Report 39r2

Hydrologic Information – Metadata

Semantic structure for the description of hydrologic data (GRDC HYDROLOGIC METADATA)

Global Runoff Data Centre

GRDC operates under the auspices of the World Meteorological Organization (WMO) with the support of the Federal Republic of Germany within the Federal Institute of Hydrology (BfG)

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About the Global Runoff Data Centre (GRDC):

The GRDC is acting under the auspices of the World Meteorological Organization (WMO) and is supported by WMO Resolutions 21 (Cg XII, 1995) and 25 (Cg XIII, 1999). Its primary task is to maintain, extend and promote a global database on river discharge aimed at supporting international organizations and programs by serving essential data and products to the international hydrologic and climate research and assessment community in their endeavour to better understand the Earth system. The GRDC was established at the German Federal Institute of Hydrology (BfG) in 1988. The National Hydrological and Meteorological Services of the191 WMO Member states and territories are the principal data providers for the GRDC.

All questions regarding this document should be directed to the author or the GRDC.

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Abstract

Metadata are commonly recognised as *data about data.* Metadata provides the information needed to identify data resources, to assess, access, and use the discovered data and products.

The GRDC HYDROLOGIC METADATA model is developed to associate the metadata describing a set of observation data with the information about the observations made to obtain the data arranged therein as well as to identify the hydrologic feature represented by the dataset. It provides a description of temporal and spatial coverages created for global exchange by further processing of source data which originates from preceding observations.

The core concept of GRDC HYDROLOGIC METADATA is that of a dataset containing the attribute values collected from observing a particular characteristic property of the hydrology phenomenon represented in the dataset. The details of the corresponding observation are understood as the metadata describing the determination of the values in the dataset. The user-oriented processing of original data into a new dataset is described as observation on its own.

This document describes the concepts of the GRDC HYDROLOGIC METADATA model. Primarily developed for the datasets created and maintained by the GRDC, the basic concepts may be generally applicable to integrate the observation metadata in the description of the dataset. Concept validation and test implementations are required to further develop and consolidate the proposed concepts for applicability and future use in the WIS and WIGOS.

Keywords

Data: access, integration, discovery, retrieval; feature; hydrology; information; metadata; model; semantics; time series; variable; WMO; WIS; WIGOS

Foreword

The Global Runoff Data Centre (GRDC) is the world-wide archive of river discharge data. It operates under the auspices of the World Meteorological Organization (WMO) with support from the Federal Republic of Germany. The GRDC is operated by the German Federal Institute of Hydrology (BfG). The world-wide exchange of hydrologic data and information in support of climate research and integrated water resources management is the principal reason for the operation of the GRDC.

The WMO promotes the utilization of international industry standards for transfer protocols, hardware and software enabling the routine data collection and automated dissemination of observed data as well as ad-hoc requests for data and products. Being a recognized international standardization body, WMO has the mandate to set standards in these areas.

The water related activities are shaped by the WMO Technical Commission for Hydrology (WMO-CHy). This includes advice on the standardization of various aspects of hydrologic observations, as well as on the sharing and exchanging of hydrologic data using modern information and communication technology. In 2012, CHy at its fourteenth session took note of the developments undertaken with respect to the work of the joint WMO/OGC Hydrology Domain Working Group. A discussion process has been started under the guidance of WIS and WIGOS to consider the OGC WaterML2.0 Part 1:Time series as standard for data exchange and the HY_FEATURES common hydrologic feature model as standard model for referencing hydrologic features in the community of WMO-CHy Member countries.

Recognizing that the lack of standardization is one of the major obstacles in the practice of data exchange, the WMO Technical Commission for Hydrology (CHy) during its thirteenth session 2009 had encouraged the GRDC to develop a standardised hydrologic metadata profile under the overall guidance of WIS/WIGOS. The CHy-14 urged the GRDC to contribute to the evolving WIGOS Metadata Profile by aligning the concepts of GRDC HYDROLOGIC METADATA model to common concepts and relevant international standards, particularly the OGC WaterML2 series of domain-specific standards and the WMO CORE METADATA PROFILE of the ISO19115:2003 Metadata.

This document describes the GRDC HYDROLOGIC METADATA model, a conceptual model for the description of sets of hydrologic data generated from observation for global exchange and reporting. Primarily developed for the datasets created and maintained by the GRDC, the basic concepts may be generally applicable to jointly provide metadata about the dataset and observational information. Concept validation and test implementations are required to further develop and consolidate the proposed concepts for applicability and future use in WIS and WIGOS.

Preface

The World Meteorological Organization (WMO) and the Open Geospatial Consortium (OGC) established in 2009 the joint WMO/OGC Hydrology Domain Working Group (HDWG) to improve the discoverability, accessibility and usability of water information and hydrologic data. Consisting of members from government, research and the commercial sectors, this working group brings organizations together to agree on the ways to significantly improve the ability to share water information. Focus of activities is on the development of WaterML2 as a series of domain-specific standards with the intention to provide a means by which diverse systems can encode their particular data in a standard way for communication with other systems and for the aggregation of data from diverse sources. In this context the GRDC has

contributed to the development of domain-specific concepts for hydrologic feature identification, especially those of general applicability across information systems that concern or interact with the hydrology domain.

In September 2012, the OGC adopted the specification WaterML2.0 Part 1:Time series as OGC Standard 10-126r3 for the encoding of water observation time series. In September 2013, the OGC adopted the discussion paper OGC 11-039r3 on the HY_FEATURES common hydrologic feature model, a conceptual model for hydrologic features independent from approximate geometric representations at different scales. This model allows common reference to both the specific semantics and individual identifiers of hydrologic features across scientific sub-disciplines in hydrology.

The GRDC HYDROLOGIC METADATA model is developed to associate the metadata describing a set of observation data with the information about the observations made to obtain the data arranged therein, as well as to identify the hydrologic feature represented by a dataset containing values of the observed characteristic property.

The GRDC HYDROLOGIC METADATA model will apply the ISO19115:2003 METADATA fundamentals in terms of the WMO CORE METADATA PROFILE, specialised with respect to the

- temporal representation of observation data,
- time series content (in addition to spatial coverages),
- lineage from preceding observations,
- reliability and maintenance of source data,
- dissemination of data using services.

The GRDC HYDROLOGIC METADATA model references the fundamental concepts of the ISO19115:Metadata and of the WaterML2.0 Part1:Timeseries standard to provide the description of the dataset as needed for Data, Access and Retrieval (DAR) services of the WIS. The corresponding observation is described using concepts of ISO19156:2011 OBSERVATION AND MEASUREMENT, in particular the monitoring station and the observation process in terms of WaterML2.0. A concept of a Variable is proposed to identify the hydrologic variable by name, concept, nature, and constraints. The HY_FEATURES common hydrologic feature model is used to reference the hydrologic feature which is represented in the dataset.

The GRDC HYDROLOGIC METADATA model is designed as a set of Application Schemas using ISO19103:2005 Conceptual Schema Language and ISO19109:2005 General Feature Model. The definitions, class relationships and attributes, their obligation and maximum occurrence may be taken from Annex: GRDC HYDROLOGIC METADATA Data Dictionary.

This document is a completely revised version of the first draft version of the GRDC HYDROLOGIC METADATA documentation and replaces the document of July 2009. It is distributed for review and comment and is subject to further change without notice. Recipients of this document are invited to provide supporting documentation. Suggested additions, changes, and comments on this report are welcome and encouraged.

The revised 2nd edition of the GRDC HYDROLOGIC METADATA model emerges from the adjustment and complete re-arrangement of the first draft version taking into account the recent developments in the WMO/OGC HDWG, particularly the OGC WaterML2 standard series and the HY_FEATURES common hydrologic feature model.

1 Introduction

Metadata are commonly recognised as *data about data* needed to identify data resources, to assess, access, and use the discovered data. The exchange of information and data requires structured metadata describing the content, lineage, maintenance, distribution of and access to a set of data. Standardised metadata support Discovery, Access and Retrieval (DAR) services, particularly automated Web services such as Catalogue Service for the Web (CSW), Web Coverage Service (WCS), Web Feature Service (WFS) and Web Map Service (WMS), or Sensor Observation Service (SOS).

WIS, the WMO Information System, provides mechanisms for the international exchange of information related to weather, climate and water. Recognising that *metadata is the descriptive data necessary to … find, process and use data, information and products*, the WMO CORE METADATA PROFILE of the ISO19115: Geographic Information - Metadata standard was developed. It is defined as an informal category-1 profile of the ISO19115:2003 Geographic information – Metadata. The current version, 1.3, defines the *content, structure and encoding of discovery metadata published within the future WIS DAR Catalogue* [WMO, 2013a]. It was approved by the WMO Executive Council in May 2013.

WIGOS, the WMO Integrated Global Observing System, is a coordinated system which is comprised of the present WMO global observing systems. Recognising the datasets in the scope of the WMO CORE METADATA PROFILE as observation results, observational information is required to comprehensively identify a dataset and evaluate the quality of the data provided in the resource. Complementary to the WIS discovery metadata, a WIGOS metadata standard is under development that allows the essential information about the observation that generated the data to be exchanged unambiguously, regardless of the format used for the transfer. WIGOS Metadata shall provide information about the object under observation and the observed variable, the monitoring station or platform used as well as the measurement process and the interpretation algorithms applied .

WIS and WIGOS provide the framework for the GRDC HYDROLOGIC METADATA intended to describe datasets and products, particularly time series, generated from observing a characteristic variable of the represented hydrologic feature. With respect to observation data compiled for global exchange, special information is required concerning

- observation origin of data,
- temporal representation of hydrologic data, particularly the description of time series of ordered time-value pairs in terms of the OGC WaterML2.0 Part 1:Time series,
- sets of secondary data created for dissemination using Web services, as intended for the Data Collection and Production Centres (DCPC) of the WIS,
- the data processing from measurement to information as well as reliability and maintenance of source data,
- references to the hydrologic feature that is represented by the resource.

2 Scope

The initial scope of the GRDC HYDROLOGIC METADATA model is defined by the concerns of WMO-CHy to facilitate the information sharing within the hydrologic community of the WMO Member countries. Exchangeable and compatible metadata are required to easily identify and access the datasets and products that are disseminated by the WMO World Data Centres in the sense of WIS DCPCs.

The exchange of hydrological data and information on the global scale is the principal reason for operating the GRDC. Its primary objective consists in supporting the water and climate related programmes and projects of the United Nations, its specialised agencies and the scientific research community by collecting and disseminating hydrological data across national borders in a long-term perspective. GRDC holds the GLOBAL RUNOFF DATABASE comprising currently river discharge data of more than 9.000 gauging stations from all over the world. The data collected and maintained by the GRDC result from observations usually undertaken by the National Hydrological Services (NHS). Based on the data held in the GLOBAL RUNOFF DATABASE, special datasets are compiled by GRDC for global exchange, as well as a number of GIS layers for the generation of map products. Metadata concepts are needed which may be applicable to time series, shape files and sets of gridded data.

The GRDC HYDROLOGIC METADATA conceptual model provides a semantic structure to describe the datasets created and maintained by the GRDC. It provides the information needed for the DAR services as required by the WIS complemented with the observation information to meet the metadata requirements of the WIGOS programme. Standard concepts documented in the ISO19000 series and corresponding OGC specifications, particularly WaterML2.0 Part 1:Time series (OGC 10-126r3) and the HY_FEATURES common hydrologic feature model (OGC 11-039r3) are used whenever suitable The definitions in GRDC HYDROLOGIC METADATA model may be subject to change according to further developments or revision of the relevant ISO and OGC standards.

3 Normative References

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

ISO19101:2002, Geographic Information—Reference Model

ISO19103:2005, Geographic Information — Conceptual schema language

ISO19107:2003, Geographic Information — Spatial schema

ISO19108:2006, Geographic Information — Temporal schema

ISO19109:2005, Geographic Information — Rules for application schemas

ISO19115:2003, Geographic Information — Metadata

ISO19123:2005, Geographic information — Schema for coverage geometry and functions

ISO19156:2011, Geographic Information — Observations and Measurements

ISO 772:2011, Hydrometry — Vocabulary and symbols

4 Conformance to relevant ISO and OGC standards

4.1 WMO CORE METADATA PROFILE of ISO19115:2003 Metadata

The WMO CORE METADATA PROFILE defines the content, structure and encoding of discovery metadata required within the WIS DAR Catalogue. The standard defined therein is an informal category-1 profile of the International Standard ISO19115:2003 Geographic information – Metadata. Part 1 of WMO CORE METADATA PROFILE defines the Conformance Requirements, Part 2 the Abstract Test Suite, Data Dictionary and Code Lists.

The GRDC HYDROLOGIC METADATA model will use the fundamental concepts of ISO 19115 Metadata standard in terms of the WMO CORE METADATA PROFILE. Additional definitions are proposed when required. It is expected that the further development of the WMO CORE METADATA PROFILE will provide the framework for the implementation of the concepts of GRDC HYDROLOGIC METADATA, particularly concerning time series generated from observation data and created for global exchange under the auspices of the WMO.

Like the HY_FEATURES conceptual model, the GRDC HYDROLOGIC METADATA concepts use as far as suitable the terminology recommended for use in the WMO Member countries and represented by the WMO/UNESCO International Glossary of Hydrology (WMO, 1992). Whenever an appropriate definition is provided in this glossary, the model captures this meaning and relationships to define relevant features and feature relationships.

4.2 OGC WaterML 2.0 Part 1:Time series implementation standard

NOTE: Text in this section is taken from OGC 10-126r3 Implementation Standard [OGC, 2013a]

4.2.1 Overview

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 Mark-up 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.

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.

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..

4.2.2 Scope of WaterML 2.0

OGC WaterML2.0 is an OGC® 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 Mark-up 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." [OGC, 2013a]

4.3 HY_FEATURES common hydrologic feature model

NOTE: Text in this section is taken from OGC 11-039r3 Discussion Paper [OGC, 2013b]

4.3.1 Overview

The HY_FEATURES model describes the major components of the hydrosphere and their fundamental relationships according to the semantics expressed in definitions endorsed by the WMO. It provides referencable concepts that may be addressed by applications reflecting a wide range of hydrologic features in different scientific disciplines in the hydrology domain and cross-domain.

The model concept allows either the description of a logic hydrologic feature like the catchment, as often required in reporting applications, but also the identification of this ultimate hydrologic feature via its multiple real-world representations.

The model was developed in a multi-step process whereby the requirements for hydrologic referencing is reconciled with typical dataset designs and semantics endorsed by the WMO-CHy. Module identification aims to simplify the scope of each part of the model in order to improve its accessibility and provide scope for testing. It is intended that each implemented data product needs to consider only those parts of the common model implicated by its scope. This is facilitated and made transparent by using only those modules that define concepts referenced by the dataset.

Differences in terminology may be explored through reconciling accepted definitions endorsed by the WMO-CHy and represented by the International Glossary of Hydrology (IGH), with the different aspects reflected in various datasets and products. It is intended to apply, wherever appropriate, the terms from the IGH to the identified semantic constructs. This has the effect of augmenting the accepted definitions with explicit semantics for the relationships with other terminology.

