity, Quantity Range, Category or Text type.

The qualifier type may also be used to specify a quality code where the WaterML2.0 quality codes are not being used (see 9.12.3.2.1); for example, where an internal quality code needs to be preserved with the data.

9.12.3.2.6 processing

The processing property allows for the categorisation of the processing that has been performed on the time series. This is closely related to the procedure information as defined at the observation level, but allows for more granular definition (i.e. on a per point basis). Often a default processing type will be set for a whole time series, such as for a forecast time series. The XML encoding handles these cases with a defaulting mechanism described in section 10.8.

9.12.3.2.7 source

This property allows for granular definition of the source of a particular timeseries value. The property points to an object of MD_DataIdentification type (from ISO19115) that provides context on where the data was sourced. This is useful derived time series where the values are aggregated from multiple sources. The property is by reference only meaning that the full MD_DataIdentification type would not be encoded directly but referenced. The XML implementation provides a means to do this.

9.13 Requirements class: Timeseries Domain-Range

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range	
Target Type	Encoding of the conceptual model
Name	Timeseries (Domain-Range)
Dependency	urn:iso:dis:iso:19123:clause:5.7 (CV_DiscreteCoverage)
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-core
Requirement	<p>/req/uml-timeseries-domain-range/domain-range-separate</p> <p>The time (domain) and values (range) shall be directly represented separately with a 1:1 relationship between each time instant and value in the range as shown in Figure 21.</p>

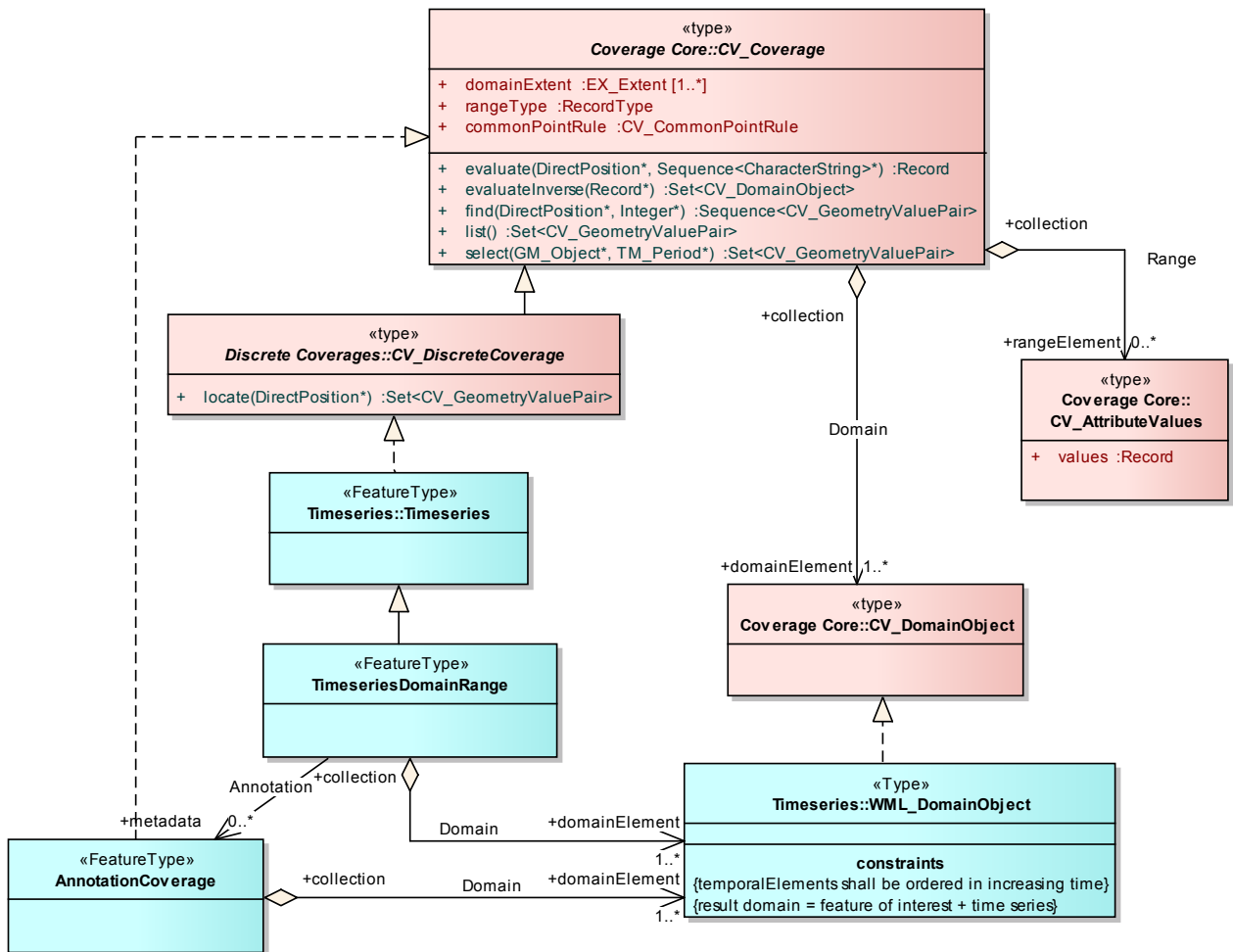


Figure 21 - Timeseries using domain-range view

9.13.1 Domain

Specifies the temporal domain of the coverage. This is the set of time elements that are mapped to the range set using a 1:1 mapping.

9.13.2 Range

Specifies the value set for the timeseries. This class keeps the value-type abstract and subclasses identify the common timeseries types, such as timeseries of measurements

9.14 Requirements class: Timeseries Time-Value Pair (interleaved)

Requirements Class
http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tyv

Target Type	Encoding of the conceptual model
Name	Timeseries (interleaved)
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-core
Dependency	urn:iso:dis:iso:19123:clause:5.7 (CV_DiscreteCoverage)
Dependency	urn:iso:dis:iso:19123:clause:5.8 (CV_GeometryValuePair)
Requirement	<p>/req/uml-timeseries-tpv/interleaved</p> <p>The time (domain) and values (range) shall be provided using using time-value pair representation as shown in Figure 22.</p>

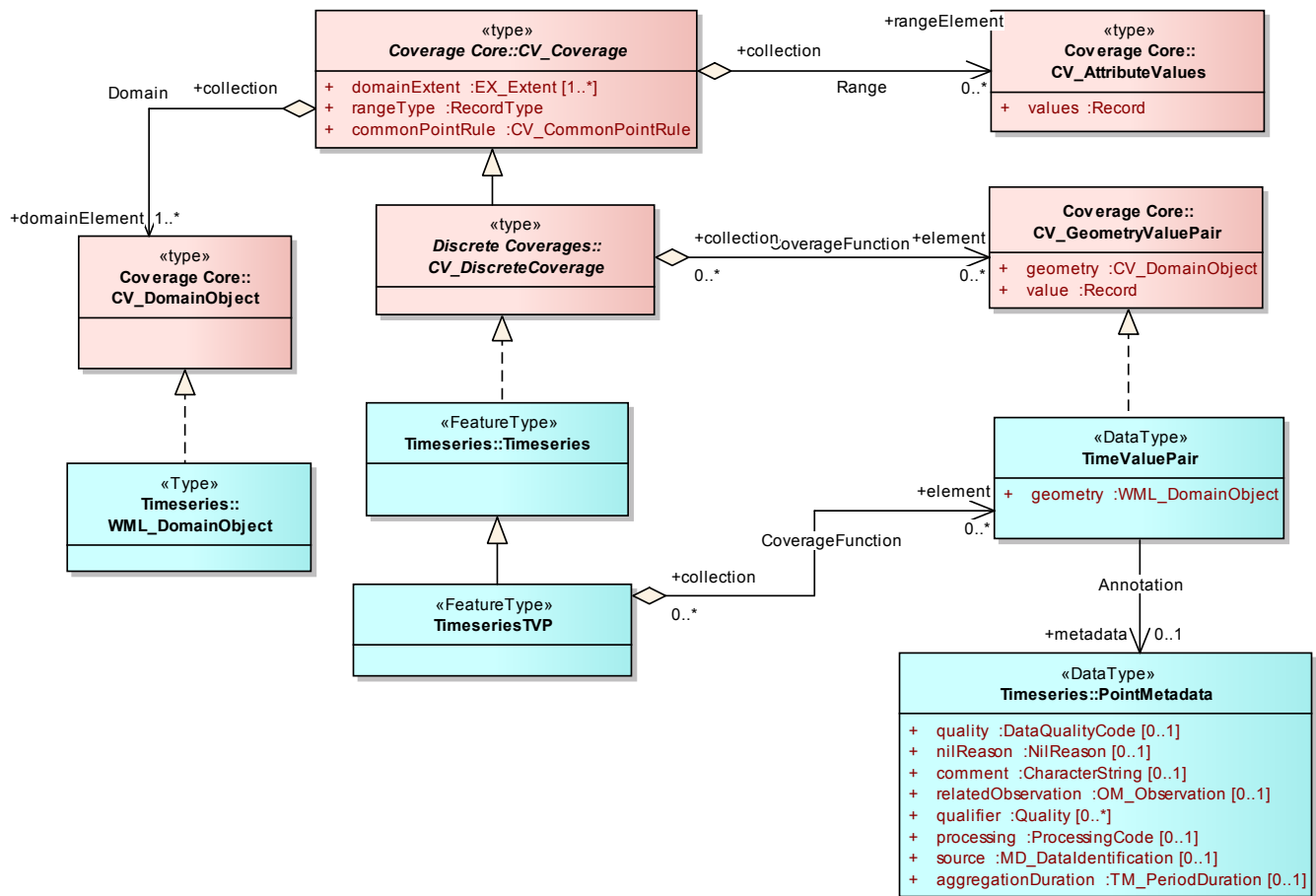


Figure 22 - Timeseries using time-value (interleaved) view

9.14.1 geometry

The ‘geometry’ property contains the temporal domain of the timeseries coverage (e.g. the time instant that a value is associated to.)

9.14.2 Value

The value is a Record (as defined by ISO19123) that indicates the value of the property of interest for the observation. This class keeps the value-type abstract and subclasses identify the common timeseries types, such as timeseries of measurements.

9.15 Requirements class: Measurement Timeseries TVP (interleaved)

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-tvp	
Target Type	Encoding of the conceptual model
Name	Measurement Timeseries (interleaved)
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp
Requirement	<p>/req/uml-measurement-timeseries-tvp/value-type</p> <p>All values of the time-value pairs of a MeasureTimeseries shall be of type Measure.</p>
Requirement	<p>/req/uml-measurement-timeseries-tvp/interpolation-type</p> <p>When specifying the interpolation type of a data point using the interpolation property (section 9.15.3.2) an appropriate URI from Table 6 shall be used.</p>

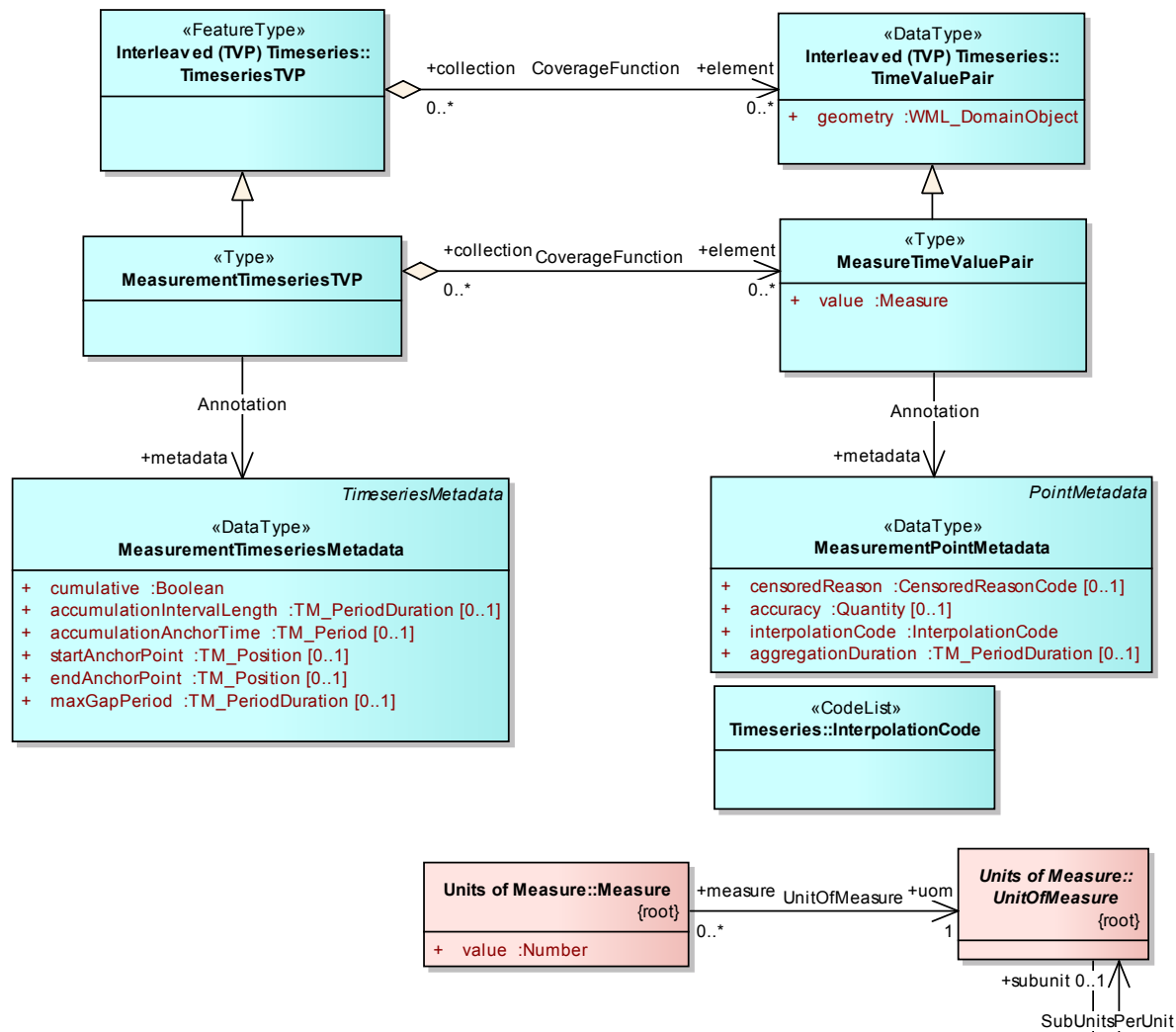


Figure 23 - Measurement Timeseries (TVP)

9.15.1 Value

The Measurement type shown in Figure 23 is always associated to a unit of measure. Conceptually, all individual points have a unit of measure; it is common that for a timeseries the unit of measure will be the same – there are mechanisms for setting default properties in the XML encoding. The units of measure themselves are not defined by WaterML2.0 but referenced through appropriate identifiers.

9.15.2 Measurement Timeseries metadata

9.15.2.1 Anchor point

The *startAnchorPoint* and *endAnchorPoint* properties are used to extend a time series to include non-explicitly represented periods of time for which the observation is valid. Individual points, when associated with their interpolation type (section 9.15.3.2), have a ‘direction’ in time: to correctly process such data it is required to understand where the boundaries of the values lie.

For example, in Figure 24, the first point of the series (position B) has a data type of average for the preceding interval. Here the value represents the average from the previous point up to this point. As there is no previous point (it is the first in the series), it is not possible to determine how far back the value should be considered to hold. The anchor point time specifies a ‘ghost’ point to allow the value to be interpreted correctly.

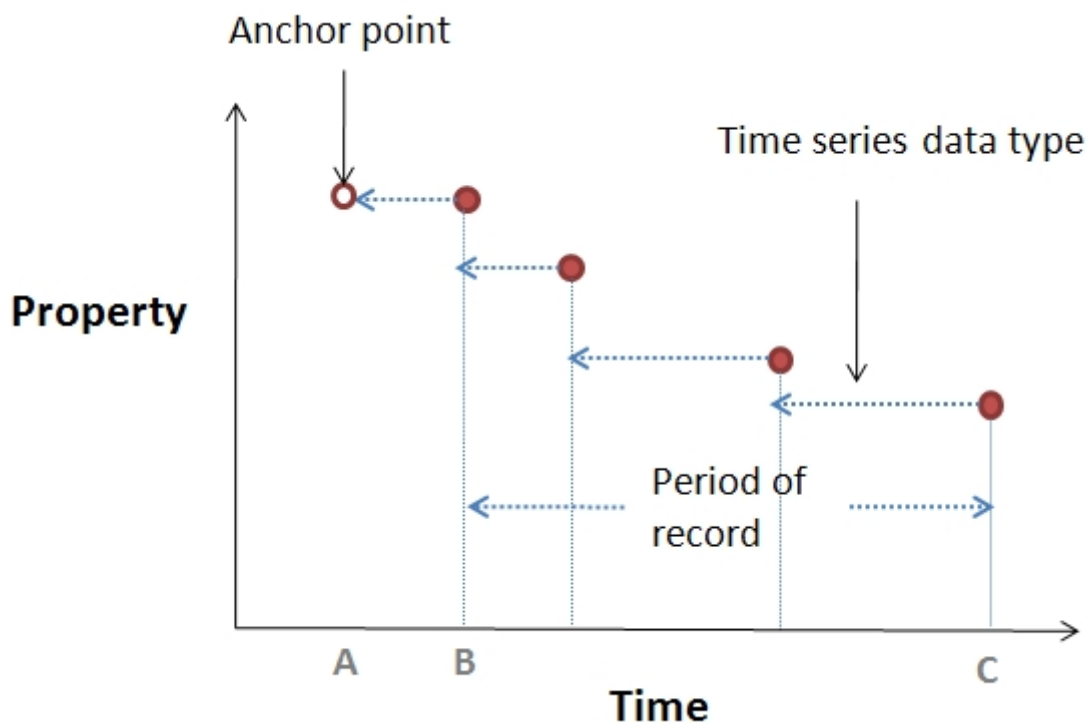


Figure 24 - Anchor points

9.15.2.2 Joining separate observation series (max gap period)

When two non-overlapping time series have been separately collected they require ‘connection’ in order to make a single time series. For example, if the latest two months of river discharge data is transferred from one system to a major archive, the series must be connected in order to make a full series over which reporting can be run (e.g. to calculate yearly summaries). Figure 25 shows an example of this scenario.

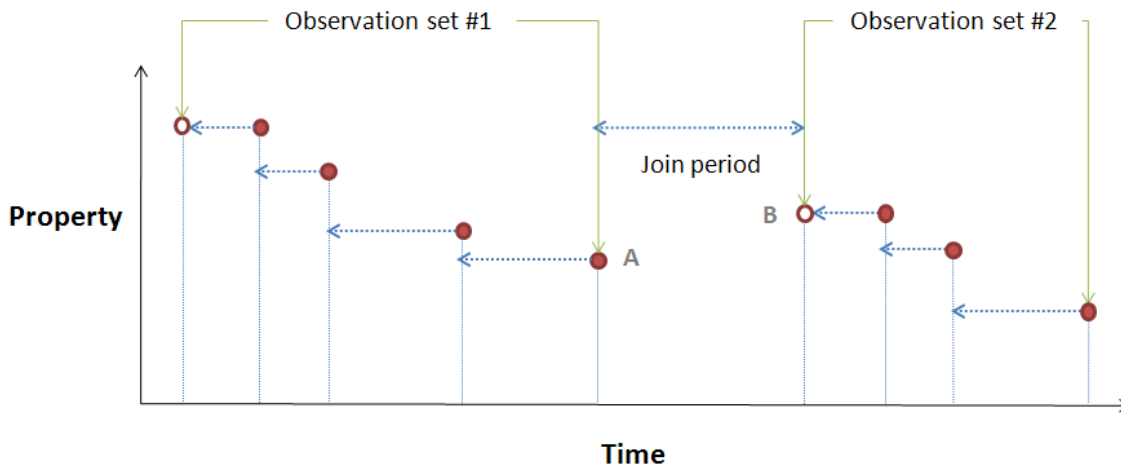


Figure 25 - Connecting two time series

Observation set #2 is the latest 2 months of data coming into the archival set shown by observation set #1. The join period between the two series will be determined by the time period between the series where no existing points exist. When any analysis is run over this series it is important to know if it is possible to interpolate between point A and point B. The `maxGapPeriod` property defines this for an observation series – if the join period is greater than the `maxGapPeriod` then the series should not be interpolated between the adjoining points.

