



# OGC® WaterML 2 – Part 3: Surface Hydrology Features (HY\_Features)

## – Conceptual Model



# **Open Geospatial Consortium**

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## **OGC® WaterML 2 – Part 3: Surface Hydrology Features (HY\_Features) – Conceptual Model**

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## **i. Abstract**

The OGC Surface Hydrology Features (HY\_Features) implementation standard defines a standard information model for the identification of surface hydrologic features independent of geometric representation and scale. The conceptual model describes hydrologic features by defining the fundamental relationships among major components of the hydrosphere. This includes relationships such as the hierarchy of catchments, the segmentation of watercourses, and the topological connectivity of hydrologic features such as watersheds and water bodies. The standard is based on the concept that a given hydrologic feature may have multiple representations. This supports referencing the same feature(s) in different information systems or products and assists the organization and cataloging of observations, model results, or other studies of a feature. The ability to represent the same watershed, river, or other hydrologic feature in several ways is critical to aggregation of cross-referenced features into integrated datasets and data products on global, regional, or basin scales. Hydrologic feature types are defined using the OGC General Feature Model (ISO 19109:2006) with reference to definitions from the International Glossary for Hydrology. The conceptual model is expressed in the Geographic Information Conceptual Schema Language (ISO 19103:2005) using the Unified Modeling Language (UML).

## **ii. Keywords**

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

ogedoc, OGC document, hydrology, feature, identification, conceptual model, UML, implementation standard.

## **iii. Preface**

This standard defines the HY\_Features common hydrologic feature model for the identification of hydrologic features. It is intended to be used to document and share information about the objects of study and reporting in Hydrology in many applications. This standard was originally commissioned to link hydrologic information across the scientific and technical programs of the World Meteorological Organization (WMO), and to assist the WMO Members to discover, access and use hydrologic data from different sources. This standard has been designed to support the need for governance and guidance by national and international authorities. Aspects of the standard that support this end are; 1) its canonical form, 2) its implementation neutrality, 3) conformity to internationally recognized standards of geographic information, and its use of semantics inferred from terminology endorsed by the WMO and the UN Educational, Scientific and Cultural Organization (UNESCO). Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. The Open Geospatial Consortium shall not be held responsible for identifying any or all such patent rights. *Recipients of this document*

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## iv. Submitting organizations

The following organizations submitted this Document to the Open Geospatial Consortium (OGC):

- U.S. Geological Survey (USGS), USA
- Federal Institute of Hydrology (BfG), Germany
- CSIRO Land and Water, Australia
- Bureau of Meteorology, Australia
- Metalinkage, Australia
- BRGM, France
- University of Texas at Austin, USA
- Eurecat, Spain
- INCLAM S. A., Spain
- 52°North, Germany

## v. Submitters

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Darren Smith	Australian Bureau of Meteorology

Bruce Simons	CSIRO Land and Water
David Arctur	University of Texas at Austin

## v. Changes to the OGC® Abstract Specification

This standard requires no changes to the OpenGIS ® Abstract Specification.

# 1. Scope

This OGC Implementation Standard defines a common feature model for the identification and description of surface hydrologic features using established models and patterns in use in the Hydrology domain and endorsed by WMO and UNESCO such as those documented in the "International Glossary of Hydrology".

Part 1 (this document) introduces the conceptual model itself. The normative model is a machine-readable UML artifact published by the OGC in conjunction with this document at: [insert URL here].

Part 2 (a future document) is expected to define an OWL and RDF representation of the conceptual model suitable for defining links between data that reference the HY\_Features model, to support documentation and discovery of data and to aid future data transformation efforts. This work may provide a basis for further work in the wider OGC on a methodology (tooling) to publish ontologies to support their practical use. The initial scope is defined by the WMO Commission for Hydrology (WMH-CHy): to facilitate data sharing within the hydrologic community of the WMO Member countries and to improve the quality of data products based on these data by defining hydrologic features to convey the identification of water-objects through the data processing chain "from measurement to hydrological information" [8].

To enable semantic interoperability of hydrologic data and services, it is necessary to agree on common concepts and methods for machine interpretation of the concepts. To this goal, the HY\_Features model was developed in order to formalize the concepts and relationships of hydrologic features using the WMO/UNESCO "International Glossary of Hydrology" as a starting point.

This standard is meant to support the linkage of data products distributed across differing applications and jurisdictions. To enable this, a holistic concept of catchment is defined and the surface-water aspects of the concept are modeled. This will allow a particular surface catchment to be represented in different data products while retaining its identity. In addition to unique identification of features in multiple systems, a second objective is to provide a standard terminology and ontology to describe relationships between hydrologic features. This may be useful in building a data transfer format for specific subsets, particularly catchment hierarchy and river network topology but such data transfer format development is not in scope for this standard.

The HY\_Features model provides a basis for common and stable references to hydrologic features in a wide variety of applications:

- to link hydrologic observations to their feature-of-interest, e.g. link a streamflow observation to the river or catchment being observed,
- to allow aggregation of cross-referenced features into integrated datasets and data products on global, regional, or basin scales,

- to enable information systems to unambiguously link data across distributed systems and domains,
- to enable cross-domain or multi-discipline services to communicate through reference to standard concepts.

This standard defines a set of Application Schemas (normative) containing feature type definitions that conform to the OGC General Feature Model (GFM) (ISO 19101:2002 and ISO 19109:2006), expressed in the Geographic Information Conceptual Schema Language (ISO 19103:2005) using the Unified Modeling Language (UML).

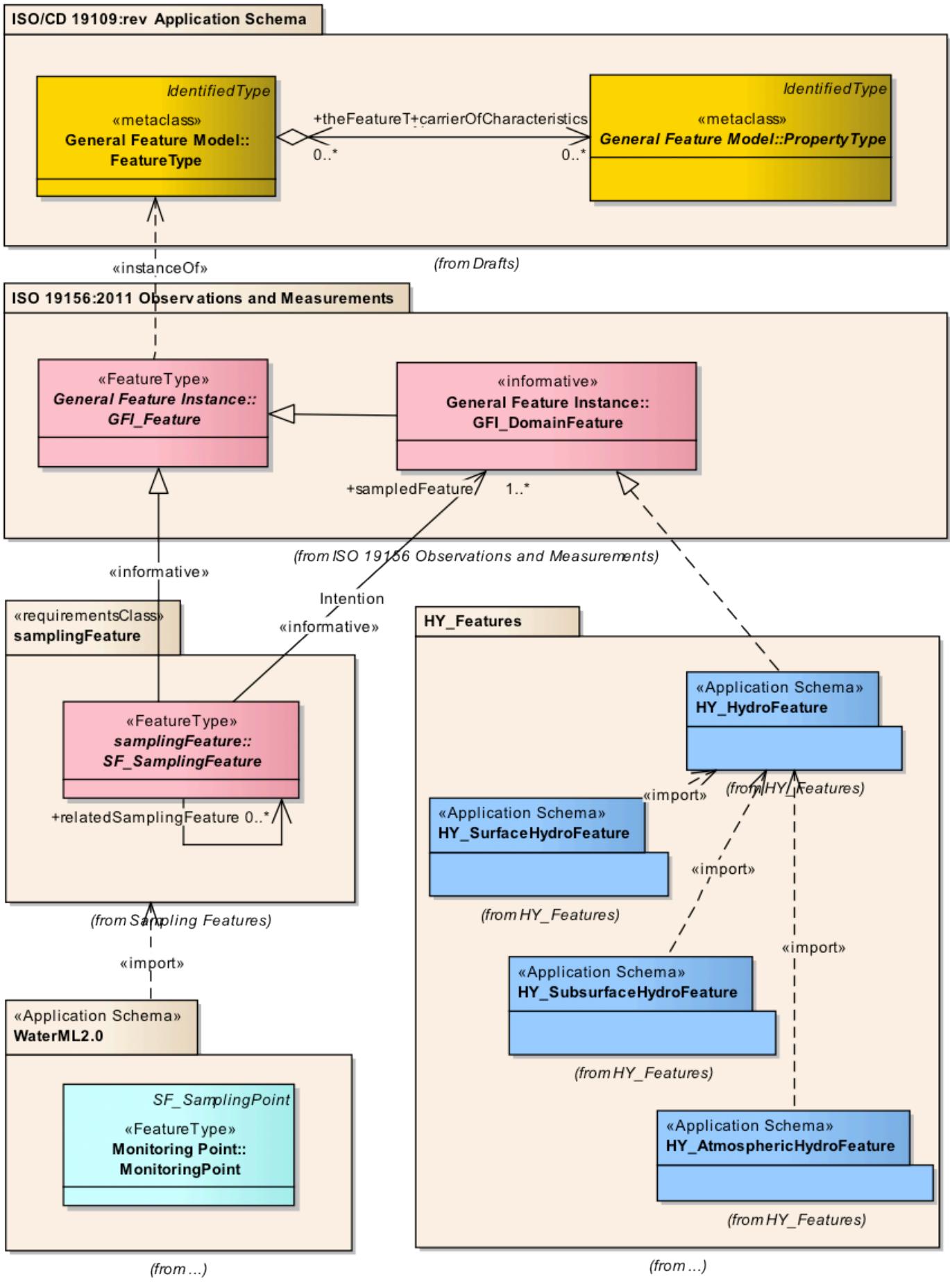
The GFM is a meta-model developed to serve as the general conceptual model for features and feature properties in the context of geographic information. A feature type is identified by a set of typical characteristics (property type) such as attributes, association, or operations as well as by possible constraints. Each attribute, association or operation is identified on its own by properties and constraints. Conformity to the GFM is assured by instantiating the general feature type as feature classes specific to the application domain.

As shown in Figure 1, the HY\_Features conceptual model realizes the GFM by providing a domain-specific instance of the general GF\_FeatureType (aka FeatureType) «metaclass» capturing the Hydrology phenomenon. Since its concern is primarily the issue of feature identification, a basic type HY\_HydroFeature is defined to reflect the overall properties hydrologic features have such as identifier, name and context. Special feature types are defined to reflect different aspects of hydrology by the typical characteristics each specialization carries. Given the complexity of the domain, a wide range of possible properties may be relevant for a given hydrologic feature type.

Figure 1 also shows how the HY\_Features model allows the feature-of-interest concept of the Observation and Measurement (O&M) model (ISO 19156:2011) to be realized for hydrologic observations. Depending on the application, the target of an observation may be a Domain Feature, like a water body, or a Sampling Feature, such as a stream gage, used as a proxy for a Domain Feature. Specifically, observation-centric data models such as the WaterML2.0 implementation profiles of O&M may use the concepts provided in this standard to identify domain-specific relationships between a sampling feature and the ultimate sampled feature.

The model concepts may be used to describe the relationships of observation results to the hydrologic feature of interest they are meant to represent and in this way to link spatial and non-spatial hydrologic data. In particular, this allows links to be implemented in a standard way between resources on the Web. For example, a discovery service such as a catalog of catchments could use the concepts defined here to provide machine interpretable pointers to services that provide differing geospatial representations of the same catchments as well as data from water quality and water quantity observations that characterize some aspects of the catchments. A client could then use those links for automated workflows and data product generation.

## class HY\_Features and OGC



*Figure 1. HY\_Features in the context of the OGC Abstract Specifications*

## 2. Conformance

This standard defines the conceptual model for identification of hydrologic features and their fundamental relationships. The conceptual model may be used in two ways: a) to derive implementation classes for data exchange or b) via reference (referred to here as mapping) from terms used in an implementation to the equivalent terms in the HY\_Features model. The form of such a mapping is not specified in this standard, but in general there is correspondence expected between particular implementations of hydrologic features and realized HY\_Features concepts. There will be an exact correspondence or a correspondence to a specialization of a HY\_Features class with narrower scope. Since no technical semantic mapping standard is supported by the OGC standards baseline at this time, only the expressivity requirements of mappings are specified in relevant conformance clauses.

Requirements for OGC HY\_Features standardization target types are considered:

- Encodings (such as OWL and RDF) of the HY\_Features conceptual UML model described in this standard and
- Application schemas formally mapped to HY\_Features concepts including Feature Type classes and associative relationships.

For brevity, the terminology *implement* is used to indicate either a direct encoding or existence of a formalized mapping that would enable a client, at run-time, to determine that a particular implementation class implements a specific HY\_Features concept.

Part 2 of this standard (a future document) is intended to provide an OWL encoding of the HY\_Features application schema, whereby the mapping from the implementation to this specification will be formalized through use of encoding rules that allow direct correspondence of schema elements with the UML elements defined.

Conformance with this standard shall be checked using all the relevant tests specified in Annex A (normative) of this document. The framework, concepts, and methodology for testing, and the criteria to be achieved to claim conformance are specified in the OGC Compliance Testing Policies and Procedures and the OGC Compliance Testing web site.

In order to conform to this OGC™ interface standard, a software implementation shall choose to implement any one of the conformance levels specified in Annex A (normative).

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

### 3. References

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

ISO 19101:2002, Geographic Information—Reference Model

ISO/TS 19103:2005, Geographic Information — Conceptual schema language

ISO 19107:2003, Geographic Information — Spatial schema

ISO 19108:2006, Geographic Information — Temporal schema

ISO 19109:2006, Geographic Information — Rules for application schemas

ISO 19111:2007, Geographic Information — Referencing by coordinates

ISO 19115:2012, Geographic Information — Metadata – Fundamentals

ISO 19148:2012, Geographic Information — Linear referencing

ISO 19156:2011, Geographic Information — Observations and Measurements

## 4. Terms and Definitions

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

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

### 4.1. application schema

Conceptual schema for data required by one or more applications [ISO 19101]

### 4.2. catchment

A physiographic unit where hydrologic processes take place. This class denotes a physiographic unit, which is defined by a hydrologically determined outlet to which all waters flow. While a catchment exists, it may or may not be clearly identified for repeated study.