4.3.2 Scope of the HY_FEATURES model

The HY_FEATURES model defines the semantics of features which are the overall objects of study and reporting in hydrology across scientific disciplines. It provides a means to identify these features independent from scales and enables multiple representations of these features in the real world to be linked to the ultimate object of study or reporting.

The initial scope of this model is defined by the concerns of the WMO-CHy to facilitate the data sharing within the hydrologic community of the WMO Member countries and to improve the quality of data products based in these data. Such as interoperability of observing systems needs standardised formats and transfer routines, the compatibility of data products requires agreed concepts to domain-specific describe the features of shared interest. In the hydrology domain these features represent results of the hydrologic processes at various stages of the water cycle, relevant to study and report the *waters above and below the land surfaces of the Earth, their occurrence, circulation and distribution, both in time and space, their biological, chemical and physical properties, and their reaction with their environment* [WMO, 1992]. This scope includes well-established data models and patterns in use in the hydrology domain, since the intended goal is to support these using a common conceptual model.

The HY_FEATURES model is intended to sufficiently describe the fundamental relationships between hydrologic features referenced in the various datasets in current use and to form a basis for a common and stable referencing of these features to assist the organisation of their observation and modelling as well as the aggregation of generated data into integrated suites of datasets on a global, regional, or basin scale.

The model encompasses different approaches of modelling hydrologic features, but enforces the semantics of relationships between different levels of detail. This provides a semantic framework for feature identifiers to be developed and embedded in individual data products without constraining the flexibility required to model complex hydrological processes at fine detail.

The HY_FEATURES model allows common reference to hydrologic features across scientific sub-disciplines in hydrology. The conceptual model is designed as a set of interrelated Application Schemas using ISO19103:2005 Conceptual Schema Language and ISO19109:2005 General Feature Model. It is factored into relatively simple components that can be reviewed, tested and extended independently.

4.3.3 Basic concepts of the HY_FEATURES model

A hydrologic feature is the abstract notion of the hydrology phenomenon. The core concept of HY_FEATURES is that a study of the hydrology phenomenon will reflect common concepts of the real world by specific modelled features (as per the General Feature Model). Depending on the scientific concern, the relevant hydrologic feature may represent different aspects of the hydrology phenomenon.

Commonly recognised as the abstract unit of study and reporting in the hydrology domain, a catchment is considered as a hydrologic feature. Each catchment may be represented in any hydrologically meaningful sub-domain model, including by a simple tree network of „blue lines“, or the nested network of catchments.

A catchment is multiple represented in the real world by a variety of hydrologic phenomena which are monitored, modelled and reported in typical applications. Catchment area, catchment boundary, flowpath, hydrographic network, channel network, or hydrometric network are alternative views representing a catchment.

The basin is defined as the catchment special due to its hydrologic determination by the common outlet which may be an arbitrary location on, or projected onto, the Earth’s surface. A basin has by definition one single outflow node. It may have one single identified inflow node, which coincides with the outflow node of an upstream basin. The basic concept of a basin is that of a “link” between outflow nodes without knowing the complex hydrology between them. This concept requires a stable identifier that is not merely a function of an

arbitrary delineation of the surface, and that basins are delineated within a simple hierarchy (tree structure).

Each basin may be nested in a containing basin in a simple *is-part-of* hierarchy as typically used for high order organisation of management and reporting units. Each basin may be sub-basin of an all-encompassing basin, either as tributary basin without an identified inflow, or as inter-basin determined by inflow and outflow.

By definition, the common outlet of a basin has no explicit location and no explicit geometry. A basin may be represented geometrically by an area (e.g. drainage area), a boundary polygon (e.g. watershed), or a curve (e.g. flowpath, or an indicative straight line). Since the geometry will vary with application, it needs to be defined there.

The HY_FEATURES model is a set of inter-related modules containing definitions for key aspects of hydrologic systems. The model is managed in sub-domain specific packages, allowing extension to the core set and involvement of relevant expert groups in the governance of individual models. [OGC, 2013b]

The HY_FEATURES model is presented using the UML pattern of ISO19103:2005. This allows a GML Application Schema to be generated by following the encoding rules in ISO19136:2011 to assure conformity with requirements for service interfaces specified by OGC, in particular WFS. The HY_FEATURES conceptual model is documented in the OGC Discussion Paper OGC 11-039r3. The core concepts are also explained in a separately in *Dornblut, I. and R. Atkinson 2013*.

5 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

5.1 Coverage

set of attribute values (→ Data) arranged with respect to a particular domain such as Space, Time, or Observation. A coverage represents the Feature that carries the Property whose varying values are displayed.

NOTE: Defined *as a function to return values from its range for any direct position within its spatial, temporal or spatiotemporal domain*. [ISO19123:2005]

NOTE: In the observation context, the *Range* refers to the consistent set of possible values that an observed property may have.

5.2 Data

abstract notion of a documented value of some characteristics of a real-world phenomenon.

NOTE: In the metadata context, data are the content of a dataset subject to description.

5.3 Dataset

identifiable collection of data.
[ISO19115:2003]

NOTE: In the metadata context, the dataset is a resource.

5.4 Data product

dataset compiled for a specific purpose, e.g. for global dissemination using Web services.

5.5 Feature

abstraction (abstract notion) of real-world phenomena.
[ISO19101:2002]

5.6 Hydrologic feature

abstract notion of the Hydrology phenomenon.
[OGC 11-039r3]

5.7 Observation

act of observing a property or phenomenon, with the goal of producing an estimate of the value of the property.
[ISO19156:2011]

NOTE: In the information hierarchy, the observation event that generated the data, is commonly recognised as origin of data.

5.8 Metadata

data describing resources.
[ISO19115:2003]

NOTE: A resource is defined as an *identifiable asset or means that fulfils a requirement. EXAMPLES: Dataset, dataset series, service, document, activity, software, person or organisation.* [ISO19115]

5.9 Primary data

data (attribute values) primarily collected, or compiled into a dataset, by the data user.

5.10 Property

abstract notion of a characteristic property of a real-world phenomenon.

NOTE: This refers to the General Feature Model, where a Feature by definition is associated with a Property.

5.11 Secondary data

data (attribute values) collected, or compiled into sets, by a processor who is not the data user.

NOTE: This is typical for a DCPC collecting and producing data.

5.12 Time series

coverage whose domain consists of a collection of ordered temporal elements and the spatial component relates to the feature of interest of the observation. For in-situ time series the spatial element will be fixed and need not be directly represented in the time series domain.
[OGC 10-123r3].

5.13 Variable

feature attributes whose values may change with Space, Time, Observation or depending on another variable.

NOTE: Values expressing the change are usually obtained by observing the variable. A variable may take any value in a range of possible values [WMO, 1992]. Variable values are displayed with respect to Space, Time or Observation in coverages [ISO19156:201]).

NOTE: A variable may be a quantity having a magnitude, additive or non-additive, or multitude expressed numerically, but also a nominal property expressed using words, alpha-numeric codes, or Boolean values.

6 Symbols and abbreviated terms

CHy	WMO Commission for Hydrology
CSW	Catalog Service for the Web
DCPC	Data Collection and Production Centre of the WIS
GFM	General Feature Model
GISC	Global Information System Centres of the WIS
GML	Geography Markup Language
GRDC	Global Runoff Data Centre
HDWG	WMO/OGC Hydrology Domain Working Group
ISO	International Organization for Standardization
NC	National Data Centre in the WIS
NHS	National Hydrological Service
OGC	Open Geospatial Consortium
O&M	Observation and Measurement (concept)
SOS	Sensor Observation Service
UML	Unified Modeling Language
WaterML2	WaterML 2.0 – application schema and implementation of the OBSERVATION model in the domain of hydrology
WCS	Web Coverage Service
WFS	Web Feature Service
WIS	WMO Information System
WIGOS	WMO Integrated Global Observing System
WML2P1	WaterML 2.0 Part1:Time series –observation model for time series in hydrology
WML2P2	WaterML 2.0 Part2: Ratings – observation model for ratings in hydrology
WMS	Web Map Service
WMO	World Meteorological Organization
XML	eXtensible Markup Language

7 Hydrologic data, datasets and data products

7.1 Results from observation

Hydrologic data report the *occurrence, circulation and distribution of waters above and below the land surfaces of the Earth, their biological, chemical and physical properties, their reaction with the environment, including their relation to living beings* [WMO, 1992a]. They document the values of an observed property, particularly a hydrologic variable. Hydrologic data represent the hydrologic feature carrying the property whose values are documented.

Observation data have no other meaning than to be an observation result. Even if documented and arranged in sets, only the interpretation of the collected attribute values regarding a domain of discourse provides the context-specific information. Taking into account that an action which results in any data is by definition an observation, the data processing chain from *measurement to hydrological information* [WMO, 2008] may be understood as a series of observations. Measurement, interpretation, aggregation and accumulation of hydrologic data are steps of a process, each with a particular result, aimed to gain information from observation. The OBSERVATION model [ISO19156:2011] supports the concept of succeeding process steps by defining a *sampling time [when] the result applies to the feature-of-interest* as well as a *resultTime when the procedure associated with the observation act was applied*.

7.2 Spatial, temporal and observation coverages

Hydrologic data are usually compiled into sets of data, wherein each value represents the observed property at a distinct position in space, time or of observation that is different from that of the others. Recognising a coverage as a set of data arranged by coupling an attribute value to a position in a given domain, a hydrologic dataset may be understood as a coverage. The domain is the set of position values in space, time or observation; it refers to the geometric representation e.g. point or grid cell. The range provides the attribute values at distinct positions. The COVERAGE model is described in detail in ISO19123:2005 Schema for coverage geometry and functions. It defines the COVERAGE as a set of value pairs, either explicitly coupled as geometry-value pairs or coupled by mapping the function between domain and range.

Spatio-temporal data are usually arranged with respect to a particular domain, assuming other domains negligible. Most common is the arrangement of values according to a position in the SPACE (domain) or TIME (domain) in spatial or temporal coverages assuming time or location constant. A popular example for a temporal coverage is a time series: the sequence of data values arranged by date and time. With respect to attribute values generated by observation and understanding observation as a non-repeatable event having a position in SPACE (e.g. coordinates) and a position in TIME (e.g. time instant), OBSERVATION may be understood as the spatio-temporal domain of the result in terms of positions set by several observation events.

Furthermore, datasets exist where the domain is built from pre-determined values of an observed base property. A very popular example in hydrology is the stage-discharge-relation, where values of water level serve as the positions for the values of discharge to be determined. In case of a flow duration function, duration is the observed property whose values are arranged according to a set of discharge values; another example is the suspended load or oxygen concentration along a river, where the location is the observed property and the values are arranged in a domain of concentration values. These datasets, commonly expressed as graphs, can be understood as coverages whose domain is the base property.

Separating the concerns according to the domain of the attribute value pairs, hydrologic data are arranged in typical coverages. The most common hydrologic datasets are:

- Time series of ordered time-value pairs (discrete temporal coverage, location fixed)
- Shape-files of points, lines or polygons (discrete spatial coverage, time fixed)
- Regular-grid files (spatial or temporal raster coverage)
- Ratings expressing the function coupling a range of attribute values to the domain of pre-determined input values.

7.3 Primary and secondary data

In the metadata context each dataset (resource) has a source intended to describe the resource used in creating the data(set) specified by the scope. This refers to the result of preceding observation, i.e. the (set of) data, rather than to the observation event. The observation event that generated a result, commonly recognised as origin of data, is a step in the life of a the dataset.

From a user perspective, data may be primary data created and compiled by the user for his specific task, or secondary data collected, processed and released by someone else who is not the user of the data itself. For example in the context of the WIS, the DCPCs are intended to collect data generated by a NHS and process them into new data for global exchange. From the perspective of the data centre these data are primary data generated for dissemination. For any external user, the data produced by the DCPC are secondary data.

Since users of primary data usually know and trust the observation they made themselves, primary data are commonly recognised as a trustworthy source, particularly those data originating from observation in the responsibility of the NHS executing a sovereign task.

In contrast, users of secondary data depend on later inspection and verification of the received data to evaluate their suitability for a specific purpose. Even if information about the source of secondary data is available, the user must trust in the origin (observation). With respect to data collected for global dissemination, a custodian of secondary data usually may assess the reliability of the origin in terms of confidence in the source, but the assessment of the original data regarding the correctness, completeness and accuracy requires further information about the observation that generated the data.

7.4 Subject to global exchange

Hydrologic data collected by the WMO International Data Centres, like the GRDC, are offered for global exchange. Datasets and data products are disseminated using services which in WMO's current practice does not mean an automated service, but rather data centres facilitating the data collection and distribution conform to the established WMO Data Policy.

The NCs and DCPCs contributing to the WIS will *collect, generate, or distribute data, forecasts, and other processed information. … GISCs support all WMO and co-sponsored Programmes, maintain the comprehensive metadata catalogue, and help to ensure the accessibility of WMO data and information globally.* [WMO, 2013a]

8 The GRDC HYDROLOGIC METADATA Concept

The core concept of GRDC HYDROLOGIC METADATA is that of a dataset (resource) containing observation results, i.e. of a set of attribute values determined from observing a particular characteristic property of the hydrology phenomenon represented in the dataset. Depending on their position in the data processing chain from *measurement to hydrological information* [WMO, 2008], special observations provide typical results ranging from a single measure up to aggregates and coverages. The details of the corresponding observation are understood as the metadata describing the determination of the attribute value.

The GRDC HYDROLOGIC METADATA model provides the semantics to describe temporal and spatial coverages created for global exchange by further processing of source data which originate from observations. Referencing an identified monitoring station and applying an identified generation process, the user-oriented processing of original data into a new dataset is considered as an observation on its own.

The GRDC HYDROLOGIC METADATA model contains the packages DATA SET DESCRIPTION providing the discovery metadata (aka WIS Metadata) and OBSERVATION DESCRIPTION providing the information about the corresponding observation (aka WIGOS Metadata). An additional package UTILITIES introduces generally applicable concepts which are neither hydrology- nor GRDC-specific, but needed to describe GRDC datasets. It is expected that the proposed special concepts of an observable property and observation process may be replaced at a later stage with more general concepts as they become available in the course of further developments or revision of the relevant ISO standards. *Figure 1* shows the dependencies.