9.15.2.3 Cumulative timeseries

A series that is defined as cumulative (using the `cumulative` property of type boolean) is one where the values indicate a sequentially increasing series; i.e. each value is added to the last so the value represents the total of a value since accumulation began. An example is shown in Figure 26. Note: cumulative series should only be used for time series of the total data types: instantaneous total, preceding total, succeeding total as these represent total quantities.

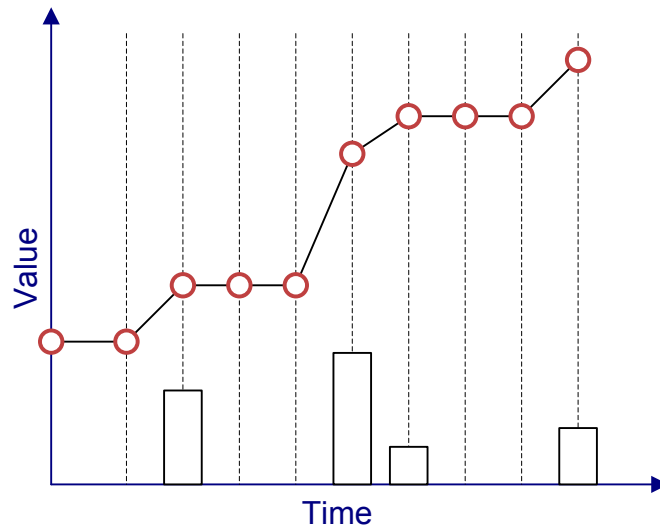


Figure 26 - A cumulative series

The *accumulationAnchorTime* is used to define the time at which accumulation begins. This is used for consistently accumulated values (such as rainfall) where the values are representing a continuous stream of totals across a certain period. The *accumulationIntervalLength* defines the duration of the period. For example, Figure 27 shows accumulated daily rainfall totals from 9am to 9am.

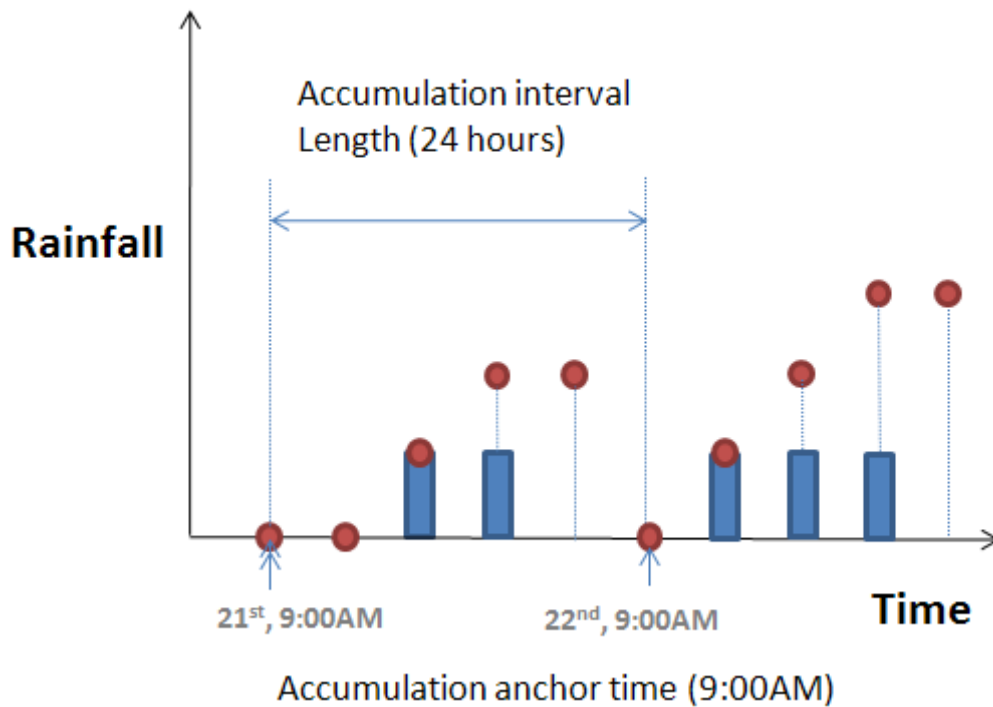


Figure 27 - Example accumulated series

9.15.3 Measurement Timeseries point metadata

9.15.3.1 censoredReason

This property allows specification of a reason for a value being censored. This is often used when the value of a measured property moves below or above the threshold of the measuring device. To specify a censor threshold (e.g. 0.02 mm), a point-level qualifier may be used (of type Quantity) as described in section 9.12.3.2.5.

9.15.3.2 accuracy

This property allows for a quantitative assertion of the estimated accuracy of the measurement value.

9.15.3.1 aggregationDuration

This property describes the time aggregation that has occurred to the value in the timeseries.

9.15.3.2 interpolationType

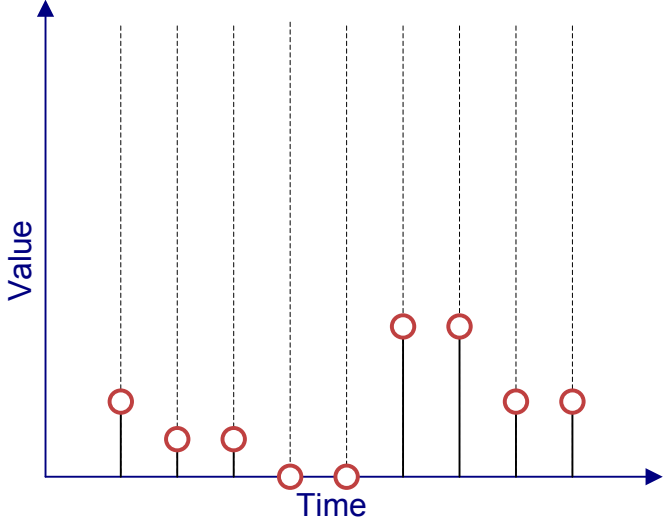
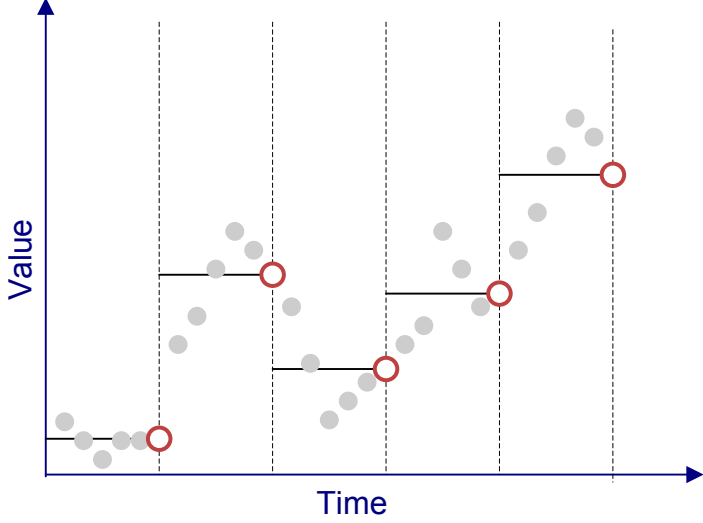
One of the core characteristics of measurement time series is the nature of the relationship between the time instant and the recorded value. This relationship is determined by the procedure that was used in making the estimate that the value represents. Representing this is crucial to correctly interpret the time series values. For example, the value may represent an average across the time period since the last point (average in preceding interval). WaterML2.0 defines a number of types of time series, as shown in Table 6.

The interpolation type is defined per point within the time series as it is possible for this to change mid series. Within the XML encoding it is possible to set a default interpolation for the series.

Table 6 - Types of time series

http://www.opengis.net/def/waterml/2.0/interpolationType/Continuous	5.3.2.1 Continuous/Instantaneous
---	----------------------------------

	<p>A continuous time series indicates the observation result is the value of a property at the indicated instant in time. The points are essentially connected and interpolation may occur between points in order to estimate the value of the property between points. The appropriate time spacing between successive points to minimise interpolation errors is related to rate of change (wrt time) of the property.</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/Discontinuous</p>	<p>5.3.2.2 Discontinuous</p>
	<p>The sampling of the property occurs such that it is not possible to regard the series as continuous. The time between samples is too large to classify the measurements as continuous.</p> <p>Example: Infrequent water sample measuring pH.</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/InstantTotal</p>	<p>5.3.2.3 Instantaneous total</p>

	<p>Value represents a total attributed to a specific time instant. This is normally generated from an event based measuring device such as a tipping bucket rain gauge.</p> <p>Example: An individual tip of a tipping bucket rain gauge.</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/AveragePrec</p>	<p>5.3.2.4 Average in preceding interval</p>
	<p>Value represents the average value over the preceding interval.</p> <p>Example: Daily mean discharge.</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/MaxPrec</p>	<p>5.3.2.5 Maximum in preceding interval</p>

	<p>Value represents the maximum value that was measured during the preceding time interval.</p> <p>Example: Monthly maximum discharge</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/MinPrec</p>	<p>5.3.2.6 Minimum in preceding interval</p>
	<p>Value represents the minimum value that was measured during the preceding time interval.</p> <p>Example: Daily minimum temperature.</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/TotalPrec</p>	<p>5.3.2.7 Preceding total</p>

	<p>Value represents the total of measurements taken within the previous time interval.</p> <p>Example: Daily pan evaporation</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/AverageSucc</p>	<p>5.3.2.8 Average in succeeding interval</p>
	<p>Value represents the average value over the following interval.</p> <p>Example: Daily mean discharge encoded as value representing beginning of interval (ODM style).</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/TotalSucc</p>	<p>5.3.2.9 Succeeding total</p>

	<p>Value represents the total of measurements taken within the following time interval.</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/MinSucc</p>	<p>5.3.2.10 Minimum in succeeding interval</p>
	<p>Value represents the minimum value for the following interval.</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/MaxSucc</p>	<p>5.3.2.11 Maximum in succeeding interval</p>
	<p>Value represents the maximum value for the following interval.</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/ConstPrec</p>	<p>5.3.2.12 Constant in preceding interval</p>
	<p>Value is constant in the preceding interval. Example: Alarm level</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/ConstSucc</p>	<p>5.3.2.13 Constant in succeeding interval</p>
	<p>Value is constant in the succeeding interval. Example: Alarm level</p>
<p>http://www.opengis.net/def/waterml/2.0/interpolationType/Statistical</p>	<p>5.3.2.14 Statistical</p>

	Interpolation type is defined by a statistical method.
--	--

9.16 Requirements class: Categorical Timeseries TVP (interleaved)

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp	
Target Type	Encoding of the conceptual model
Name	Categorical Timeseries (interleaved) TVP
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp
Requirement	<p>/req/uml-categorical-timeseries-tvp/value-type</p> <p>All values of the time-value pairs of a <i>CategoricalTimeseriesTVP</i> shall be of type <i>Category</i> as shown in the UML in Figure 28.</p>

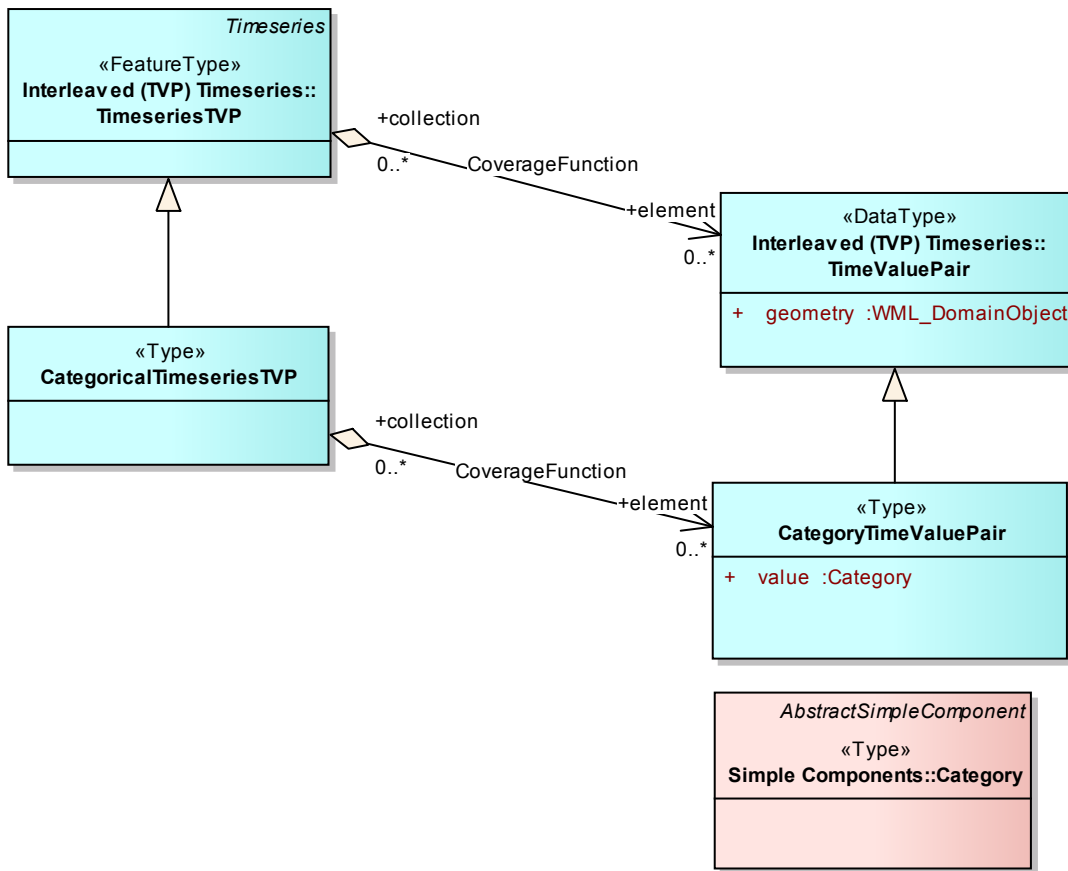


Figure 28 - Categorical timeseries (TVP)

9.17 Requirements class: Measurement Timeseries (Domain-Range)

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-domain-range	
Target Type	Encoding of the conceptual model
Name	Timeseries (Domain-Range)
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range
Requirement	/req/uml-measurement-timeseries-domain-range/value-type The type of all the range elements of a <i>MeasurementTimeseriesDomainRange</i> shall be of type <i>Measure</i> .

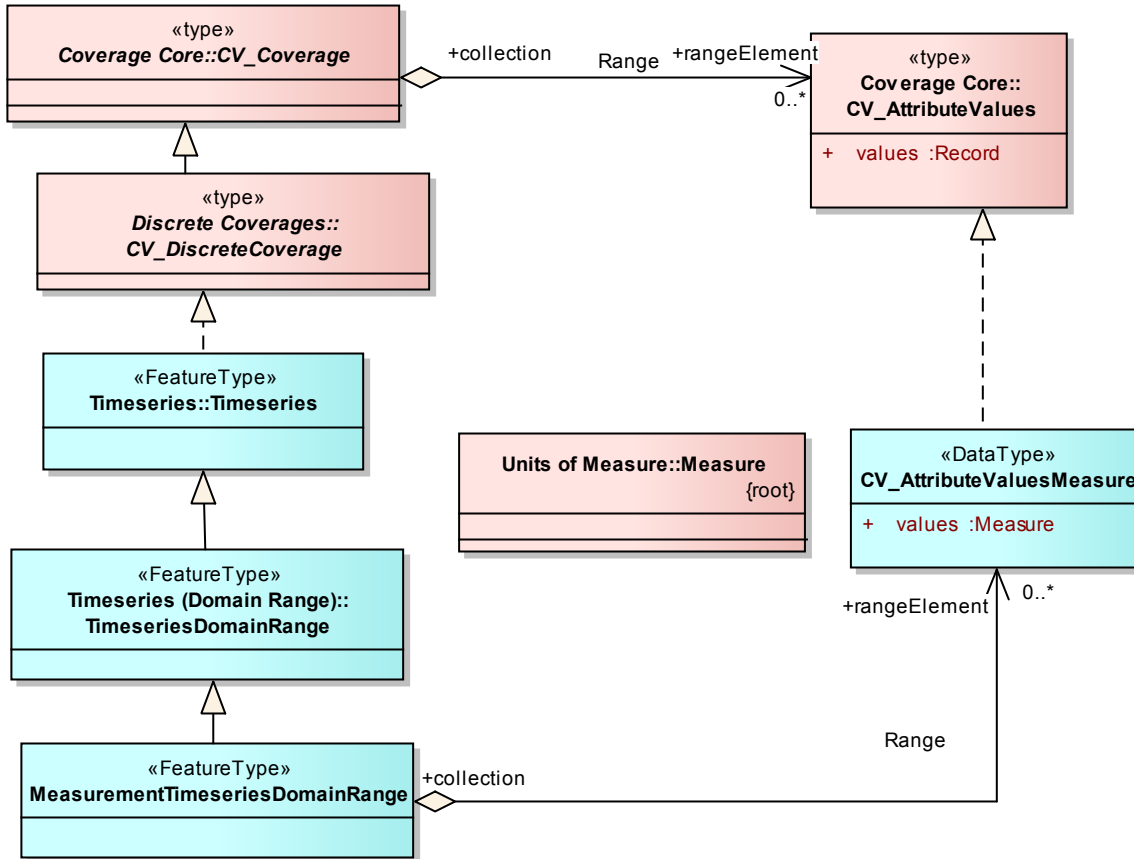


Figure 29 - Measurement timeseries (domain range)

9.18 Requirements class: Categorical Timeseries (Domain-Range)

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-domain-range	
Target Type	Encoding of the conceptual model
Name	Categorical Timeseries (Domain-Range)
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range
Requirement	/req/uml-categorical-timeseries-domain-range-category/value-type The type of all the range elements of a <i>CategoricalTimeseriesDomainRange</i> shall be of type <i>Category</i> as shown in the UML in Figure 30.