**NOTE**

This approach considers the catchment concept to be the basic unit of study in hydrology, water resources management, and environmental reporting. The approach is meant to be holistic, referring to the continuous interaction of surface and subsurface waters within a catchment, even if a particular representation of the catchment refers to only surface or subsurface aspects of the catchment. Special subtypes such as drainage basin and groundwater basin may be defined with a particular application.

The synonym use of the terms catchment and catchment area as documented in the WMO-UNESCO International Glossary of Hydrology (which is the key reference for the definitions in the Hydrologic Features (HY\_Features) model) does not clearly distinguish between the catchment concept and its geometric representations such as catchment area, nor between catchment and its possible specializations like drainage basin and groundwater basin.

The essential logical separation of concerns between a common concept and its representation (interpretable data) is dealt with by defining separate features for the catchment and its representation and may be understood as a refinement of the complex, ambiguous definition given in the glossary. See also clause 5.4 of this standard on the use of WMO terminology.

### 4.3. data

Documented value of some characteristics of a real-world phenomenon.

## 4.4. data set

Data compiled and arranged into a set.

## 4.5. data product

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

## 4.6. domain feature

Feature of a type defined within a particular application domain [ISO 19156].

## 4.7. feature

Abstraction of real-world phenomena [ISO 19101].

## 4.8. hydrographic network

Aggregate of rivers and other permanent or temporary watercourses, and also lakes and reservoirs [WMO, 2016].

**NOTE**

Not to be confused with the network of hydrological stations and observing posts.

## 4.9. hydrography

Science dealing with the description and measurement of open bodies of water [WMO, 2016].

**NOTE**

In this context, hydrography refers to the description of surface water bodies. Its measurement in terms of surveying, e.g. for navigational purposes, is not in the concern of the HY\_Features model. **[is this still true? - thinking on water edge]**

## 4.10. hydrologic complex

Collection of separate hydrologic features forming a closed, hydrologically determined system where the union of catchment(s) and a common outlet (conceptualized as an outfall) is realized by a ‘complex’ of hydrologic features. This concept is rooted in the idea of topological closure of catchment and outfall such that a realization of the logical catchment is always of higher topological dimension than the realization of the corresponding outfall. For example, a linear flowpath realizing a catchment may be understood as an edge between inflow and outflow nodes; the areal realization of a catchment as a face bounded by linear inflow and outflow.

**NOTE**

Hydrologic determination means that any catchment has a common outlet for its runoff. Any place to which water may flow can be associated with a corresponding catchment, even if catchment and outfall may be unknown or unrepresented in a particular application.

#### 4.11. hydrologic feature

Feature (abstraction of a real-world phenomenon) of a type defined in the hydrology domain. A feature whose identity needs to be maintained and tracked through a processing chain from measurement to distribution of hydrologic information.

#### 4.12. hydrologic realization

Hydrologic feature that realizes a hydrologic concept within the hydrologic complex.

#### 4.13. hydrology

Science that deals with 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, their reaction with their environment, including their relation to living beings [WMO, 2016].

#### 4.14. hydrometric feature

Feature (abstraction of a real-world phenomenon) of a type defined in the process of measurement and analysis of water including methods, techniques and instrumentation used in hydrology (hydrometry) [WMO, 2016].

**NOTE**

The hydrometric feature refers to a physical structure intended to observe properties of a hydrologic feature. Used to sample a hydrologic feature, a hydrometric feature may be considered a sampling feature of observation. A sampling feature is described in general in ISO 19156: Observation and Measurement, the special monitoring point of hydrologic observation is described in the OGC WaterML 2.0: Part 1- Timeseries standard [4].

#### 4.15. hydrometry

Science of the measurement and analysis of water including methods, techniques and instrumentation used in hydrology [WMO, 2016].

## 4.16. mapping

Establishing a semantic relationship between particular implementations of a common concept and the realized normative concept using a formalism that specifies how elements from a source model may be transformed to a target model.

## 4.17. named feature

Feature identified by a name.

**NOTE**

Hydrologic features and their real-world representations have names within common experience, but may have different names in their cultural, political and historical contexts.

## 4.18. representation

Any processable data, data set, or data product, which can be used in the place of an existing feature concept.

## 4.19. river positioning system

Linear system used to reference indirect positions along a watercourse.

## 4.20. storage (of water)

Impounding of water in surface or underground reservoirs, for future use [WMO, 2016].

**NOTE**

Storage refers to a water body in terms of a usable water resource. The management of the reservoir as human action with the objective to efficient and sustainable use the resource, is not in the scope of the conceptual model. Yet, often an indication is required whether a water body is used for storage.

## 4.21. water body

Mass of water distinct from other masses of water [WMO, 2016].

## 5. Conventions

This sections provides details and examples for any conventions used in the document. Examples of conventions are symbols, abbreviations, use of XML schema, or special notes regarding how to read the document.

### 5.1. Identifiers

The normative provisions in this specification are denoted by the URI

<http://www.opengis.net/spec/{standard}/{m.n}>

All requirements and conformance tests that appear in this document are denoted by partial URIs which are relative to this base.

### 5.2. Symbols (and abbreviated terms)

#### **CHy**

WMO Commission for Hydrology

#### **GML**

Geography Markup Language

#### **GRDC**

Global Runoff Data Centre (GRDC)

#### **GWML2**

GroundwaterML 2

#### **HDWG**

OGC Hydrology Domain Working Group

#### **ISO**

International Organization for Standardization

#### **OGC**

Open Geospatial Consortium

#### **OWL**

Web Ontology Language

## **UML**

Unified Modeling Language

## **WaterML 2**

WaterML 2.0 – an observation model for hydrology

## **WIS**

WMO Information System

## **WIGOS**

WMO Integrated Global Observing System

## **WMO**

World Meteorological Organization

## **XML**

eXtensible Markup Language

## **5.3. UML notation**

Most diagrams that appear in this specification are presented using the Unified Modelling Language (UML) static structure diagram, as described in Sub-clause 5.2 of the OGC Web Services Common Implementation Specification (OGC 04-016r2). UML classes are named in UpperCamelCase and property names in lowerCamelCase.

## **5.4. WMO Terminology**

The HY\_Features model uses—as far as possible—terminology recommended by the WMO Commission for Hydrology for use in the WMO Member countries. The key reference is the "International Glossary of Hydrology" [9], a joint publication of the WMO and the UNESCO. Wherever appropriate, terms from this glossary are applied to the feature concepts in this standard to capture meaning and contextual relationships. The synonym approach widely used in this glossary is interpreted in that way that glossary terms, when explicitly defined as synonyms, were defined as such even if they are not synonymous in every respect. Differences in terminology were explored through reconciling the explicit definitions documented in the glossary with aspects reflected in various data sets and products in use. The accepted terms were augmented with the relationships inferred from other terminology in order to define complex terms that do not clearly distinguish between a specific logical concept and its geometric representation or between a general term and its specific conceptual meaning. The definitions used in the conceptual model described in this standard may be understood as a conceptual refining of the definitions given in the WMO/UNESCO Glossary of Hydrology.

Though basically rooted in the definitions given in the WMO Glossary of Hydrology, for the purpose of testing the applicability of the conceptual model in the context of surface water hydrology, the definitions applied to hydrologic features defined in this standard refer to surface water.

Some requirements classes defined in this standard refer to the Scoped Name concept of ISO 19103: CONCEPTUAL SCHEMA. Intended to form a basis for information and data sharing in the community of the WMO member countries, the Scoped Name should reflect a name endorsed by the WMO.

## 5.5. Naming convention

The *HY*-prefix used in the UML model follows the ISO naming conventions for UML elements. There is no explicit requirement to use this name in an implementation for the same semantic elements, but it is required to provide an explicit mapping between terminology used and *HY\_Features* to unambiguously indicate hydrologic feature concepts to support unambiguous interpretation in cross-domain applications. While there is not a recognized standard method for recording mappings between abstract element names and implementations; it is expected that system interoperability will be facilitated by making such mappings available as part of a dataset's documentation.

## 6. Clauses not Containing Normative Material

### 6.1. The abstract idea of the hydrology phenomenon

Processes that continuously deplete and replenish water resources cause or result in a wide range of phenomena that are the subject of monitoring, modeling and reporting in hydrology and related sciences. These distinctly named or otherwise uniquely identified real-world hydrologic phenomena are conceptualized and referred to as hydrologic features in this standard. This standard applies to data and data products that represent these hydrologically defined features.

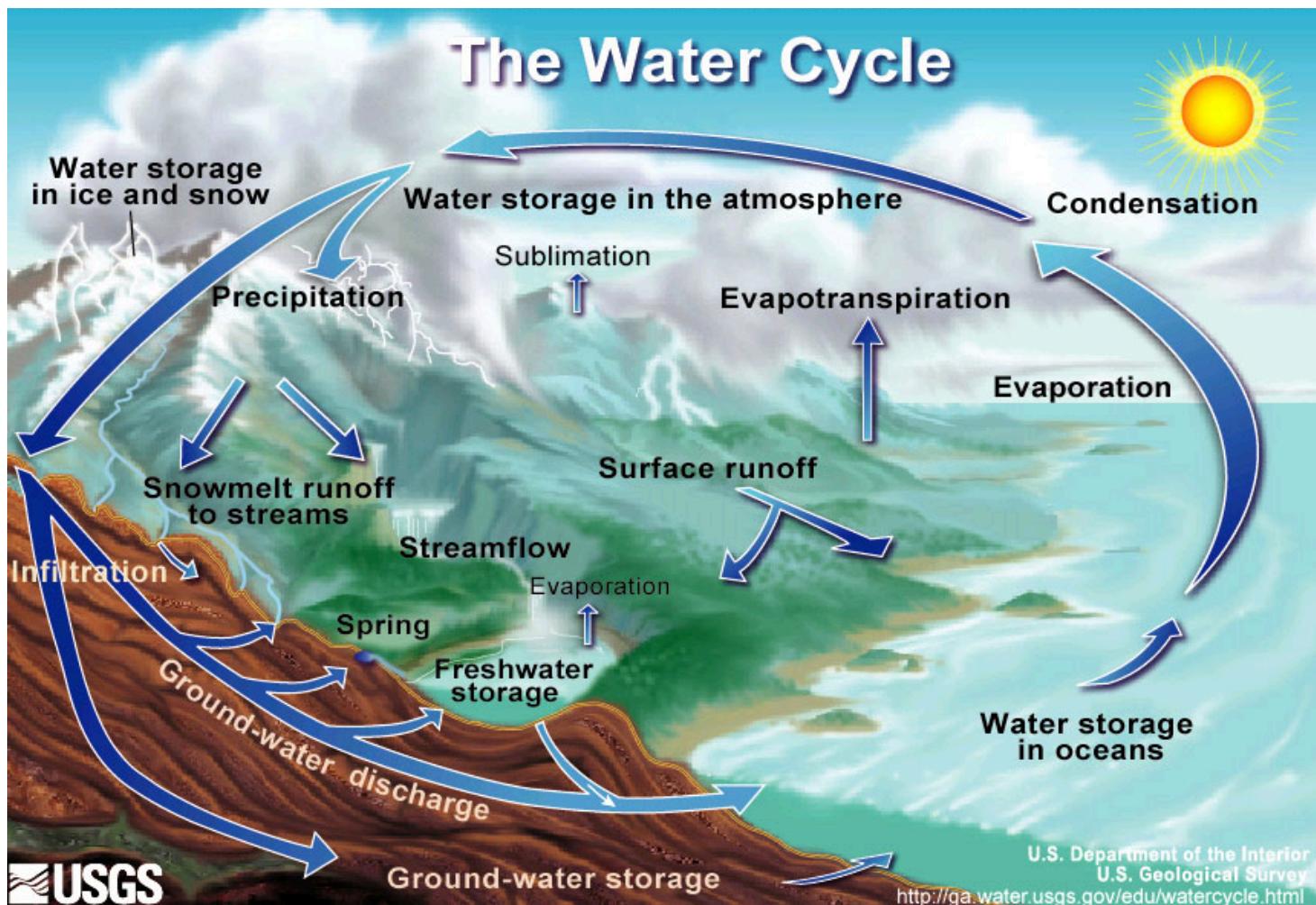


Figure 2. Processes of the Hydrologic Cycle

Water is moving from the atmosphere to the Earth and back to the atmosphere due to the processes forming the Water Cycle (Figure 2). Water from precipitation reaching the land surface is accumulated in water bodies occupying empty space on the land surface or in water bearing formations of soil and rock. Excess water overflows these formations and is driven downhill by gravity. Water flowing over soil or rock causes erosion to occur. This erosion tends to concentrate flowing water into water bodies that flow downhill using a connecting system of channels intersecting other water bodies along their way to a common outlet, conceptualized as a potentially complex outfall feature.

Looking back upstream from the outfall, the corresponding catchment feature can be described as a main linear flowpath feature, an areal feature, a boundary feature that encompasses the drained area, a network of water body features, a network of channel features, or a network of hydrometric station features, all representing the catchment. The concepts and terminology used in the preceding sentences form the conceptual and semantic basis for this standard.