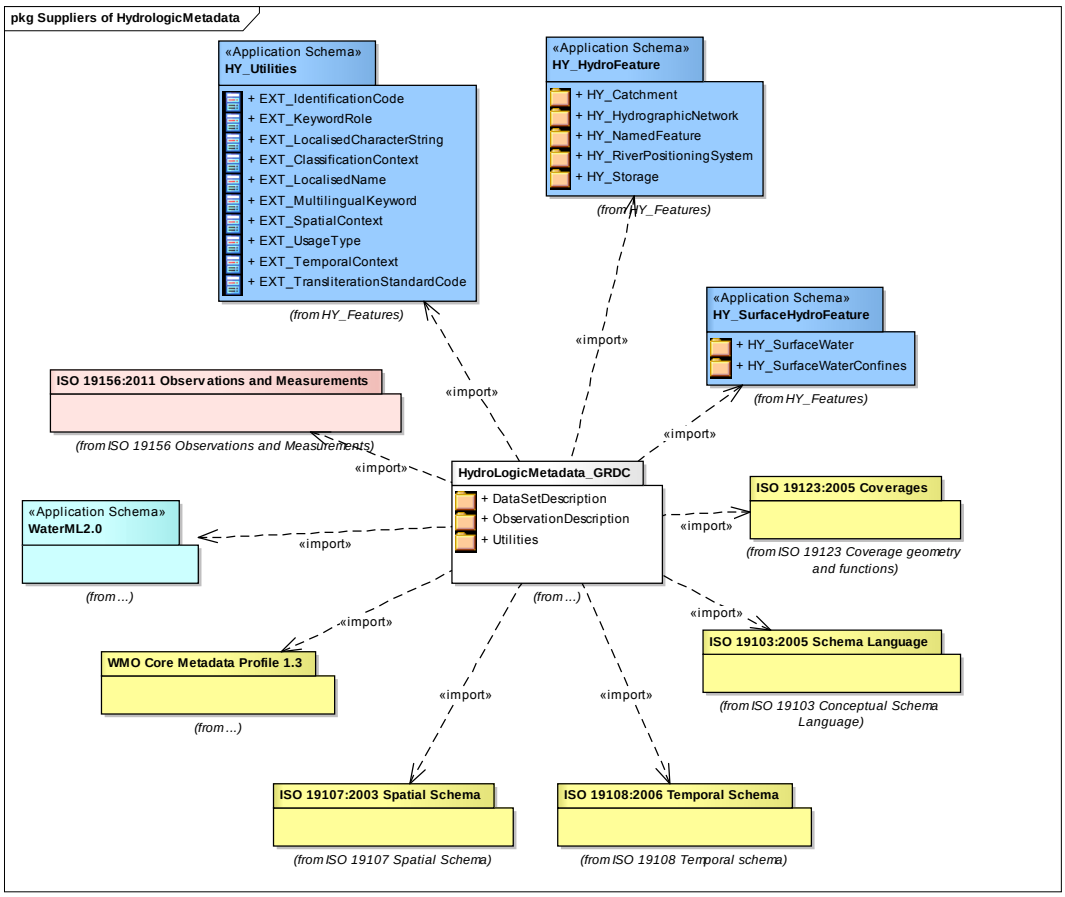

Figure 1: Dependencies of Hydrologic Metadata (GRDC)

The following sections describe the concepts of GRDC HYDROLOGIC METADATA. Figures will show dependency and class diagrams from the corresponding UML model. Class relationships and attributes, their obligation and maximum occurrence may be taken from the GRDC HYDROLOGIC METADATA Data Dictionary (Annex).

8.1 Dataset Description

The DATA SET DESCRIPTION package will provide information about the dataset as required for the DAR services in the WIS context, exemplarily for the spatial and temporal coverages maintained by the GRDC. *Figure 2* shows the dependencies of DATA SET DESCRIPTION.

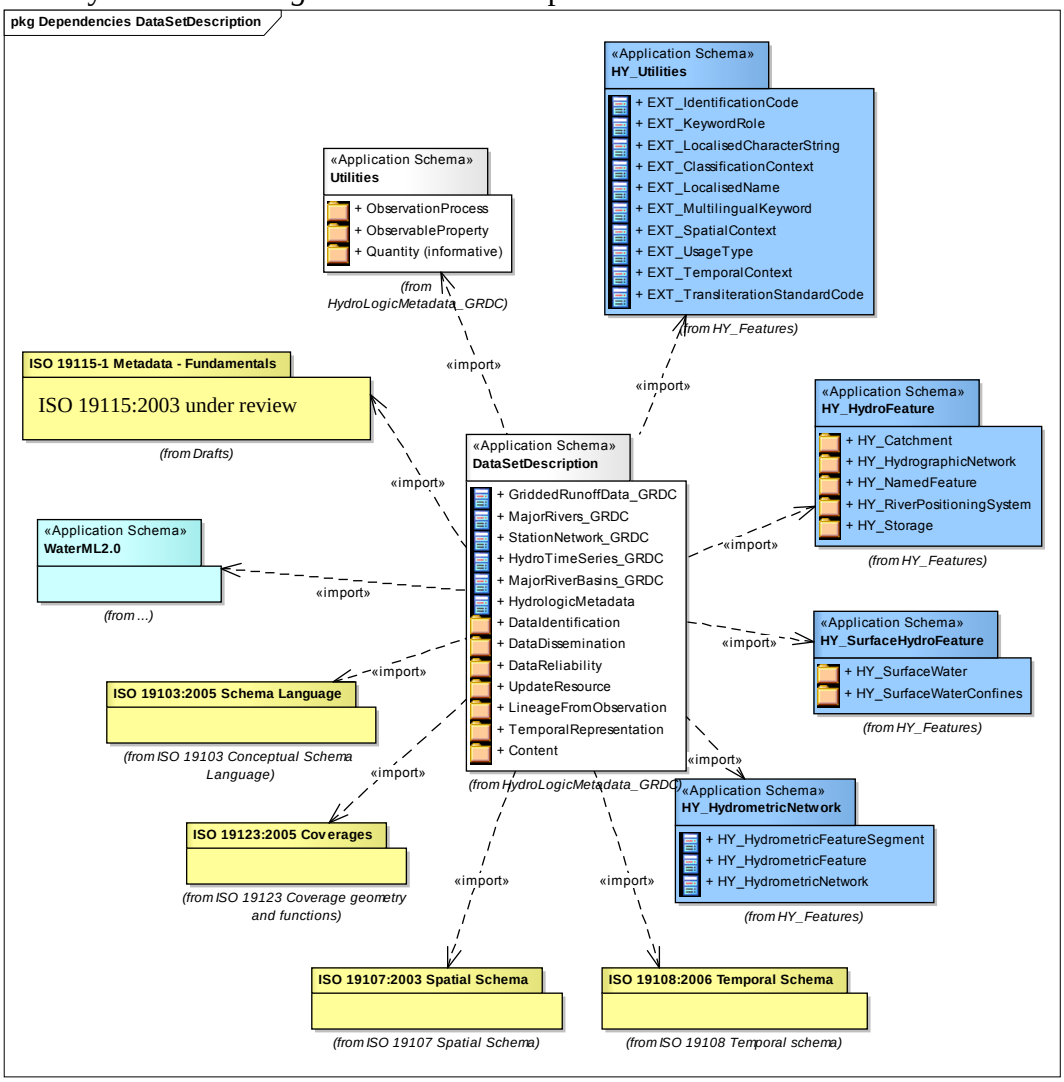

Figure 2: Dependencies of Data Set Description

The GRDC HYDROLOGIC METADATA are defined in terms of the WMO CORE METADATA profile of the ISO19115:2003 Metadata. They are special due to their identification (being subject to WMO data policy), temporal representation, content (particularly time series), lineage from observation, maintenance including updating source data, reliability of secondary data, and data dissemination on a global scale using services.

Recognised as coverages, the description of the GRDC datasets follows a concept of decomposition by domain and coverage geometry. This allows to associate the relevant concept of the COVERAGE model [ISO19123:2005] as well as to separately consider different representations of a multiple represented hydrologic feature.

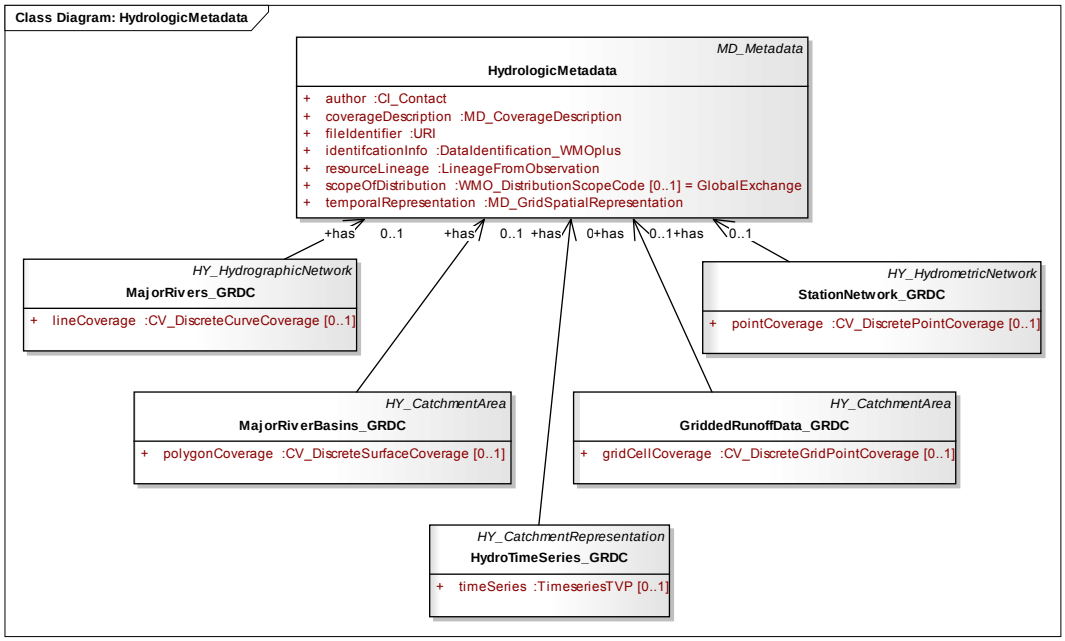

Figure 3: Class diagram: Hydrologic metadata

Each GRDC dataset is assigned to a type CATCHMENT REPRESENTATION in terms of the HY_FEATURES model (*Figure 3*) to relate the GRDC data to the catchment they represent in terms of the commonly recognised unit of study shared across the scientific disciplines in hydrology and the related programmes of the WMO.

8.1.1 Data Identification

DATA IDENTIFICATION provides the basic information to identify the dataset in terms of the WMO CORE METADATA profile 1.3. Some attributes defined according to the current version may be changed in the course of the current review of ISO19115:2003.

The WMO Data Policy expressed in WMO Resolution 40 (Cg-XII) and Resolution 25 (Cg-XIII)) is described according to WMO core metadata specialising LEGAL CONSTRAINTS. The release of data to the research and education communities for non-commercial activities is stated as *WMOAdditional*. The *access constraints* describes distribution constraints in terms of releasability defined by the owner or custodian of the resource, e.g. a NHS or a DCPC. Use limitations determined by the processing status may be described as *use constraints.* The GRDC data offered for global exchange are by default, described as *historical* (data).

8.1.2 Data Dissemination

DATA DISSEMINATION is intended to provide additional information about data distribution using a dissemination service such as capabilities, user identification and permissions, or the technical environment. It is defined in the sense of a dissemination project aggregating several datasets of interest for a specific purpose, e.g. on a user request. Using the general concepts of DISTRIBUTION and IDENTIFICATION [ISO 19115:2003] with respect to the providing service, it refers to the FUNDAMENTALS defined within the current revision ISO19115-1 of the ISO METADATA standard. They may be subject to change in the course of future developments and review of this standard.

8.1.3 Data Reliability

DATA RELIABILITY is intended to provide information required with respect to the reliability of secondary data, compiled in the resource, such as completeness and precision of original data, information about error corrections made as well as the evaluation in terms of passing a quality assessment made by the owner or custodian of data to a potential user. This is usually required for data generated for global dissemination to information networks, Internet portals or for automated transfer.

ERROR CORRECTION information is provided by identifying type and source of error as well as the correction applied to the measure to obtain a closer approximation to the true value. COMPLETENESS and PRECISION may be expressed as numeric value, e.g. in percent, or by degree using a code or controlled term.

8.1.4 Update Resource

The intended DCPCs of the WIS, like the GRDC, will continuously update their data bases. Datasets and data products are usually compiled on the basis of the actual status of the database. For example, time series of long-term means are compiled for a given set of stations on the basis of the data actually provided by the NHS to the GRDC. Continuous observations made by the NHS result in new data whose up-to-date consideration is expected by the user. Even if the values in the dataset have changed according to the expanded reference period, the structure of the dataset is still the same.

UPDATE RESOURCE is intended to provide additional MAINTENANCE information with respect to the temporal extent of updates as well as to updating the source data after the resource is initially completed.

This answers to the requirement to document the temporal and spatial extension of the source data, particularly of secondary data updated by the owner or custodian after compilation and dissemination of a particular data set or product.

8.1.5 Lineage From Observation

LINEAGE FROM OBSERVATION provides additional lineage information required to identify the observation origin of the resource by setting scope to *dataset* and the lineage statement to *observation result*. Additional attributes will provide information about the reliability of the source data and their updating. The *reported feature* attribute is defined to simply identify the hydrologic feature under observation without the need of the complex observation description.

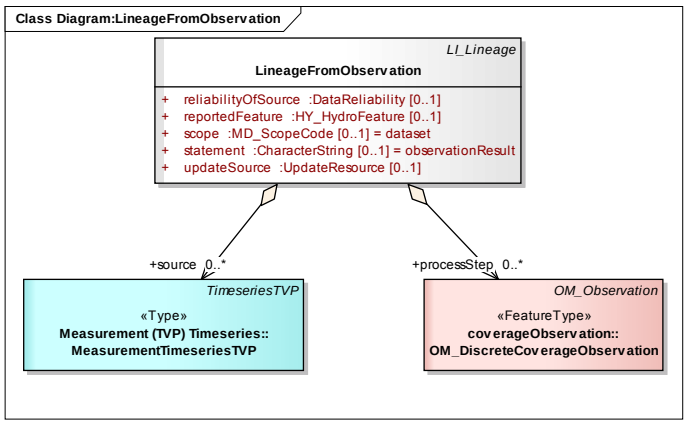

Figure 4: Class diagram: Lineage from observation

LINEAGE FROM OBSERVATION associates the source data processed into the resource as well as the observation event in terms of a process step in the life of the resource. With respect to the temporal or spatial coverages generated by the GRDC on the basis of measures compiled by a NHS, a MEASUREMENT TIMESERIES in terms of WaterML 2.0 is the associated source. The corresponding process step may be any subtype of a DISCRETE COVERAGE OBSERVATION [ISO19156:2011] (*Figure 4*). Special observations each generating a typical GRDC dataset are defined with the observation metadata (see section 7.2 of this report).

8.1.6 Temporal Representation

Representation information is required to identify the means used to present attribute values for information, particularly the geometric representation.

TEMPORAL REPRESENTATION as special GRID SPATIAL REPRESENTATION in terms of ISO19115:2003 is intended to identify the time raster representing the time-value pairs, particularly the data types TIME VALUE PAIR and WML DOMAIN OBJECT as defined within WaterML 2.0 to couple attribute values to time instants, geometrically understood as point in Time.

8.1.7 Content

The CONTENT package provides additional information about the content of the hydrologic dataset required for the description of temporal coverages, particularly series of ordered time-value pairs. CONTENT uses the general concepts defined for the range of a coverage in the COVERAGE DESCRIPTION [ISO19115:2003] to the domain of a coverage (*Figure 5*).