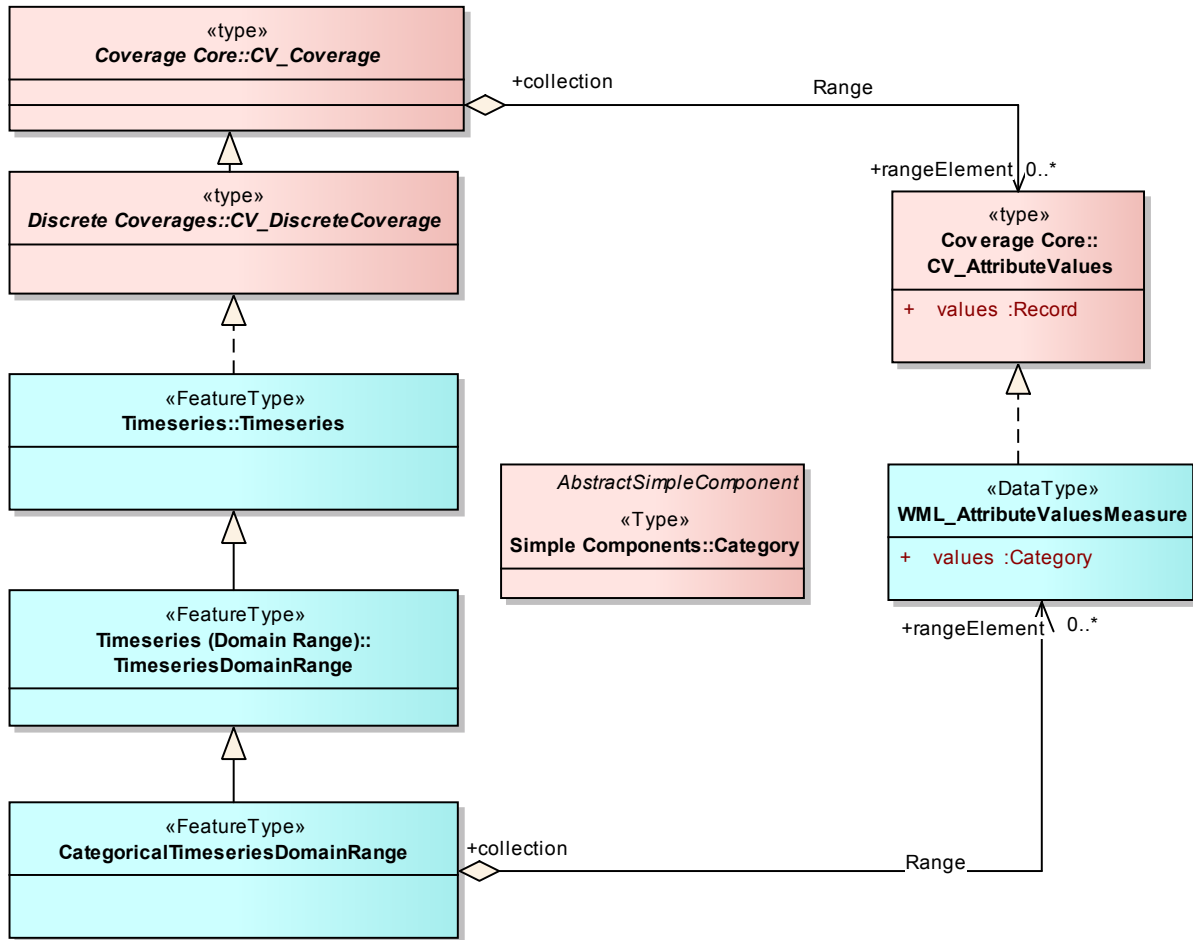


Figure 30 - Categorical timeseries (domain range)

9.19 Requirements class: Monitoring Points

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point	
Target Type	Encoding of the conceptual model
Name	Monitoring point
Dependency	urn:iso:dis:iso:19156:clause:9
Requirement	/req/uml-monitoring-point/valid An encoding of MonitoringPoint shall represent the class(es) described in Figure 31 with all attributes and associations.
Recommendation	/rec/uml-monitoring-point/time-zone-abbreviation

	When using a time zone abbreviation, an abbreviation from the list supplied at http://www.timeanddate.com/library/abbreviations/timezones/ should be used.
--	--

Monitoring points within the hydrological domain are often referred to as stations, sites or locations. These are sometimes equivalent, but the meaning can be subtly different across usages. The differences are often in how these terms relate to each other in groups or hierarchies, for example sometimes a station or a site may have many measuring locations.

In WaterML2.0, in-situ monitoring points are described using the Sampling Features packages of the O&M model. As described in section 7.1, sampling features are used in the following two circumstances:

1. the observation does not obtain values for the whole of a domain feature;
2. the observation procedure obtains values for properties that are not characteristic of the type of the ultimate feature (e.g. measuring electrical conductivity as a proxy for salinity)

Case 1 here is typical of the majority of in-situ observations in hydrology, where a body is sampled to obtain an estimate of the whole. A domain feature is defined as a “feature of a type within a particular application domain”.

Examples of domain features for hydrology include:

- Rivers
- Reservoirs
- Lakes
- Canals
- Glaciers
- Aquifers

Such domain features almost always have properties whose value may be estimated by observation. Extending the example domain features from the above list, some example property types of interest for hydrology are shown in Table 7.

Table 7 - Examples of property-types mapped to domain feature-types

Domain feature	Example property types
River	Stage (or level), temperature, velocity, turbidity, pH

Reservoirs	Stage (or level), volume, temperature
Lakes	Stage (or level), volume, temperature
Snow drift	Depth, water equivalent

The estimation of such properties is performed by sampling the domain feature at a particular point, which is then used as an estimate of the larger domain body. For example, measuring the temperature at a point on a river gives an estimate of temperature at that exact point, whereas the temperature for the full body of water would be a spatially more complex result, changing in relation to its depth and position upstream or downstream (i.e. a type of spatial coverage). Whilst the distinction is subtle, since O&M is a cross-domain model with the intent of integrating data across different observation styles, it is an important one.

This standard does not define the domain features specific to hydrology but it does allow for the relationship between the sampling feature (site, station, location) and the domain feature to be expressed. This is done using the ‘*sampledFeature*’ property that is defined in the O&M base type, ‘*SF_SamplingFeature*’.

Properties (or attributes) of sampling points that are of interest within the hydrology domain include:

- Name, alternate names;
- Connection to a group of measuring sampling points;
- Identifiers (individual organisations may have separate identifiers);
- Responsible organisation;
- Classification of the sampling point;
- Operator;
- Time zone in which the sampling point is located;
- Spatial location, optionally including altitude;
- Links to hydrological hierarchies such as catchments, stream networks, regions etc.
- Comments containing extra descriptive information regarding the sampling point.

NOTE: Separate sampling points should only be defined if the particular site is different; where there are multiple observed properties (e.g. multiple sensors being used at one site) should reference the same sampling point.

MonitoringPoint is defined as a specialisation of the O&M *SF_SamplingPoint* and thus also inherits the properties of this feature type. *SF_SamplingPoint* restricts the *SF_SamplingFeature*'s shape property to be a point. The UML for *MonitoringPoint* is shown in Figure 31.

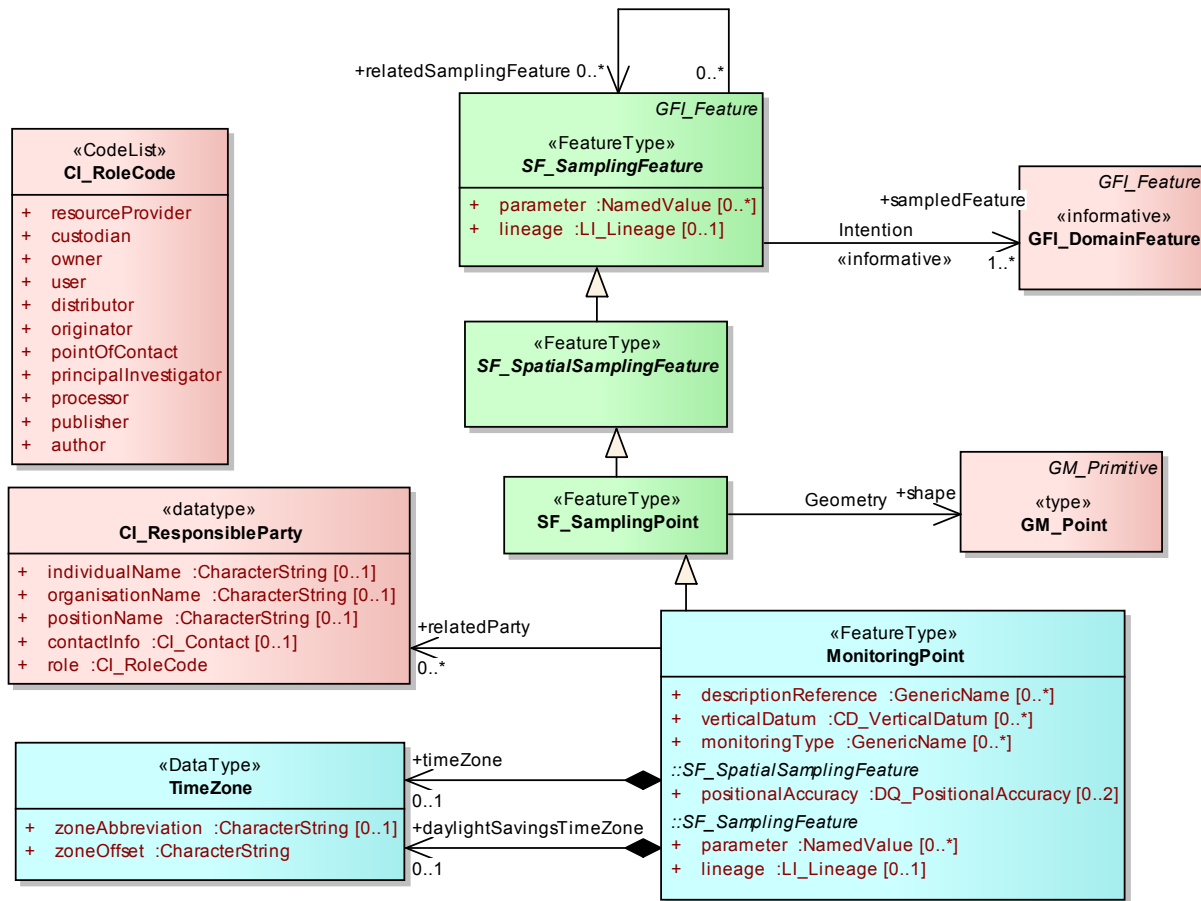


Figure 31 - MonitoringPoint

The properties of sampling points are described in the following sections.

9.19.1 shape (SF_SamplingFeature)

The shape property describes the geometry of the sampling feature. For a *MonitoringPoint* this is a point.

9.19.2 sampledFeature (SF_SamplingFeature)

This property provides a reference to the ultimate domain feature that is being observed. The type of this feature will depend on the type of sampling feature being used; some examples are shown in Table 7.

9.19.3 lineage (SF_SamplingFeature)

Used to describe the history of a sampling point. Examples include replacement of equipment, previous names etc. The lineage type (from ISO19115) allows for either simple statements of history, or the definition of chained sources and process steps that have occurred to the sampling feature.

9.19.4 parameter (SF_SamplingFeature)

A name-value parameter allowing soft-typed properties to be specified. This can be used to extend the set of existing properties. E.g. specifying geomorphic characteristics in the vicinity of a sampling point is a specialised requirement that does not exist in the current model but may be added through this property.

9.19.5 positionalAccuracy (SF_SpatialSamplingFeature)

Used to specify the accuracy of the positioning of the sampling point. This will be dependent upon the method used for calculating the coordinates of the point. E.g. differentially corrected GPS, resulting in accuracy of +/- 0.1 meter.

9.19.6 timeZone and daylightSavingsTimeZone

Specifies the time zone that the sampling point is located in. The zone offset must be specified (e.g. +10:00 GMT), with an optional zone abbreviation (e.g. AEST). The daylightSavingsTimeZone property can be used to specify the time zone for daylight time if applicable.

9.19.7 relatedParty

Describes parties –individuals or organisations – that are related to the monitoring point. Multiple related parties may be described using the role code list (from ISO 19115). The most common relationships within the context of this standard (and specifically, monitoring points) include: owner, originator, pointOfContact, principalInvestigator and distributor.

9.19.8 descriptionReference

A property meant to hold links to external descriptions of the monitoring station. For example, links to photos, html description pages etc.

Note: gml:descriptionReference specifies it should link to a text description hence was not used.

9.19.9 monitoringType

This property categorises the style of monitoring that occurs at the station. This is often contains a number of categories. WMO [5] defines a set of community topics appropriate for this use (WMO_CommunityTopicCategoryCode), listed in Annex G. Note that sampling points may fall under multiple classifications, as sampling points are often multi-purpose.

9.19.10 verticalDatum

Specifies the elevation that is used as the zero point, or datum, for stage measurements. The datum is defined using a vertical datum, which may be defined using the ISO19111 type CD_VerticalDatum, or an agreed upon datum may be reference by its identifier. E.g. the Australian Height Datum (AHD), Tasmania = “EPSG::5112”.

The CD_VerticalDatum type allows specification of the local gauge zero as a height above a reference datum. E.g. local gauge zero is 23m above the AHD.

9.20 Requirements class: Monitoring Point feature of interest

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point-feature-of-interest	
Target Type	Encoding of the conceptual model
Name	Monitoring point
Dependency	urn:iso:dis:iso:19156:clause:9
Requirement	<p>/req/uml-monitoring-point-feature-of-interest/foi</p> <p>The target of the featureOfInterest property of the TimeseriesObservation shall be a MonitoringPoint type or a reference to an object of this type.</p>

Most direct timeseries observations in hydrology use a monitoring point to sample a domain feature (e.g. edge of a river, on a point on a lake etc.). This requirements class describes this case. This restriction is not captured in the core timeseries observation requirements class, as it is common for derived observations to have a feature of interest as the domain feature (e.g. a derived storage volume measurement is a direct ‘observation’ of the storage’s volume property).

9.21 Requirements class: Sampling Feature Collections

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-sampling-feature-collections	
Target Type	Encoding of the conceptual model
Name	Sampling feature collections
Dependency	urn:iso:dis:iso:19156:clause:9
Requirement	<p>/req/uml-sampling-feature-collections/groups</p> <p>Groups of sampling points shall be described using SamplingFeatureCollection feature type from ISO19156.</p>

Defining groups of sampling points is often required, allowing multiple sampling points to be associated with a particular identifier or name. This is common in hydrology as organisations often have a number of sampling points (often closely located) that may be named for the purposes of site visits, maintenance or reporting. A SamplingFeatureCollection is how a group such as a “field site with many sampling locations” would be expressed.

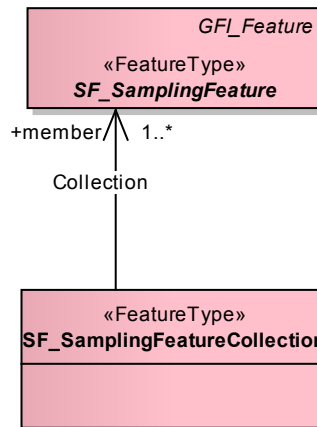


Figure 32 - SF_SamplingFeatureCollection as defined by ISO19156

A sampling group may be defined by fully defining each of the sampling features contained in the group, or by referencing each of the sampling points in the group.

It is possible to implement sampling groups in both directions:

- When defining the sampling point, include a relation to the sampling features in the group using the *relatedSamplingFeature* property.
- Define a SF_SamplingFeatureCollection that contains the sampling points. Note: this can be done by referencing already defined sampling points through an identifier or by defining the containing points directly inline.

The two approaches are useful in different scenarios; guidance on their use is expanded in examples and future best practice guides.

9.22 Requirements class: Observation process

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-observation-process	
Target Type	Encoding of the conceptual model
Name	Observation process
Dependency	urn:iso:dis:iso:19156:clause:9

Requirement	/req/uml-observation-process/valid The om:procedure property shall point to a feature type that represents the ObservationProcess class described in Figure 33 with attributes and associations.
Requirement	/req/uml-observation-process/processType The processType property of ObservationProcess shall use the appropriate type from Table 8 .

Within O&M, the *ProcessUsed* association links the observation to the OM_Process used to generate the result. OM_Process is abstract and does not define any attributes or associations. This standard specialises O&M to define process specific to hydrology, as shown in Figure 33.

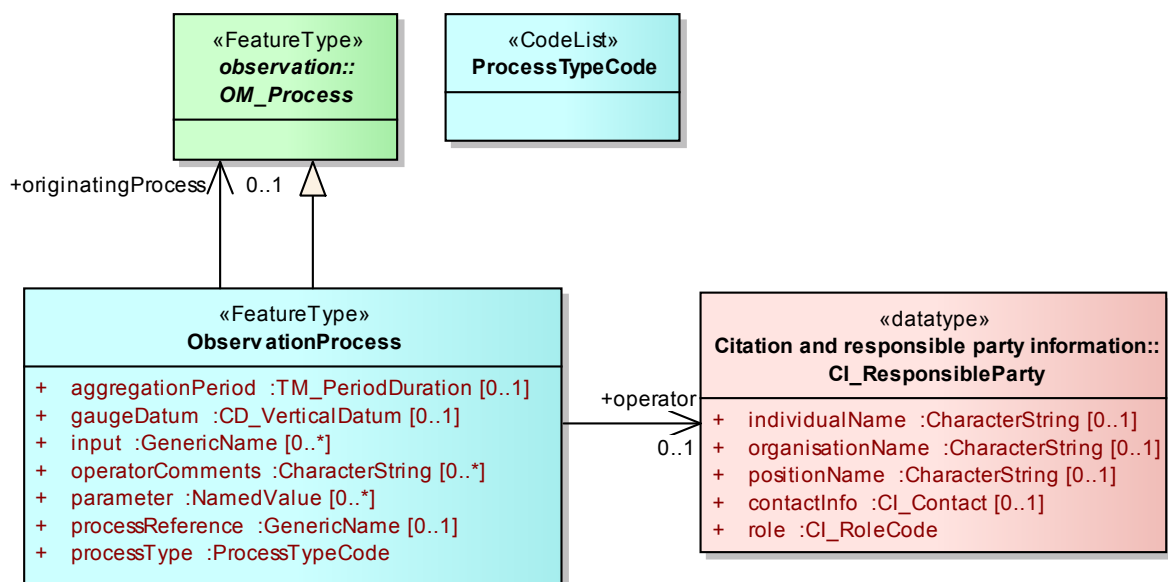


Figure 33 - Observation process feature type

A large number of direct in-situ hydrological observations are performed by a sensor or sensor system. Common types of sensors include rain gauges, water level gauges, water quality sensors such as temperature, turbidity etc.

Manual procedures may also be used to make measurements at a particular sampling point. These may be ad-hoc visits to a particular point, or continued visits to a well identified sampling point.

Procedures that generate derived or synthetic results also exist, such as those produced by algorithms or simulations. Algorithms are commonly implemented in hydrological software to process data sets for reporting or other purposes. Examples include:

- Temporal interpolation or aggregation;
- Spatial interpolation;

- Quality assurance related tasks such as automatic spike removal or gap filling;
- Derivation of new “observed phenomena” such as calculation of volume from stage, discharge (flow) from stage etc.

These operations are performed on raw observational data to create separate data products more appropriate for particular types of reporting, ingestion into models, or for archival purposes. Maintaining information on the procedure used in the creation of a new ‘observation’ is important for correct interpretation of an observations result. Note here that the data being described is not strictly an observation but the O&M model is appropriate for such description, and encourages such use:

“An instance of OM_Process is often an instrument or sensor, but may be a human observer, a simulator, or a process or algorithm applied to more primitive results used as inputs.”

WaterML2 defines an ObservationProcess feature type. This a generic class to describe processes related to the creation of hydrological results.

Table 8 - available types of processes

Process type	OGC Name
Simulation	http://www.opengis.net/def/waterml/2.0/processType/Simulation
Manual Method	http://www.opengis.net/def/waterml/2.0/processType/ManualMethod
Sensor	http://www.opengis.net/def/waterml/2.0/processType/Sensor
Algorithm	http://www.opengis.net/def/waterml/2.0/processType/Algorithm
Unknown	http://www.opengis.net/def/nil/OGC/0/unknown

The following sections describe the properties available in *ObservationProcess*.

9.22.1 processType

Identifies the process type that was used to generate this observation. The available process types are listed in Table 8. Note that this should be the last process that operated on the observation. The original source of the data should be identified using the originalSource property.

9.22.2 processReference

A reference to an external process that was used. This could be the specification sheet for a sensor, a piece of code implementing an algorithm, or a reference to a methods repository, such as National Environmental Method Index (<https://www.nemi.gov/>).

9.22.3 verticalDatum

A datum reference is available here (a property also exists in the description of monitoring points, see section 9.19) for cases where the vertical datum used for level measurements differs from the datum associated with the monitoring point.

The CD_VerticalDatum type allows specification of the local gauge zero as a height above a reference datum. E.g. local gauge zero is 23m above the AHD.

9.22.4 aggregationDuration

If the process involves temporal aggregation of a result set, the time duration over which data has been aggregated should be expressed here. E.g. hourly, daily aggregates.

9.22.5 parameter

A soft-typed parameter to allow arbitrary properties to be added to the description. This property uses the name-value type from ISO19156.

9.22.6 operator

Describes the party responsible for performing the process. E.g. the person performing the method or operating the sensor.

9.22.7 comment

Free text comments that may be inserted by the operator or the system performing the process

9.22.8 input

Provides a list of references to the inputs used in the simulation process.

Note: The process model requires further harmonisation with SensorML and/or ISO19139 LI_Lineage.