As described above, the most general abstraction of the hydrology phenomenon is the catchment. A catchment is a recognized unit of study where hydrologic processes form physiographic features that are realized in various data products. In this specification, the term realization is used to imply that a catchment is recognized and identified for the purpose of referencing it by name or within a topology of other catchments. The term representation is used where geometry is used to represent a catchment's physical features. Using these definitions, we can say that a catchment is an unrealized conceptual feature that can be realized by features for use in topological networks and features with explicit geometry.

Depending on application and scale, the same catchment may be realized in many different ways. The following describe different examples where this multiple realization concept is important:

- The most typical example is that scaling a map-visualization up or down leads to multiple more or less detailed representations of the same realized hydrologic feature.
- Analyses and reports from various disciplines reference differing spatial representations of the same conceptual catchment.
- Some applications require cartographic (visual) representations while others are focused on topological (network connectivity) realizations only (Figure 3).
- A catchment may be represented geometrically by streamlines, drainage area or the bounding polygon, or realized topologically as a face, edge, and/or nodes.

Catchments can be realized as geographic streams and outfalls, simplified geographic stream representations, schematics of streams and outfalls, an aggregate of catchments, simplified representations of catchment aggregates, or schematics showing how catchments relate.

The concept of catchment used in this standard is that it is described physically as illustrated above. It can also be described as the recognized unit of water resources assessment and management across administrative jurisdictions. In multi-stakeholder collaboration and cross-domain research projects, the catchment is recognized as a shared monitoring and reporting unit, in that monitoring stations are usually on a river in a recognized catchment, attributes of the catchment may be in reference to its geometry, and its inflow and outflow are network locations connecting it

to other catchments in a topology. Examples of catchments include "Hydrologic Unit Code" (HUC) catchments defined by the U.S. Geological Survey for research and regulatory data systems to use as a reference [7] and "River Basin Districts" of the European Water Framework Directive [1].

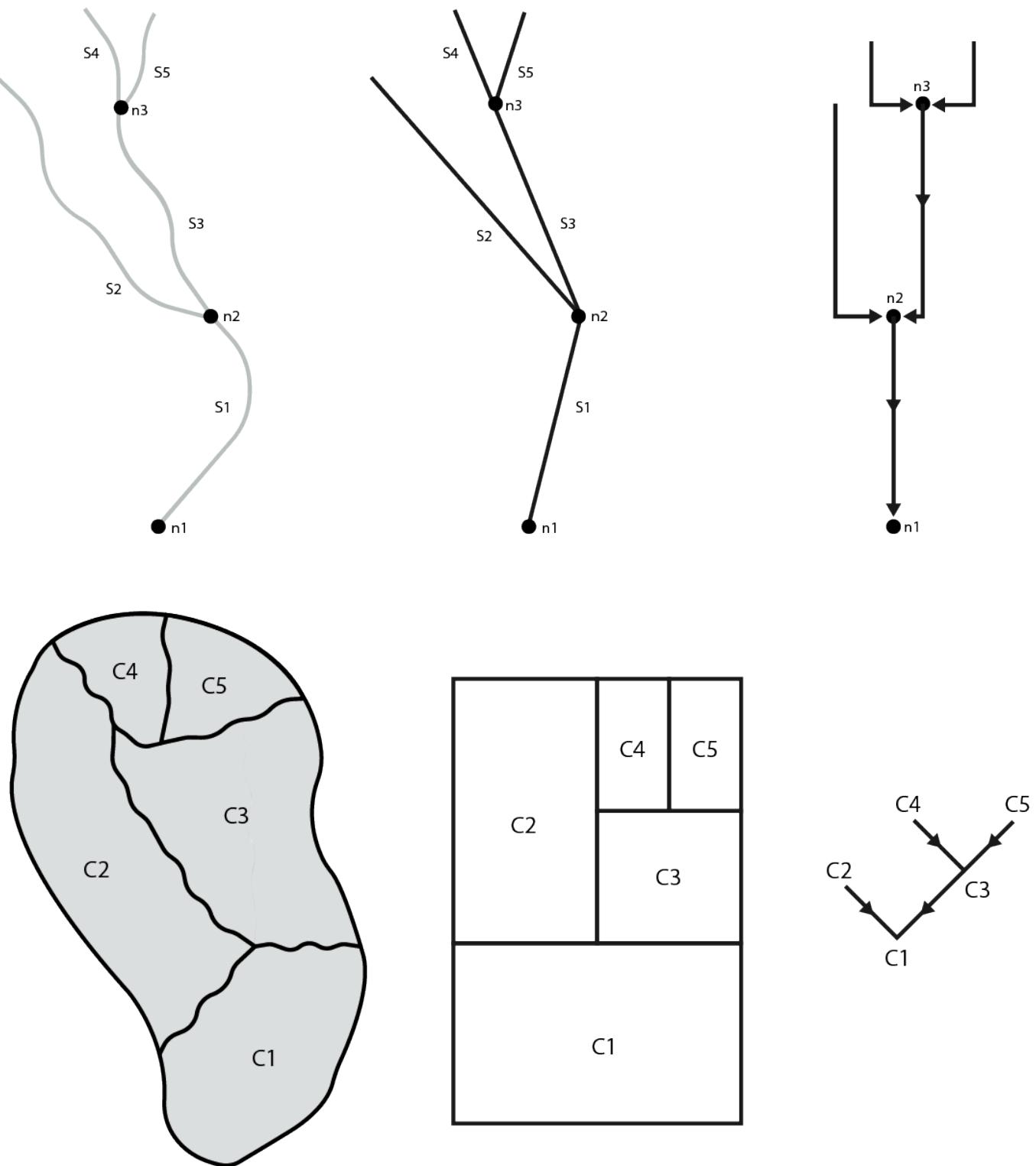


Figure 3. Illustration of multiple representations of a catchment

## 6.2. Catchment and realizations of the catchment concept

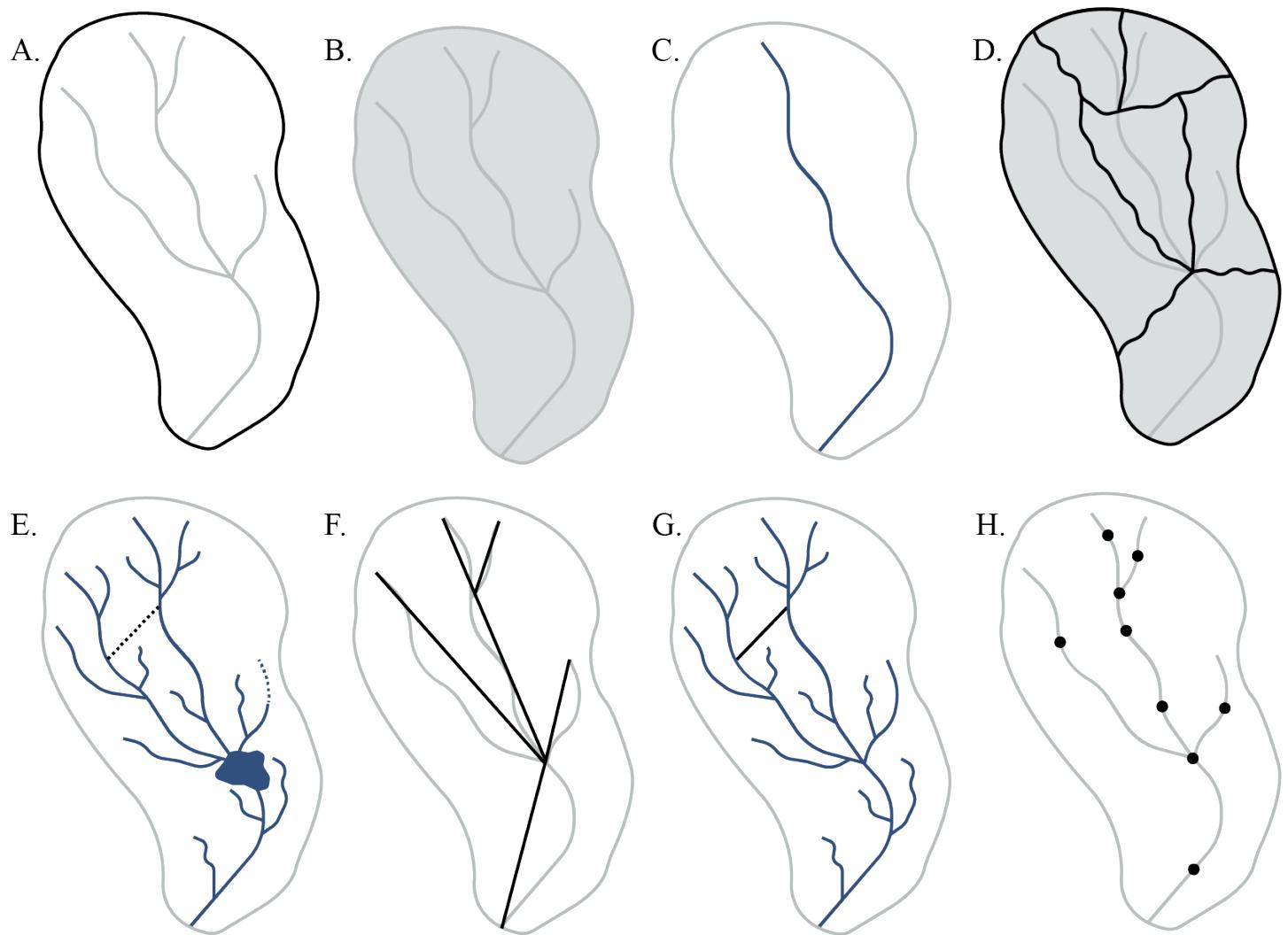
The core concept of the HY\_Features model is that a study of the Hydrology phenomenon will reference common conceptual entities of the real world such as catchment, water body, channel, or stream gaging site, through the use of features according to a specific model (as per ISO 19109 General Feature Model). Depending on the field of study or application, complex hydrology phenomenon features may be realized in many ways. This leads to the idea that each study of a catchment may portray it in a particular way leading to multiple realizations of the same conceptual entity.



*Figure 4. Idealized catchment. This idealized catchment diagram is used to represent the catchment concept with no emphasis on any realization or representation. In the diagrams below, aspects of this diagram are highlighted to emphasize particular concepts of the HY\_Features conceptual model.*

Across hydrologic disciplines the concept of catchment defined in this standard is the recognized conceptual unit of study where hydrologic processes take place. Catchment boundary, catchment area, and linear flowpath are the most common geometric realizations of a catchment, and are widely used to create cartographic views of a catchment.

Map layers that separately visualize the hydrographic network of water bodies (typically as blue lines for small rivers and blue polygons for larger rivers and lakes) and of channels (typically lines displaying a drainage pattern indicating the path flow may follow), or a network of hydrometric monitoring stations, are usually combined to portray the represented catchment as a whole. Such cartographic data products are usually exposed in map services, while the water body or channel features are provided with an appropriate geometry and location usually in features services. To illustrate these ideas, Figure 4 shows an idealized watershed with different graphical representations highlighted.



*Figure 5. Multiple graphical realizations of a catchment (from top left to bottom right): a) Catchment boundary, b) Catchment area, c) flowpath of catchment d) network of sub catchments, e) cartographic view, f) abstract flow paths, g) hydrographic network, h) network of logically connected monitoring stations.*

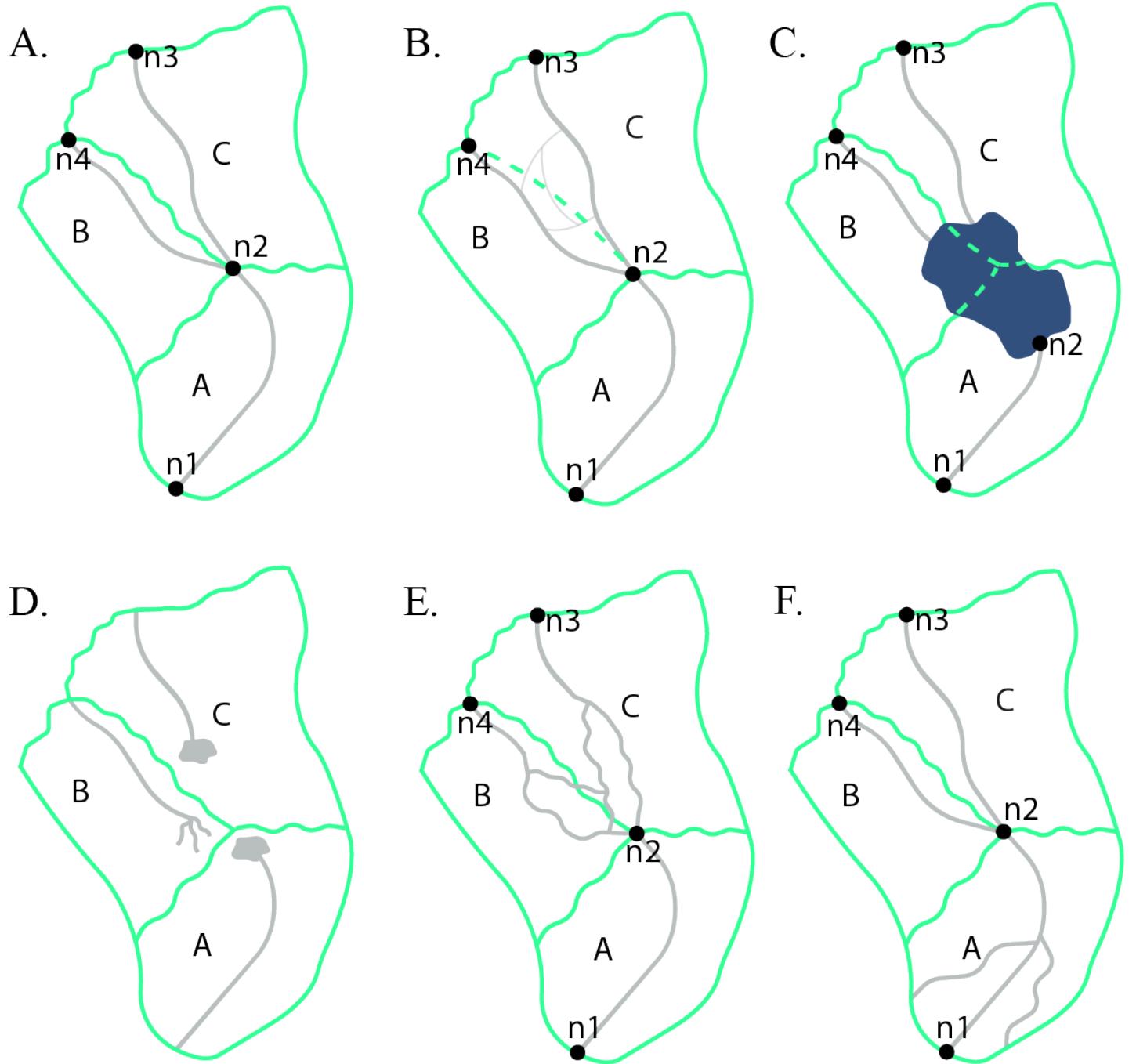
Each of these graphical realizations is a different way of looking at the catchment and its interaction with other features. It is generally not possible to inspect a particular realization and understand all characteristics of the catchment because different types of features are often realized using identical data models. For example, a map showing a set of catchment polygons may display an aggregate of sub-catchments, or a collection of catchment polygons that overlap each other occupying the same space. In order to understand what catchment concept is being