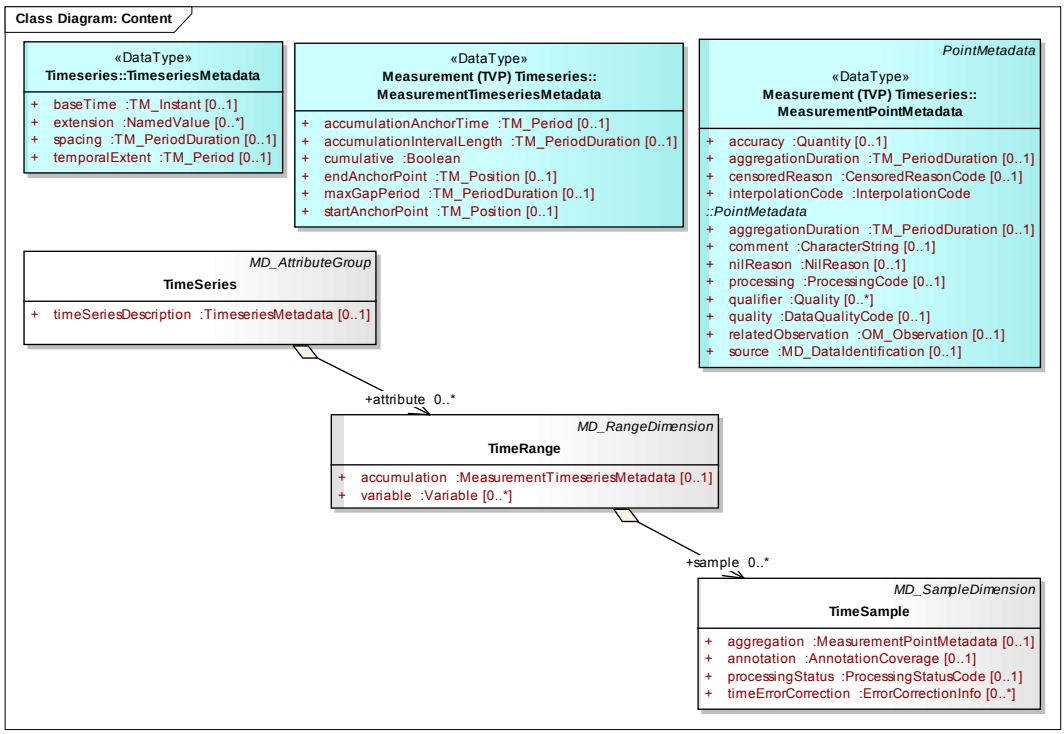

Figure 5: Class diagram: Coverage description applied to Time series

While RANGE DIMENSION refers to the physical dimension whose attribute values are contained in the coverage, TIME RANGE refers to the domain wherein the values are accumulated. The Time range will describe the temporal accumulation of attribute values. The

variable attribute allows to describe in more detail the dimension identified by *name* in the dimension range.

While SAMPLE (of) DIMENSION describes in detail each single dimension (attribute), TIME SAMPLE is used to describe the temporal aggregation into a discrete sample of Time including information about the correction of time errors and the status of the sample, e.g. *real time*.

8.2 Observation Description

The OBSERVATION DESCRIPTION provides the observational metadata as required for the WIGOS observational metadata. OBSERVATION DESCRIPTION provides a description of the SAMPLING FEATURE, of the OBSERVED PROPERTY, the PROCEDURE and the SAMPLED FEATURE. This refers to the core concepts of the OBSERVATION model as of ISO19156:2011 in terms of the WaterML 2.0 specification.

The OBSERVATION DESCRIPTION uses concepts of the WaterML 2.0 standard, particularly TIMESERIES OBSERVATION and MONITORING POINT. Observation details not yet sufficiently defined within the WaterML 2 standard series are proposed, particularly regarding the observed HYDROLOGIC VARIABLE and the applied DATA GENERATION PROCESS (*Figure 6*).

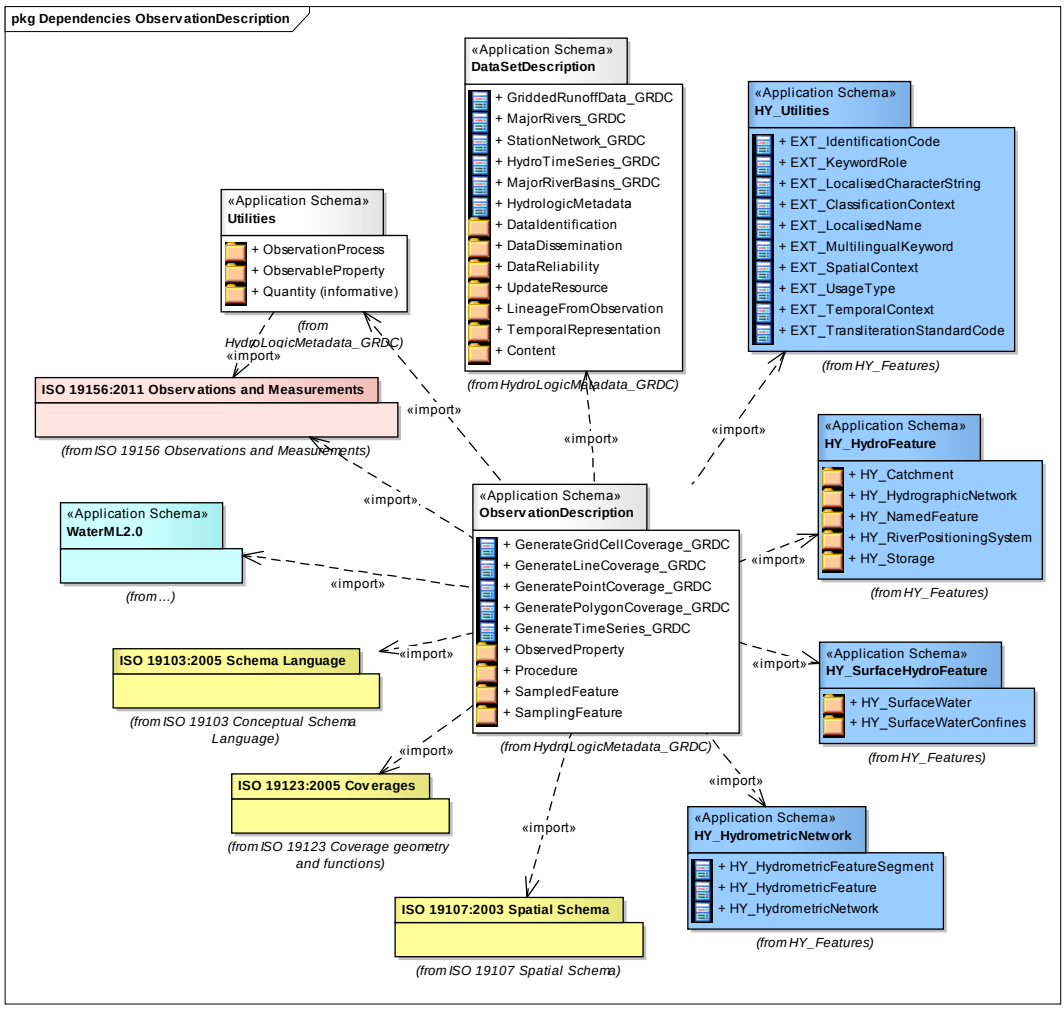

Figure 6: Dependencies of Observation Description

According to the special result that they generate, special GRDC observations are defined. All observations made by the GRDC are understood as DISCRETE COVERAGE OBSERVATIONS in

terms of the OBSERVATION model, particularly as a TIMESERIES OBSERVATION in case of a time series (*Figure 7*).

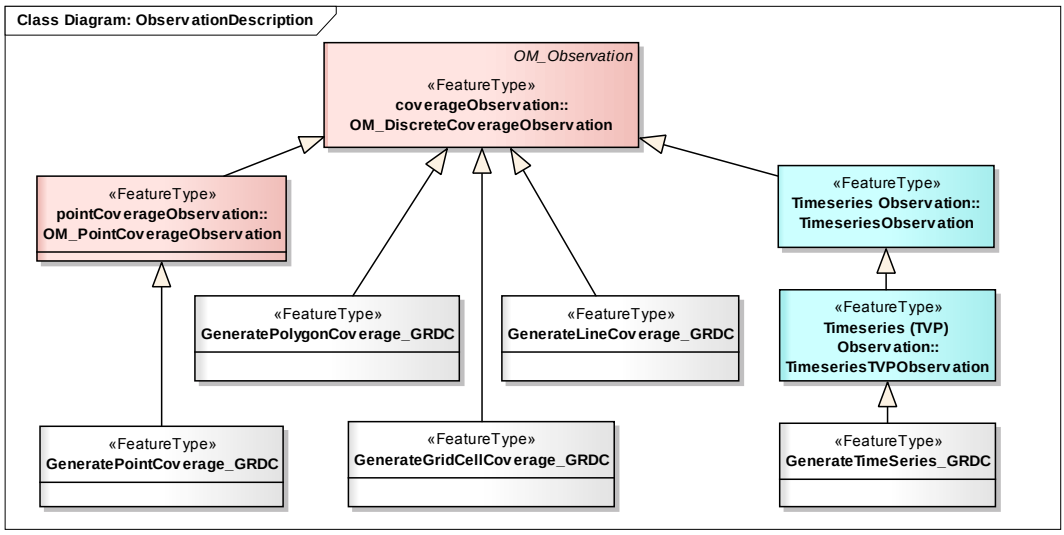

Figure 7: Class diagram: GRDC Coverage Observation

Each special observation is described by the HYDROLOGIC VARIABLE in terms of the *observed property*, the GRDC STATION in terms of the MONITORING POINT used as sampling *feature (of interest*) and the DATA GENERATION PROCESS in terms of the *procedure* applied.

8.2.1 Sampling Feature

The SAMPLING FEATURE package describes the GRDC STATION used for the generation of a GRDC dataset. This follows the core concept of WaterML 2.0 where the *feature of interest* is understood as a SAMPLING FEATURE used as a proxy to observe a DOMAIN FEATURE.

The GRDC STATION is defined as a MONITORING POINt in terms of Water ML 2.0. A GRDC STATION associates a station operated in the responsibility of a NHS. A relation to an immediately downstream station is defined which allows to describe a logic network of GRDC stations as well as to the RIVER as part of the HYDROGRAPHIC NETWORK. This allows to describe the represented catchment using the HY_FEATURES common hydrologic feature model.

The NHS Station is defined in the sense of the MONITORING POINT used in the source observation. It relates additional information about an instrument bound to the station, e.g. stage-discharge-relation, and about the particular water body (segment) under observation. *Hosted procedure* refers to the *Platform*, *sampled feature* to the *Intention* concept of the OBSERVATION model.

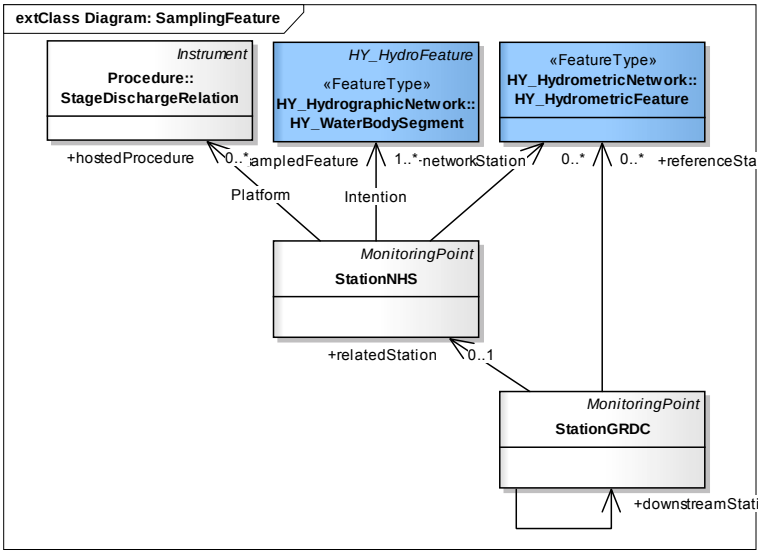

Figure 8: Class diagram: Sampling Feature

Both, GRDC STATION and NHS STATION may be associated with a HYDROMETRIC FEATURE in a HYDROMETRIC NETWORK of monitoring stations and observing posts. This allows to relate an arbitrary station to the corresponding BASIN using the HY_FEATURES model. *Figure 8* shows the relationships of GRDC and NHS Station. Attributes are defined as required by the GRDC, particularly regarding coordinates and height datum in the relevant national systems and the corresponding EPSG code, or the information about preceding and succeeding stations.

8.2.2 Observed Property

The OBSERVED PROPERTY package describes the observed HYDROLOGIC VARIABLE or HYDROLOGIC PROCESS reported in the dataset. HYDROLOGIC PROCESS refers to a process of the Water Cycle determined by one or more process variables which may be hydrologic variables. The hosting unit wherein the process takes place, the catchment, is described in terms of the HY_FEATURES model. The HYDROLOGIC VARIABLE is a variable carried by a hydrologic feature.

HYDROLOGIC VARIABLES have names in common discourse, which are often differently used depending on the context. It is common practice that the name is used to not only express the subject, but also the sampled feature, carrier medium, or procedure. Common examples are: river discharge, sediment discharge, mean discharge, discharge per area.

The HYDROLOGIC VARIABLE is special due the relation to the characterised water body and the station used for monitoring. This refers to a requirement of the OBSERVATION model that *the observedProperty shall be a phenomenon associated with the feature of interest* [ISO19156:2011].

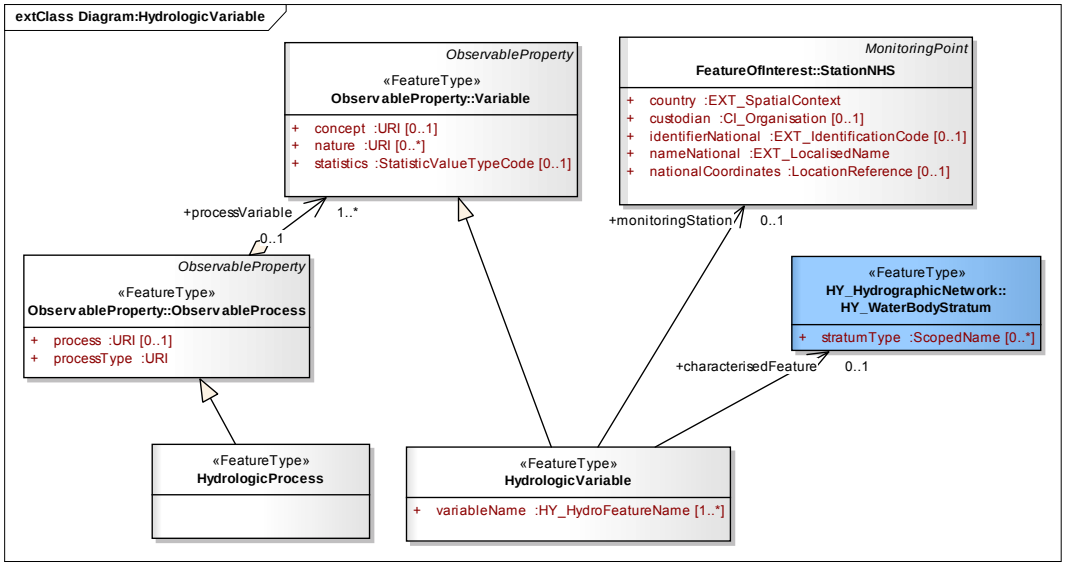

Figure 9: Class Diagram: Hydrologic Variable and Hydrologic Process

Figure 9 shows HYDROLOGIC VARIABLE and HYDROLOGIC PROCESS and their relationships. The proposed concept of the VARIABLE is described in section 8.3 Utilities of this report.