9.23 Requirements Class: Collection

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/uml-collection	
Target Type	Encoding of the conceptual model
Name	Collection
Dependency	urn:iso:dis:iso:19156:clause:9
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point

Requirement	<p><code>/req/uml-collection/valid</code></p> <p>A collection shall have the ability to contain multiple sampling features or sampling feature collections; observations; and inline dictionaries as described by the UML in Figure 34.</p>
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WaterML2.0 defines a generic collection feature type, *Collection*, to allow the grouping of observations and/or sampling features with metadata to describe the nature of the collection. Its UML is shown in Figure 34. Such collections are required in a number of data exchange scenarios; whether the underlying transport technology is web services, FTP or other technologies.

The grouping may indicate a relationship between the contained entities, however the relationship will depend on the individual use of the collection class. For example, a collection of observations may be all the observations within the last 24 hours for a particular measuring location, but this would be determined by the system creating or handling the documents.

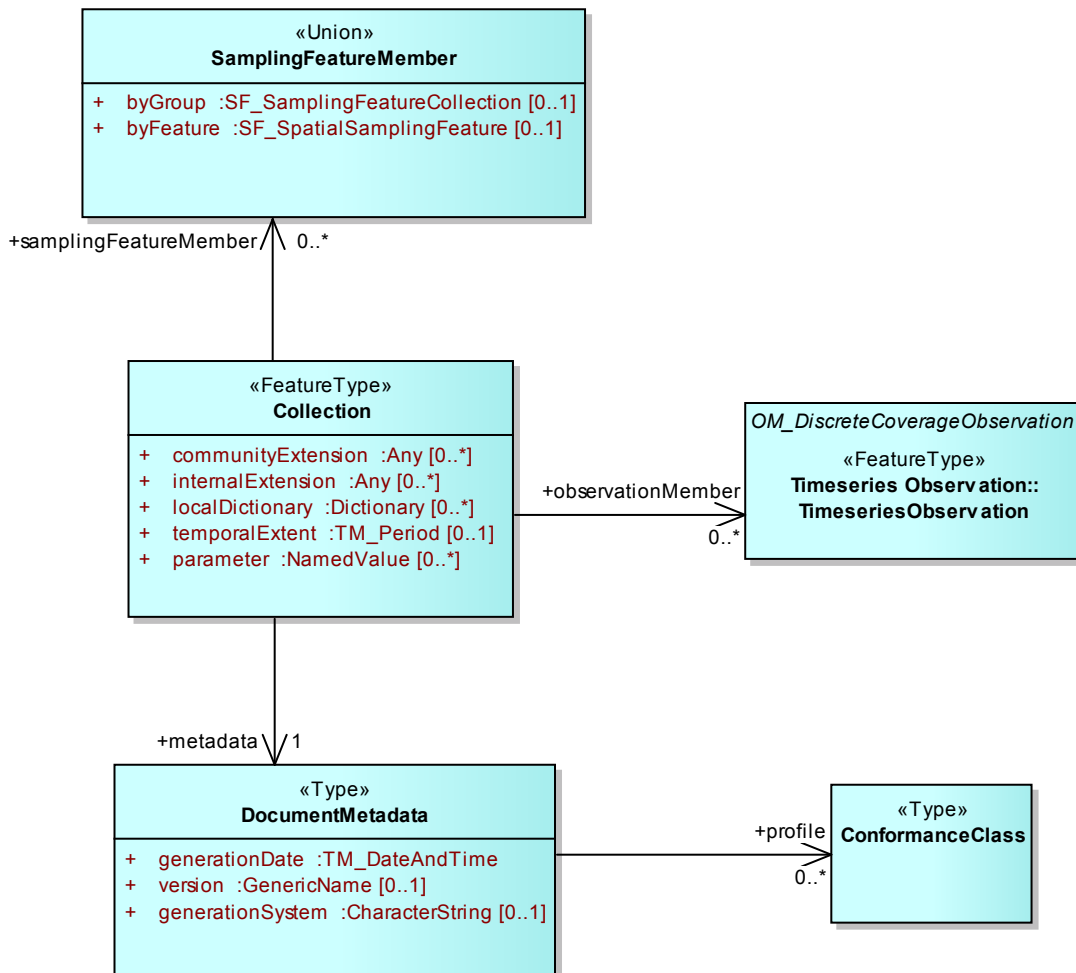


Figure 34 - Collection

The collection class also allows for local definitions of codes, such as quality codes and qualifiers. The local dictionaries are a convenience to allow elements that normally reside in code lists to be specified locally in the document. There are two benefits to this: it allows metadata to be provided alongside each code item; and it allows more compact encoding for code list items that need to be referenced regularly.

The contents of a collection will be determined by the scenario in which it is used; some examples include:

- Web service responses
- Transactional updates
- Groups of model outputs (ensemble models)

The collection class may be replaced by services that already define such collections - such as in the Sensor Observation Service - but the model may be used as a guide to the content of collections.

9.23.1 metadata

Describes the metadata associated with the document. See section 9.23.8 for the definition of *DocumentMetadata*.

9.23.2 samplingFeatureMember

This property allows for multiple sampling features to be described within the document. The feature member may also be a sampling feature collection (*SF_SamplingFeatureCollection*).

9.23.3 observationMember

This property allows for multiple *TimeseriesObservation* members to be included in the collection document.

9.23.4 temporalExtent

Describes the temporal extent of the all the observation members that exist in the document.

9.23.5 parameter

A soft-typed parameter to allow arbitrary properties to be added to the collection. This property uses the name-value type from ISO19156.

9.23.6 Extension (community and internal)

The *communityExtension* and *internalExtension* properties provide a schema extension point that allows new schema types to be used if required. The Any type allows elements from other namespaces to be included. The community extension should be used to place extension types that have been agreed upon by a community (such as the Hydro Domain Working Group); the

internal extension allows organisations to use internal extensions without affecting agreed on extensions.

9.23.7 Local dictionaries

The `localDictionary` property allows code lists to be locally defined in a document. This is useful where external vocabularies may want to be stored alongside data to preserve its integrity or resolution to vocabulary services may not be available. These dictionaries may contain, for example, code lists for quality, qualifiers or other regularly referenced terms. In an XML encoding the dictionary allows code items to be encoded and then internally referenced using `xlink:href` to the `gml:id` of the required code. This helps to reduce redundancy if codes are used in multiple places.

9.23.8 Document metadata

The *metadata* property of the *Collection* class defines the metadata relating to the document.

9.23.9 generationDate

Specifies the date the document was generated.

9.23.10 version

This version property is distinct from the schema version. It indicates the package version that is being used where package is the combination of schema, vocabularies and any profiles used. This allows versions to be more specific based on their implemented usage of the schema.

9.23.11 generationSystem

A textual description of the system that generated the document.

9.23.12 profile

This property identifies the conformance classes that are being adhered to within the collection document. This allows the collection to explicitly identify the profile (which is a set of conformance classes) that is being used. Ultimately the conformance classes would be identified by their URL(s) within the implementation (e.g. as done in the XML implementation).

10 XML Implementation (normative)

This standard defines a GML XML Schema implementation that is compliant to the UML conceptual models defined in Section 9. Preliminary XML schemas were auto generated from the models following the encoding rules Annex E of OGC Geography Markup Language v3.2 (ISO 19136:2007). These were then modified to meet the requirements outlined.

Schematron patterns are also implemented for additional requirements where appropriate.

Table 9 - Mapping of WaterML2.0 UML classes to XML elements

WaterML 2.0 UML	WaterML 2.0 XML
MeasurementTimeseriesTVPObservation	om:OM_Observation*
CategoricalTimeseriesTVPObservation	om:OM_Observation*
ObservationProcess	wml2:ObservationProcess
MonitoringPoint	wml2:MonitoringPoint
TimeseriesTVP	wml2:Timeseries
MeasurementTimeseriesTVP	wml2:MeasurementTimeseries
CategoricalTimeseriesTVP	wml2:CategoricalTimeseries
TimeValuePair	wml2:TimeValuePair
MeasurementTimeValuePair	wml2:MeasurementTVP
CategoricalTimeValuePair	wml2:CategoricalTVP
TimeseriesMetadata	wml2:TimeseriesMetadata
MeasurementTimeseriesMetadata	wml2:MeasurementTimeseriesMetadata
PointMetadata	wml2:TVPMetadata
MeasurementPointMetadata	wml2:TVPMeasurementMetadata
ObservationMetadata	wml2:ObservationMetadata
Collection	wml2:Collection
* The specialisation of OM_Observation is provided through Schematron rather than a specialised XML type.	

Table 10 - O&M URIs for observation specialisations

WaterML v2.0	OGC Name	Content of om:result in WaterML2 XML ¹
MeasurementTimeseriesTVPObservation	http://www.opengis.net/def/observationType/waterml/2.0/MeasurementTimeseriesTVPObservation	type='wml2:MeasurementTimeseries'
CategoricalTVPTimeseriesObservation	http://www.opengis.net/def/observationType/waterml/2.0/CategoricalTVPTimeseriesObservation	type='wml2:CategoricalTimeseries'

10.1 Scope of XML implementation

The normative part of this XML implementation does not target the domain-range style of timeseries encoding. This was not included, as the schema design has not progressed through the required analysis from the Standards Working Group. The domain-range XML encoding is provided as an informative schema, within its own namespace, allowing it to be used with the normative WaterML2.0 schema. The implementation is a conformant extension to the gmlcov schema (<http://www.opengis.net/gmlcov/1.0>), adding support for the WaterML2.0 types. Future work will ensure the schema design is consistent with stakeholder requirements. The major design issue relates to providing the value-level metadata that a time-value pair encoding supports. The current approach uses supplementary coverages to describe time-varying metadata such as quality assertions. An example is provided in Annex B.

Table 11 - Mapping of UML to XML conformance classes

WaterML v2.0 UML Conformance Class		WaterML2.0 XML Conformance Class
Timeseries Observation http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-observation		/conf/xsd-timeseries-observation
Monitoring point feature of interest http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point-feature-of-interest		/conf/xsd-feature-of-interest-monitoring-point
Interleaved (TVP) style	<i>Timeseries TVP (interleaved)</i> http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp	/conf/xsd-timeseries-tvp
	<i>Measurement Timeseries TVP (interleaved)</i> http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-tvp	/conf/xsd-measurement-timeseries-tvp
	<i>Categorical Timeseries TVP (interleaved)</i> http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp	/conf/xsd-categorical-timeseries-tvp
	<i>Timeseries TVP (interleaved) Observation</i> http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp-observation	/conf/xsd-timeseries-tvp-observation
	<i>Measurement Timeseries TVP (interleaved) Observation</i> http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-tvp-observation	/conf/xsd-measurement-timeseries-tvp-observation
	<i>Categorical Timeseries TVP (interleaved) Observation</i> http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp-observation	/conf/xsd-categorical-timeseries-tvp-observation
Monitoring point exchange http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point http://www.opengis.net/spec/waterml/2.0/req/uml-sampling-feature-collections		/conf/xsd-monitoring-point
Collection exchange http://www.opengis.net/spec/waterml/2.0/req/uml-collection		/conf/xsd-collection
Observation process exchange http://www.opengis.net/spec/waterml/2.0/req/uml-observation-process		/conf/xsd-observation-process

10.2 XML encoding principles

10.2.1 Virtual typing

In accordance with OMXML, the specialisation of the OM_Observation result type is provided through schematron restriction. The om:type element may be used to specify the type of OM_Observation that is being encoded. This shall be done using the OGC Name URI for the corresponding type from Table 10.

10.2.2 Abstract requirements and conformance classes

As noted in the OGC Modular Specification section 6.2, the tests for abstract conformance classes may need to be described in the subclass classes if the base requirements class are ambiguous for the abstract class. This is the case for the two styles of timeseries conformance classes, domain-range and interleaved (time-value pair). Some requirements for these classes are re-specified in more concrete terms to allow more explicit testing.

10.2.3 XML Examples

Some of the requirements listed below have example XML snippets for informative purposes. A complete example is shown in Annex B. In all examples, the following namespaces are used:

Table 12 - XML Example Code Namespaces

Identifier	Namespace URL
xsi	http://www.w3.org/2001/XMLSchema-instance
gml	http://www.opengis.net/gml/3.2
om	http://www.opengis.net/om/2.0
xlink	http://www.w3.org/1999/xlink
wml2	http://www.opengis.net/waterml/2.0
gmd	http://www.isotc211.org/2005/gmd
gco	http://www.isotc211.org/2005/gco
sam	http://www.opengis.net/sampling/2.0
sams	http://www.opengis.net/samplingSpatial/2.0

10.3 Requirements Class: XML Rules

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules	
Target Type	Data instance

Name	Rules for encoding XML
Dependency	http://www.w3.org/TR/xmlschema-2
Dependency	http://www.opengis.net/doc/IS/GML/3.2/clause/2.4
Dependency	http://www.opengis.net/spec/SWE/2.0/req/xsd-simple-components
Dependency	urn:iso:dis:iso:8601:2004:clause:4
Requirement	<p>/req/xsd-xml-rules/iso8601-time</p> <p>All date-time elements shall be encoded using ISO8601 extended time format.</p>
Requirement	<p>/req/xsd-xml-rules/time-zone</p> <p>The value of each time element (defined in the TimeValuePairType ‘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)</p>
Requirement	<p>/req/xsd-xml-rules/unit-of-measure</p> <p>All units of measure shall use the appropriate code from the The Unified Code for Units of Measure (UCUM) code system. The unit of measure shall be identified by encoding the UCUM code¹ in the ‘code’ attribute of the wml2:uom element.</p>
Requirement	<p>/req/xsd-xml-rules/swe-types</p> <p>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 also not be used.</p>
Recommendation	/rec/xsd-xml-rules/xlink-title

¹ The UCUM base codes are available in XML form here: <http://aurora.regenstrief.org/~ucum/ucum-essence.xml>.

	If an xlink:href is used to reference a controlled vocabulary item, the element should encode the xlink:title attribute with a text description of the referenced item.
Recommendation	/rec/xsd-xml-rules/vocabulary-references When specifying references to vocabulary (code) items using an xlink:href, a resolvable HTTP URL should be used which, when resolved, should provide suitable description of the concept being referenced.

This requirements class defines common rules and recommendations for all XML instances.

10.3.1 Use of vocabularies in XML

Within this GML application schema, code or vocabulary items are referenced using the xlink:href attribute which provides a reference to the appropriate code item. This follows existing best practices for referencing code items from XML documents, where the endpoint of the reference provides adequate description of the concept being referenced, possible relationships to other terms (hierarchical) and multi-lingual labels and descriptions. As discussed in section 9.3, WaterML2.0 defines a number of vocabularies that exist within the <http://opengis.net> namespace, according to the OGC's NA policies. It is possible to reference vocabularies from other namespaces within WaterML2.0 documents. It is recommended that such concepts have an available online definition and have been recognised by some level of authority.

In the following example, the time of the time-value pair is encoded in the ISO8601 time format, using a time-zone offset. The quality is encoded as a reference to a controlled vocabulary, using xlink:href to refer to the term and xlink:title to provide a text description.

```
<wml2:point>
  <wml2:MeasurementTVP>
    <wml2:time>2011-11-16T00:00:00+11:00</wml2:time>
    <wml2:value>2.0</wml2:value>
    <wml2:metadata>
      <wml2:TVPMeasurementMetadata>
        <wml2:quality xlink:href="http://www.opengis.net/def/waterml/2.0/quality/suspect"
          xlink:title="suspect"/>
      </wml2:TVPMeasurementMetadata>
    </wml2:metadata>
  </wml2:MeasurementTVP>
</wml2:point>
```

XML Example 1 - XML rules example

10.4 Requirements Class: Timeseries Observation

This requirements class restricts the content model for the XML element OM_Observation relating specifically to timeseries observations. The requirements classes that depend on this class describe specific result types of time series. The restrictions rules for OM_Observation are captured in the '*timeseries-observation.sch*' Schematron file.

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-observation	
Target Type	Data instance
Name	Timeseries observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules
Requirement	<p>/req/xsd-timeseries-observation/procedure</p> <p>The xml element om:procedure shall contain a wml2:ObservationProcess element, a member of its substitution group or a reference to an external definition of the process using the xlink:href attribute.</p>
Requirement	<p>/req/xsd-timeseries-observation/metadata</p> <p>If present, the xml element om:metadata shall contain a wml2:ObservationMetadata element, a member of its substitution group or a reference to an external definition of the metadata using the xlink:href attribute.</p>
Requirement	<p>/req/xsd-timeseries-observation/result</p> <p>The xml element om:result shall contain a concrete subelement in the substitution group wml2:Timeseries.</p>
Requirement	<p>/req/xsd-timeseries-observation/phenomenonTime</p> <p>The om:phenomenonTime element shall contain a gml:TimePeriod element that represents the temporal extent of the timeseries result of the observation.</p>
Recommendation	<p>/rec/xsd-timeseries-observation/resultQuality</p> <p>The om:resultQuality should use an xlink:href to reference the qualitative tests that have been applied, according to the ISO19115 (encoded in ISO19139) information model.</p>

10.4.1 observedProperty

As outlined in section 9.4.1.1, this standard does not define a list of controlled codes for the observed property. The om:observedProperty element is defined by O&M as a gml:ReferenceType, which uses xlink to reference a URI (URN or URL) that identifies the phenomenon being observed. It is desirable to have a URL that is resolvable to a resolvable description of the phenomenon where possible. There are best practices for management of vocabularies, but their deployment and use is out of scope for this standard.

An example vocabulary that defines a (small) set of observable properties in a hierarchical form is the SWEET ontology².

10.4.2 resultQuality

It is recommended (as per /rec/xsd-timeseries-observation/resultQuality) that the resultQuality (of type DQ_Element) not be encoded directly in the XML document but through an xlink:href to the encoded XML. This allows references to be made to the XML description of these tests if they are available. More granular quality descriptions (and qualifiers) are supported at the timeseries level.

10.5 Requirements Class: Timeseries Time-Value Pair (interleaved) Observation

This requirements class captures the core type of timeseries observation – one with a result of an interleaved time-value pair timeseries. This restriction is defined in the ‘*timeseries-tvp-observation.sch*’ Schematron file.

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tvp-observation	
Target Type	Data instance
Name	Time-value pair (interleaved) timeseries observation
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-observation
Requirement	<p>/req/xsd-timeseries-tvp-observation/result</p> <p>The xml element om:result shall have a value that matches the content model defined by wml2:Timeseries.</p>

² <http://sweet.jpl.nasa.gov/2.2/phenHydro.owl>

10.6 Requirements Class: Measurement time-value pair Timeseries (interleaved) Observation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-measurement-timeseries-tvp-observation	
Target Type	Data instance
Name	Measurement TVP (interleaved) timeseries observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-measurement-timeseries-tvp
Requirement	<p>/req/xsd-measurement-timeseries-tvp-observation/result</p> <p>The xml element om:result shall have a value that matches the content model defined by wml2:MeasurementTimeseries.</p>

The example below shows a measurement timeseries observation with appropriate metadata, phenomenon time, procedure and result elements. The result uses an interleaved timeseries (time-value pair) encoding which references the example in listing XML Example 3 for brevity.

```

<om:OM_Observation gml:id="xsd-timeseries-observation.example">
  <om:metadata>
    <wml2:ObservationMetadata>
      <gmd:contact xlink:href="http://www.example.com" xlink:title="Example Pty Ltd"/>
      <gmd:dateStamp>
        <gco:DateTime>2011-11-21T12:30:00+10:00</gco:DateTime>
      </gmd:dateStamp>
      <gmd:identificationInfo xlink:href="http://www.example.com/observations/example"
        xlink:title="Example Observation"/>
    </wml2:ObservationMetadata>
  </om:metadata>
  <om:phenomenonTime>
    <gml:TimePeriod gml:id="time-period.1">
      <gml:beginPosition>2011-11-21T12:26:00+10:00</gml:beginPosition>
      <gml:endPosition>2011-11-21T12:27:00+10:00</gml:endPosition>
    </gml:TimePeriod>
  </om:phenomenonTime>
  ...
  <om:procedure>
    <wml2:ObservationProcess gml:id="observation-process.1">
      <wml2:processType
        xlink:href="http://www.opengis.net/def/waterml/2.0/processType/ManualMethod"
        xlink:title="Manual Collection"/>
      <wml2:processReference xlink:href="http://www.example.com/manual/1.0"
        xlink:title="Manual Sampling Regime 1.0"/>
    </wml2:ObservationProcess>
  </om:procedure>
  ...
  <om:result xlink:href="#xsd-measurement-timeseries-tvp.example" />
</om:OM_Observation>

```

XML Example 2 - Measurement timeseries observation

10.7 Requirements Class: Categorical time-value pair Timeseries (interleaved) Observation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-categorical-timeseries-tvp-observation	
Target Type	Data instance
Name	Categorical TVP (interleaved) timeseries observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-categorical-timeseries-tvp
Requirement	<p>/req/xsd-categorical-timeseries-tvp-observation/result</p> <p>The xml element om:result shall have a value that matches the content model defined by wml2:CategoricalTimeseries.</p>

10.8 Requirements Class: Timeseries – time-value pair representation

This requirements class describes the structure of the interleaved timeseries. The structure supports time-value pair representation with the ability to associate metadata on a point-by-point basis. This class satisfies both the core timeseries requirements class and the time-value pair representation as described in sections 9.12 and 9.14 respectively.