realized, the more detailed information about their type and role in a data model needs to be declared. These relationships and potential constraints may be declared between a high-order catchment and the catchments generally nested therein, or between an aggregate network of catchments that encompasses nested catchments without any overlap, or the upstream-downstream direction of flow for a set of catchment polygons.

In some cases, a catchment may be realized as an identified feature without specified geometry that takes part in a topological network of catchments. This is common, for example, in data systems supporting hydrologic modeling. Catchment attributes needed to parameterize a model may be generated using various geospatial data sets, but the geometric information is not necessary for the actual modelling. In applications like this, and in data systems supporting such applications, a catchment can be realized by an identifier, attributes, and topological connections that are not necessarily the same as would be implied by geometric representation of a catchment. That is, while a catchment has a geometric representation that is an area, which would imply it is a topological face, the catchment can have a non-geometric realization that is a topological edge which conveys flow from inflow to outflow. This flexibility, where a realization of a catchment feature does not need to have an explicit geometric representation allows a decoupling of visual and conceptual concerns with the ability to explicitly link data products that would not otherwise be easily related.

### 6.3. Catchment hierarchy and network topology

Catchments may be connected in topological networks which provide continuity between catchments, the ability to aggregate catchments, and to trace catchment networks up- or down-stream. Topological connectivity is typically indicated by adjacent polygon edges, nesting of polygons, or through connection of linear features at nodes. However, since geometric realization of hydrography serves many purposes and may not be needed at all, it is not appropriate to rely only on geometry as the basis for topology. Instead, topology can be expressed as relationships between conceptual features of a particular type which may or may not have explicit geometric realizations.



*Figure 6. (C1-C5, from left to right): C1, Typical catchments with one inflow and one outflow each; C2, Joined (conjoint) catchments flowing into a single downstream catchment; C3, catchments joining in a waterbody or wetland with no clear network; C4, catchments joining through intermittent or subsurface flows C5, catchments that join through areas of complex or braided channels*

In a network of catchments, morphological detail may be specified in many ways. Inflows are generally conceptual in headwaters, and outflows are often complex where water flows out of a network. As shown in Figure 6 catchments may connect through simple confluences (C1), water bodies or wetlands (C3), intermittent or subsurface

flows (C4) or complex braided streams (C5). Although these cases require different geographic representations, they can be represented using the same catchment topology. Since all these cases can be specified using simple topology, no special treatment is required to handle the variation of flow processes.

### 6.3.1. Hierarchy of catchments

Any catchment may be nested or aggregated in a larger containing catchment or split into multiple sub units forming a hierarchy of catchments. Two types of catchment hierarchy are supported in HY\_Features: basic nesting and dendritic aggregation: 1) Basic nesting allows any catchment to have a reference to a containing catchment (Figure 7). This allows collections of sub-catchments to be grouped into larger units, but does not define any particular interconnections between these sub-catchments. 2) Dendritic hierarchies are collections of catchments with simple topological relationships that allow determination of contribution of flow to downstream catchments. To reflect the organization of catchments in dendritic networks, a special dendritic catchment is defined that permanently contributes exorheic flow to a receiving catchment (Figure 8), and an interior catchment of endorheic flow that contributes temporarily to a receiving catchment.

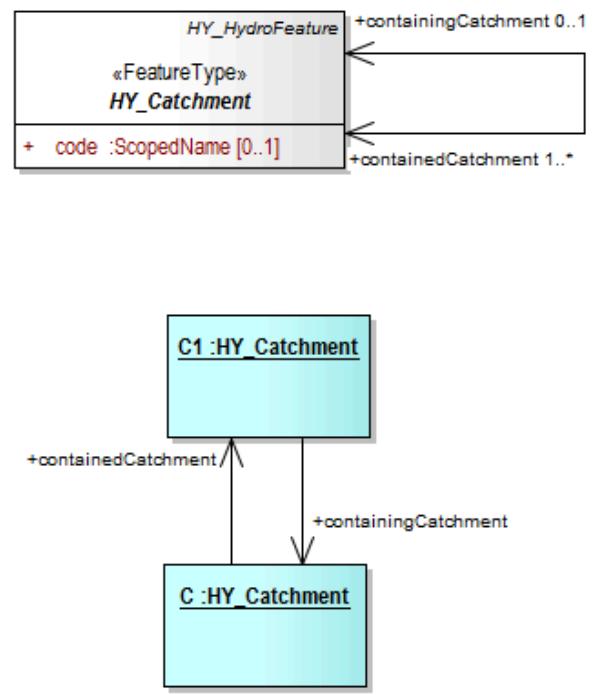
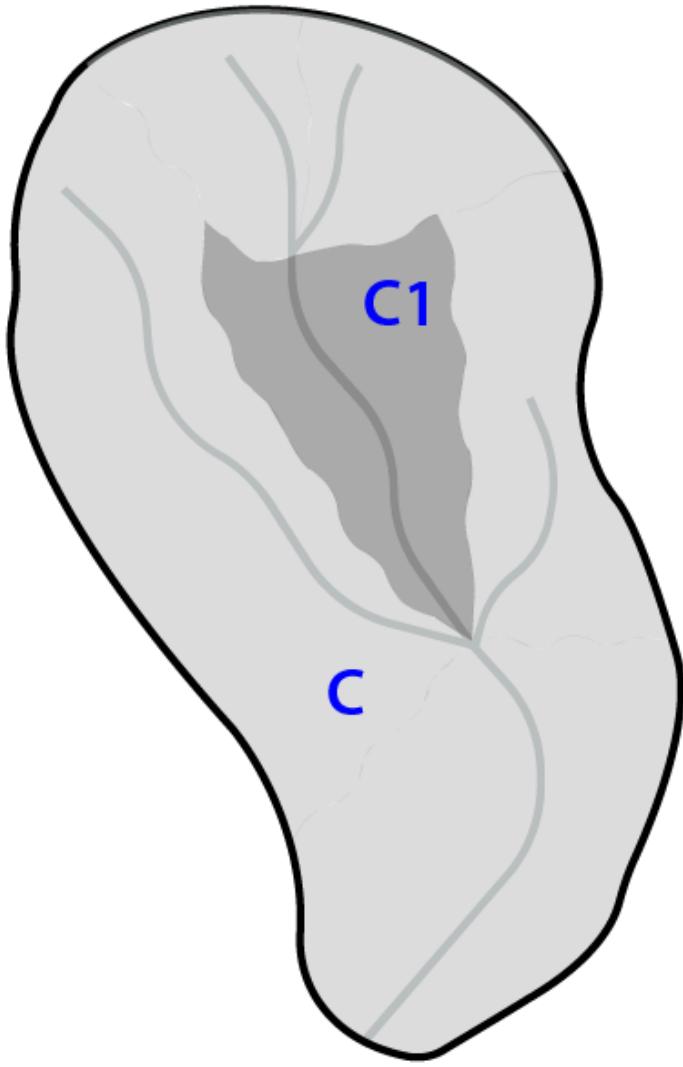
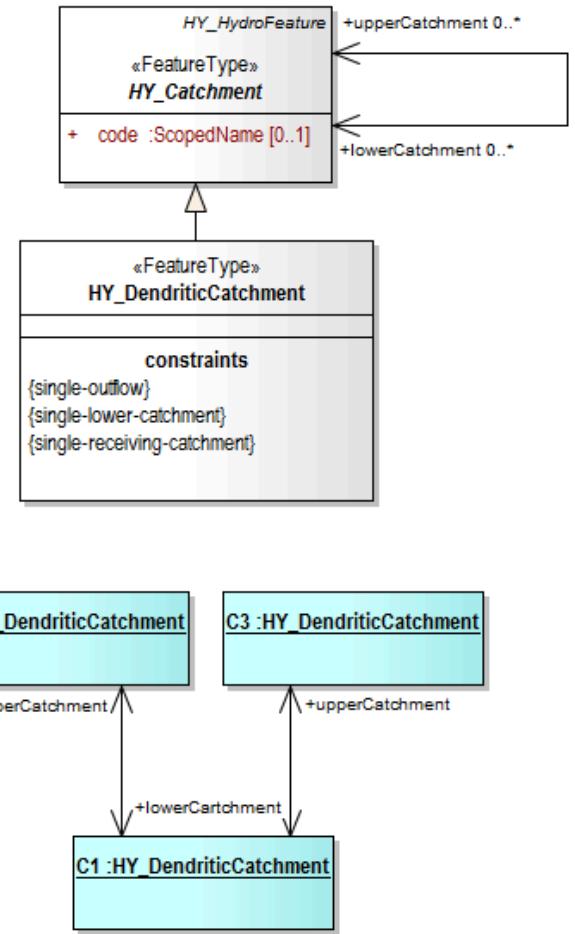
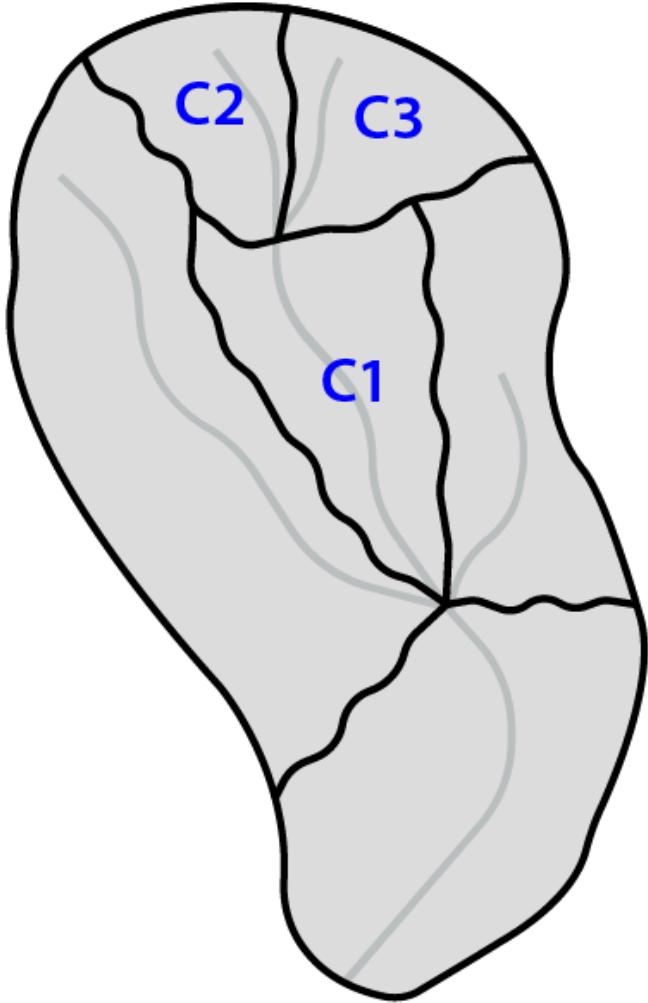


Figure 7. Catchment hierarchy – A catchment (dark grey), may be nested within a containing catchment which is another catchment (light grey)



*Figure 8. Catchment hierarchy – A catchment (C1, C2, or C3) may be part of a simple dendritic network of catchments which is also a catchment.*

### 6.3.2. Topological network of catchments

Given the idea that a non-geospatial schematic representation of a feature can show its connection in a topological network, a catchment can be thought of as a hydrologic unit whose terrain and morphology results in a topological link between inflow and outflow. The red line in Figure 9 illustrates how a single catchment, represented by a boundary, an area, a stream network, and a main flowline, could also be represented using a single line that is not geospatially representative but is a valid schematic representation of the connection between inflow and outflow.