8.2.3 Procedure

The PROCEDURE package describes the special observation process applied to generate the dataset. The DATA GENERATION PROCESS is described in terms of a calculation process special due to additional error correction information. This refers to a general requirement of passing correction information whenever given by the owner or custodian of the data to the potential data user.

A STAGE-DISCHARGE RELATION is described in terms of an INSTRUMENT, independent from the gauging observation that generated the set of discharge values arranged in the domain of stage values. A description of the GAUGING OBSERVATION, the CONVERSION relationship and the CONVERSION TABLE are provided in detail in WaterML 2.0 Part 2: Ratings and Gaugings [OGC, 2013a]. Concepts for INSTRUMENT and CALCULATION PROCESS are proposed in the UTILITIES package, described in section 8.3 of this report.

8.2.4 Sampled Feature

The sampled hydrologic feature is usually a water body, or a part of this, representing the catchment. From the perspective of the GRDC, which is collecting river discharge data for global exchange under the auspices of the WMO, the sampled feature is a River in terms of the HY_FEATURES model representing a drainage basin which is part of a WMO Subregion.

The SAMPLED FEATURE package describes the hydrologic feature of which a characteristic variable is observed. BASIN_GRDC and RIVER_GRDC are defined in terms of the HY_FEATURES model [OGC, 2013b]. Additional attributes are defined regarding the reliability and updating of the river and basin description, particularly the contextual identification of the WMO Region and Subregion.

RIVER_GRDC provides an association with the HYDROLOGIC VARIABLE. This may be used to provide information about an observable characteristic property, of which observation data are expected but not yet provided.

8.3 Utilities

The UTILITIES package summarizes commonly available concepts for the observable property, and the observation process as required by the GRDC HYDROLOGIC METADATA model. These classes are neither hydrology- nor GRDC-specific and may be replaced at a later stage with more general concepts as they become available in the course of further developments or revisions of the relevant ISO standards. *Figure 10* shows the package dependencies.

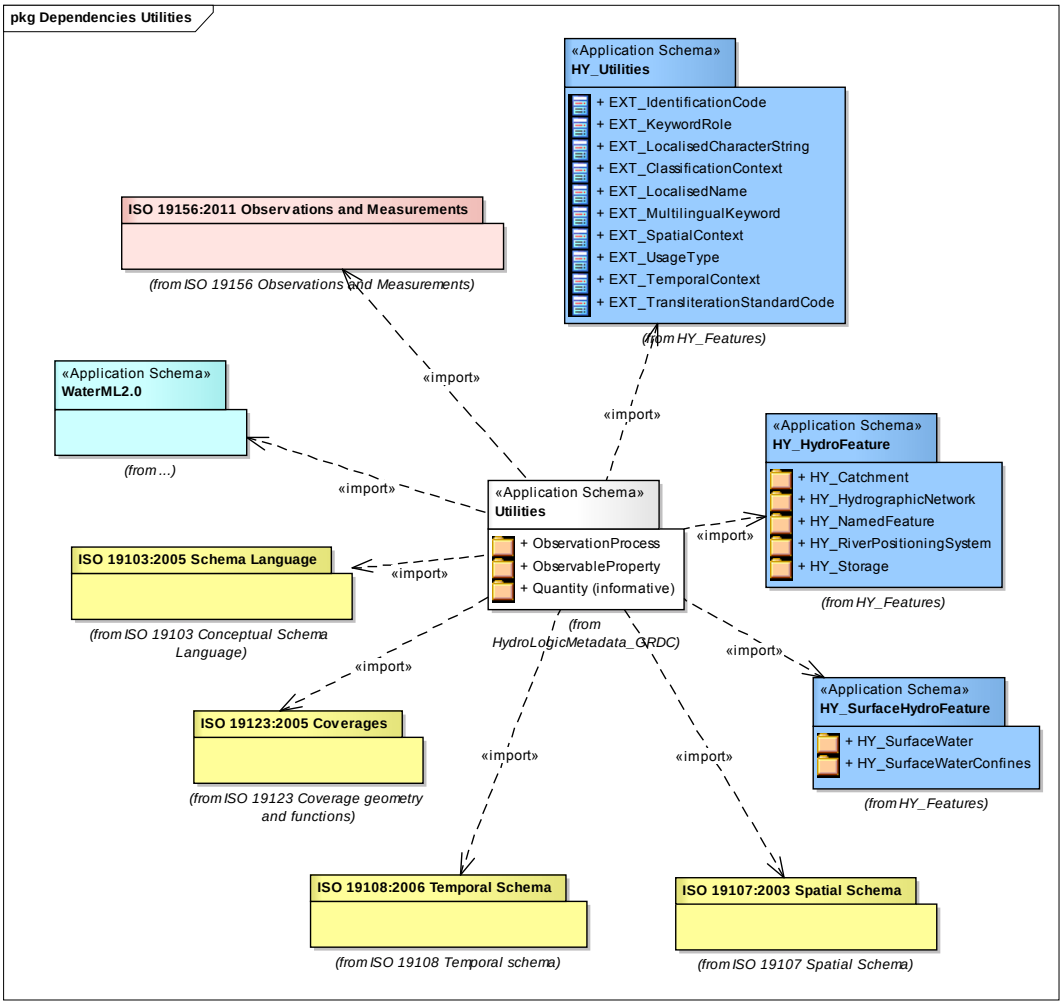

Figure 10: Dependencies of Utilities

8.3.1 Observation Process

The OBSERVATION PROCESS package contains special concepts of Observation Process with respect to instruments and calculation processes. The separation into INSTRUMENT and CALCULATION PROCESS reflects a concept defined in the initial OBSERVATION model, version 1.0, where an instrument is defined as the *observation procedure corresponding to a physical instrument or sensor*, and calculation process as the *observation procedure corresponding to an algorithm or computational procedure* [ISO19156:2011]. The proposed structure to relate instrument, sensor and calculation process is shown in *Figure 11*.

The INSTRUMENT is described as a system of sensors and calculation processes. The SENSOR is defined in ISO 772:Hydrometry as the *device that responds to a physical or chemical stimulus*. The recording as well as the encoding algorithm used to convert the response into a specific code are understood as integral part of the instrument, expressed by the *encoding* role. A variable may be associated to express the special suitability of the instrument for a

typical variable, *measurand*, as recommended by the Observation model and required by the WMO Logical Data Model under development [WMO, 2013b].

The CALCULATION PROCESS describes the algorithm or computational procedure used to calculate a dependent variable based on independent variables, or on empirical constants.

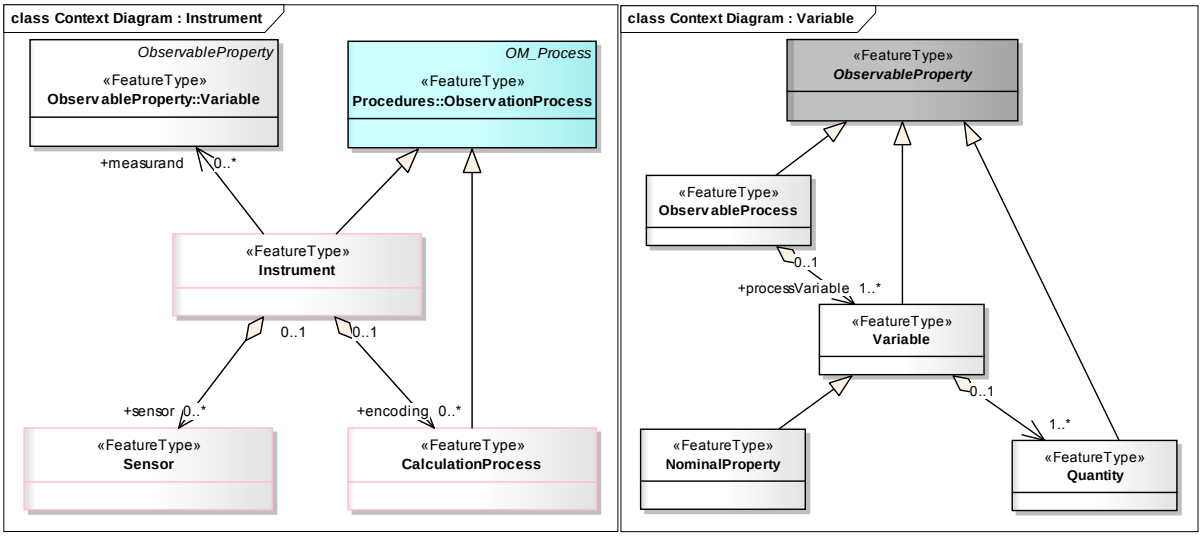

Figure 11: Context diagrams: Instrument and Variable

8.3.2 Observable Property

The OBSERVABLE PROPERTY package is intended to structure the description of a *characteristic property of a real-world object which may take any one of a specified set of values* [WMO, 1992a]. The OBSERVABLE PROPERTY is intended to realise the PROPERTY meta-class as defined in the GENERAL FEATURE MODEL [ISO19109:2005].The GFM which is currently under review, particularly the relationship between the feature property and its constraints. According to this review and the future development of the GFM, the OBSERVABLE PROPERTY may be replaced by common concepts allowing to describe VARIABLE, OBSERVABLE PROCESS and NOMINAL PROPERTY.

The core concept of OBSERVABLE PROPERTY is that of an OBSERVABLE PROCESS represented by variables, each VARIABLE composed of quantities observed as a proxy for a variable which is often not known at the date of the actual measurement (*Figure 11*). This refers to the common practice of indirect observation *relying on direct observation of a more convenient parameter, which is a proxy for the ultimate property of interest* [ISO19156:2011].

The OBSERVABLE PROPERTY carries an inherited attribute *constraint by* which shall be expressed in terms of an optional thematic attribute constraint. A THEMATIC ATTRIBUTE CONSTRAINT is defined to identify the material, substance, or organism as well as an algorithm or configuration, which may multiple constrain their determination. This follows a recommendation in WaterML 2.0 that the *observed phenomena may be separated from the physical medium that is being sampled in order to make the observation* [OGC, 2012].

The VARIABLE carries *concept*, *nature* and *statistics* attributes. This allows to simply identify the base concept and conformity to this as well as statistics and probability functions without the details of mathematics. A STATISTIC VALUE TYPE CODE lists the most common types of statistic values.

The special NOMINAL PROPERTY is introduced to describe variables whose values are expressed using words, alpha-numeric codes and symbols, or Boolean values.

The QUANTITY is defined in terms of a reference to the concept applied. This allows to identify different concepts of quantities in use, and under development. Key reference might be the ISO 80000-1:2009. The URI is used as a proxy for any type of reference. With respect to the *Symbols and Units* [WMO, 2006] recommend for use within the community of the WMO Member countries, a WMO QUANTITY TYPE CODE codelist of the most common terms is proposed with the UML model.

8.3.3 Quantity, informative

The informative package summarizes most common concepts of a quantity:

- Continuous Quantity: quantity representing a magnitude,
- Discrete Quantity: quantity representing a multitude created from counting entities,
- Ordinal Quantity: quantity, for which a total ordering relation can be established with other quantities of the same kind, but for which no algebraic operations among these exist.

9 Outlook: Contribution to WIS and WIGOS

The description of datasets created for Global exchange by collecting and processing results from observations usually made in the responsibility of National Services is the primary goal to develop the GRDC HYDROLOGIC METADATA model. The intention is to meet the special requirements of passing the information provided by the owner or custodian of secondary data to the potential user in order to assess their suitability for its specific purpose. GRDC will implement the proposed concepts in a future metadata catalogue, to support Web discovery services, particularly those under development within the WIS.

The GRDC HYDROLOGIC METADATA model is intended to contribute to the development of WIS and WIGOS Metadata structures. Even if exemplarily described for typical datasets and products created by the GRDC for global exchange, the model provides generally applicable concepts to link the description of the dataset and the information about the underlying observation.

The concepts proposed for the Dataset Description regarding identification, dissemination, maintenance, lineage and content of a dataset as well as regarding representation and reliability of the contained data, need to be evaluated with respect to suitability within the WIS.

The concepts proposed for the Observation Description in terms of a sampling feature of interest, observed property, procedure and sampled feature, need validation with respect to the requirements of WIGOS metadata.

Factored into single components, the GRDC HYDROLOGIC METADATA model can be reviewed, tested and extended independently. The model is presented using the UML pattern [OMG, 2004]. This allows a GML Application Schema to be generated by following the encoding rules in ISO19136 to assure conformity with requirements for service interfaces specified by OGC, particularly such as CSW, WCS and SOS.

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ANNEX: GRDC HYDROLOGIC METADATA Data Dictionary

This document provides the elements of the GRDC HYDROLOGIC METADATA conceptual model. It is distributed for review and comment. It will be updated whenever required in the course of the further development of the UML model and is subject to change without notice.

The GRDC HYDROLOGIC METADATA model is a conceptual UML model. It uses the ISO19115:2003 Metadata standard, the OGC WaterML2.0 Part 1:Time series (OGC 11-126r3) standard, the fundamental concepts of OGC Observations and Measurements standard (ISO19156:2011) and the HY_FEATURES Discussion Paper OGC 10-039r2).

This data dictionary describes the packages of the GRDC HYDROLOGIC METADATA model, the relationships between classes and general attributes, their obligation and maximum occurrence.

The data dictionary lists for all elements of the GRDC HYDROLOGIC METADATA model:

- name of the model component
- description
- source of external description
- element type
- target (of relation)
- source specification of the target (external)
- obligation/condition (mandatory, conditional, optional)
- maximum occurrence

Each table column is named, each row is numbered.