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tvp	
Target Type	Data instance
Name	TimeseriesTVP
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-core
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp
Requirement	<p>/req/xsd-timeseries-tvp/valid</p> <p>The content model of this XML element shall have a value that matches the content model defined by wml2:Timeseries.</p>

Requirement	/req/xsd-timeseries-tvp/time-increasing The domain elements (implemented as the wml2:point element) shall be ordered in increasing time.
Requirement	/req/xsd-timeseries-tvp/record-homogenous The type of the wml2:value element (range) shall be the same for each point in the timeseries, with the exception null values which may be used on any value.
Requirement	/req/xsd-timeseries-tvp/domain-time The domain of the timeseries coverage shall consist only of a temporal component.
Requirement	/req/xsd-timeseries-tvp/default-point-metadata If the element <i>defaultPointMetadata</i> is present, the specified metadata elements apply as default values to all subsequent <i>point</i> elements encoded in the timeseries. If a metadata element is specified for a point then it overrides the default value. For elements with multiple cardinality (e.g. qualifiers), all defaults shall be overridden if a single element is defined in the metadata.
Requirement	/req/xsd-timeseries-tvp/equidistant-encoding If the <i>baseTime</i> and <i>spacing</i> elements are defined, the <i>time</i> element shall not be encoded. The time instants shall be calculated according to the follow: time (n) = baseTime + (n * spacing) n = zero-based point index. e.g. baseTime= 2011-01-01T00:00:00, spacing=P15M points: [0] - 2011-01-01T00:00:00 [1] - 2011-01-01T00:15:00 [2] - 2011-01-01T00:30:00 [3] - 2011-01-01T00:45:00 [4] - 2011-01-01T01:00:00
Requirement	/req/xsd-timeseries-tvp/time-mandatory If the <i>baseTime</i> and <i>spacing</i> elements are not present, the <i>time</i> element shall be encoded.
Requirement	/req/xsd-timeseries-tvp/null-value To indicate a value is null, the xsi:nil attribute shall be set to 'true'.
Requirement	/req/xsd-timeseries-tvp/null-point-reason If a point is specified as null, a nilReason or censoredReason shall be

	provided.
Requirement	<p>/req/xsd-timeseries-tvp/timeseries-metadata</p> <p>The type of the wml2:metadata element shall be wml2:TimeseriesMetadata or an element in the wml2:TimeseriesMetadata substitution group.</p>
Recommendation	<p>/rec/xsd-timeseries-tvp/nil-reason-vocab</p> <p>When specifying a null point reason (nilReason), one of the following URLs should be used:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Inapplicable (http://www.opengis.net/def/nil/OGC/0/inapplicable) <input type="checkbox"/> Missing (http://www.opengis.net/def/nil/OGC/0/missing) <input type="checkbox"/> Template (http://www.opengis.net/def/nil/OGC/0/template) - value will be available at later date. <input type="checkbox"/> Unknown (http://www.opengis.net/def/nil/OGC/0/unknown) <input type="checkbox"/> Withheld (http://www.opengis.net/def/nil/OGC/0/withheld.html)

This requirements class implements the /req/uml-timeseries-core and /req/uml-timeseries-tvp requirements classes from the UML model. See the specialised timeseries requirements classes for specific examples.

10.8.1 Spatially varying timeseries

This implementation adds the simplifying requirement that the domain of the timeseries is fixed in space and only varies through time. Timeseries that vary in space for each value will be addressed in future work – this case is supported the conceptual UML model where the domain may encode varying spatial components.

10.8.2 Defaulting point-based metadata

This XML implementation provides a mechanism for defaulting point metadata for a whole series and overriding for individual points if required. This technique is optional (defaultPointMetadata has cardinality 0..1) and should be used where timeseries are largely homogenous in terms of the individual metadata elements, such as units of measure, quality, and so on. The behaviour for the defaulting is described by requirement /req/xsd-timeseries-tvp/defaultPointMetadata. An example is show in XML Example 3.

10.9 Requirements Class: Measurement Timeseries – time-value pair representation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-measurement-timeseries-tvp	
Target Type	Data instance
Name	Measure Timeseries – time value pair
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-

	timeseries-tvp
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tvp
Requirement	<p>/req/xsd-measurement-timeseries-tvp/interpolation-type</p> <p>The interpolation type of each point shall be specified at each point using the interpolationType element or through the use of the defaultPointMetadata/interpolationType element.</p>
Requirement	<p>/req/xsd-measurement-timeseries-tvp/value-measure</p> <p>The type of the wml2:point element shall be wml2:MeasurementTVP.</p>
Requirement	<p>/req/xsd-measurement-timeseries-tvp/unit-of-measure</p> <p>Every value within the time series must have a unit of measure specified, either explicitly or from a specified default.</p>
Requirement	<p>/req/xsd-measurement-timeseries-tvp/timeseries-metadata</p> <p>The type of the wml2:metadata element shall be wml2:MeasurementTimeseriesMetadata.</p>
Requirement	<p>/req/xsd-measurement-timeseries-tvp/point-metadata</p> <p>The type of the wml2:point/wml2:MeasurementTVP/wml2:metadata element shall be wml2:TVPMeasurementMetadata.</p>

The following timeseries shows an example of an equidistant coding of a time series, using default point-metadata and a nil value. The measurements occur at 12:27:00, 12:28:00 and 12:29:00. The measurement expected at 12:29:00 is missing. The temporal extent of the time series runs from 12:27:00 to 2:30:00.

```

<wml2:MeasurementTimeseries gml:id="xsd-measurement-timeseries-tvp.example">

  <gml:description>Example timeseries for XML encoding
  http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-time-value-pair</gml:description>

  <wml2:metadata>
    <wml2:MeasurementTimeseriesMetadata>
      <wml2:temporalExtent>
        <gml:TimePeriod gml:id="time-period.1">
          <gml:beginPosition>2011-11-21T12:27:00+10:00</gml:beginPosition>
          <gml:endPosition>2011-11-21T12:30:00+10:00</gml:endPosition>
        </gml:TimePeriod>
      </wml2:temporalExtent>
      <wml2:baseTime>2011-11-21T12:27:00+10:00</wml2:baseTime>
      <wml2:spacing>PT1M</wml2:spacing>
    </wml2:MeasurementTimeseriesMetadata>
  </wml2:metadata>

  <wml2:defaultPointMetadata>
    <wml2:DefaultTVPMeasurementMetadata>
      <wml2:uom code="m"/>
      <wml2:interpolationType
        xlink:href="http://www.opengis.net/def/waterml/2.0/interpolationType/Continuous"
        xlink:title="Instantaneous"/>
    </wml2:DefaultTVPMeasurementMetadata>
  </wml2:defaultPointMetadata>

```

```

<wml2:point>
  <wml2:MeasurementTVP>
    <wml2:value>3.0</wml2:value>
  </wml2:MeasurementTVP>
</wml2:point>

<wml2:point>
  <wml2:MeasurementTVP>
    <wml2:value>3.2</wml2:value>
    <wml2:metadata>
      <wml2:TVPMeasurementMetadata>
        <wml2:accuracy>
          <swe:Quantity>
            <swe:uom code="m"/>
            <swe:value>0.1</swe:value>
          </swe:Quantity>
        </wml2:accuracy>
      </wml2:TVPMeasurementMetadata>
    </wml2:metadata>
  </wml2:MeasurementTVP>
</wml2:point>

<wml2:point>
  <wml2:MeasurementTVP>
    <wml2:value xsi:nil="true"/>
    <wml2:metadata>
      <wml2:TVPMeasurementMetadata>
        <wml2:nilReason xlink:href="http://www.opengis.net/def/nil/OGC/0/missing"
xlink:title="missing"/>
      </wml2:TVPMeasurementMetadata>
    </wml2:metadata>
  </wml2:MeasurementTVP>
</wml2:point>

<wml2:point>
  <wml2:MeasurementTVP>
    <wml2:value>3.63</wml2:value>
  </wml2:MeasurementTVP>
</wml2:point>
</wml2:MeasurementTimeseries>

```

XML Example 3 – Measurement timeseries (time-value pair)

This example shows the use of the qualifier element to provide extra point-based metadata. Here the qualifier is used to describe the lower threshold for a censored value.

```
<wml2:point>
  <wml2:MeasurementTVP>
    <wml2:value xsi:nil="true"></wml2:value>
    <wml2:metadata>
      <wml2:TVPMeasurementMetadata>
        <wml2:qualifier>
          <swe:Quantity definition="http://www.example.com/sensors/lower_threshold">
            <swe:description>Lower limit for sensor</swe:description>
            <swe:uom code="m"/>
            <swe:value>1.0</swe:value>
          </swe:Quantity>
        </wml2:qualifier>
        <wml2:censoredReason xlink:href="http://www.opengis.net/def/nil/OGC/0/BelowDetectionRange"
          xlink:title="Below threshold of sensor"/>
      </wml2:TVPMeasurementMetadata>
    </wml2:metadata>
  </wml2:MeasurementTVP>
</wml2:point>
```

XML Example 4 - Use of qualifiers

Notes on implementation of ISO19123 in XML-GML Schema:

gmlcov does not contain an implementation of the geometry-value representation of ISO19123 coverage.

The best practice at http://bp.schemas.opengis.net/06-188r2/cv/0.2.2_gml32/discreteCoverage.xsd contains an implementation of the geometry-value representation and restricts the geometry to gml:TimeInstantPropertyType (in the CV_TimeInstantValuePairType type). This is not a sub-type of the CV_DomainObject (which has a temporal and spatial element) and as such is not strictly a direct implementation (without a minor mapping rule). The CompactTimeValuePair also does not encode the CV_DomainObject directly, but collapses straight to the required temporal type (for the temporalElement).

The timeseries implementation here uses the deviations described as follows:

The 'geometry' element of the CV_GeometryValuePair that holds the CV_DomainObject has been renamed 'time' and is typed as a gml:TimePositionType which is an implementation of the model described in 9.12. This is consistent with the approach taken in 06-188r2. Future work should define a geometry-value GML encoding by aligning with GML Coverage (09-146r1). This was out of scope for the initial version of this standard.

The type of the 'value' (range) element is restricted to be one of the supported timeseries types as defined in the requirement: <http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tp/record-homogenous>.

The domainExtent of a discrete time coverage describes the temporal bounds of the time series and was renamed temporalExtent to describe more closely its relation to the timeseries.

The deviations allow for a schema that more closely reflects the needs of the community. A transformation may be used on instances conforming to this schema to derive a fully compliant instance if required. Future work should investigate harmonising the OGC definition of timeseries from the coverage, GML and SWE Common viewpoints.

10.10 Requirements Class: Categorical Timeseries – time-value pair representation

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-categorical-timeseries-tvp	
Target Type	Data instance
Name	Categorical Timeseries – time value pair
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tvp
Requirement	/req/xsd-categorical-timeseries-tvp/value-category The type of the wml2:point XML element shall be wml2:CategoricalTVP.

```

<wml2:CategoricalTimeseries gml:id="cat_ts_ex_2">
  <gml:description>This is an example showing a categorical time series describing a series of
  manual weather observations. </gml:description>
  <wml2:temporalExtent>
    <gml:TimePeriod gml:id="tp_1">
      <gml:beginPosition>2011-11-16T00:00:00+11:00</gml:beginPosition>
      <gml:endPosition>2011-11-18T00:00:00+11:00</gml:endPosition>
    </gml:TimePeriod>
  </wml2:temporalExtent>
  <wml2:point>
    <wml2:CategoricalTVP>
      <wml2:time>2011-11-16T00:00:00+11:00</wml2:time>
      <wml2:value>
        <swe:Category>
          <swe:description>Fairly uniform precipitation composed exclusively of very small water
          droplets (less than 0.5 mm in diameter) very close to one another</swe:description>
          <swe:codeSpace xlink:href="http://www.bom.gov.au/info/wwords/">
          <swe:value>Drizzle</swe:value>
        </swe:Category>
      </wml2:value>
    </wml2:CategoricalTVP>
  </wml2:point>
  <wml2:point>
    <wml2:CategoricalTVP>
      <wml2:time>2011-11-17T00:00:00+11:00</wml2:time>
      <wml2:value>
        <swe:Category>
          <swe:description>Usually begin and end suddenly. Relatively short-lived, but may last
          half an hour. Fall from cumulus clouds, often separated by blue sky. Showers may fall in patches
          rather than across the whole forecast area. Range in intensity from light to very
          heavy</swe:description>
          <swe:codeSpace xlink:href="http://www.bom.gov.au/info/wwords/">
          <swe:value>Showers</swe:value>
        </swe:Category>
      </wml2:value>
    </wml2:CategoricalTVP>
  </wml2:point>
  <wml2:point>
    <wml2:CategoricalTVP>
      <wml2:time>2011-11-18T00:00:00+11:00</wml2:time>
      <wml2:value xsi:nil="true"></wml2:value>
      <wml2:metadata>

```

```

    <wml2:TVPMetadata>
      <wml2:nilReason xlink:href="http://www.opengis.net/def/nil/OGC/0/missing"/>
      <wml2:comment>No observation performed.</wml2:comment>
    </wml2:TVPMetadata>
  </wml2:metadata>
</wml2:CategoricalTVP>
</wml2:point>
</wml2:CategoricalTimeseries>

```

XML Example 5 - Categorical timeseries (time-value pair)

10.11 Requirements Class: Monitoring point as feature of interest

This requirements class captures the restriction of OM_Observation where the feature of interest is a monitoring point. This class is to be used for most in-situ style monitoring situations where the WaterML2.0 monitoring point is sufficient for representing the location metadata. This would not be used in cases where a specific community profile is being used to describe the sampling feature (e.g. a groundwater well) or the observation is made of a whole domain feature (e.g. a derived observation representing lake storage).

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-feature-of-interest-monitoring-point	
Target Type	Data instance
Name	Monitoring point feature of interest
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/observation
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-observation
Requirement	<p>/req/xsd-feature-of-interest-monitoring-point/featureOfInterest</p> <p>The <i>featureOfInterest</i> element of TimeseriesObservation shall have a value that matches the content model defined by wml2:MonitoringPoint.</p>

Example

This example uses xlink:href to refer to the same monitoring point as defined in section 10.13.

```

<om:featureOfInterest xlink:href="#xsd-monitoring-point.example" xline:title="Deddington"/>

```

10.12 Requirements Class: Observation Process

This requirements class is used to describe the process involved in making timeseries observation. The class is targeted at providing basic process description; full process languages such as SensorML may be used if more detailed information is required.

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-observation-process	
Target Type	Data instance
Name	Observation process
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-observation-process
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules
Requirement	<p>/req/xsd-observation-process/valid</p> <p>The content model of this element shall have a value that matches the content model defined by wml2:ObservationProcess.</p>

The following example shows an algorithmic process that takes data from another process (Observation 1.8) and applies a further process (min_daily_mean_monthly) to it. The process accepts as an input the water height from the source process and applies a bias parameter to it.

```
<?xml version="1.0" encoding="UTF-8"?>
<wml2:ObservationProcess gml:id="xsd-observation-process.example">
  <wml2:processType
    xlink:href="http://www.opengis.net/def/waterml/2.0/processType/Algorithm"
    xlink:title="Algorithmic Process"/>
  <wml2:originatingProcess
    xlink:href="http://www.example.com/observations/1.8"
    xlink:title="Timeseries Observation 1.8"/>
  <wml2:aggregationDuration>P1D</wml2:aggregationDuration>
  <wml2:verticalDatum xlink:href="urn:ogc:def:crs:EPSG::5711" xlink:title="Australian height datum"/>
  <wml2:processReference
    xlink:href="http://kisters.de/tsm_agent/min_daily_mean_monthly"
    xlink:title="Minimum Daily Mean Monthly"/>
  <wml2:input
    xlink:href="http://sweet.jpl.nasa.gov/2.3/propSpaceThickness.owl#WaterHeight"
    xlink:title="Water Height"/>
  <wml2:parameter>
    <om:NamedValue>
      <om:name
        xlink:href="http://sweet.jpl.nasa.gov/2.3/propDifference.owl#Bias"
        xlink:title="Bias"/>
      <om:value>-0.1</om:value>
    </om:NamedValue>
  </wml2:parameter>
</wml2:ObservationProcess>
```

XML Example 6 - Observation process

10.13 Requirements Class: Monitoring Point

This requirements class is to be used to describe monitoring points (sampling points) that are described using a point-based geometry. WaterML2.0 extends the OMXML Sampling Point type to add metadata specific to hydrological monitoring.

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-monitoring-point	
Target Type	Data instance
Name	Monitoring point
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules
Dependency	http://www.opengis.net/spec/OMXML/2.0/req/samplingPoint
Requirement	<p>/req/xsd-monitoring-point/valid</p> <p>The content model of this element shall have a value that matches the content model defined by wml2:MonitoringPoint.</p>

The Deddington monitoring point samples the Nile river. The monitoring point is at latitude 41.814935S and longitude 147.568517W and uses the Australian height datum as a reference datum. The monitoring point is in the Australian Eastern Daylight Timezone, 11 hours ahead of UTC.

```
<wml2:MonitoringPoint gml:id="xsd-monitoring-point.example">
  <gml:description>Nile river at Deddington, South Esk catchment, Tasmania</gml:description>
  <gml:name codeSpace="http://www.csiro.au/">Deddington</gml:name>
  <sam:sampledFeature
    xlink:href="http://csiro.au/features/ivers/nile "
    xlink:title="Nile River"
  />
  <sams:shape>
    <gml:Point gml:id="location_deddington">
      <gml:pos srsName="urn:ogc:def:crs:EPSG::4326">-41.814935 147.568517 </gml:pos>
    </gml:Point>
  </sams:shape>
  <wml2:verticalDatum
    xlink:href="urn:ogc:def:crs:EPSG::5711"
    xlink:title="Australian height datum"
  />
  <wml2:timeZone>
    <wml2:TimeZone>
      <wml2:zoneOffset>+11:00</wml2:zoneOffset>
      <wml2:zoneAbbreviation>AEDT</wml2:zoneAbbreviation>
    </wml2:TimeZone>
  </wml2:timeZone>
</wml2:MonitoringPoint>
```

XML Example 7 - Monitoring point

10.14 Requirements Class: Collection

This requirements class is to be used to describe collections of objects from WaterML2.0. This includes observations, sampling features, sampling feature groups and inline dictionaries.

Requirements Class	
http://www.opengis.net/spec/waterml/2.0/req/xsd-collection	
Target Type	Data instance
Name	Collection
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-collection
Dependency	http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules
Requirement	<p><code>/req/xsd-collection/valid</code></p> <p>The content model of this element shall have a value that matches the content model defined by wml2:Collection.</p>

See Annex B for an example collection.

10.14.1 Use of inline dictionaries

The localDictionary element allows dictionary/code items to be encoded within the collection. This allows local references to be made to the dictionary rather than external links via xlink. Examples of its use are provided in Annex B.