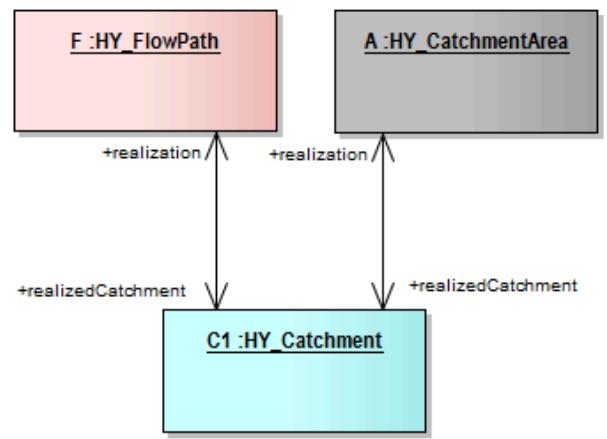
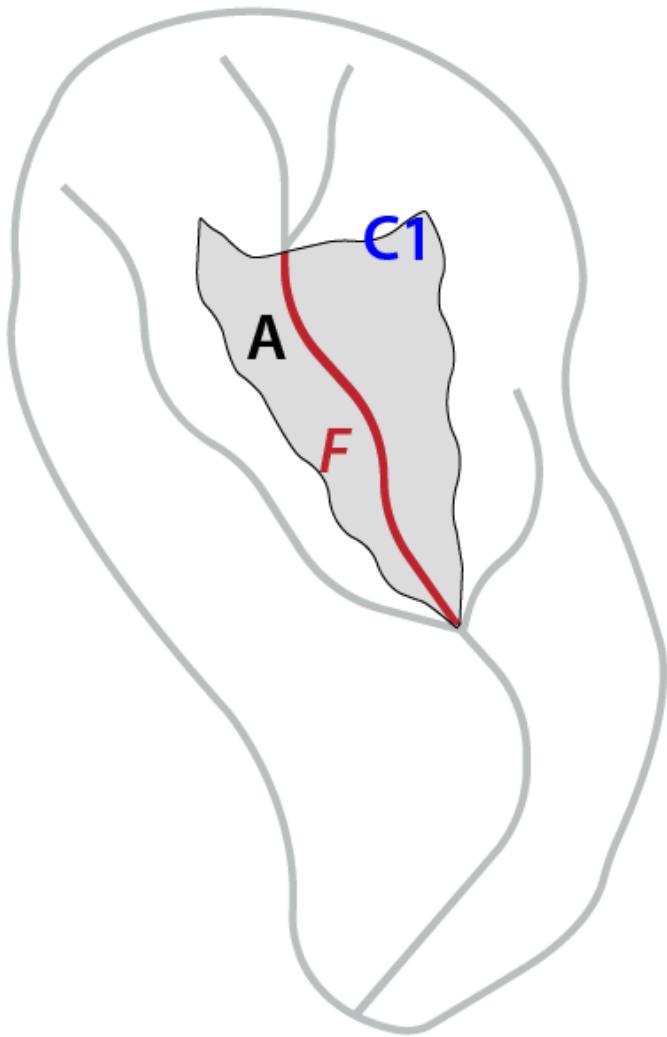


Figure 9. A catchment area (grey) and a flowpath connecting inflow to outflow (red) depicting a definable unit where hydrological processes take place.

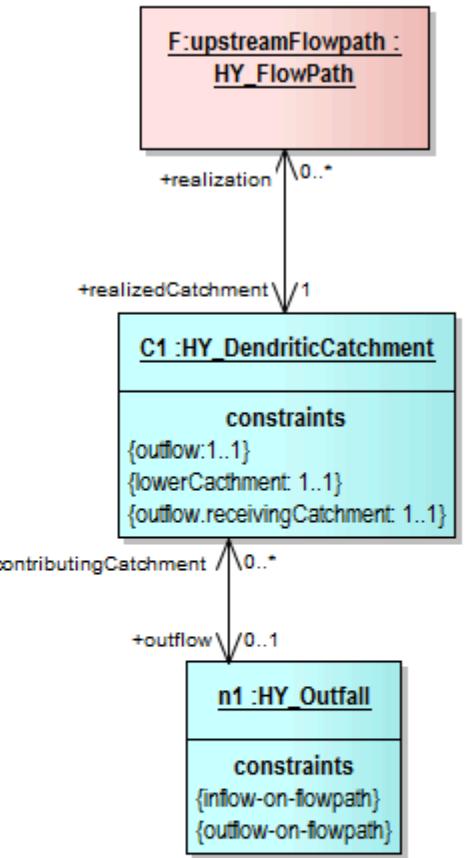
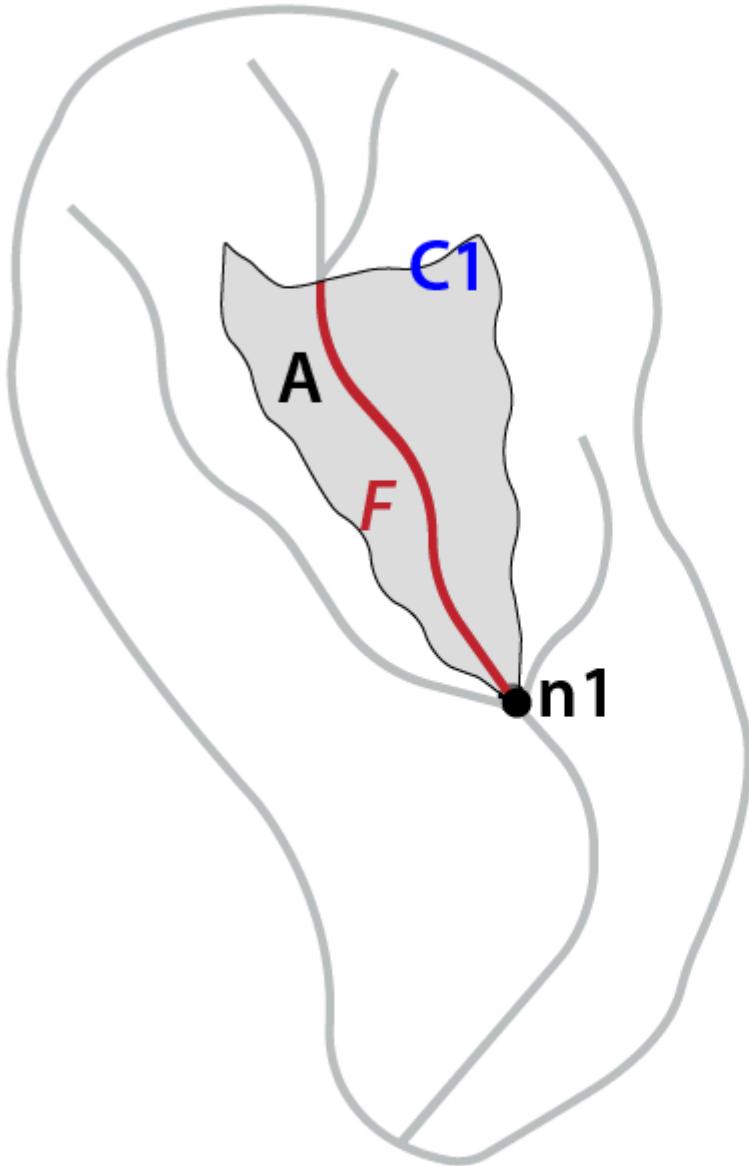
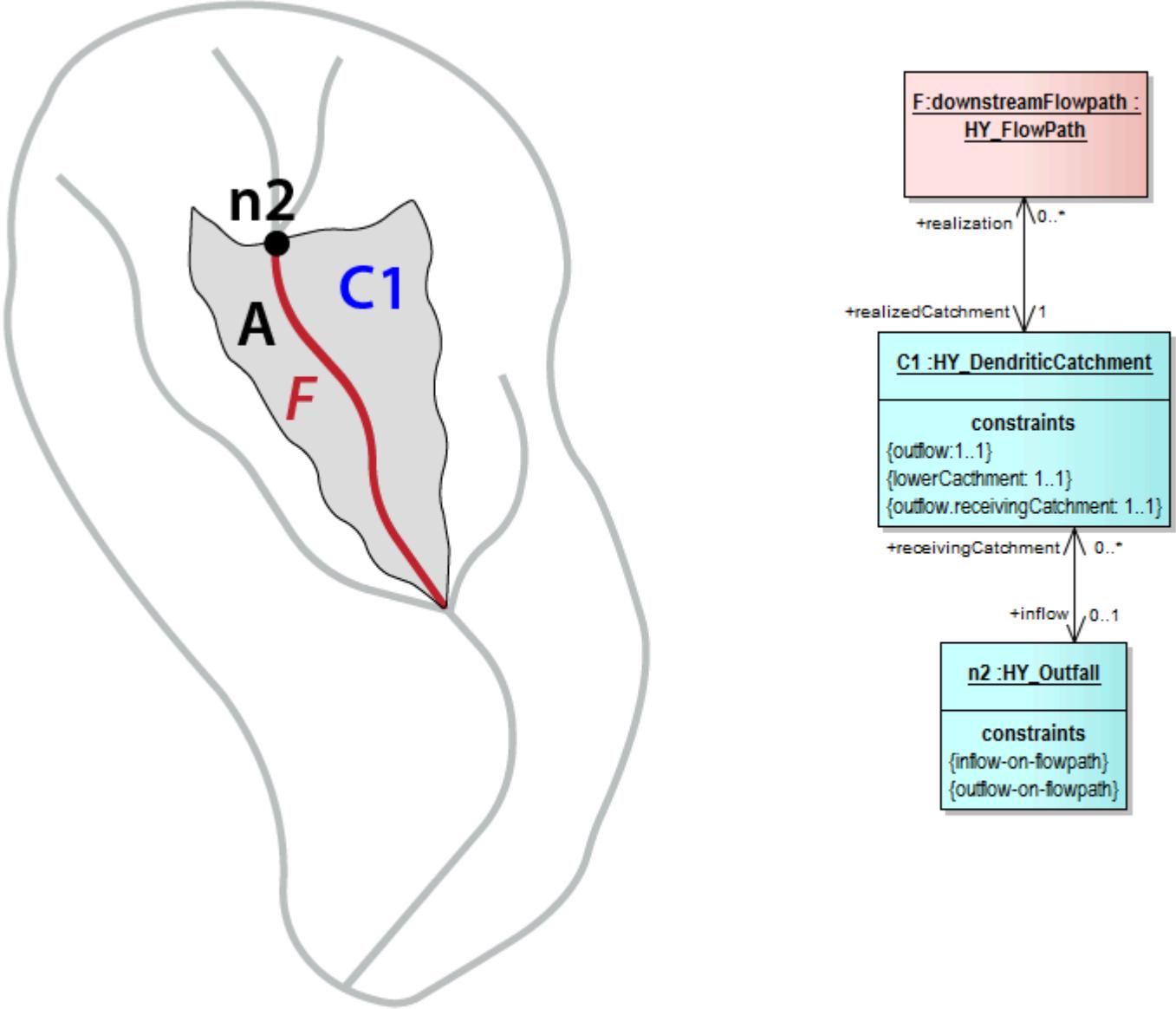


Figure 10. Catchments contributing to an identified outflow node. Note that some catchments contribute to a common outflow node.



*Figure 11. Catchments receive inflow via an identified inflow node. Note that nodes are not necessarily geographic features, but are rather nodes in a graph representation of the river network.*

The catchment C1, shown in Figure 10, contributes flow to outflow node n1. Node n2, shown in Figure 11, contributes inflow to catchment C1. Networks of catchments can be constructed using this construct and the idea that two or more catchments that flow into the same downstream catchment, first flow to the same outflow node which is the inflow node of the receiving downstream catchment. In a network of dendritic catchments, outflow nodes on the network serve only one receiving catchment.