Tables in Annex:

Table 1: GRDC_Hydrologic Metadata (main)

	A	B	C	D	E	F	G	H
1	**Name**	**Description**	**Source of description (external)**	**Element type**	**Target**	***Target specified externally in:***	**Obligation/ Condition - mandatory (M) - conditional (C) - optional (O)**	**Maximum Occurrence**
2	HydroLogicMetadata_GRDC	Application schema intended to be used for the description of hydrologic datasets, i.e. datasets originated from observation of waters above, on and below the Earth's surfaces undertaken to obtain values of their biological, chemical and physical properties. HydrologicMetadata provides, exemplarily for the GRDC datasets, the semantics to describe temporal or spatial coverages created by a data processing institution by further processing of data which are results of preceding source observations. Referencing an identified sampling feature and using an identified procedure, the compilation of primary observation data into a new secondary dataset is also considered as an observation on its own. The core concept is that of information (metadata) needed for Discovery, Access and Retrieval (DAR) services (aka WIS metadata) accompanied by observational information, i.e. the details of the observation that generated the secondary dataset as well as of the source observation whose results provide the input for further processing (aka WIGOS metadata). HydrologicMetadata uses the fundamental concepts of ISO19115:Metadata in terms of the WMO Core Metadata profile. They are special due to their identification (being subject to WMO data policy), temporal representation, content (particularly time series), lineage from observation, maintenance including updating source data, reliability of secondary data, and data dissemination on a global scale using services. Observational information follows the basic concepts of Observation & Management (ISO19156:2011) in terms of WaterML2.0 (OGC10-126r3). The information about the sampled feature and the overall, shared unit of study, reporting or management (catchment) uses concepts of the OGC HY_Features common hydrologic feature model (OGC 11-039r3). HydrologicMetadata contains the packages DataSetDescription (with respect to WIS metadata) and ObservationDescription (with respect to WIGOS metadata). An additional package Utilities contains the sub-packages ObservableProperty and ObservationProcess proposing concepts which are not hydrology-specific, but required by the HydrologicMetadata model. It is expected that the classes proposed therein may be replaced by common concepts in the course of further developments or revision of the relevant ISO standards.						

3	HydrologicMetadata	description of a dataset compiled for "global exchange" by further processing of data which are results of a preceding hydrologic observation. *Note: hydrologic observation refers to direct measurement or other evaluation of one or more hydrologic variables, such as stage, discharge, water temperature, etc.*		generalisation	MD_Metadata	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
4	author	required by WMO Core Profile 1.3	[5]	attribute	CI_Contact	ISO19115 (ISO19115-1)	M	1
5	fileIdentifier	mandatory required by WMO Core Profile 1.3	[5]	attribute	MD_Identifier	ISO19115 (ISO19115-1)	M	1
6	scopeOfDistribution	required by WMO Core Profile 1.3 initial value: *GlobalExchange* set with respect to GRDC in the role of a global datacentre	[5]	attribute	WMO_DistributionScopeCode	WMO Core1.3	O	1
7	identificationInfo	data identification information according to the WMO Core Profile 1.3 *Note: some attributes according to WMO Core Profile 1.3 referencing ISO19115:2003/2006 may be subject to change according to the review of ISO19915 and in course of the further development of ISO19115-1 (draft 2012)*	[5]	attribute	DataIdentification_WMO	WMO Core1.3	M	1
8	resourceLineage	information about the lineage of the resource.		attribute	LineageFromObservation		M	1
9	spatialRepresentationInfo	information about the spatio-temporal objects in the resource.		attribute	TemporalGridRepresentation		M	1
10	coverageDescription	description of the spatial or temporal coverage.		attribute	TemporalCoverageDescription	ISO19115 (ISO19115-1)	M	1
11		*intentionally left blank*						
12		*intentionally left blank*						

Table 2: DatasetDescription

1	**Name**	**Description**	**Source of description (external)**	**Element type**	**Target**	***Target specified externally in:***	**Obligation/ Condition - mandatory (M) - conditional (C) - optional (O)**	**Maximum Occurrence**
13	DataSetDescription	The DataSetDescription package provides information about the data set needed for Data, Access and Retrieval (DAR) services (so-called WIS metadata). The GRDC Hydrologic Metadata are defined in terms of the WMO Core Metadata profile of the ISO19115:2003 Metadata. They are special due to their identification (being subject to WMO data policy), temporal representation, content (particularly time series), lineage from observation, maintenance including updating source data, reliability of secondary data, and data dissemination on a global scale using services. Recognised as coverages, the description of the GRDC datasets follows a concept of decomposition by domain and coverage geometry. This allows to associate the relevant concept of the Coverage model of ISO19123:2005 as well as to separately consider different representations of a multiple represented hydrologic feature.						
14	HydroTimeSeries_GRDC	collection of time-value pairs representing a catchment by values of an observed variable, created by the GRDC (temporal coverage)		generalisation	HY_CatchmentRepresentation	OGC 11-039r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
15	timeSeries	description of the time series as series of ordered time-value pairs		attribute	TimeseriesTVP	OGC10-126r3	O	N
16	has	metadata describing the time series as temporal coverage resulting from observation		association	HydrologicMetadata		O	1
17	dataDissemination	dissemination project the time series is part of		aggregation	DataDissemination		O	N
18	StationNetwork_GRDC	network of stations representing a catchment by values of an observed variable, created by the GRDC.		generalisation	HY_HydrometricNetwork	OGC 11-039r3	use obligation / condition from referencing object	use maximum occurrence from referencing object

19	pointCoverage	geometric description of the station network as a collection of points		attribute	CV_DiscretePointCoverage	ISO 19123	O	N
20	has	metadata describing the data set as point coverage resulting from observation		association	HydrologicMetadata		O	1
21	dataDissemination	dissemination project the point shape file is part of		aggregation	DataDissemination		O	N
22	MajorRivers_GRDC	collection of polylines representing a catchment by values of an observed variable, created by the GRDC.		generalisation	HY_HydrographicNetwork	OGC 11-039r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
23	lineCoverage	geometric description of the dataset as collection of polylines		attribute	CV_DiscreteCurveCoverage	ISO19123	O	N
24	has	metadata describing the data set as line coverage resulting from observation		association	HydrologicMetadata		O	1
25	dataDissemination	dissemination project the polyline shape file is part of		aggregation	DataDissemination		O	N
26	MajorRiverBasins_GRDC	collection of polygons representing a catchment by values of an observed variable, created by the GRDC.		generalisation	HY_CatchmentArea	OGC 11-039r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
27	polygonCoverage	geometric description of the data set as a collection of polygons		attribute	CV_DiscreteSurfaceCoverage	ISO19123	O	N
28	has	metadata describing the data set as polygon coverage resulting from observation		association	HydrologicMetadata		O	1
29	dataDissemination	dissemination project the polygon shape file is part of		aggregation	DataDissemination		O	N
30	GriddedRunoffData_GRDC	set of grid cells representing a catchment by values of observed (calculated) runoff, created by the GRDC.		generalisation	HY_CatchmentArea	OGC 11-039r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
31	gridCellCoverage	geometric description of the data set as collection of grid points		attribute	CV_DiscreteGridPointCov	ISO19123	O	N

					erage			
32	has	metadata describing the data set as grid cell coverage resulting from observation		association	HydrologicMetadata		O	1
33	dataDissemination	dissemination project the gridded data set is part of		aggregation	DataDissemination		O	N
34		*intentionally left blank*						
35	DataIdentification	This package provides information about the data set as required by the WMO Core Profile 1.3. of ISO 19115 ... will provide information about the data policy applied within the community of WMO.						
36	DataIdentification_WMO	data identification info according to the WMO Core Profile 1.3 *Note: some attributes according to WMO Core Profile 1.3 referencing ISO 19115:2003/2006 may be modified in course of the further development of ISO19115-1 (draft 2012)*		generalisation	MD_DataIdentification	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
37	beginningDate	*as defined by WMO Core Profile 1.3*	[5]	attribute	EX_TemporalExtent	ISO19108	O	1
38	endingDate	*as defined by WMO Core Profile 1.3*	[5]	attribute	EX_TemporalExtent	ISO19108	O	1
39	keywords	*as defined by WMO Core Profile 1.3*	[5]	attribute	MD_Keywords	ISO19115 (ISO19115-1)	M	N
40	subject	*as defined by WMO Core Profile 1.3*	[5]	attribute	MD_Keywords	ISO19115 (ISO19115-1)	M	1
41	topicCategoryWMO	*as defined by WMO Core Profile 1.3*	[5]	attribute	WMO_CategoryCode		M	1
42	dataReliabilityInfo	information about the reliability of source data which are compiled into the secondary dataset.		attribute	DataReliability		M	1
43	resourceDistribution	information about the data dissemination service.		attribute	DataDissemination		M	1
44	resourceConstraints	legal constraints set by WMO in respect to discovery, access and use of the resource		attribute	DataPolicy_WMO	WMO Core1.3	M	1
45	resourceMaintenance	information about updating the resource incl. the source data of the secondary data set.		attribute	UpdateResource		M	1

46	DataPolicy_WMO	legal constraints representing the WMO Data Policy of free and unrestricted access to data and products exchanged under the auspices of WMO to the research and education communities for non-commercial activities.		generalisation	MD_LegalConstraints	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
47	accessConstraints	dissemination constraints usually defined by the owner or custodian of the resource, e.g. a National Hydrological Service		attribute	MD_Releasability	ISO19115 (ISO19115-1)	O	1
48	otherConstraints	as defined by WMO Core Profile 1.3 {DataPolicy_WMO.otherConstraints:WMO_DataLicenseCode = "WMOAdditional"}	[5]	attribute	WMO_DataLicenseCode	WMO Core1.3	M	1
49	useConstraints	use limitations determined by the processing status of the data usually stated by the owner or custodian of the resource, e.g. a National Hydrological Service. {DataPolicy_WMO.useConstraints:ProcessingStatusCode = "historical"}		attribute	ProcessingStatusCode		O	1
50	ProcessingStatusCode	list of terms expressing the status of processing with respect to the life cycle of observation data from measurement to information.		codelist				
51	realTime	data provided without significant delay to the time of observation/measurement		codelist item	CharacterString	ISO19103		
52	realDay	data provided without significant delay to the day of observation/measurement		codelist item	CharacterString	ISO19103		
53	realMonth	data provided without significant delay to the month of observation/measurement		codelist item	CharacterString	ISO19103		
54	realYear	data provided without significant delay to the year of observation/measurement		codelist item	CharacterString	ISO19103		
55	historical	data provided from observation/measurement that dates back more than a year.		codelist item	CharacterString	ISO19103		
56		*intentionally left blank*						
57	DataDissemination	This package provides information about data dissemination additionally required for the provision of datasets in terms of a distribution service.						
58	DataDissemination	description of the data dissemination service.		generalisation	MD_Distribution	ISO19115 (ISO19115-1)	use obligation / condition from referencing	use maximum occurrence from referencin

							object	g object
59	endUser	institution or individual with permission to data access		attribute	CI_Responsibility	ISO19115 (ISO19115-1)	M	1
60	enduserInfoUpdate	information about updating the information about the end user		attribute	LI_ProcessStep	ISO19115 (ISO19115-1)	O	1
61	disseminationProject	unique project identifier		attribute	MD_Identifier	ISO19115 (ISO19115-1)	M	1
62	disseminationProjectUpdate	information about an update of the dissemination project		attribute	LI_ProcessStep	ISO19115 (ISO19115-1)	O	1
63	extent	spatial and temporal extent of the dissemination project		attribute	EX_Extent	ISO19115 (ISO19115-1)	O	1
64	permission	consent for access given to the end user		attribute	MD_Releasability	ISO19115 (ISO19115-1)	O	N
65	serviceUsed	information about the service used for data dissemination, incl. technical environment providing the resource.		attribute	SV_ServiceIdentification	ISO19115 (ISO19115-1)	O	N
66	transferFormat	transfer format supported by the dissemination service		attribute	MD_Format	ISO19115 (ISO19115-1)	O	N
67	transferOptions	transfer options supported by the dissemination service		attribute	MD_DigitalTransferOptions	ISO19115 (ISO19115-1)	O	1
68	distributor	information about the distributor	ISO19115	association	MD_Distributor	ISO19115 (ISO19115-1)	O	N
69	distributionFormat	description of the computer language construct that specifies the representation of data objects in a record, file, message, storage device or transmission channel	ISO19115	association	MD_Format	ISO19115 (ISO19115-1)	O	N
70	transferOptions	technical means and media by which a resource is obtained from the distributor	ISO19115	association	MD_DigitalTransferOptions	ISO19115 (ISO19115-1)	O	N
71	associatedTimeSeries	time series disseminated using the dissemination service		association	TimeSeries_GRDC		O	N
72	associatedPointData	point coverage disseminated using the dissemination service		association	StationNetwork_GRDC		O	N
73	associatedLineData	line coverage disseminated using the dissemination service		association	MajorRivers_GRDC		O	N
74	associatedPolygonData	polygon coverage disseminated using the dissemination service		association	MajorRiverBasins_GRDC		O	N

75	associatedGriddedData	grid coverage disseminated using the dissemination service		association	GriddedRunoffData_GRDC		O	N
76		*intentionally left blank*						
77	DataReliability	This package provides information additionally required with respect to the reliability of source data compiled into the resource, usually provided by the owner/custodian of the input data and passed on to users by the processor Note: Although the responsibility for the quality of the source data is usually with the owner/custodian of the source data, the processing organization is asked to assess the reliability and suitability regarding further accumulation or aggregation.						
78	DataReliability	information regarding the reliability of source data which are compiled into a secondary data set.		class				
79	completenessStatement	statement regarding completeness of the resource		attribute	CompletenessStatement		O	1
80	errorCorrectionInput	information about the error correction applied in the source (input) data		attribute	ErrorCorrectionInfo		O	1
81	evaluationReference	reference to the data evaluation procedure		attribute	DataQualityEvaluation		M	1
82	precisionStatement	statement regarding precision of data values in the resource		attribute	PrecisionStatement		O	1
83	CompletenessStatement	information about the completeness of the resource as well as the source data processed into a secondary data set		class				
84	completeness	numerical expression of completeness, e.g. missing values in percent		attribute	DQ_QuantitativeResult	ISO19157	O	1
85	completenessCode	term from a controlled vocabulary expressing the degree of completeness.		attribute	DataQualityCode	OGC10-126r3	O	1
86	DataQualityEvaluation	information about the evaluation of the quality of the data processed into the resource, usually provided by the custodian of the input data and passed on to users by the processor		class				
87	evaluationDate	date when the data in the resource was evaluated.		attribute	CI_Date	ISO19115 (ISO19115-1)	O	1
88	evaluationMethod	method applied for evaluation of the data.		attribute	DQ_EvaluationMethod	ISO19157	O	1
89	evaluationScope	process step (in the processing chain of the resources) in scope of the evaluation		attribute	ScopedName	ISO19103	O	1
90	institutionInCharge	institution that has performed the evaluation of the data.		attribute	CI_Organisation	ISO19115 (ISO19115-1)	M	1

91	PrecisionStatement	statement about the precision of observation, i.e. the smallest unit of division on a scale of measurement used.	[2]	class				
92	precision	numerical expression of precision		attribute	DQ_QuantitativeResult	ISO19157	O	1
93	precisionCode	term from a controlled vocabulary expressing the degree of the precision.		attribute	DataQualityCode	OGC10-126r3	O	1
94	ErrorCorrectionInfo	information about the correction of measurement errors.		class				
95	correctionValue	value added to the result of a measurement to obtain a closer approximation to the true value.	[2]	attribute	Real		O	1
96	correctionProcedure	procedure applied to obtain a closer approximation to the true value.		attribute	CI_Citation	ISO19115 (ISO19115-1)	O	1
97	sourceOfError	identified source of error		attribute	CharacterString	ISO19103	O	1
98	typeOfError	principal type of identified error		attribute	CharacterString	ISO19103	O	1
99		*intentionally left blank*						
100	UpdateResource	This package provides information about the maintenance of the hydrologic dataset additionally required to describe the spatial-temporal extent of updates of the source data used for the compilation of the secondary data.						
101	UpdateResource	information about updating the resource, particularly the spatial-temporal extent		generalisation	MD_MaintenanceInformation	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
102	spatialTemporalExtent	temporal extent of the update with respect to station location.		attribute	EX_SpatialTemporalExtent	ISO19108	O	1
103	updateSourceData	information about updating the source data used for the compilation of the secondary data		association	UpdateResource		O	N
104		*intentionally left blank*						