Annex A Abstract test suite (normative)

A.1 Conformance classes - UML Package

A.1.1 Conformance Class: Timeseries Observation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-observation	
Dependency	urn:iso:dis:iso:19156:clause:A.1.1	
Test	/conf/uml-timeseries-observation/result	
	Requirement	/req/uml-timeseries-observation/result
	Test purpose	Verify that an observation produces a result that is a Timeseries.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-timeseries-observation/featureOfInterest	
	Requirement	/req/uml-timeseries-observation/featureOfInterest
	Test purpose	Verify that if featureOfInterest of the observation is not a domain feature then the featureOfInterest property shall be SF_SpatialSamplingFeature or a subtype of this class.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-timeseries-observation/procedure	
	Requirement	/req/uml-timeseries-observation/procedure
	Test purpose	Verify that the procedure of the Observation is of a type ObservationProcess or a reference to an appropriate

		definition of the process used in generating the timeseries.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-timeseries-observation/metadata	
	Requirement	/req/uml-timeseries-observation/metadata
	Test purpose	Verify that the metadata property of the Observation is of a type ObservationMetadata.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-timeseries-observation/observedProperty	
	Requirement	/req/uml-timeseries-observation/observedProperty
	Test purpose	This requirement reflects the requirement from ISO19156 that an observation must specify the observed property of the observation. Verify that the observedProperty property of the OM Observation has been implemented.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-timeseries-observation/phenomenonTime	
	Requirement	/req/uml-timeseries-observation/phenomenonTime
	Test purpose	Verify that the OM_Observation:phenomenonTime property describes the temporal range of the timeseries result (OM_Observation:result).
	Test method	Inspect the model or software implementation to verify the above requirement.

	Test type	Capability
--	-----------	------------

A.1.2 Conformance Class: Domain Range Timeseries Observation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-domain-range-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-domain-range	
Test	/conf/uml-timeseries-domain-range-observation/result	
	Requirement	/req/uml-timeseries-domain-range-observation/result
	Test purpose	Verify that an observation result is a Timeseries using the domain range structure.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.3 Conformance Class: Measurement (Domain Range) Timeseries Observation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-measurement-timeseries-domain-range-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-domain-range-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-domain-range-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-measurement-timeseries-domain-range	
Test	/conf/uml-measurement-timeseries-domain-range-observation/result	
	Requirement	/req/uml-measurement-timeseries-domain-range-observation/result
	Test purpose	Verify that an observation result conforms to the structure of a <i>MeasurementTimeseriesDomainRange</i> .

	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.4 Conformance Class: Categorical (Domain Range) Timeseries Observation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-categorical-timeseries-domain-range-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-domain-range-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-domain-range-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-categorical-timeseries-domain-range	
Test	/conf/uml-categorical-timeseries-domain-range-observation/result	
	Requirement	/req/uml-categorical-timeseries-domain-range-observation/result
	Test purpose	Verify that an observation result conforms to the structure of a <i>CategoricalTimeseriesDomainRange</i> .
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.5 Conformance Class: TVP Timeseries Observation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-tvp-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-tvp	
Test	/conf/uml-timeseries-tvp-observation/result	
	Requirement	/req/uml-timeseries-tvp-observation/result
	Test purpose	Verify that an observation result is a Timeseries using the interleaved (time-value pair) structure.

	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.6 Conformance Class: Measurement TVP Timeseries Observation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-measurement-timeseries-tvp-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-tvp-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-tvp-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-measurement-timeseries-tvp	
Test	/conf/uml-measurement-timeseries-tvp-observation/result	
	Requirement	/req/uml-measurement-timeseries-tvp-observation/result
	Test purpose	Verify that an observation result conforms to the structure of a <i>MeasurementTimeseriesTVP</i> .
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.7 Conformance Class: Categorical TVP Timeseries Observation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-categorical-timeseries-tvp-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-tvp-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-categorical-timeseries-tvp	
Test	/conf/uml-categorical-timeseries-tvp-observation/result	
	Requirement	/req/uml-categorical-timeseries-tvp-observation/result

	Test purpose	Verify that an observation result conforms to the structure of a <i>CategoricalTimeseriesTVP</i> .
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.8 Conformance Class: Timeseries Core

Conformance Class	
http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-core	
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-core
Test	/conf/uml-timeseries-core/domain-object
Requirement	/req/uml-timeseries-core/domain-object
Test purpose	Verify that the Timeseries is a coverage with domain consisting of a single temporal element and no spatial element.
Test method	Inspect the model or software implementation to verify the above requirement.
Test type	Capability
Test	/conf/uml-timeseries-core/time-increasing
Requirement	/req/uml-timeseries-core/time-increasing
Test purpose	Verify that the time elements of the time series are ordered in increasing time.
Test method	Inspect the model or software implementation to verify the above requirement.
Test type	Capability
Test	/conf/uml-timeseries-core/record-homogenous
Requirement	/req/uml-timeseries-core/record-homogenous

	Test purpose	Verify that the record-type for each value (range element) of the timeseries is all the same for the whole series (coverage).
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-timeseries-core/coverage-type	
	Requirement	/req/uml-timeseries-core/coverage-type
	Test purpose	Verify that the structure of the timeseries (coverage) is defined according to the domain-range timeseries conformance class OR the time-value pair (interleaved) timeseries conformance class.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-timeseries-core/quality	
	Requirement	/req/uml-timeseries-core/quality
	Test purpose	Verify that the quality assertions used for the timeseries use a URI from the data quality URIs defined in section 9.12.3.2.1.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-timeseries-core/metadata	
	Requirement	/req/uml-timeseries-core/metadata
	Test purpose	Verify that the metadata property is valid by implementing all the required properties and associations.
	Test method	Inspect the model or software implementation to verify the above requirement.

	Test type	Capability
Test		/conf/uml-timeseries-core/point-metadata
	Requirement	/req/uml-timeseries-core/point-metadata
	Test purpose	Verify that the implementation supports point-based metadata with all the required properties and associations as described in the UML.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.9 Conformance Class: Timeseries Domain Range

Conformance Class		
	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-domain-range	
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-domain-range	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-core	
Test	/conf/uml-timeseries-domain-range/domain-range-separate	
	Requirement	/req/uml-timeseries-domain-range/domain-range-separate
	Test purpose	Verify the domain (time) and range (value) parts of the timeseries are represented as separate data items.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.10 Conformance Class: Timeseries Time-Value Pair (interleaved)

Conformance Class	
	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-tvp
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-tvp
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-core
Test	/conf/uml-timeseries-tvp/interleaved

	Requirement	/req/uml-timeseries-tvp/interleaved
	Test purpose	Verify the timeseries is structured using time-value pairs as defined by the TimeValuePair class.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.11 Conformance Class: Measurement Timeseries TVP (Interleaved)

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-measurement-timeseries-tvp		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-tvp	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-tvp	
Test	/conf/uml-measurement-timeseries-tvp/value-type	
	Requirement	/req/uml-measurement-timeseries-tvp/value-type
	Test purpose	Verify the values (range elements) of the timeseries are of type Measure.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-measurement-timeseries-tvp/interpolation-type	
	Requirement	/req/uml-timeseries-core/interpolation-type
	Test purpose	Verify that the interpolation type used for the timeseries uses a URI from the interpolation type URIs defined in section 9.15.3.2.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.12 Conformance Class: Categorical Timeseries TVP (Interleaved)

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-categorical-timeseries-tvp		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-tvp	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-tvp	
Test	/conf/uml-categorical-timeseries-tvp/value-type	
	Requirement	/req/uml-categorical-timeseries-tvp/value-type
	Test purpose	Verify the values (range elements) of the timeseries are of type Category.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.13 Conformance Class: Measurement Timeseries (Domain Range)

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-measurement-timeseries-domain-range		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-measurement-timeseries-domain-range	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-domain-range	
Test	/conf/uml-measurement-timeseries-domain-range/value-type	
	Requirement	/req/uml-measurement-timeseries-domain-range/value-type
	Test purpose	Verify the values (range elements) of the timeseries are of type Measure.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.14 Conformance Class: Categorical Timeseries (Domain Range)

Conformance Class	
http://www.opengis.net/spec/waterml/2.0/conf/uml-categorical-timeseries-domain-range	

Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-categorical-timeseries-domain-range	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-domain-range	
Test	/conf/uml-categorical-timeseries-domain-range/value-type	
	Requirement	/req/uml-categorical-timeseries-domain-range/value-type
	Test purpose	Verify the values (range elements) of the timeseries are of type Category.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.15 Conformance Class: Monitoring Point

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-monitoring-point		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point	
Dependency	urn:iso:dis:iso:19156:clause:A.2.4	
Test	/conf/uml-monitoring-point/valid	
	Requirement	/req/uml-monitoring-point/valid
	Test purpose	Verify the implementation represents all the required attributes and associations for a monitoring point.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.16 Conformance Class: Monitoring Point feature of interest

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-monitoring-point-feature-of-interest		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point-	

	feature-of-interest	
Dependency	urn:iso:dis:iso:19156:clause:A.1.1	
Test	/conf/uml-monitoring-point-feature-of-interest/foi	
	Requirement	/req/uml-monitoring-point-feature-of-interest/foi
	Test purpose	Verify the featureOfInterest property of the OM_Observation object is of type MonitoringPoint (or a reference to such a type).
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.17 Conformance Class: Sampling feature collections

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-sampling-feature-collections		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-sampling-feature-collections	
Dependency	urn:iso:dis:iso:19156:clause:A.2.2	
Test	/conf/uml-sampling-feature-collections/groups	
	Requirement	/req/uml-sampling-feature-collections/groups
	Test purpose	Verify the collections of sampling features are represented using the SamplingFeatureCollection type specified in ISO19156.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.18 Conformance Class: Observation process

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-observation-process		

Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-observation-process	
Dependency	urn:iso:dis:iso:19156:clause:A.1.1	
Test	/conf/uml-observation-process/valid	
	Requirement	/req/uml-observation-process/valid
	Test purpose	Verify the procedure property uses the ObservationProcess type or a reference to such a type.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability
Test	/conf/uml-observation-process/processType	
	Requirement	/req/uml-observation-process/processType
	Test purpose	Verify the processType property of the ObservationType uses an appropriate URL as defined in section 9.22.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.1.19 Conformance Class: Collection

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/uml-collecton		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/uml-collection	
Dependency	urn:iso:dis:iso:19156:clause:A.2.2	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-core	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-monitoring-point	
Test	/conf/uml-collection/valid	
	Requirement	/req/uml-collection/valid
	Test purpose	Verify the model or implementation supports collections of sampling features or collections of sampling features,

		observations and inline dictionaries as described by the UML in section 9.23.
	Test method	Inspect the model or software implementation to verify the above requirement.
	Test type	Capability

A.2 Conformance classes – XML Implementation

This is the core conformance class for XML implementation of WaterML 2.0.

There is a dependency on the conformance class for GML documents, defined in clause 2.4 (with the test suite in A.3) of *OGC Geography Markup Language v3.2*.

There is a dependency on the conformance class for Geographic Metadata XML encoding, described in Clause 2 and Annex A of *Geographic information – metadata – XML implementation*.

There is a dependency on the conformance class for Observations and Measurements XML encoding, described Annex A of *Observations and Measurements – XML implementation*.

A.2.1 Conformance Class: XML Rules

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-xml-rules		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-xml-rules	
Dependency	http://www.opengis.net/spec/SWE/2.0/conf/xsd-simple-components	
Dependency	http://www.w3.org/TR/xmlschema-2	
Dependency	http://www.opengis.net/doc/IS/GML/3.2/clause/2.4	
Dependency	urn:iso:dis:iso:8601:2004:clause:4	
Test	/conf/xsd-xml-rules/iso8601-time	
	Requirement	/req/xsd-xml-rules/iso8601-time
	Test purpose	Verify that all time instants are valid according to the XML Schema implementation of ISO8601.
	Test method	Validate the content of each time element against the XML Schema dateTime content type, available here http://www.w3.org/TR/xmlschema-2/#schema . Pass if no errors are reported. Fail otherwise.
	Test type	Capability

Test	/conf/xsd-xml-rules/time-zone	
	Requirement	/req/xsd-xml-rules/time-zone
	Test purpose	Verify that all time instants include a time zone specifier.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/xml-rules.sch . Pass if no errors are reported for the “time-zone” test. Fail otherwise
	Test type	Capability
Test	/conf/xsd-xml-rules/unit-of-measure	
	Requirement	/req/xsd-xml-rules/unit-of-measure
	Test purpose	Verify that all time units are specified using the UCUM units system.
	Test method	Inspect the XML document and ensure all units of measure are valid according to UCUM. Fail otherwise. (No automated check against UCUM currently available).
	Test type	Capability
Test	/conf/xsd-xml-rules/swe-types	
	Requirement	/req/xsd-xml-rules/swe-types
	Test purpose	Ensure that only applicable SWE types are used. Some SWE types are related specifically to the SWE encoding style, which is not used.
	Test method	<p>Verify that following SWE elements are not used in the encoding:</p> <ul style="list-style-type: none"> <input type="checkbox"/> swe:quality(<i>AbstractSimpleComponentType</i>) <input type="checkbox"/> swe:nilValues (<i>AbstractSimpleComponentType</i>) <input type="checkbox"/> swe:constraint (<i>QuantityType</i>, <i>QuantityRangeType</i>, <i>CategoryType</i>) <p>Verify the following SWE attributes are not used:</p>

		'optional' and 'updatable' from the base type 'AbstractDataComponent'
	Test type	Capability

A.2.2 Conformance Class: Timeseries Observation XML (abstract)

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-timeseries-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-observation	
Dependency	http://www.opengis.net/spec/OMXML/2.0/conf/observation	
Test	/conf/xsd-timeseries-observation/procedure	
	Requirement	/req/xsd-timeseries-observation/procedure
	Test purpose	Verify that the om:procedure element has a value that matches the content model defined by wml2: ObservationProcess or an appropriate reference is used.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/timeseries-observation.sch . Pass if no errors are reported for the "procedure" test. Fail otherwise.
	Test type	Capability
Test	/conf/xsd-timeseries-observation/metadata	
	Requirement	/req/xsd-timeseries-observation/metadata
	Test purpose	Verify that the om:metadata element has a value that matches the content model defined by wml2: ObservationMetadata or an appropriate reference is used.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/timeseries-observation.sch . Pass if no errors are reported for the "metadata" test. Fail otherwise.
	Test type	Capability

Test	/conf/xsd-timeseries-observation/result	
	Requirement	/req/xsd-timeseries-observation/result
	Test purpose	Verify that the om:result element has a value that matches the content model defined by wml2:TimeseriesType or is in the substitution group wml2:Timeseries.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/timeseries-observation.sch . Pass if no errors are reported for the “result” test. Fail otherwise.
	Test type	Capability
Test	/conf/xsd-timeseries-observation/phenomenonTime	
	Requirement	/req/xsd-timeseries-observation/phenomenonTime
	Test purpose	Verify that the phenomenon time describes the temporal extent of the observation result.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/timeseries-observation.sch . Pass if no errors are reported for the ‘phenomenonTime’. Fail otherwise.
	Test type	Capability

A.2.3 Conformance Class: TVP (Interleaved) Timeseries Observation XML

Conformance Class	
http://www.opengis.net/spec/waterml/2.0/conf/xsd-timeseries-tvp-observation	
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/uml-timeseries-tvp-observation
Test	/conf/xsd-timeseries-tvp-observation/result
	Requirement

	Test purpose	Verify that the om:result element has a value that matches the content model defined by wml2:Timeseries.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/timeseries-tvp-observation.sch . Pass if no errors are reported for the “ <i>result</i> ” test. Fail otherwise.

A.2.4 Conformance Class: Measurement TVP (Interleaved) Timeseries Observation XML

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-measurement-timeseries-tvp-observation		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-measurement-timeseries-tvp-observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/xsd-timeseries-tvp-observation	
Test	/conf/xsd-measurement-timeseries-tvp-observation/result	
	Requirement	/req/xsd-measurement-timeseries-tvp-observation/result
	Test purpose	Verify that the om:result element has a value that matches the content model defined by wml2:MeasurementTimeseries.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/measurement-timeseries-tvp-observation.sch . Pass if no errors are reported for the “ <i>result</i> ” test. Fail otherwise.

A.2.5 Conformance Class: Categorical TVP (Interleaved) Timeseries Observation XML

Conformance Class	
http://www.opengis.net/spec/waterml/2.0/conf/xsd-categorical-timeseries-tvp-observation	
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-categorical-timeseries-tvp-observation
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/xsd-timeseries-tvp-observation
Test	/conf/xsd-categorical-timeseries-tvp-observation/result
	Requirement

	Test purpose	Verify that the om:result element has a value that matches the content model defined by wml2:CategoricalTimeseries.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/categorical-timeseries-tvp-observation.sch . Pass if no errors are reported for the “ <i>result</i> ” test. Fail otherwise.

A.2.6 Conformance Class: Timeseries (Core)

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-timeseries-core		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-core	
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-timeseries-core	
Test	/conf/xsd-timeseries-core/domain-object	
	Requirement	/req/xsd-timeseries-core/domain-object
	Test purpose	Verify that the XML instance is a valid coverage timeseries consisting of single temporal element.
	Test method	Specific tests for this conformance class are defined in the dependent concrete conformance classes; see section 10.2.2 for details.
Test	/conf/xsd-timeseries-core/time-increasing	
	Requirement	/req/xsd-timeseries-core/time-increasing
	Test purpose	Verify that each point in the timeseries is increasing in time.
	Test method	Specific tests for this conformance class are defined in the dependent concrete conformance classes; see section 10.2.2 for details.
Test	/conf/xsd-timeseries-core/record-homogenous	
	Requirement	/req/xsd-timeseries-tvp/record-homogenous
	Test purpose	Verify that the record type for each point in the series is the same. E.g. all of type Measurement or Categorical.

	Test method	Inspect the value-type (range type) of the coverage and ensure that the record type is homogenous. Implementation specific tests exist for this conformance class in the concrete conformance classes, as described in section 10.2.2.
Test	/conf/xsd-timeseries-core/time-mandatory	
	Requirement	/req/xsd-timeseries-tp/time-mandatory
	Test purpose	Ensure that the time component of the timeseries coverage is sufficiently specified.
	Test method	Specific tests for this conformance class are defined in the dependent concrete conformance classes; see section 10.2.2 for details.
Test	/conf/xsd-timeseries-core/null-point-reason	
	Requirement	/req/xsd-timeseries-tp/null-point-reason
	Test purpose	Ensure that a reason is specified for each point that is defined as null.
	Test method	Specific tests for this conformance class are defined in the dependent concrete conformance classes; see section 10.2.2 for details.

A.2.7 Conformance Class: Timeseries – TVP representation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-timeseries-tp		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-timeseries-tp	
Dependency		
Test	/conf/xsd-timeseries-tp/valid	
	Requirement	/req/xsd-timeseries-tp/valid
	Test purpose	Verify that the XML instance is a valid timeseries.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/timeseries.xsd . Pass if no errors are reported. Fail otherwise.

Test	/conf/xsd-timeseries-tvp/time-increasing	
	Requirement	/req/xsd-timeseries-tvp/time-increasing
	Test purpose	Verify that each point in the timeseries is increasing in time.
	Test method	Inspect the value of each wml2:time element in the series and ensure the time instant is after the previous wml2:time instant.
Test	/conf/xsd-timeseries-tvp/record-homogenous	
	Requirement	/req/xsd-timeseries-tvp/record-homogenous
	Test purpose	Verify that the record type for each point in the series is the same. E.g. all of type MeasurementTVP or CategoricalTVP.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/timeseries.xsd . Pass if no errors are reported. Fail otherwise.
Test	/conf/xsd-timeseries-tvp/default-point-metadata	
	Requirement	/req/xsd-timeseries-tvp/default-point-metadata
	Test purpose	Ensure the default metadata is applied to each point in the timeseries unless it has been overridden.
	Test method	This requirement describes the logic for defaulting behavior. Conformance is to be tested when creating or parsing the instance document, rather than directly on an instance document.
Test	/conf/xsd-timeseries-tvp/equidistant-encoding	
	Requirement	/req/xsd-timeseries-tvp/equidistant-encoding
	Test purpose	Ensure the equidistant timeseries metadata has been sufficiently defined.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/timeseries.sch . Pass if no errors are reported for the 'equidistant series'

		test. Fail otherwise.
Test	/conf/xsd-timeseries-tpv/time-mandatory	
	Requirement	/req/xsd-timeseries-tpv/time-mandatory
	Test purpose	Ensure each point in the series has a time specified, either through definition of an equidistant series or explicitly for each point.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/timeseries.sch . Pass if no errors are reported for the 'time-mandatory' test. Fail otherwise.
Test	/conf/xsd-timeseries-tpv/null-point-reason	
	Requirement	/req/xsd-timeseries-tpv/null-point-reason
	Test purpose	Ensure that a reason is specified for each point that is defined as null.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/timeseries.sch . Pass if no errors are reported for the 'null-point-reason' test. Fail otherwise.