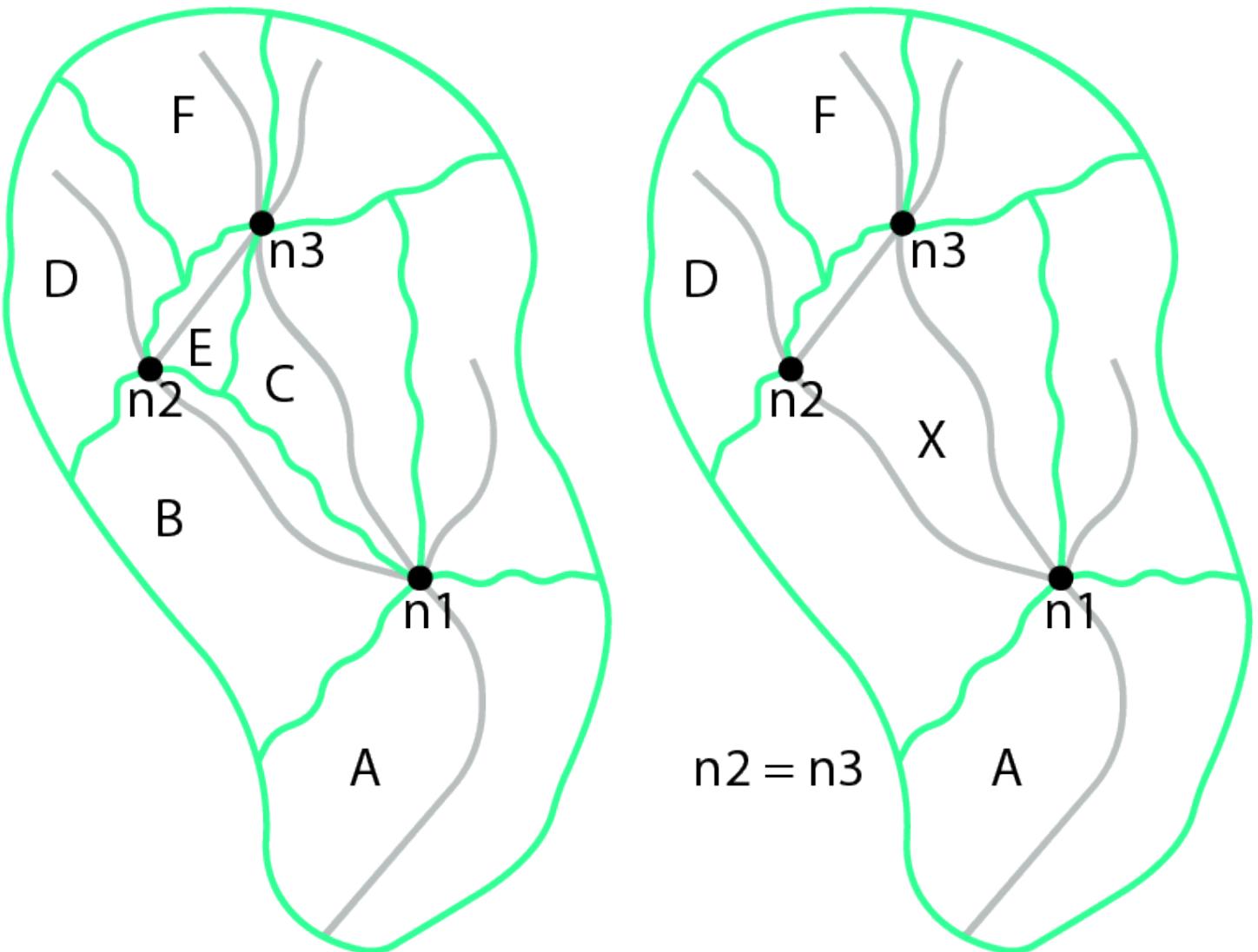
Nodes may seem to stand alone as points of interaction in the network, but in reality, they are (potentially complex) watershed outlets, denoted as outfall features. Whether an outfall (node) is referred to as an inflow or outflow node is always in reference to a particular catchment. This means that a node serves as the outflow node of some

contributing catchment(s) and the inflow node of some receiving catchment(s). In this standard, the inflow and outflow role names of the conceptual outfall (node) are used to unambiguously describe the node's role with respect to a catchment.

In a dendritic network, the outflow node that one or more dendritic catchments flow to (which is not necessarily a single geometric point) must contribute to one and only one receiving catchment, unless it is a terminal catchment. Given that the dendritic catchment is defined as a special type of the more general catchment concept, it inherits the general nesting as defined for the catchment as shown in Figure 7.

Being topological nodes, inflow and outflow nodes have no explicit positions but are potentially complex watershed outlets. In fact, a node may be represented by a complex geometry with multiple parts. This is important in the case of a catchment that contains a broad river bottom with complex braided channels and two or more primary inflows. There may be no clear way to identify an inflow location, but from a topological perspective each contributing catchment can be said to contribute to the same node and that diffused inflow can be said to contribute to the catchment in question (Figure 12). Note that in this case, the complexity required to support geospatially accurate linear referencing may be lost in the interest of easy network navigation capabilities.

It is worth noting that non-dendritic networks are often represented as a dendritic catchment network by introducing joint catchments that contain the non-dendritic parts. Figure 12 shows an example of a network with a non-dendritic topology, where it is not possible to determine to what extent flow from catchment F contributes to catchments E, B or C (C7). C8 shows the same topology where catchments E, B, and C have been aggregated and the nodes N2 and N3 are treated as a single virtual inflow node, so that all the flow from catchments D and F accumulate in the resulting catchment X. Using this encapsulation approach, catchments can be represented using a simple tree structure where an upstream-downstream relation can be built without the need for complex hydrography between inflow and outflow nodes.

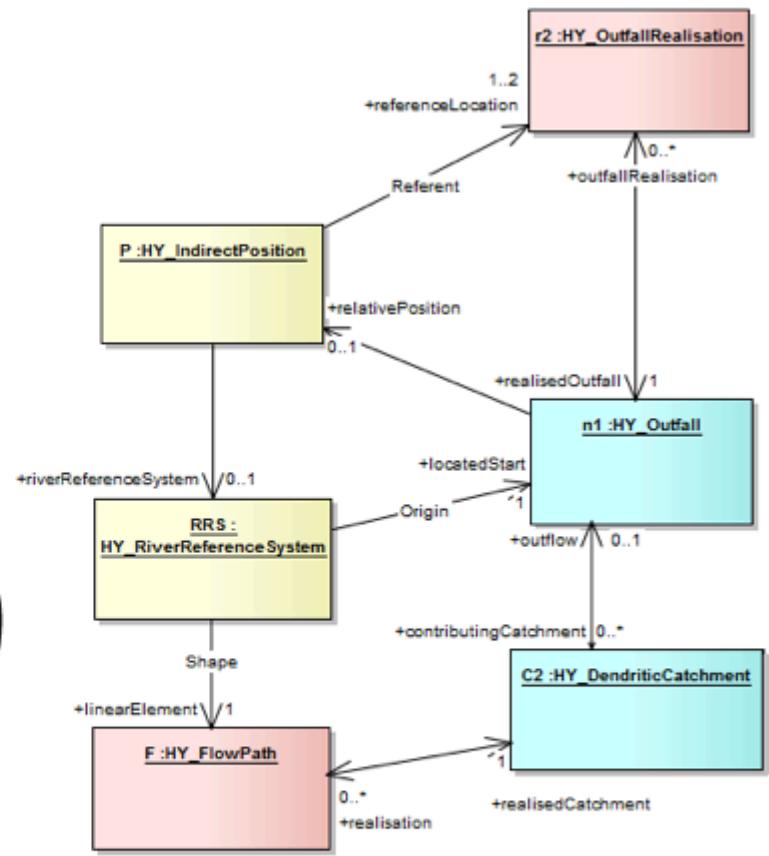
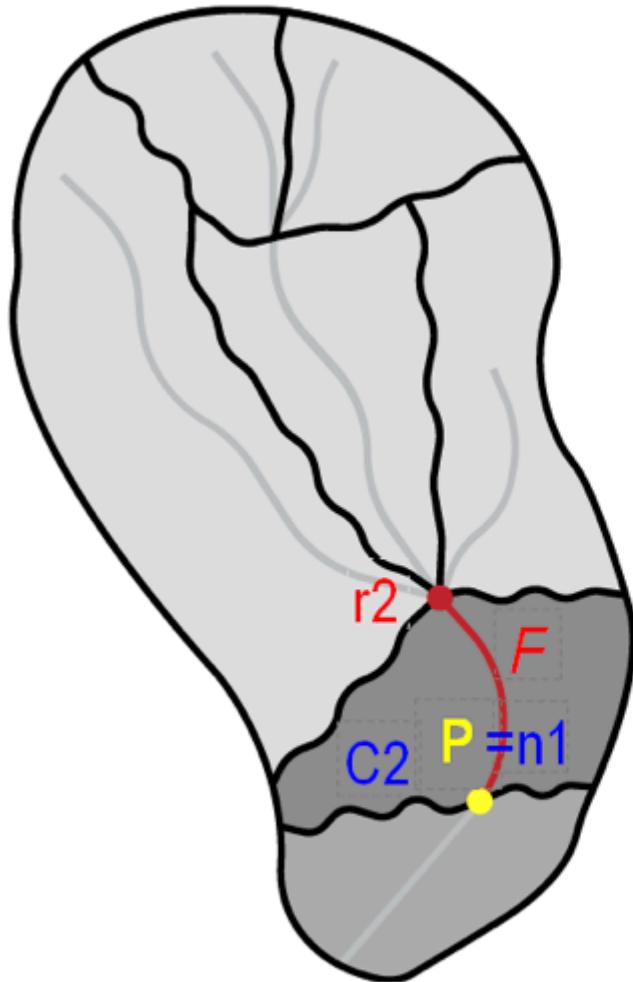


*Figure 12. Encapsulation of non-dendritic stream network topology. The left figure shows a case where it is not possible to determine to what extent flow from catchment F contributes to catchments E, B or C. The right figure shows how catchments E, B, and C can be aggregated so nodes N2 and N3 are treated as a single virtual inflow node, so that all the flow from catchments D and F accumulate in the resulting catchment X.*

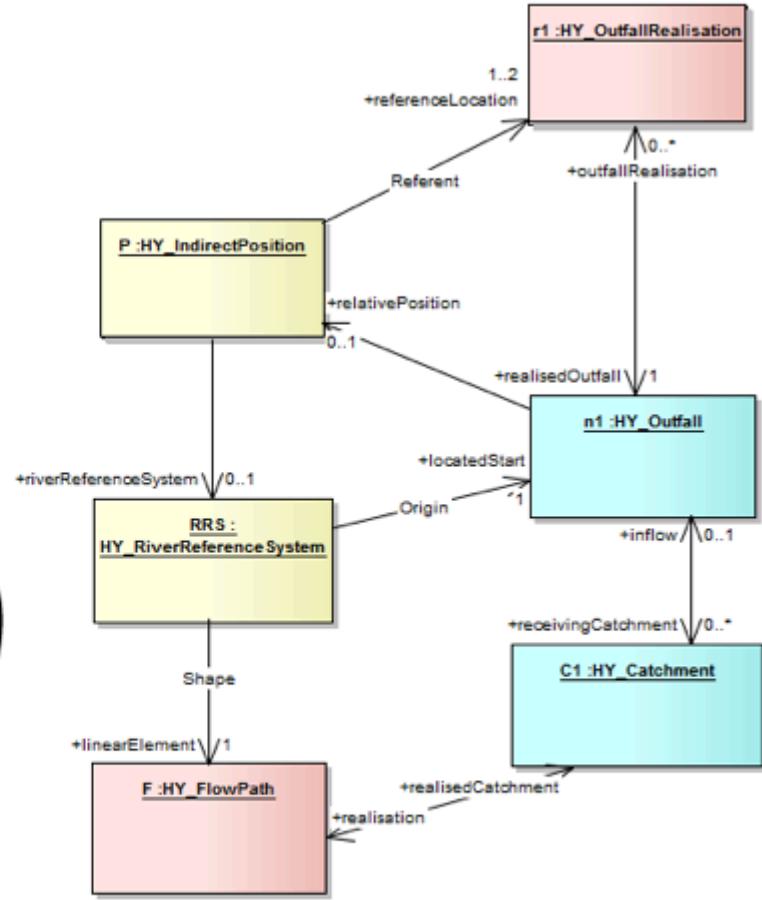
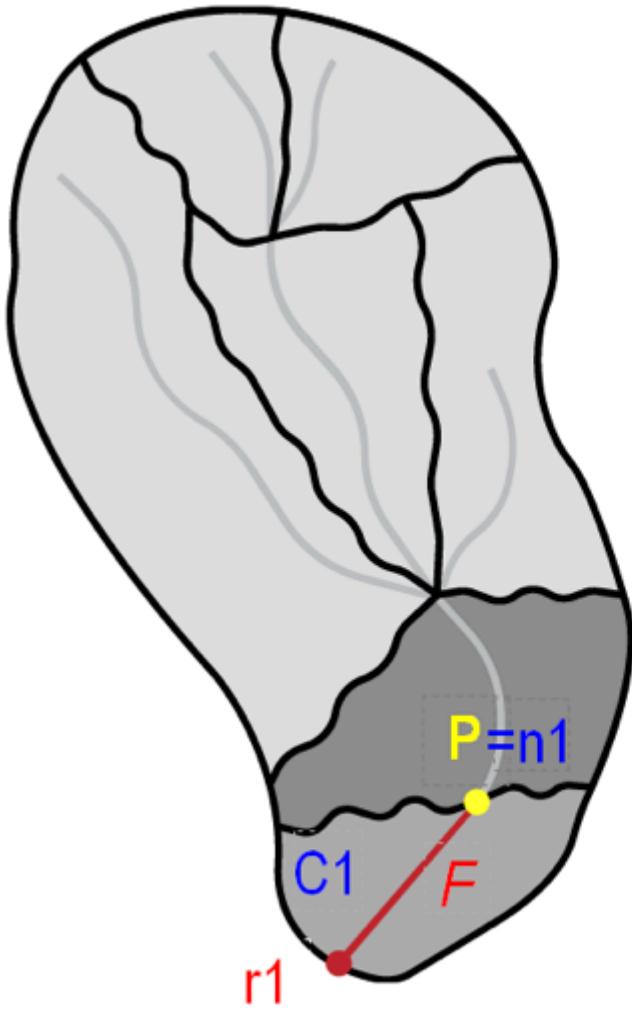
## 6.4. River reference system

Considering any identified location on a network as the outflow node of a contributing catchment, or the inflow node of a receiving catchment, an arbitrary new location can be placed on the network in reference to the existing outfall up- or downstream. Understanding such a reference as a positioning "along a river", the linear flowpath representation of a catchment can be used for linear referencing. HY\_Features defines the concept of a river reference system which has three components: 1) an origin at an inflow or outflow outfall; 2) a shape defined by the flowpath of a catchment that connects to the origin; and 3) a linear distance or relative (percentage) measurement system. Each catchment has its own reference system which can be combined as necessary using catchment

topology; each river reference system must have one outfall (origin) and one representing flowpath (shape). Figure 13, and Figure 14 illustrate how a newly introduced network location can be located downstream of a catchment inflow, or upstream of a catchment outflow.