105	LineageFromObservation	This package provides information about the lineage of the hydrologic data set additionally required for the description of observation results. ... provides the association to the source data processed into secondary data. *Note 1: the observation event is understood as the first process step in the life of the data set.* *Note 2: the compilation of secondary data is understood as observation based on a preceding source observation.*						
106	LineageFromObservation	information about the observation origin of the data set.		generalisation	LI_Lineage	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
107	reportedFeature	Note: provided in the sense of a short-cut in order to relate the data set to the hydrologic feature under observation without the need of the complex observation description		attribute	HY_HydroFeature	OGC 11-039r3	O	1
108	scope	identifies the type of the resource: ="dataset" {LI_Lineage.scope:MD_ScopeCode = "dataset"}	ISO19115	attribute	MD_ScopeCode	ISO19115 (ISO19115-1)	O	1
109	statement	identifies the dataset as ="observation result" {LI_Lineage.statement = "observationResult"}	ISO19115	attribute	CharacterString	ISO19103	O	1
110	updateSource	information about updating the source data.		attribute	UpdateResource			
111	reliabilityOfSource	information about the reliability of the source data processed into the resource.		attribute	DataReliability			
112	source	result of a preceding observation event, usually a time series resulting from measurement, which are the source of the resource	ISO19115	association	MeasurementTimeseriesTVP	OGC10-126r3	O	N
113	processStep	observation that generated the resource. This may be any type of observation, e.g. special observations resulting in temporal or spatial coverages, but also the gauging observation that generated a stage-discharge relation.	ISO19115	association	OM_DiscreteCoverageObservation (GenerateTimeSeries_GRDC; GeneratePointCoverage_GRDC; GenerateLineCoverage_GRDC;	ISO19156	O	N

					GeneratePolygonCoverage_GRDC; GenerateGridCellCoverage_GRDC)			
114		*intentionally left blank*						
115	TemporalRepresentation	This package provides information about the temporal representation of hydrologic data additionally required for the description of temporal coverages. ... specialises MD_GridSpatialRepresentation (ISO19115-1) with respect to time series.						
116	TemporalGridRepresentation	information about the temporal grid representing the data values		generalisation	MD_GridSpatialRepresentation	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
117	timeRangeObject	time series element, where time (domain) and value (range) are represented separately with a 1:1 relationship between each time instant and value in the range	WML2.0 P1	attribute	WML_DomainObject	OGC10-126r3	O	1
118	timeValuePair	time series element, where time (domain) and value (range) represented as a time-value pair	WML2.0 P1	attribute	TimeValuePair	OGC10-126r3	O	1
119		*intentionally left blank*						
120	ContentInfo	This package provides information about the content of the hydrologic data set additionally required for the description of temporal coverages, particularly series of ordered time-value pairs. ... includes a specialisation of MD_RangeDimension and MD_SampleDimension with respect to time.						
121	TimeSeries	description of the time series as a whole, according to WML2.0 *Note: relates the "TimeseriesMetadata" of WML2.0 application schema, which currently is not associated with MD_Content.*		generalisation	MD_AttributeGroup	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
122	timeSeriesDescription	description of the time series as a whole, in terms of WML2.0	WML2.0 P1	attribute	TimeseriesMetadata	OGC10-126r3	O	1
123	attribute	variable of which values are collected in the time series (this association is inherited from MD_AttributeGroup)		association	TimeSeriesRange		O	*

124	TimeRange	description of the temporal grid used to arrange the values for the (observed) property. provide the information about the accumulation of values over time.		generalisation	MD_RangeDimension	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
125	accumulation	details of how individual values are accumulated in the time series, particularly a measurement time series according to WML2.0. {MD_CoverageDescription.attributeGroup//MD_AttributeGroup.contentType="physical measurement"}	WML2.0 P1	attribute	MeasurementTimeseriesMetadata	OGC10-126r3	O	1
126	variable	description of the variable whose values are collected in the time series .		attribute	Variable		O	N
127	timeSeries	time series wherein the values of the variable are collected (this association is inherited from MD_AttributeGroup)		aggregation	TimeSeries		O	1
128	TimeSample	description of the temporal grid to which the individual value, or a range of values, is assigned. provide the information about the accumulation of values over time.		generalisation	MD_SampleDimension	ISO19115 (ISO19115-1)	use obligation / condition from referencing object	use maximum occurrence from referencing object
129	timeErrorCorrection	information about the correction of time errors applied in respect to the synchronization of data.		attribute	ErrorCorrectionInfo		O	N
130	processingStatus	information about the status of data processing with respect to the life cycle of the individual data value		attribute	ProcessingStatusCode		O	1
131	aggregation	aggregation of values by time to the individual time series element, particularly a measurement time series point, in terms of WML2.0.	WML2.0 P1	attribute	MeasurementPointMetadata	OGC10-126r3	O	1
132	annotations	description of temporally ranging annotations related to the data value, in terms of WML2.0	WML2.0 P1	attribute	AnnotationCoverage	OGC10-126r3	O	1
133		*intentionally left blank*						
134		*intentionally left blank*						

Table 3: ObservationDescription

1	**Name**	**Description**	**Source of description (external)**	**Element type**	**Target**	***Target specified externally in:***	**Obligation/ Condition - mandatory (M) - conditional (C) - optional (O)**	**Maximum Occurrence**
135	ObservationDescription	The Observation Description package provides the observational information (so-called WIGOS metadata). Observation Description provides a description of the Sampling Feature, of the Observed Property, the Procedure and the Sampled Feature. This refers to the core concepts of the OBSERVATION model as of ISO19156:2011 in terms of the OGC WaterML 2.0 specification (OGC10-126r3). The information about the Hydrologic Variable and the Data Generation Process is provided using concepts proposed at the application level (described in the Utilities package). The SampledFeature is a Water Body in terms of the HY_Features common hydrologic feature model (OGC 11-039r3r2). Attributes, their obligation and maximum occurrence reflect the requirements of the GRDC metadata concept.						
136	GenerateTimeSeries_GRDC	observation made by the GRDC (e.g. data generation process) whose result is a series of ordered time-value pairs.	WML2.0 P1	generalisation	TimeseriesObservation	OGC10-126r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
137	observedProperty	variable for which the observation provides an estimate of its value	ISO 19156	association	HydrologicVariable		1	1
138	procedure	process used to generate the result	ISO 19156	association	DataGenerationProcess_GRDC		1	1
139	featureOfInterest	feature intended to sample the real-world object whose properties are under observation	ISO 19156	association	StationGRDC		M	1

140	relatedObservation	observation whose result is input for the generation of the resource (observation result) .		association	MeasurementTimeseriesTVPObservation		O	N
141	GeneratePointCoverage_GRDC	observation made by the GRDC whose result is a point coverage wherein each point provides a value of the observed property.		generalisation	OM_PointCoverageObservation	ISO19156	use obligation / condition from referencing object	use maximum occurrence from referencing object
142	observedProperty	variable for which the observation provides an estimate of its value	ISO 19156	association	HydrologicVariable		1	1
143	procedure	process used to generate the result	ISO 19156	association	DataGenerationProcess_GRDC		1	1
144	featureOfInterest	feature intended to sample the real-world object whose properties are under observation	ISO 19156	association	StationGRDC		M	1
145	GenerateLineCoverage_GRDC	observation made by the GRDC whose result is a line coverage wherein each line, or line segment) provides a value of the observed property.		generalisation	OM_DiscreteCoverageObservation	ISO19156	use obligation / condition from referencing object	use maximum occurrence from referencing object
146	observedProperty	variable for which the observation provides an estimate of its value	ISO 19156	association	HydrologicVariable		1	1
147	procedure	process used to generate the result	ISO 19156	association	DataGenerationProcess_GRDC		1	1
148	featureOfInterest	feature intended to sample the real-world object whose properties are under observation	ISO 19156	association	StationGRDC		M	1
149	GeneratePolygonCoverage_GRDC	observation made by the GRDC whose result is a polygon coverage wherein each polygon provides a value of the observed property.		generalisation	OM_DiscreteCoverageObservation	ISO19156	use obligation / condition from referencing object	use maximum occurrence from referencing object
150	observedProperty	variable for which the observation provides an estimate of its value	ISO 19156	association	HydrologicVariable		1	1
151	procedure	process used to generate the result	ISO 19156	association	DataGenerationProcess_GRDC		1	1

152	featureOfInterest	feature intended to sample the real-world object whose properties are under observation	ISO 19156	association	StationGRDC		M	1
153	GenerateGridCell Coverage_GRDC	observation made by the GRDC whose result is a grid coverage wherein each grid cell provides a value of the observed property.		generalisatio n	OM_Discrete CoverageObs ervation	ISO19156	use obligation / condition from referencing object	use maximum occurrence from referencin g object
154	observedProperty	variable for which the observation provides an estimate of its value	ISO 19156	association	HydrologicVa riable		1	1
155	procedure	process used to generate the result	ISO 19156	association	DataGenerati onProcess_G RDC		1	1
156	featureOfInterest	feature intended to sample the real-world object whose properties are under observation	ISO 19156	association	StationGRDC		M	1
157	SamplingFeature	This package provides information about the monitoring station used to observe a characteristic property of a hydrologic feature by applying a suitable procedure.						
158	Station_GRDC	description of the reporting location "operated" by the GRDC. the GRDC station usually coincides with the identified monitoring point (as of WML2.0) associated with the related observation providing the input data.		generalisatio n	MonitoringPoi nt	OGC10-126r3	use obligation / condition from referencing object	use maximum occurrence from referencin g object
159	climaticRegion	region in which there is a relatively uniform climate, according to specific criteria.	[2]	attribute	EXT_Spatial Context	OGC 11-039r3	O	1
160	coordinatesWGS8 4	coordinates with reference to WGS84		attribute	GeographicC oordinates_W GS84		M	1
161	countryCodeGRD C	country number (1-9); specific part of GRDC Station-Id		attribute	EXT_Classifi cationContext	OGC 11-039r3	O	1
162	identifier	GRDC station number		attribute	CharacterStri ng	ISO19103	M	1
163	notes	remarks to the station (not published with data files)		attribute	CharacterStri ng	ISO19103	O	1
164	predecessorStatio n	preceding (old) GRDC station, e.g. when the identifier has been changed		attribute	StationGRDC		O	1
165	stationIdentifierG RDC	station number (000-999); specific part of GRDC Station-Id		attribute	Number	ISO19103	O	1
166	stationInfoReliabili ty	reliability of a station information		attribute	DataReliabilit y		O	1

167	stationInfoUpdate	updating the station information		attribute	LI_ProcessStep	ISO19115 (ISO19115-1)	O	1
168	successorStation	succeeding GRDC station (when a station is closed)		attribute	StationGRDC		O	1
169	wmoRegion	WMO Region code, specific part of GRDC Station-Id		attribute	EXT_ClassificationContext	OGC 11-039r3	O	1
170	wmoSubregion	WMO Subregion code, specific part of GRDC Station-Id		attribute	EXT_ClassificationContext	OGC 11-039r3	O	1
171	sampledFeature	real-world object whose properties are under observation		association	RiverGRDC		M	N
172	relatedStation	monitoring station, referenced by the GRDC station, operated in the responsibility of a National Hydrological Service		association	StationNHS		O	1
173	downstreamStation	GRDC station(s) located immediately downstream of the GRDC station		association	StationGRDC		O	1
174	referenceStation	gauging station referenced by the GRDC station, usually owned and maintained by a National Hydrological Service *Note: the associated hydrometric feature provides a position (on river) which allows to relate the station to the corresponding basin.*		association	HY_HydrometricFeature	OGC 11-039r3	O	N
175	Station_NHS	description of the reporting location operated by a National Hydrological Service		generalisation	MonitoringPoint	OGC10-126r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
176	country	country code, usually the 2-digits code of ISO3166		attribute	EXT_SpatialContext	OGC 11-039r3	O	1
177	custodian	information about the custodian of the station, usually the organisation providing information and data		attribute	CI_Organisation	ISO19115 (ISO19115-1)	O	2
178	identifierNational	station identifier used by the National Hydrological Service		attribute	EXT_IdentificationCode	OGC 11-039r3	O	1
179	nameNational	station name used by the National Hydrological Service		attribute	EXT_LocalisedName	OGC 11-039r3	M	1
180	nationalCoordinates	national coordinates and height datum (EPSG code) - required for transformation		attribute	LocationReference		O	1
181	networkStation	station in a network of hydrologic stations and observing posts situated within any given area (river basin, administrative region) in such a way as to provide the means of studying the hydrological regime.		association	HY_HydrometricFeature	OGC 11-039r3	O	N
182	sampledFeature	water body sampled using the identified station operated by the NHS		association	HY_WaterBodySegment	OGC 11-039r3	1	N

183	hostedProcedure	instruments or procedures hosted repetitively or permanently at the sampling feature	ISO 19156	association	StageDischargeRelation		O	N
184	relatedParty	parties –individuals or organisations – that are related to the monitoring point (inherited from MonitoringPoint)	WML2.0 P1	association	CI_Responsibility	ISO19115 (ISO19115-1)	O	N
185	LocationReference	coordinates and height datum of the reference point in the relevant national systems, including reference to the EPSG Geodetic Parameter Dataset		generalisation	HY_ReferencePoint	OGC 11-039r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
186	coordinateReference_EPSG	coordinate reference to the EPSG Geodetic Parameter Dataset		attribute	EXT_ClassificationContext	OGC 11-039r3	M	1
187	easting	eastward-(x)-coordinate in a cartesian coordinate system		attribute	Length	ISO19103	O	1
188	elevation	height above a reference point		attribute	Distance	ISO19103	O	1
189	geodeticDatum_EPSG	datum reference to the EPSG Geodetic Parameter Dataset		attribute	EXT_ClassificationContext	OGC 11-039r3	M	1
190	geographicCoordinates	position identified by geographic coordinates		attribute	DirectPosition	ISO19107	O	1
191	northing	northward-(y)-coordinate in a cartesian coordinate system		attribute	Length	ISO19103	O	1
192	networkLocation	location of reference point in the related network of basins.	HY_Features	association	HY_Outfall	OGC 11-039r3	O	1
193	GeographicCoordinates_WGS84	geographic coordinates (latitude, longitude) and elevation (altitude) referencing the WGS84.		class				
194	altitude	altitude (0-point) of station (in metres)		attribute	Length	ISO19103	O	1
195	coordinateInfoReliability	reliability of coordinate information provided by with the resource or source data		attribute	DataReliability		O	1
196	latitude	latitude (geographic coordinates), usually in decimal degrees, N="+", S="-"		attribute	Angle	ISO19103	M	1
197	longitude	longitude (geographic coordinates), usually in decimal degrees, E="+", W="-"		attribute	Angle	ISO19103	M	1
198		*intentionally left blank*						
199	ObservedProperty	This package provides (application-specific) information about the hydrologic variable to be observed using the monitoring station and applying a suitable procedure. Note: WML2.0 recommends that the observed phenomena be separated from the physical medium that is being sampled and the units used for measurement (see from WML2.0: MeasurementTimeseries in section 9.15.3).						