A.2.8 Conformance Class: Measurement Timeseries – TVP representation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-measurement-timeseries-tpv		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-measurement-timeseries-tpv	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/xsd-timeseries-tpv	
Test	/conf/xsd-measurement-timeseries-tpv/interpolation-type	
	Requirement	/req/xsd-measurement-timeseries-tpv/interpolation-type
	Test purpose	Verify that each point within a timeseries has a defined interpolation type.

	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/measurement-timeseries-tvp.sch . Pass if no errors are reported for the 'interpolation-type' test. Fail otherwise.
Test	/conf/xsd-measurement-timeseries-tvp/value-measure	
	Requirement	/req/xsd-measurement-timeseries-tvp/value-measure
	Test purpose	Verify that each point in the timeseries has a value-type of a measure.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/timeseries.xsd . Pass if no errors are reported. Fail otherwise.
Test	/conf/xsd-measurement-timeseries-tvp/unit-of-measure	
	Requirement	/req/xsd-measurement-timeseries-tvp/unit-of-measure
	Test purpose	Verify that each value in the timeseries has a unit of measure specified.
	Test method	Validate the XML document using the Schematron document http://schemas.opengis.net/waterml/2.0/measurement-timeseries-tvp.sch . Pass if no errors are reported for the 'value-measure-unit-of-measure' test. Fail otherwise.
Test	/conf/xsd-measurement-timeseries-tvp/timeseries-metadata	
	Requirement	/req/xsd-measurement-timeseries-tvp/timeseries-metadata
	Test purpose	Verify that the type of the wml2:metadata element is wml2:MeasurementTimeseriesMetadata.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/timeseries.xsd . Pass if no errors are reported. Fail otherwise.
Test	/conf/xsd-measurement-timeseries-tvp/point-metadata	
	Requirement	/req/xsd-measurement-timeseries-tvp/point-metadata

	Test purpose	Verify that the type of the wml2:point/wml2:MeasurementTVP/wml2:metadata element is wml2:TVPMeasurementMetadata.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/timeseries.xsd . Pass if no errors are reported. Fail otherwise.

A.2.9 Conformance Class: Categorical Timeseries – TVP representation

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-categorical-timeseries-tpv		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-categorical-timeseries-tpv	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/xsd-timeseries-tpv	
Test	/conf/xsd-categorical-timeseries-tpv/value-category	
	Requirement	/req/xsd-categorical-timeseries-tpv/value-category
	Test purpose	Verify that each point in the timeseries has a value-type of a category.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/timeseries.xsd . Pass if no errors are reported. Fail otherwise.

A.2.10 Conformance Class: Monitoring point feature of interest

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-feature-of-interest-monitoring-point		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-feature-of-interest-monitoring-point	
Dependency	http://www.opengis.net/spec/OMXML/2.0/conf/observation	
Dependency	http://www.opengis.net/spec/waterml/2.0/conf/xsd-monitoring-point	
Test	/conf/xsd-feature-of-interest-monitoring-point/featureOfInterest	
	Requirement	/req/xsd-feature-of-interest-monitoring-point/featureOfInterest
	Test purpose	Verify that the om:featureOfInterest element has a value that matches the content model defined by wml2:MonitoringPoint.
	Test method	Validate the XML document using the Schematron document

		http://schemas.opengis.net/waterml/2.0/monitoring-point-feature-of-interest.sch . Pass if no errors are reported. Fail otherwise.
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A.2.11 Conformance Class: Observation Process

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-observation-process		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-observation-process	
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-observation-process	
Test	/conf/xsd-observation-process/valid	
	Requirement	/req/xsd-observation-process/valid
	Test purpose	Verify that the OM_Observation defines a valid ObservationProcess type or contains a reference to its definition.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/observationProcesses.xsd . Pass if no errors are reported. Fail otherwise.

A.2.12 Conformance Class: Monitoring Point

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-monitoring-point		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-monitoring-point	
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-monitoring-point	
Test	/conf/xsd-monitoring-point/valid	
	Requirement	/req/xsd-monitoring-point/valid
	Test purpose	Verify that the MonitoringPoint is a valid definition.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/monitoringPoint.xsd . Pass if no errors are reported. Fail otherwise.

A.2.13 Conformance Class: Collection

Conformance Class		
http://www.opengis.net/spec/waterml/2.0/conf/xsd-collection		
Requirements	http://www.opengis.net/spec/waterml/2.0/req/xsd-collection	
Dependency	http://www.opengis.net/spec/waterml/2.0/req/uml-collection	
Test	/conf/xsd-collection/valid	
	Requirement	/req/xsd-collection/valid
	Test purpose	Verify that the Collection is a valid definition.
	Test method	Validate the XML document using the XML Schema document http://schemas.opengis.net/waterml/2.0/collection.xsd . Pass if no errors are reported. Fail otherwise.

Annex B Example XML instances (informative)

Examples are provided here for informative purposes, other examples are available with the normative schema.

B.1 Full collection example

The following example shows a complete collection. The temporal extent, a local dictionary of phenomenon descriptions and the sampling point for the observations are provided as common data for any observations in the collection.

This example conforms to the following conformance classes:

- /conf/xsd-xml-rules
- /conf/xsd-collection
- /conf/xsd-timeseries-observation
- /conf/xsd-timeseries-tvp-observation
- /conf/xsd-timeseries-tvp
- /conf/xsd-feature-of-interest-monitoring-point
- /conf/xsd-measurement-timeseries-tvp
- /conf/xsd-observation-process

```
<wml2:Collection
  gml:id="xsd-collection.example">
  <gml:description>Example collection for XML encoding
  http://www.opengis.net/spec/waterml/2.0/req/xsd-collection. Time series observation of water
  temperature</gml:description>
  <wml2:metadata>
    <wml2:DocumentMetadata gml:id="document-metadata.1">
      <wml2:generationDate>2011-11-28T10:05:05+11:00</wml2:generationDate>
      <wml2:version xlink:href="http://www.opengis.net/waterml/2.0" xlink:title="WaterML 2.0"/>
      <wml2:generationSystem>Manual</wml2:generationSystem>
      <wml2:profile xlink:href="http://www.opengis.net/spec/waterml/2.0/conf/xsd-xml-rules"/>
      <wml2:profile xlink:href="http://www.opengis.net/spec/waterml/2.0/conf/xsd-measurement-
  timeseries-tvp-observation"/>
      <wml2:profile xlink:href="http://www.opengis.net/spec/waterml/2.0/conf/xsd-measurement-
  timeseries-tvp"/>
      <wml2:profile xlink:href="http://www.opengis.net/spec/waterml/2.0/conf/xsd-feature-of-
  interest-monitoring-point"/>
      <wml2:profile xlink:href="http://www.opengis.net/spec/waterml/2.0/conf/xsd-collection"/>
      <wml2:profile xlink:href="http://www.opengis.net/spec/waterml/2.0/conf/xsd-observation-
  process"/>
    </wml2:DocumentMetadata>
  </wml2:metadata>

  <wml2:temporalExtent>
    <gml:TimePeriod gml:id="time-period.1">
      <gml:beginPosition>2011-11-21T12:27:00+10:00</gml:beginPosition>
      <gml:endPosition>2011-11-21T12:57:10+10:00</gml:endPosition>
    </gml:TimePeriod>
  </wml2:temporalExtent>

  <wml2:localDictionary>
    <gml:Dictionary gml:id="phenom_codes">
      <gml:identifier codeSpace="
  http://sweet.jpl.nasa.gov/2.3/">sweet_phenomenon</gml:identifier>
      <gml:dictionaryEntry>
        <gml:Definition gml:id="temperature">
```

```

    <gml:identifier
codeSpace="http://sweet.jpl.nasa.gov/2.3/propTemperature.owl">Temperature</gml:identifier>
    <gml:name
codeSpace="http://sweet.jpl.nasa.gov/2.3/propTemperature.owl">Temperature</gml:name>
    <gml:remarks>NASA SWEET definition of temperature</gml:remarks>
    </gml:Definition>
  </gml:dictionaryEntry>
</gml:Dictionary>
</wml2:localDictionary>

<wml2:samplingFeatureMember>
  <wml2:MonitoringPoint gml:id="monitoring-point.1">
    <gml:name codeSpace="http://www.csiro.au/">Deddington</gml:name>
    <sam:sampledFeature xlink:href="http://csiro.au/features/rivers/south_esk/deddington"
xlink:title="Deddington"/>
    <sams:shape>
      <gml:Point gml:id="location_deddington">
        <gml:pos srsName="urn:ogc:def:crs:EPSG::4326">-41.814935 147.568517 </gml:pos>
      </gml:Point>
    </sams:shape>
    <wml2:verticalDatum xlink:href="urn:ogc:def:crs:EPSG::5711" xlink:title="Australian height
datum"/>
    <wml2:timeZone>
      <wml2:TimeZone>
        <wml2:zoneOffset>+11:00</wml2:zoneOffset>
        <wml2:zoneAbbreviation>AEDT</wml2:zoneAbbreviation>
      </wml2:TimeZone>
    </wml2:timeZone>
  </wml2:MonitoringPoint>
</wml2:samplingFeatureMember>

<wml2:observationMember>
  <om:OM_Observation gml:id="observation.1">
    <gml:identifier codeSpace="http://www.example.com/observations">EX.OB.B.1</gml:identifier>
    <om:metadata>
      <wml2:ObservationMetadata>
        <gmd:contact xlink:href="http://www.example.com" xlink:title="Example Pty Ltd"/>
        <gmd:dateStamp>
          <gco:DateTime>2011-11-28T10:01:00+10:00</gco:DateTime>
        </gmd:dateStamp>
        <gmd:identificationInfo xlink:href="http://www.example.com/observations/C.1"
xlink:title="Observation C.1"/>
        <wml2:intendedObservationSpacing>PT15M</wml2:intendedObservationSpacing>
        <wml2:status xlink:href="http://water.usgs.gov/provisional.html"
xlink:title="Provisional data"/>
        <wml2:sampledMedium xlink:href="http://www.opengis.net/def/waterml/2.0/medium/Water"
xlink:title="Water"/>
      </wml2:ObservationMetadata>
    </om:metadata>
    <om:phenomenonTime xlink:href="#time-period.1" xlink:title="Temporal Extent"/>
    <om:resultTime>
      <gml:TimeInstant gml:id="time-instant.1">
        <gml:timePosition>2011-11-21T13:05:00+10:00</gml:timePosition>
      </gml:TimeInstant>
    </om:resultTime>
    <om:procedure>
      <wml2:ObservationProcess gml:id="observation-process.1">
        <wml2:processType xlink:href="
http://www.opengis.net/def/waterml/2.0/processType/Sensor" xlink:title="Sensor"/>
        <wml2:processReference xlink:href="http://www.example.com/sensor/1.0"
xlink:title="Sensor Sampling Regime 1.0"/>
      </wml2:ObservationProcess>
    </om:procedure>
    <om:observedProperty xlink:href="#temperature" xlink:title="Temperature"/>
    <om:featureOfInterest xlink:href="#monitoring-point.1" xlink:title="Deddington"/>
    <om:result>
      <wml2:MeasurementTimeseries gml:id="timeseries.1">

```

```

    <wml2:metadata>
      <wml2:TimeseriesMetadata>
        <wml2:temporalExtent xlink:href="#time-period.1"/>
      </wml2:TimeseriesMetadata>
    </wml2:metadata>
    <wml2:defaultPointMetadata>
      <wml2:DefaultTVPMeasurementMetadata>
        <wml2:uom code="Cel"/>
        <wml2:interpolationType
xlink:href="http://www.opengis.net/def/waterml/2.0/interpolationType/Continuous"
xlink:title="Instantaneous"/>
      </wml2:DefaultTVPMeasurementMetadata>
    </wml2:defaultPointMetadata>
    <wml2:point>
      <wml2:MeasurementTVP>
        <wml2:time>2011-11-21T12:27:00+10:00</wml2:time>
        <wml2:value>10.5</wml2:value>
      </wml2:MeasurementTVP>
    </wml2:point>
    <wml2:point>
      <wml2:MeasurementTVP>
        <wml2:time>2011-11-21T12:44:35+10:00</wml2:time>
        <wml2:value>10.5</wml2:value>
      </wml2:MeasurementTVP>
    </wml2:point>
    <wml2:point>
      <wml2:MeasurementTVP>
        <wml2:time>2011-11-21T12:57:10+10:00</wml2:time>
        <wml2:value>10.4</wml2:value>
      </wml2:MeasurementTVP>
    </wml2:point>
  </wml2:MeasurementTimeseries>
</om:result>
</om:OM_Observation>
</wml2:observationMember>
</wml2:Collection>

```

B.2 Categorical timeseries example

The following example shows an example categorical timeseries. This example demonstrates the following conformance classes:

- /conf/xsd-xml-rules
- /conf/xsd-timeseries-tvp-observation
- /conf/xsd-categorical-timeseries-tvp

```

<wml2:CategoricalTimeseries gml:id="ts_id33">
  <gml:description>This is an example showing a categorical time series in waterml2.0.
  Describes a timeseries of manual weather observations. </gml:description>

  <wml2:metadata>
    <wml2:TimeseriesMetadata>
      <wml2:temporalExtent>
        <gml:TimePeriod gml:id="tp_1">
          <gml:beginPosition>2011-11-16T00:00:00+11:00</gml:beginPosition>
          <gml:endPosition>2011-11-18T00:00:00+11:00</gml:endPosition>
        </gml:TimePeriod>
      </wml2:temporalExtent>
    </wml2:TimeseriesMetadata>
  </wml2:metadata>

  <wml2:point>
    <wml2:CategoricalTVP>
      <wml2:time>2011-11-16T00:00:00+11:00</wml2:time>
      <wml2:value>

```

```

    <swe:Category>
      <swe:description>Fairly uniform precipitation composed exclusively of very small water
droplets (less than 0.5 mm in diameter)
      very close to one another</swe:description>
      <swe:codeSpace xlink:href="http://www.bom.gov.au/info/wwords/">
      <swe:value>Drizzle</swe:value>
    </swe:Category>
  </wml2:value>
</wml2:CategoricalTVP>
</wml2:point>
<wml2:point>
  <wml2:CategoricalTVP>
    <wml2:time>2011-11-17T00:00:00+11:00</wml2:time>
    <wml2:value>
      <swe:Category>
        <swe:description>Usually begin and end suddenly. Relatively short-lived, but may last
half an hour. Fall from cumulus clouds, often separated by blue sky. Showers may fall in patches
rather than across the whole forecast area. Range in intensity from light to very
heavy</swe:description>
        <swe:codeSpace xlink:href="http://www.bom.gov.au/info/wwords/">
        <swe:value>Showers</swe:value>
      </swe:Category>
    </wml2:value>
  </wml2:CategoricalTVP>
</wml2:point>
<wml2:point>
  <wml2:CategoricalTVP>
    <wml2:time>2011-11-18T00:00:00+11:00</wml2:time>
    <wml2:value xsi:nil="true"></wml2:value>
    <wml2:metadata>
      <wml2:TVPMetadata>
        <wml2:nilReason xlink:href="http://www.opengis.net/def/nil/OGC/0/missing"/>
        <wml2:comment>No observation performed.</wml2:comment>
      </wml2:TVPMetadata>
    </wml2:metadata>
  </wml2:CategoricalTVP>
</wml2:point>
</wml2:CategoricalTimeseries>

```

B.3 Monitoring point example

The following example shows an example monitoring point description, including a description of the station owner.

```

<wml2:MonitoringPoint gml:id="xsd-monitoring-point.example"
  <gml:description>Example monitoring point for XML
http://www.opengis.net/spec/waterml/2.0/req/xsd-monitoring-point. Nile river at Deddington, South
Esk catchment, Tasmania</gml:description>

```

```

  <gml:name codeSpace="http://www.csiro.au/">Deddington</gml:name>
  <sam:sampledFeature xlink:href="http://csiro.au/features/rivers/nile" xlink:title="Nile river"/>

  <sams:shape>
    <gml:Point gml:id="location_deddington">
      <gml:pos srsName="urn:ogc:def:crs:EPSG::4326">-41.814935 147.568517 </gml:pos>
    </gml:Point>
  </sams:shape>

  <wml2:relatedParty>
    <gmd:CI_ResponsibleParty>
      <gmd:organisationName>
        <gco:CharacterString>Department of Primary Industries, Parks,
Water and Environment (DPIPWE)</gco:CharacterString>
      </gmd:organisationName>
    </gmd:CI_ResponsibleParty>
  </wml2:relatedParty>

```

```

    <gmd:role>
      <gmd:CI_RoleCode
codeList="http://asdd.ga.gov.au/asdd/profileinfo/gmxCodeLists.xml#CI_RoleCode"
      codeListValue="CI_RoleCode_owner">Owner</gmd:CI_RoleCode>
    </gmd:role>
  </gmd:CI_ResponsibileParty>
</wml2:relatedParty>

  <wml2:verticalDatum xlink:href="urn:ogc:def:crs:EPSG::5711" xlink:title="Australian height
datum"/>
  <wml2:timeZone>
    <wml2:TimeZone>
      <wml2:zoneOffset>+11:00</wml2:zoneOffset>
      <wml2:zoneAbbreviation>AEDT</wml2:zoneAbbreviation>
    </wml2:TimeZone>
  </wml2:timeZone>
</wml2:MonitoringPoint>

```

B.4 Forecasting example

The following example shows an example forecast of river discharge, using a measurement timeseries.

```

<wml2:Collection gml:id="deterministic_forecast_TAPM4_20100506T00Z">
  <gml:description>Example of a Hydrologic Forecast timeseries
  </gml:description>
  <wml2:metadata>
    <wml2:DocumentMetadata gml:id="doc_d">
      <wml2:generationDate>2011-09-21T16:46:00+10:00</wml2:generationDate>
      <wml2:version xlink:href="http://www.opengis.net/waterml/2.0"/>
    </wml2:DocumentMetadata>
  </wml2:metadata>

  <wml2:observationMember>
    <om:OM_Observation gml:id="series_one">
      <om:phenomenonTime>
        <gml:TimePeriod gml:id="forecast_period">
          <gml:beginPosition>2010-05-06T12:00:00Z</gml:beginPosition>
          <gml:endPosition>2010-05-16T12:00:00Z</gml:endPosition>
        </gml:TimePeriod>
      </om:phenomenonTime>

      <om:resultTime>
        <gml:TimeInstant gml:id="forecast_available">
          <gml:timePosition>2010-05-06T05:00:00Z</gml:timePosition>
        </gml:TimeInstant>
      </om:resultTime>

      <om:validTime>
        <gml:TimePeriod gml:id="valid_period">
          <gml:beginPosition>2010-05-06T05:00:00Z</gml:beginPosition>
          <gml:endPosition>2010-05-07T05:00:00Z</gml:endPosition>
        </gml:TimePeriod>
      </om:validTime>

      <om:procedure xlink:href="NCRFC:MinnesotaRiver_Forecast"
xlink:title="NCRFC:MinnesotaRiver_Forecast"
      xlink:arcrole="http://www.opengis.net/def/waterml/2.0/processType/Simulation"/>

      <om:parameter>
        <om:NamedValue>
          <om:name xlink:title="T0 (Time of analysis)" xlink:role="analysisTime"/>