*Figure 13. Position (yellow dot) downstream of a reference point (red dot). While referenced positions (P) are usually referenced to permanent locations like confluences (r2), they can also be considered to be the outflow of contributing catchment and thus, the origin of a river reference system of their own.*



*Figure 14. Position (yellow dot) upstream of a reference point (red dot). Typically, r1 would be the origin and P, the referenced point; however, the river reference system model allows for the referenced point to be the origin of its own river reference system.*

## 6.5. Hydrographic and hydrometric networks

Hydrographic data is commonly organized into networks. HY\_Features includes catchment realizations for the hydrographic network of waterbodies, channel network connected conveyances, and hydrometric network of monitoring stations. The following sections first describe the individual network types uniquely, then describe how these networks relate to each other in the context of the overall HY\_Features model. The main function of these network models is to allow an aggregate of hydrologic features at one scale to act as a single encapsulated entity at another scale.

### 6.5.1. Hydrographic and channel networks

Following the definitions in the UNESCO-WMO "International Glossary of Hydrology" [9] a water body is understood as the mass of liquid water accumulated on or below the land surface as a body of flowing water, which in some parts may have stagnant water that is not moving or flowing. The water body concept formalized in this

specification is consistent with this definition, but focuses on surface water bodies only. A conceptual model capturing the specifics of bodies of groundwater as well as aquifers containing groundwater are provided by the WaterML2 Part 4 - GroundwaterML2 specification [6].

A watercourse is commonly understood as a natural or man-made channel through or along which water may or may not flow [9]. A water body is generally a flowing body of water contained by a natural watercourse, but could also be in a manmade open or closed conduit [9]. Given that the channel network (or drainage pattern) exists independent of whether it contains water, HY\_Features conceptually separates natural and manmade hydrographic features into the body of water and the unit that contains the water body. This distinction is helpful to separate concerns of hydrology—studying the occurrence, accumulation, and circulation of water—and hydraulics—focused on the analysis and design of watercourses. Note that flow-through lakes and lakes without outflows are considered to be water bodies whose container is modeled as a surface depression.

Water bodies with their associated water courses can be aggregated into hydrographic and channel networks identified as the hydrographic or channel network of the catchment the network drains. Individual waterbodies can be described with vertical cross- or longitudinal sections. A water body may also be stratified into distinct horizontal layers for distinct thermal, salinity, oxygen, nutrient, or storage characteristics. Water may be stored and managed in reservoirs for future use, regulation, or control. Conceptually, each water body accumulating water may be managed as a reservoir. To model reservoir storage at multiple reservoir stages or elevations, HY\_Features includes an association between a reservoir and its waterbody stratum. The concept of stratum could also be applied to bathymetric contours of a lake to describe the container of a lake water body.

To place waterbodies topologically or geographically in a network, the HY\_Features model provides a mechanism to associate waterbodies with a realization of a catchment outfall. In the case of a hydrographic network that realizes an entire catchment, the HY\_Features catchment relationships can be used for both the larger catchment realized by the whole hydrographic network and the catchment(s) whose outfalls are used to locate waterbodies within the hydrographic network. This builds the idea outlined in section 6.3 in that every identified waterbody has a conceptual catchment that can be arranged topologically within a catchment network and is described in greater detail in section 6.5.3.

### 6.5.2. Hydrometric networks

Water bodies are observed using monitoring stations which are typically physical locations with a well-established cross section they monitor. It is common practice to locate a monitoring station in relation to local landmarks and permanent reference points along a stream or in relation to the outlet of the monitored water body. The river reference system, described in section 6.4, gives a mechanism to locate such points in relation to establish catchment outfall locations such as confluences. When aggregated into a network, monitoring stations within a catchment can be said to make up a logically connected hydrometric network which monitors a catchment.

The purpose of HY\_Features hydrometric stations and network is to support linking identified monitoring stations, (thought to be the sampling feature in terms of the observations and measurements standard) and a river or other hydrologic feature (thought to be the domain or sampled feature in terms of observations and measurements). The monitoring feature role of hydrometric features is unique in contrast to all other outfall realizations in HY\_Features, which would be used as observed domain features in observations and measurements.

#### 6.5.3. HydroNetwork: hydrographic network, channel network and station network - different views of catchment topology

Maps displaying a representation of a catchment are very common in hydrology research and engineering. Depending on the scientific concern, different aspects of the hydrology phenomenon are represented using application specific map symbols. Respecting the separation of scientific concerns, HY\_Features distinguishes between these by defining separate realizations of the catchment and outfall concepts which may be simple points, lines, or polygons, and may be complex aggregate networks made up of collections of point, line, or polygon representations. The need to support such collections across scales is supported through the general concept of the HydroNetwork described below.

The holistic idea of catchment, where a conceptual catchment has many real-world realizations, allows us to consider realizations of a catchment that correspond to different phenomena as variations of a common catchment pattern. Using this approach, the relationship of a catchment to a set of catchments can be transferred to any representation of that catchment regardless of the geometric representation in a particular data product. For example, an entire hydrographic network representation of a catchment can have simple relationships to the hydrographic network of its up and downstream catchments if the network itself is understood to adopt basic catchment characteristics.

This standard defines a hydrologically determined topology model of directed outfalls, acting as inflow or outflow nodes, and the catchment which can act as the link between them. This topological catchment network pattern can be transferred to context-specific network realizations such as hydrographic networks of water bodies or channel networks that may convey water, as well as to their various representations as (poly)lines and polygons. For example, a fixed landmark on a water body, a cross-section separating a watercourse, or a station along the network, can be considered to be outfalls (outflow nodes) of a contributing catchment (link); a flowpath representing a catchment may be drawn from an ‘inflow’ node to the ‘outflow’ node linking the nodes through the represented catchment. As with the hydrographic (water body) and channel (conveyance) network, the abstract catchment topology model can be applied to any logical or virtual network, e.g. a network of logically connected hydrometric stations.

### Starting from Catchment Outfall Going Counter Clockwise:

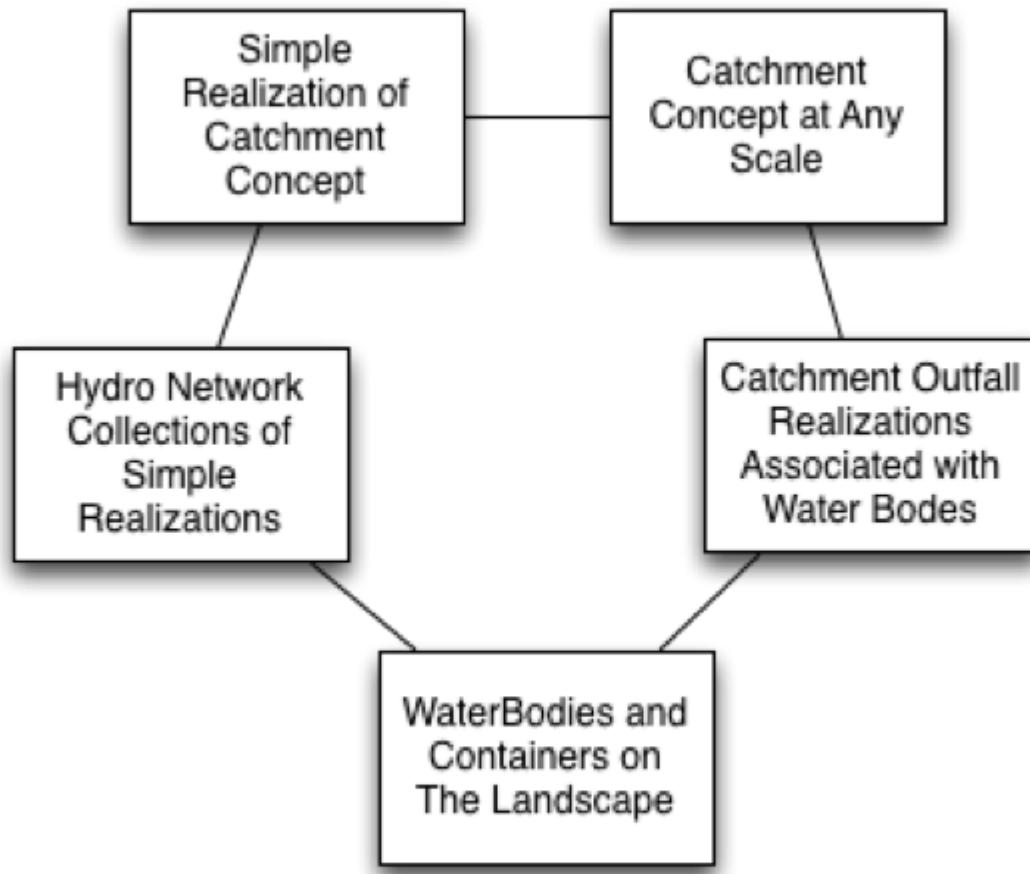
- An outfall implies a catchment upstream of it.

- A catchment has a simple realization which can be an area, boundary, or flow path.

- Simple realizations can be aggregated to form network realizations.

- Waterbodies, their containers, and their monitoring stations make up networks.

- An outfall realization is associated with a waterbody or place on a waterbody.



### Starting from Catchment Going Clockwise:

- Every catchment has an outfall of some sort.

- Every outfall is associated with a place or waterbody on a network.

- Waterbodies and monitoring stations are aggregated into networks.

- Networks are made up of line and area representations of catchments.

- Simple and network realizations of catchments represent particular catchments.

Figure 15. Cyclic nature of the HY\_Features basic model

Figure 15 illustrates the circular relationship between five functional components of the HY\_Features model: the catchment concept, catchment realization, hydro networks, waterbodies, and outfalls. The cyclic nature of the basic model supports crossing scale through nesting of more or less detailed catchment realizations.

#### 6.5.4. FlowPath

In practice, catchments are associated with a single mainstem flowpath (Figure 5c). Some elevation-derived hydrographic datasets define one flowpath per catchment such that every line connecting two confluences has a single associated drainage area. Others have an identifiable mainstem river that flows from headwaters or inflow to outflow. In either case, the main flowpath typically carries the name of the catchment and its outlet is considered the mouth of the river or catchment. HY\_Features includes a simple linear realization of the catchment concept that is meant to encompass the mainstem idea.

The flowpath concept is associated with a hydrographic or channel network in that any hydrographic or channel network can have one identified flowpath connecting its inflow to outflow node. In this way, at large scales, complex networks of channels can have one mainstem flowpath made up of many smaller scale reaches. At very small scales a network made up of one reach also has a single main flowpath. In both cases, the flowpath is associated with a catchment and should be understood to be the one linear connection between inflow and outflow node. Because hydrographic and channel networks are aggregates of waterbodies and channels, it follows that the flowpath concept is related to waterbodies and channels through the networks that aggregate them.

## 6.6. Discussion of purpose and relation to ISO standards baselines.

The intention of this standard is to provide the conceptual basis for linkage of identified hydrologic features (catchments) encoded in data products. Given that any given real world hydrologic entity can be a subject of study over time, between organizations, and across disciplines, the identified feature is often represented in many ways in differing data products. The ability to reference such features between data products requires a scale-independent, nestable catchment model that can be visualized using common geometric shapes to represent the catchment in geographic maps and geo-schematic views. In correspondence with the fundamentals of hydrology, catchment topology is determined through the common outlet to which all waters flow from within a bounding watershed. This is in contrast to use of geometric representation for determination of catchment topology (although geometric representations may of course assist in the determination of a set of common outlets).

The hydrologic feature model described in this standard describes the hydrosphere as a scale-independent hierarchical network of catchments. The defined catchment topology follows hydrologic patterns governed by physical laws in a way that is independent of any possible geometric realization. The pattern can be replicated multiple times to build hierarchical networks of hydrologically discrete catchments. In practice, the highest-level of this hierarchy reflects a river system flowing into a sea or an internal sink and the lowest level is the smallest defined unit of study. Depending on the scientific concern of a study, the hierarchical network of catchments will be used to describe differing phenomena, but are typically visualized using common geometric shapes.

### 6.6.1. Catchment topology, comparison with the ISO topology model

The catchment model in this standard defines the common outlet to which all waters flow as the topological outfall of a corresponding catchment. With respect to the catchment, the topological outfall is defined as the inflow node of a receiving catchment or the outflow node of contributing catchment. The catchment forms the topological link connecting the outfall nodes located on the bounding catchment divide. Determined by the orientation of the outfall, a receiving catchment links inflow nodes to the outflow node downstream, and a contributing catchment links an outflow node to upstream inflow nodes. Repeating this topological pattern of connecting inflow and outflow nodes, a network of upper and lower catchments can be built, which can then be traced upstream or downstream.

Depending on the perspective of a study, the network of upper and lower catchments is realized as hydrographic or channel network of seemingly connected watercourses, or as a network of logically connected stations. Each such catchment network view forms a hydrological system wherein the pattern of catchment and outfall (link and node) is realized as water bodies or channels and associated reference locations or stations. These realizations are represented in data products using geometric points, lines or polygons.

The topological concept of outfall node and catchment link applies to all defined special subtypes of a catchment. Specializations are defined with respect to (catchment) network connectivity. A dendritic catchment is defined, which is connected to other catchments through an identified outflow node which coincides with the inflow node of an associated lower catchment; an interior catchment is defined which is generally not connected to other catchments, but may temporarily participate in the network. With respect to the aggregation of catchments, a catchment aggregate is defined which encompasses dendritic catchments and envelopes interior catchments.