200	HydrologicVariable	characteristic property of a hydrologic feature reported in the dataset. the observation of the variable may be constrained by the medium (material, organism, substance) or a procedure (algorithm or configuration).		generalisation	Variable		use obligation / condition from referencing object	use maximum occurrence from referencing object
201	variableName	name given to the hydrologic variable in common discourse		attribute	HY_HydroFeatureName	OGC 11-039r3	M	N
202	characterisedFeature	hydrologic feature, or part of this, that carries the hydrologic variable. This association provides the relation to the represented catchment/basin. *Note: the water body stratum is associated as the smallest part of the characterised hydrologic feature.*		association	HY_WaterBodyStratum	OGC 11-039r3	O	1
203	monitoringStation	monitoring station (point) where a hydrologic variable is reported, operated by the NHS this refers to the requirement of O&M: {procedure shall be associated with the feature of interest}.this requirement of the observation model (O&M) needs to be designed at the application level.		association	StationNHS		O	1
204	HydrologicProcess	process of the hydrologic cycle. Process stages are represented by hydrologic objects and may be examined by observing hydrologic variables.		generalisation	ObservableProcess		use obligation / condition from referencing object	use maximum occurrence from referencing object
205	hostingUnit	physiographic unit wherein the hydrologic process takes place		association	HY_Catchment	OGC 11-039r3	O	1
206		*intentionally left blank*						
207	Procedure	This package provides information about the procedure applied to observe a characteristic property of a hydrologic feature using a monitoring station as a proxy, ... with respect to a data set generated by processing data from a preceding observation. ... with respect to stage-discharge relation as a special instrument to estimate discharge values.						
208	DataGenerationProcess_GRDC	special algorithm or computational procedure applied by the GRDC to generate the GRDC data set.		generalisation	CalculationProcess		use obligation / condition from referencing object	use maximum occurrence from referencing object

209	errorCorrection	identification of errors resulting from the data generation process and error correction applied		attribute	ErrorCorrectionInfo		O	1
210	StageDischargeRelation	relation between stage and discharge used as instrument to estimate discharge values. *Note: the stage-discharge relation is understood as the result (parameter coverage) of a gauging observation.*	[1]	generalisation	Instrument		use obligation / condition from referencing object	use maximum occurrence from referencing object
211	gaugingObservation	observation performed to measure two related variables with the aim of defining their relationship using a rating curve and/or table.	WML2 P2	attribute	GaugingObservation	OGC 13-021	O	1
212	ratingTable	table expressing the relation between stage and discharge of a stream at a hydrometric station	WML2 P2	attribute	ConversionTable	OGC 13-021	O	1
213	has	metadata describing the stage-discharge relation as a result of an observation representing a parameter-value pair in a containing a (parameter-)coverage		association	HydrologicMetadata		O	1
214		*intentionally left blank*						
215	SampledFeature	This package provides information about the hydrologic feature of which a characteristic property is observed using a monitoring station and applying a suitable procedure.						
216	RiverGRDC	description of the river, as required by the GRDC		generalisation	HY_River	OGC 11-039r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
217	riverInfoReliability	description of the reliability of the river information		attribute	DataReliability		O	1
218	riverInfoUpdate	description of updating the river information		attribute	LI_ProcessStep	ISO19115 (ISO19115-1)	O	N
219	riverSegment	role of the sampled river in the hydrographic network (aggregate of water bodies)		association	HY_WaterBodySegment	OGC 11-039r3	O	1
220	observableProperty	characteristic property of the river amenable to observation.		association	HydrologicVariable		1	N
221	BasinGRDC	description of the catchment, as required by the GRDC		generalisation	HY_Basin	OGC 11-039r3	use obligation / condition from	use maximum occurrence from

							referencing object	referencing object
222	basinCodeWMO	classification (code) representing the basin in the WMO context.		attribute	EXT_ClassificationContext	OGC 11-039r3	O	1
223	basinArea	quantity expressing the average drainage area of the basin, incl. the unit of measure applied.		attribute	Area	ISO19103	O	1
224	basinAreaReliability	reliability of the basin area value		attribute	Reliability		O	1
225	inflowNode	location served as the node where the receiving basin gets inflow.	HY_Features	association	HY_Outfall	OGC 11-039r3	O	1
226	outflowNode	location served as the node where water flows out of the contributing basin.	HY_Features	association	HY_Outfall	OGC 11-039r3	M	1
227	upstreamBasin	basin located immediately upstream of the basin.	HY_Features	association	HY_Basin	OGC 11-039r3	O	1
228	encompassingBasin	all comprising system (highest level hierarchy) containing a network of sub-basins.	HY_Features	association	HY_BasinAggregate	OGC 11-039r3	M	1
229	containingCatchment	containing catchment->basin in a nested hierarchy of catchments.	HY_Features	association	HY_Catchment	OGC 11-039r3	O	1
230		*intentionally left blank*						
231		*intentionally left blank*						

Table 4: Utilities (within GRDC HYDROLOGIC METADATA)

1	**Name**	**Description**	**Source of description (external)**	**Element type**	**Target**	***Target specified externally in:***	**Obligation/ Condition - mandatory (M) - conditional (C) - optional (O)**	**Maximum Occurrence**
232	Utilities	The Utilities package contains utility classes for common patterns. This classes are neither hydrology- nor GRDC-specific, but required by the GRDC Metadata. They may be replaced at a later stage with more general concepts as they become available in the course of further developments or revision of the relevant ISO standards.						
233	ObservationProcess	This package provides a specialisation of observation process as defined within WML2. An observation process may be either a sensor or a system of sensors (instrument) using an internal recording procedure, or an algorithm/computational procedure used to calculate the data value. *Note: this refers to a requirement of the observation model (O&M) {procedure shall be suitable for observedProperty}*						
234	CalculationProcess	algorithm or computational procedure applied to estimate a value of the observed property, based on quantities determined in an (external) observation, or on empirical constants.		generalisation	ObservationProcess	OGC10-126r3	use obligation / condition from referencing object	use maximum occurrence from referencing object
235	instrument	instrument using the calculation process.		aggregation	Instrument		O	1
236	formula	algebraic algorithm used to calculate a dependent variable based on independent variables.		attribute	CharacterString		O	N
237	inputVariable	variable on which another variable depends (independent, base quantity)		attribute	Variable		O	N
238	outputVariable	variable depending on other variables (dependent quantity)		attribute	Variable		O	1
239	Instrument	physical instrument, or system of sensors used to obtain a value of the observed property.		generalisation	ObservationProcess	OGC10-126r3	use obligation / condition from referencing	use maximum occurrence from referencing

							object	object
240	instrument	physical artifact used to observe a property		attribute	MI_Instrument	ISO19115 (ISO19115-1)	O	N
241	uncertainty	interval about the measurement within which the true value of a quantity can be expected to lie with a stated probability	[2]	attribute	Measure		O	2
242	encoding	algorithm or computational procedure used to convert the response to a specific code.	[6]	association	CalculationProcess		O	1
243	sensor	sensor component of a multi-sensor instrument.		association	Sensor		O	N
244	measurand	property observed using the instrument (as required by the WMO Logical Data Model METCE)		association	Variable		O	N
245	Sensor	device that responds to a physical or chemical stimulus, used to obtain a value of the observed property. the sensor may be component of a multi-sensor instrument.	[6]	class				
246	sensor	description of the sensor		attribute	SD_Sensor	ISO19130	O	1
247	instrument	system of sensors the sensor is part of		aggregation	Instrument		O	1
248		*intentionally left blank*						
249	ObservableProperty	This package provides fundamental relationships of a feature property which is the abstract notion of an object property in the real-world whose values may be determined by observation. The core concept are that of an observable process represented by variables, each variable composed of quantities observed as a proxy for a variable which is often not known at the date of the actual measurement. This refers to the common practice of indirect observation relying on direct observation of a more convenient parameter, which is a proxy for the ultimate property of interest [ISO19156:O&M]. The determination of the (hydrologic) variable may be constrained by a carrier medium (material, organism, or substance) or a standard procedure (algorithm or configuration).						

250	ObservableProperty <abstract>	characteristic property or process carried by the sampled feature, e.g. a hydrologic feature, and amenable to observation. the observable property may be constrained by the medium wherein observed or standard procedure applied. *Note 1: an observable exists and persists independent of its determination by observation and independent of any possible value that may be determined.* *Note 2: intended to instantiate the general Property Type (meta-class) of the General Feature Model (ISO19109, under review)*						
251	constrainedBy	any constraint that significantly limits the determination of the attribute value *Note: this is intended to realise the attribute "constrainedBy" of the general Property Type (meta-class) of the General Feature Model (ISO19109, under review)*		attribute	ThematicAttributeConstraint		O	N
252	ObservableProcess	process, e.g. of the hydrologic cycle, of which stages are represented by real world objects and that may be examined by observing the characteristic properties of these.		generalisation	ObservableProperty		use obligation / condition from referencing object	use maximum occurrence from referencing object
253	process	reference to the examined natural process, usually a term in a controlled vocabulary.		attribute	URI	ISO19136	O	1
254	processType	reference to the principal process type, usually a term in a controlled vocabulary.		attribute	URI	ISO19136	M	1
255	processVariable	variable/characteristics representing the stage of the process.		association	Variable		M	N

256	Variable	characteristic property of a real-world object which may take any value of a specified set of values. *Note: Variables usually refer to a basic concept (definition), carry own properties such as unit of measure and may be multiple constrained e.g. by the sampled medium, a procedure configuration, or a probability function (in case of variate). An observed variable is often proxy for an ultimate variable.*	[1]	generalisation	ObservableProperty		use obligation / condition from referencing object	use maximum occurrence from referencing object
257	observableProcess	variable/characteristics representing the stage of the process.		aggregation	ObservableProcess		O	1
258	concept	reference to the principal concept of the variable, usually a term in a controlled vocabulary. Example: streamflow		attribute	URI	ISO19136	O	1
259	nature	reference to a fundamental characteristic of the observable property in respect to conformity with a common concept, usually a term in a controlled vocabulary. Examples: natural/naturalised/artifical, normal/normalised, generic/specific,synthetic/analytic, etc.		attribute	URI	ISO19136	O	N
260	statistics	reference to the statistic concept of the variable, usually a term in a controlled vocabulary. Examples: mean, median, maximum, etc.		attribute	URI	ISO19137	O	N
261	quantity	quantity observed as a proxy for the variable of interest.		association	Quantity		1	1
262	Quantity	quantity, defined by a conventional measurement procedure, for which a total ordering relation can be established, according to magnitude, with other quantities of the same kind, but for which no algebraic operations among those quantities exist .	[7]	generalisation	ObservableProperty		use obligation / condition from referencing object	use maximum occurrence from referencing object
263	variable	ultimate variable of interest for which the quantity is observed as a proxy.		aggregation	Variable		O	1
264	quantityName	reference to the observable quantity, usually a term in a controlled vocabulary.		attribute	URI	ISO19136	M	1
265	quantityName_WMO	term (name) recommended for use within the community of the WMO Member countries		attribute	QuantityUnitCode_WMO		O	1
266	base	base quantity of a derived quantity		association	Quantity		O	N

267	NominalProperty	property of a phenomenon, body, or substance, where the property has no magnitude, or multitude. Such properties usually represent an idea or a logic concept, where the property has a category value that can be expressed by words, alpha-numerical codes etc..	[7]	generalisation	Variable		use obligation / condition from referencing object	use maximum occurrence from referencing object
268	ThematicAttribute Constraint	material, substance, organism, standard algorithm or configuration that constrains the determination of the property of interest.						
269	algorithm	(standard) algorithm or process chain typically applied for property valuation.		association	CalculationProcess		O	1
270	configuration	(standard) configuration of instruments applied for property valuation.		association	Instrument		O	1
271	material	reference to the constraining material, usually a term in a controlled vocabulary.		attribute	URI	ISO19136	M	1
272	organism	reference to the constraining organism, usually a term in a controlled vocabulary.		attribute	URI	ISO19136	M	1
273	substance	reference to the constraining substance, usually a term in a controlled vocabulary.		attribute	URI	ISO19136	M	1
274		*intentionally left blank*						
275	Quantity (informative)	This informative package contains fundamental, generally applicable types of quantities that may be observed using a sampling feature and applying a procedure. *Note: the observable property may be a quantity having a magnitude (continuous quantity) or multitude (discrete quantity) whose values can be expressed by a number and reference, but also a nominal property expressed using words, alpha-numeric codes, or boolean values. depending on application, quantities may be divided into discrete and continuous ones, and further detailed into extensive (with an additive magnitude) and intensive (with non-additive magnitude) ones.*						
276	OrdinalQuantity	quantity, defined by a conventional measurement procedure, for which a total ordering relation can be established, according to magnitude, with other quantities of the same kind, but for which no algebraic operations among those quantities exist.	[7]	generalisation	Quantity		use obligation / condition from referencing object	use maximum occurrence from referencing object

277	DiscreteQuantity	quantity representing a multitude created from counting entities, i.e answering the question "how many?" (similar to quantity as defined in clause 3.1 of ISO 80000-1:2009, wherein quantities are not divided into discrete and continuous ones, and multitudes are not explicitly treated, but a "number of entities" is regarded as quantity in clause 3.4)	[7]	generalisation	Quantity		use obligation / condition from referencing object	use maximum occurrence from referencing object
278	ContinousQuantity	quantity representing a magnitude, i.e. answering the question "how much?" (according to quantity as defined in clause 3.1 of ISO 80000-1:2009)	[7]	generalisation	Quantity		use obligation / condition from referencing object	use maximum occurrence from referencing object
279	ExtensiveQuantity	quantity whose magnitude increase/decrease with the extent, i.e. is additive. Examples: volume, mass, thermodynamic temperature. *Note 1: the ratio of two extensive quantities is an intensive quantity, e.g. density is mass per volume.* *Note 2: a percentage is the ratio between quantities of the same dimension, i.e. an intensive quantity.* *Note 3: the derivative of an extensive quantity is an intensive quantity.*		generalisation	ContinousQuantity		use obligation / condition from referencing object	use maximum occurrence from referencing object
280	IntensiveQuantity	continuous quantity whose magnitude is not additive, i.e. independent of the extent of the system or the amount of the entities inside the system. Examples: temperature, pressure, intensity, density, velocity, viscosity.		generalisation	ContinousQuantity		use obligation / condition from referencing object	use maximum occurrence from referencing object
281	QuantityUnitCode_WMO (not listed in detail in this document)	quantities, symbols and units recommeded for use within the community of the WMO Member countries (not listed in detail in this document, for detailed listing see [3])	[3]	codelist				
282		*intentionally left blank*						
283		*intentionally left blank*						

References of column C in Annex: Source of external description

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	(12 pp, annex 20 pp)

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