```



```

    <om:value xsi:type="gml:TimePositionType">2010-05-06T00:00:00+00:00</om:value>
  </om:NamedValue>
</om:parameter>
<om:parameter>
  <om:NamedValue>
    <om:name xlink:title="Init time of model" xlink:role="initTime"/>
    <om:value xsi:type="gml:TimePositionType">2010-05-03T12:00:00+00:00</om:value>
  </om:NamedValue>
</om:parameter>

<om:observedProperty xlink:href="http://sweet.jpl.nasa.gov/2.3/phenHydro.owl#Discharge"
xlink:title="streamflow"/>
<om:featureOfInterest xlink:href="http://www.nws.noaa.gov/hb5id/TAPM4" xlink:title="Paradise
12W, MN"/>
<om:result>
  <wml2:MeasurementTimeseries gml:id="ts_one">
    <wml2:metadata>
      <wml2:MeasurementTimeseriesMetadata>
        <wml2:temporalExtent>
          <gml:TimePeriod gml:id="fc_1">
            <gml:beginPosition>2010-05-06T00:00:00+00:00</gml:beginPosition>
            <gml:endPosition>2010-05-16T12:00:00+00:00</gml:endPosition>
          </gml:TimePeriod>
        </wml2:temporalExtent>
        <wml2:baseTime>2010-05-06T00:00:00+00:00</wml2:baseTime>
        <wml2:spacing>PT6H</wml2:spacing>
      </wml2:MeasurementTimeseriesMetadata>
    </wml2:metadata>
    <wml2:defaultPointMetadata>
      <wml2:DefaultTVPMeasurementMetadata>
        <wml2:qualifier xlink:href="http://www.example.com/hydro/forecasts/status/approved"
xlink:title="Approved and issued"/>
        <wml2:uom code="m3/s"/>
        <wml2:interpolationType
xlink:href="http://www.opengis.net/def/waterml/2.0/interpolationType/Continuous"
xlink:title="Instantaneous"/>
      </wml2:DefaultTVPMeasurementMetadata>
    </wml2:defaultPointMetadata>
    <wml2:point>
      <wml2:MeasurementTVP>
        <wml2:value>21.7</wml2:value>
      </wml2:MeasurementTVP>
    </wml2:point>
    <wml2:point>
      <wml2:MeasurementTVP>
        <wml2:value>21.7</wml2:value>
      </wml2:MeasurementTVP>
    </wml2:point>
    <wml2:point>
      <wml2:MeasurementTVP>
        <wml2:value xsi:nil="true"/>
      <wml2:metadata>
        <wml2:TVPMeasurementMetadata>
          <wml2:nilReason xlink:href="http://www.opengis.net/def/nil/OGC/0/missing"
xlink:title="missing"/>
        </wml2:TVPMeasurementMetadata>
      </wml2:metadata>
    </wml2:MeasurementTVP>
    </wml2:point>
    <wml2:point>
      <wml2:MeasurementTVP>
        <wml2:value>21.8</wml2:value>
      </wml2:MeasurementTVP>
    </wml2:point>
    <wml2:point>
      <wml2:MeasurementTVP>
        <wml2:value>22.0</wml2:value>
      </wml2:MeasurementTVP>
    </wml2:point>
  </wml2:MeasurementTimeseries>
</om:result>

```

```

    </wml2:MeasurementTVP>
  </wml2:point>
  <wml2:point>
    <wml2:MeasurementTVP>
      <wml2:value>22.6</wml2:value>
    </wml2:MeasurementTVP>
  </wml2:point>
</wml2:MeasurementTimeseries>
</om:result>
</om:OM_Observation>
</wml2:observationMember>
</wml2:Collection>

```

Annex C Use cases and requirements (informative)

C.1 Operational forecasting activity at hydrological forecasting service in support of flooding related emergencies	
Summary	Routine work at NMHSs in order to provide emergency agencies, decision makers and citizens with accurate assessment on hydrological hazards, observed or forecasted. This includes post-processing and visualization of observations and simulations results at designated forecast points addressing peak to flood, flood duration, flood extent.
Users/actors	Forecaster at operational Meteorological and Hydrological Services (NMHSs), emergency decision-makers, citizens.
Information types	<ul style="list-style-type: none"> <input type="checkbox"/> In-situ observations at hydro stations (gages, reservoirs) and meteo stations; <input type="checkbox"/> Forecast products (deterministic timeseries, ensembles) at forecast points, generated by simulations and statistical processing; <input type="checkbox"/> Emergency agency-oriented alerts (of threshold exceedence) and reports.
Query types	<p><i>For forecasters:</i></p> <ul style="list-style-type: none"> <input type="checkbox"/> Subscribe for data updates (including data quality or confidence) at known points (in-situ and forecast points) and incremental retrieval of spatio-temporal subset updates to be ingested for the forecasting process.

	<ul style="list-style-type: none"> <input type="checkbox"/> Retrieve availability of spatio-temporal subsets, <input type="checkbox"/> Discover product and service metadata, <input type="checkbox"/> Retrieve spatio-temporal subsets (including time series) to be visualized. <p><i>For emergency agencies:</i></p> <ul style="list-style-type: none"> <input type="checkbox"/> Subscribe to alerting service based on threshold exceedence. <input type="checkbox"/> Retrieve data by geographic area, retrieve data for set of points, retrieve observations and forecast product (including confidence) to be visualized
C.2 Routine operational forecasting activity in support of infrastructure operation	
Summary	Routine work at NMHSs and infrastructure operators (reservoirs, water supply systems, polder systems) in order to exchange information on expected inflow (to reservoirs) or intakes (in water supply systems) and planned releases (of reservoirs) or discharges having an effect on downstream conditions.
Users/actors	Forecaster at operational Meteorological and Hydrological Services (NMHSs), infrastructure operators.
Information types	<ul style="list-style-type: none"> <input type="checkbox"/> In-situ observations at hydro stations (gages, reservoirs) and meteo stations; <input type="checkbox"/> Forecast products (deterministic timeseries, ensembles) at forecast points, generated by simulations and statistical processing; <input type="checkbox"/> Time series of planned intake and releases/discharge; <input type="checkbox"/> Operator-oriented alerts (of threshold exceedence) and report.
Query types	<i>For forecasters:</i>

	<ul style="list-style-type: none"> <input type="checkbox"/> Subscribe for data updates (including data quality or confidence) at known points (in-situ, forecast points, infrastructure points) and incremental retrieval of spatio-temporal subset updates to be ingested for the forecasting process. <input type="checkbox"/> Retrieve availability of spatio-temporal subsets, <input type="checkbox"/> Discover product and service metadata, retrieve spatio-temporal subsets (including time series) to be visualized <input type="checkbox"/> Subscribe to alerting service based on threshold exceedence. Retrieve data by geographic area, retrieve data for set of points, retrieve observations and forecast product (including confidence) to be visualized <p><i>For operators:</i></p> <ul style="list-style-type: none"> <input type="checkbox"/> Subscribe for data updates (including data quality or confidence) at known points (in-situ, forecast points, infrastructure points) and incremental retrieval of spatio-temporal subset updates to be ingested for the operation planning process. <input type="checkbox"/> Subscribe to alerting service based on threshold exceedence. Retrieve data by geographic area, retrieve data for set of points, retrieve observations and forecast product (including confidence) to be visualized.
--	---

C.3 Exchange of groundwater levels across international borders

Summary	Exchange of groundwater levels in wells across the US-Canada border to allow enhanced understanding of cross-border aquifer issues.
User communities/actors	USGS, NRCan (Natural Resources Canada), Interested party
Information types	<ul style="list-style-type: none"> <input type="checkbox"/> Well locations (sampling features) and description <input type="checkbox"/> Observations of water level within wells (dynamic and static/archival)

	<ul style="list-style-type: none"> <input type="checkbox"/> Identify the process used in making the observation.
Query types	<ul style="list-style-type: none"> <input type="checkbox"/> Retrieve all wells within a bounding box. <input type="checkbox"/> Retrieve all level observations within a bounding box. <input type="checkbox"/> Download observation data
C.4 Generic data exchange scenario between stakeholders	
Summary	Generic exchange scenario describing the transfer of data from one stakeholder to another.
User communities/actors	<p>Potential stakeholders:</p> <ul style="list-style-type: none"> <input type="checkbox"/> Public data consumer <input type="checkbox"/> Professional data providers <input type="checkbox"/> Community data providers <input type="checkbox"/> Research data providers <input type="checkbox"/> Research data users <input type="checkbox"/> Water policy data users <input type="checkbox"/> Mature data users with automated systems
Purpose of exchange	<ul style="list-style-type: none"> <input type="checkbox"/> Forecast data delivery <input type="checkbox"/> adhoc transfer of raw values <input type="checkbox"/> adhoc transfer of aggregated values <input type="checkbox"/> Archive synchronisation <input type="checkbox"/> Incremental update <input type="checkbox"/> Aggregated data / data product
	<p>In order for correctly interpretable data to be exchanged, the exchange document must conform to the following requirements:</p> <p>Data content</p> <ul style="list-style-type: none"> <input type="checkbox"/> Data points in a transfer are considered to be chained, gaps in data should be clearly indicated. <input type="checkbox"/> Total type data series need to have a anchor point before the first value <input type="checkbox"/> A document may contain many parameters <input type="checkbox"/> A document should describe how the contained data

	<p>set is connected to earlier data, if it is connected at all</p> <ul style="list-style-type: none"> □ A document should contain data licensing text □ A document should describe the type of data contained <ul style="list-style-type: none"> □ Is it raw □ Is it data produced by some function □ A document should contain reference to a function that has been applied to the data □ A document should contain information about its creation <ul style="list-style-type: none"> □ Source system □ Creation data □ Source query parameters? □ A document should state the period for which the time series(s) contained apply □ A document should enable the removal of time series data in the destination system □ A document should enable the replacement of time series data in the destination system □ A document should enable the creation of time series data in the destination system □ A data chains period of application is the primary update key rather than the DT value of data points <p>Document size</p> <ul style="list-style-type: none"> □ A document should be able to transmit the full period of record for multiple parameters □ A document should be able to transmit a series fragment to be appended to an existing series □ A document should be able to transmit raw, as observed values □ A document should be able to transmit derived or modified values □ A document should be able to transmit multiple
--	---

	<p>version of the same parameter, all uniquely identified</p> <ul style="list-style-type: none"> <input type="checkbox"/> Each version of the same parameter should have its own series description metadata
--	---

C.5 Retrieval for data by external users	
Summary	A data provider exposes services for consumption by outside users.
User communities/actors	CUAHSI
Information types	<ul style="list-style-type: none"> <input type="checkbox"/> Observation Period of Record/Offering <input type="checkbox"/> Site/Station location and description <input type="checkbox"/> Timeseries observations of observed properties, such as Stream Discharge <input type="checkbox"/> Identify the process used in making the observation, <input type="checkbox"/> References to analytical sample information, if appropriate.
Query types	<ul style="list-style-type: none"> <input type="checkbox"/> Discover stations for a specified observed property in a specified bounding box. <input type="checkbox"/> Discover vocabularies and code lists for a data source/data provider. <input type="checkbox"/> Retrieve observations for a specified observed property from a single station <input type="checkbox"/> Retrieve all observations for a specified observed property for sites in a bounding box.

Annex D Relationships to other conceptual models (informative)

Annex D (Best practices in use of the observation and sampling models) of ISO19156 identifies the relationship between sampling observations that produce coverage results. [CSMLv3] also identifies this relationship, extending the comparison to include Unidata netCDF Common Data Model and Climate Forecasts Point Observation Conventions. CSML categorises the core types as shown in Table 13.

Table 13 - Climate Science Markup Language (CSML) spatialtemporal sampling categories

CSML Observation type	Observation ‘phenomenon time’	Observation ‘feature-of-interest’	Description	Example
<i>Point</i>	instant	sampling point	Single point measurement in time and space	Single raingauge precipitation measurement
<i>PointSeries</i>	period	sampling point	Time-series of point measurements at a fixed location in space.	Time-series of daily raingauge precipitation measurements; river-flow time-series
<i>Profile</i>	instant	sampling curve	Single instantaneous ‘profile’ of a property along a vertical line in space.	Expendable bathythermograph observation of seawater temperature
<i>ProfileSeries</i>	period	sampling curve	Time-series of vertical profiles at a fixed horizontal location.	Radar wind profiler measurement

<i>Grid</i>	instant	sampling solid	A gridded field at a single time instant.	Midnight atmospheric surface pressure field analysed on a grid
<i>GridSeries</i>	period	sampling solid	An evolving gridded field at a succession of time instants	Time-series of three-dimensional oceanic velocity field from a finite-difference general circulation model
<i>Trajectory</i>	period	sampling curve	Property varying along a meandering curve in time and space.	Pollutant concentration from mobile air quality sensor
<i>Section</i>	period	sampling surface	Series of profiles topologically offset from a trajectory	Vertical profiles of water current measurements taken by an acoustic doppler current profiler towed along a ship's track
<i>Swath</i>	instant	sampling surface	Two-dimensional surface grid along a satellite ground path	AVHRR satellite imagery
<i>ScanningRadar</i>	period	sampling surface	Profiles along a radar look direction rotating in azimuth at fixed elevation.	Weather radar

A WaterML2.0 *TimeseriesObservation* is consistent with the *PointSeries* CSML Observation type with one variation: the feature of interest in a WaterML2.0 *TimeseriesObservation* does not restrict the feature of interest property to be a sampling feature. This was not done as timeseries observations may have a domain-level feature of interest such as a river section, dam, lake etc. Often such observations will be an aggregation of multiple sampling feature observations.

Annex E Describing observed properties/phenomena (informative)

This profile does not define a list of observed phenomena for the hydrology domain. A number of existing initiatives exist that have started to harmonise on the potential set of hydrological observables. This set is most often dynamic, with new additions being required due to new sensing techniques or new properties being identified for measure (this is very typical in the water quality area).

The observed phenomenon is specified through linking to a definition of the concept through an identifier (e.g. a URI). The identifier will link to a definition of the concept, preferably one maintained by a recognised standards group, such as WMO.

‘OGC 11-120 – Observable Property Specification’ is a draft submission to OGC describing a conceptual and XML implementation model for observed properties. This model has not been directly used in this standard, as it is work in progress; some initial background into its use is provided here for future consideration.

```
<op:ComplexObservableProperty gml:id="daily mean water temp">
  <op:label>Daily mean water temperature</op:label>
  <op:basePhenomenon
xlink:href="http://nwis.waterdata.usgs.gov/usa/nwis/pmcodes?pm_group=Physical&
radio_pm_search=pm_search&pm_search=00010&casrn_search=&srsname_search=&
format=html table&show=parameter_group_nm&show=parameter_nm&show=casrn&show=srsname&show=parameter
_units" xlink:title="Water temperature" />
  <op:qualifier>
    <op:StatisticalQualifier gml:id="daily_mean">
      <op:statisticalOperator xlink:href="http://www.uncertml.org/statistics/mean" />
      <op:statisticalPeriod>P1D</op:statisticalPeriod>
    </op:StatisticalQualifier>
  </op:qualifier>
</op:ComplexObservableProperty>
```

Code listing 1 - Example showing daily mean temperature

```
<op:ComplexObservableProperty gml:id="daily_mean_water_temp_6ft">
  <op:label>Daily mean water temperature - 6ft down</op:label>
  <op:basePhenomenon xlink:href="#daily_mean_water_temp" />
  <op:constraint>
    <swe:Quantity definition="http://www.opengis.net/def/waterml/2.0/vertical_offset">
      <swe:label>6ft depth</swe:label>
      <swe:uom xlink:href="ft" />
      <swe:value>6</swe:value>
    </swe:Quantity>
  </op:constraint>
</op:ComplexObservableProperty>
```

Code listing 2 - Example showing derived daily mean temperature

Annex F

Use of SWE Common encoding (informative)

The use of the SWE Common 2.0 encoding techniques was investigated but given its tendency towards run-time definition of structure, the WaterML2 community decided to proceed with a traditional GML-XML style encoding to allow stricter definitions and re-use of XML tools. A SWE Common 2.0 profile will be investigated and continued, most likely through the SWE Common SWG. The group has been previously discussing setting up basic profiles in which common structures may be defined (such as timeseries). An example SWE data record structure is shown for informative purposes only.

```
<swe:DataRecord>
  <!-- http://www.opengis.net/WaterML2.0/def/sweCommonProfile/ -->
  <swe:field name="waterML2_timeseries">
    <swe:DataRecord>
      <swe:field name="period_of_record">
        <swe:TimeRange
          definition="http://www.opengis.net/WaterML2.0/def/sweCommonProfile/period_of_record">
            <swe:uom xlink:href="urn:ogc:def:unit:ISO:8601"/>
          </swe:TimeRange>
        </swe:field>
        <!-- other time series level metadata if needed... -->
        <swe:field name="series">
          <swe:DataArray>
            <swe:elementCount>
              <swe:Count
                definition="http://www.opengis.net/WaterML2.0/def/sweCommonProfile/count"></swe:Count>
              </swe:elementCount>
              <swe:elementType name="point">
                <swe:DataRecord>

                  <!-- Time field -->
                  <swe:field name="time">
                    <swe:Time
                      definition="http://www.opengis.net/WaterML2.0/def/sweCommonProfile/time">
                        <gml:name>Time instant</gml:name>
                        <swe:uom xlink:href="urn:ogc:def:unit:ISO:8601"/>
                      </swe:Time>
                    </swe:field>

                    <!-- The value of the observed property -->
                    <swe:field name="value">
                      <swe:Quantity
                        definition="http://www.opengis.net/WaterML2.0/def/sweCommonProfile/value">
                          <gml:name>Value of observed property &#8212; observed property specified by O&M
                        </gml:name>

                        <!-- What to do here? -->
                        <swe:uom xlink:href=""/>
                      </swe:Quantity>
                    </swe:field>

                    <!-- The value of the uom property -->
                    <swe:field name="uom">
                      <swe:Category
                        definition="http://www.opengis.net/WaterML2.0/def/sweCommonProfile/uom">

```

```

        <gml:name>Specifies the UCUM code</gml:name>
        <swe:codeSpace xlink:href="http://unitsofmeasure.org/" />
      </swe:Category>
    </swe:field>

    <!-- The interpolation type of the time series -->
    <swe:field name="datatype">
      <swe:Category
definition="http://www.opengis.net/WaterML2.0/def/sweCommonProfile/datatype">
        <gml:name>Specifies the data type of the time series</gml:name>
        <swe:codeSpace
xlink:href="http://www.opengis.net/WaterML2.0/def/timeseriesType"/>
        </swe:Category>
      </swe:field>

      <!-- Free text comment field -->
      <swe:field name="comment">
        <swe:Text
definition="http://www.opengis.net/WaterML2.0/def/sweCommonProfile/comment">
          <gml:name>Free text comment associated with a data point</gml:name>
        </swe:Text>
      </swe:field>

      <!-- Code list qualifier -->
      <swe:field name="qualifier">
        <swe:Category>
          <gml:name>A qualifier code for the point</gml:name>
          <swe:codeSpace
xlink:href="http://www.opengis.net/WaterML2.0/def/sweCommonProfile/qualifier"/>
          </swe:Category>
        </swe:field>

      </swe>DataRecord>
    </swe:elementType>
  </swe:DataArray>
</swe:field>
</swe>DataRecord>
</swe:field>
</swe>DataRecord>

```

Annex G - WMO monitoring type categories (informative)

WMO_CommunityTopicCategoryCode

- 001 weather observations
- 002 Weather forecasts
- 003 meteorology
- 004 hydrology
- 005 climatology
- 006 landMeteorologyClimate
- 007 synopticMeteorology
- 008 marineMeteorology

009 agriculturalMeteorology
010 Aerology
011 marineAerology
012 oceanography
013 landHydrology
014 rocketSounding
015 Pollution
016 waterPollution
017 landWaterPollution
018 seaPollution
019 landPollution
020 airPollution
021 glaciology
022 actinometry
023 satelliteObservation
024 airplaneObservation
025 observationPlatform

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