A general topology model of nodes and edges is defined in ISO 19107: Spatial Schema. While consistent with typical feature geometry, this topology model is defined separate from the geometric realization and may provide a general framework to define the scale-free catchment topology using the model of nodes and edges. Such a model can be seen as being comparable to the linear shape and origin of a river reference system as well as the connecting link and node to navigate in the catchment network upstream or downstream. A catchment may be topologically realized as a solid bounded by inflow/outflow faces, each face bounded by inflow/outflow edges, and each edge bounded by inflow/outflow nodes. Each of these realizations can be represented using an appropriate geometry type.

Understanding the catchment as a hydrologically determined complex, various multiple realizations of the logical catchment may be derived from the basic topological feature realization. The domain-specific feature types and properties defined in this standard to model the catchment's topology, its realization(s) and representation(s), may also be used to express catchment topology expressed in linked data and data products. Such data and products will normally represent a specific aspect of the hydrosphere or a particular place or time where water occurs or is distributed. Furthermore, special network or routing models may be related to the hierarchical network of catchments.

### 6.6.2. River Reference System, comparison with ISO linear referencing model

It is common practice in hydrology to add new features (typically observation stations, but also designated reaches, or flood plain zones) to an existing network of such features, and to reference such features along a network of watercourses. Provided that the hierarchical network of catchments is realized, and that the realized catchments have linear realizations, any feature can be referenced along this linear realization of the catchment based on catchment topology alone. This is possible considering that any location on the land surface can be an outfall of a catchment. In this case, the new location is placed as an outfall in an existing catchment network relative to an already established outfall used as a referent. This concept of an indirect position requires a reference system ‘along a river’.

This standard defines a simple linear river reference system with the linear flowpath realization of a catchment as its shape and the outfall of the catchment as its origin. Understanding the feature of interest as outfall of a corresponding catchment, the unknown position of this outfall can be determined relative to an outfall up or downstream. Each outfall is potentially the origin of its own river reference system and uses the flowpath representing a catchment between this origin and another already established outfall as its shape.

A standard model for a linear referencing is described in ISO 19148: Linear Referencing. It defines the position of an event, or referenced feature, located on a linear element (understood as directed edge in terms of the ISO 19107) as a distance relative to a referent using a particular referencing method. The indirect position concept defined in this standard is comparable to the general concept defined in ISO 19148. In the terms used by ISO 19148, a linear realization of a catchment can be understood as the linear element; the already established outfall can be thought of as the referent; and the newly referenced outfall as an event. In order to use an interpolative (percentage along a reach) linear referencing method, the linear catchment realization used as the river reference system’s shape must be bounded by an inflow and outflow node.

The ISO 19148 model is not ‘imported’ in the hydrologic feature conceptual model because this standard intends to reference the hydrologically determined catchment topology, to use terms for the origin, referent and linear element from the hydrology domain, and to include a precision and accuracy statement.

### 6.6.3. Catchment Network Navigation, comparison with ISO network (navigation) model

Provided that a catchment topology of inflow/outflow nodes and catchment links is defined and that the hierarchical network of catchments is expressed in a particular hydrologic dataset, the upstream-downstream tracking of the catchment network can be transferred to a related set of water bodies. This is true for any visual or data representation of flowing or stagnant water or channels containing a water body either permanently or temporarily.

Thinking about catchments as topological edges bounded by outfall nodes, a dendritic network of catchments may be traced upstream from the sea or a sink to the inflow/outflow nodes of (multiple) upper catchments. From there, one can navigate further ‘upstream’ eventually arriving at the outflow node of the headwater catchments. Starting at a spring, the catchment network can be traced in the ‘downstream’ direction, first to the single outflow node to

which the catchment contributes then further downstream eventually arriving at the inflow node of a branching (non-dendritic), estuary or delta. In a given realization, a sequence of linear flowpaths, each realizing a catchment connected in the catchment network, may be drawn as streams or watercourses, which may or may not be geometrically connected in the representation. For example, water bodies and channel parts of a particular network may be displayed using different geometric shapes, and may look connected on a map even if they are not.

In ISO 19133: Tracking and Navigation standard, a network model is defined as a complex of nodes and links specializing the directed node and directed edge types defined in ISO 19107. Based on a catchment topological realization comparable with the ISO topology model, understanding the catchment as a topological edge and the outfall as a (inflow/outflow) node, the catchment network (as well as its hydrographic, geomorphologic or hydrometric realizations) may be navigated from outfall node to outfall node along the catchment link, from fixed landmark to fixed landmark along a water body, from section to section along a channel, and from station to station along a virtual line.

## 7. Clause containing normative material

### 7.1. The HY\_Features conceptual model

This standard defines the HY\_Features conceptual model as a standard for the identification and description of hydrologic features reflecting both hydrologic significance and topological connectivity of hydrologic features. HY\_Features formalizes the fundamental relationships between components of the hydrosphere. It describes the hydrosphere as a hierarchical network of hydrologically connected catchments, their organization in networks of catchments and/or waterbodies, and their various visual and topological realizations.

Core concepts of HY\_Features are: 1) an abstract idea of 'catchment' which has many possible 'realizations', 2) upstream - downstream catchment topology and nested hierarchy, 3) aggregation of networks of watercourses within catchment networks, and 4) linear referencing along a river using a nominal main flow path. The single concept that governs HY\_Features is that any place on the land surface can be thought of as the outfall of a corresponding catchment and be placed into a hydrologic topology of connected, often named, hydrologic features.

The conceptual model is implemented in several discrete modules. It is intended that implementations of the conceptual model need to consider only those parts of the model required. An implementation may include or exclude feature properties, or allow cardinality of one or more associations to be 'nullable'. Table 1 lists the application schemas, the leaf packages included and the concepts reflected therein.

Application Schema	Concepts Reflected	Leaf package included
HY_HydroFeature	fundamental properties and relationships between features governed by the physical laws of Hydrology, naming of hydrologic features, location of hydrologic feature along a line	NamedFeature, HydroComplex, RiverPositioningSystem
HY_SurfaceHydroFeature	hydrologic features on the Earth's land surface without complexity and detail of hydrologic and hydraulic models	ChannelNetwork, HydrographicNetwork, WaterBodyTypes, Storage

Application Schema	Concepts Reflected	Leaf package included
HY_HydrometricNetwork	hydrometric network of logically connected hydrometric features located on or along a hydrologic feature	— -

The conceptual model is expressed in the Geographic Information Conceptual Schema Language (ISO 19103:2005) based on the Unified Modeling Language (UML). The organization into packages and package dependencies are shown in Figure 16. The following sections describe requirements classes for each application schema, whereby each feature addressed in the requirements shall be understood as an instance of the GF\_FeatureType (aka FeatureType) «metaclass». For the purpose of consistency with the conceptual UML model the British spelling of feature type names and properties has been adopted.

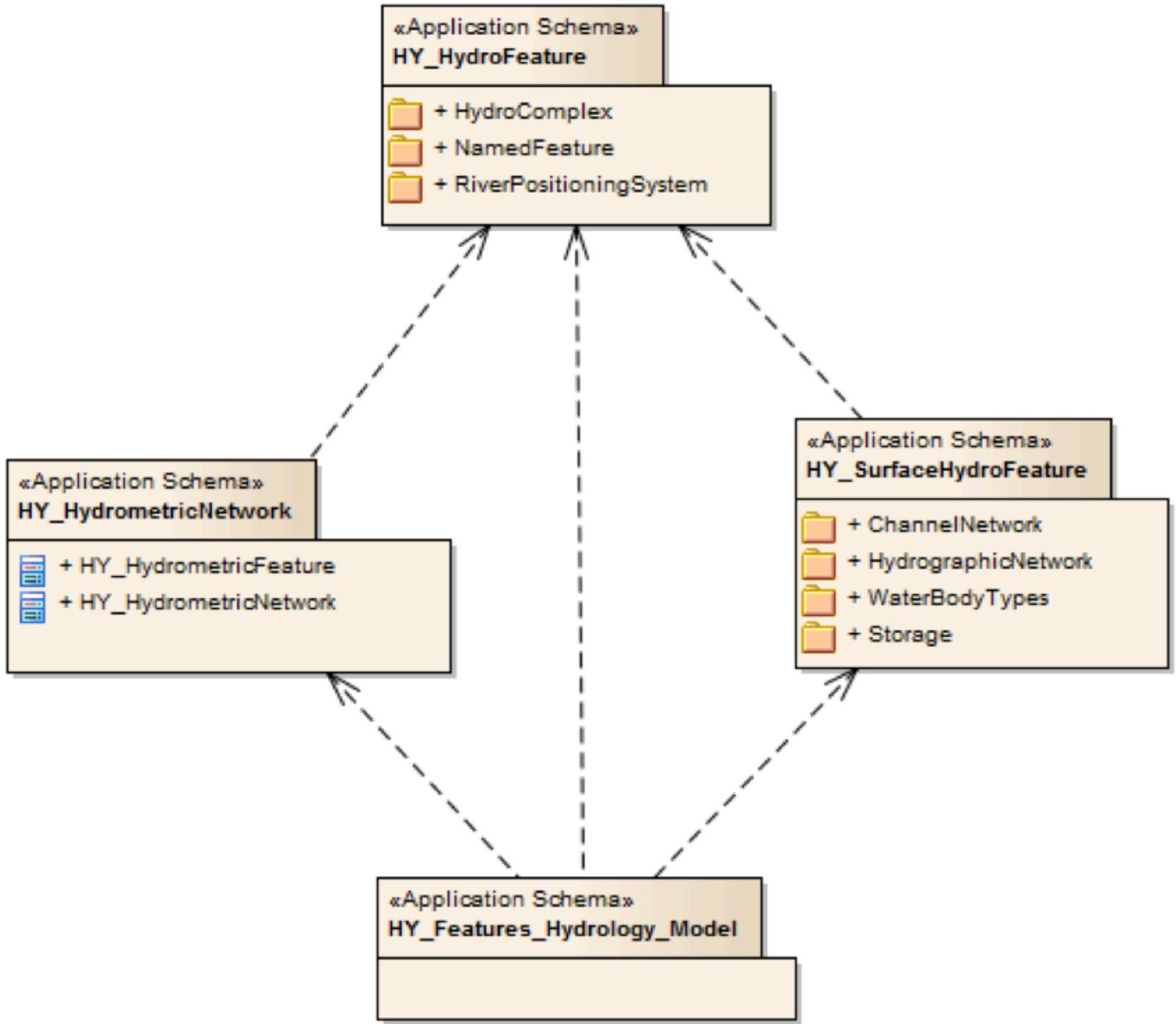


Figure 16. HY\_Features modules and packages

## 7.2. The HY\_Features conceptual conformance (mapping)

The HY\_Features model is a 'conceptual model', not intended to be directly implementable for data exchange or persistence. The conformance target of the HY\_Features model is therefore a logical model of an implementation that encodes aspects of the HY\_Features model.

Conformance to the HY\_Features model is a matter of being able to unambiguously identify what elements of an implementation schema map to the HY\_Features model, and inclusion of all mandatory properties of the defined Feature Types in such mappings.

The HY\_Features conceptual model provides the basis for determining whether two references to hydrologic features are references to the same feature. i.e. to specify the real world type of features independent of their implementation or format. More specifically, it provides the means to distinguish between the reference concept (e.g. a catchment) and its realizations as geographic features (e.g. flowpath, catchment area or boundary), and hence to declare that different realizations share common hydrological connectivity.

Disparate systems describing hydrologic features may be mapped to the equivalent HY\_Features definitions to disambiguate the local usage of terminology and specific implementation choices made.

Note that a direct encoding of HY\_Features to an implementation format such as RDF may be implemented through annotation or direct correspondence of names to the HY\_Feature elements.

Requirements Class	
<u>/req/hy_features_conceptual_model</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_features_conceptual_model">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_features_conceptual_model</a> )	
Target type	Implementation Schema
Name	HY_Features Conceptual Conformance
Dependency	<u>/iso/19109/</u> ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )
Requirement	<u>/req/ hy_features_conceptual_model/mapping</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/%20hy_features_conceptual_model/mapping">https://github.com/opengeospatial/HY_Features/blob/master/req/%20hy_features_conceptual_model/mapping</a> )
1	

An implementation schema conforming to HY\_Features SHALL provide a formal mapping from one or more Feature Types present in the implementation schema to Feature Types defined in this standard specification, including all mandatory properties defined by the realized HY\_Features concept. Default values to be assumed must be specified in this mapping.

## 7.3. The HY\_Features data conformance (encoding)

As a conceptual model HY\_Features does not specify conformance requirements regarding the structure of possible encodings. It does however specify that equivalence of feature instances can be expressed. The requirement that arises is therefore that the content of feature identification elements can be matched among implementations. This does not demand the use of identical identifiers across different implementations, but it does require that implementations provide a mechanism to match identifiers from different schemes.

## Requirements Class

/req/hy\_features\_conceptual\_model

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_features\\_conceptual\\_model](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_features_conceptual_model))

Target type	Dataset
Name	HY_Features Data Conformance
Dependency	/req/hy_features_conceptual_model ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_features_conceptual_model">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_features_conceptual_model</a> )
Dependency	/iso/19109/ ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )
Dependency	/iso/19150/ ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )
Dependency	/iso/19136/ ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )
<b>Requirement</b> <b>1</b>	/req/ hy_features_conceptual_model/identifiers ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/%20hy_features_conceptual_model/identifiers">https://github.com/opengeospatial/HY_Features/blob/master/req/%20hy_features_conceptual_model/identifiers</a> )

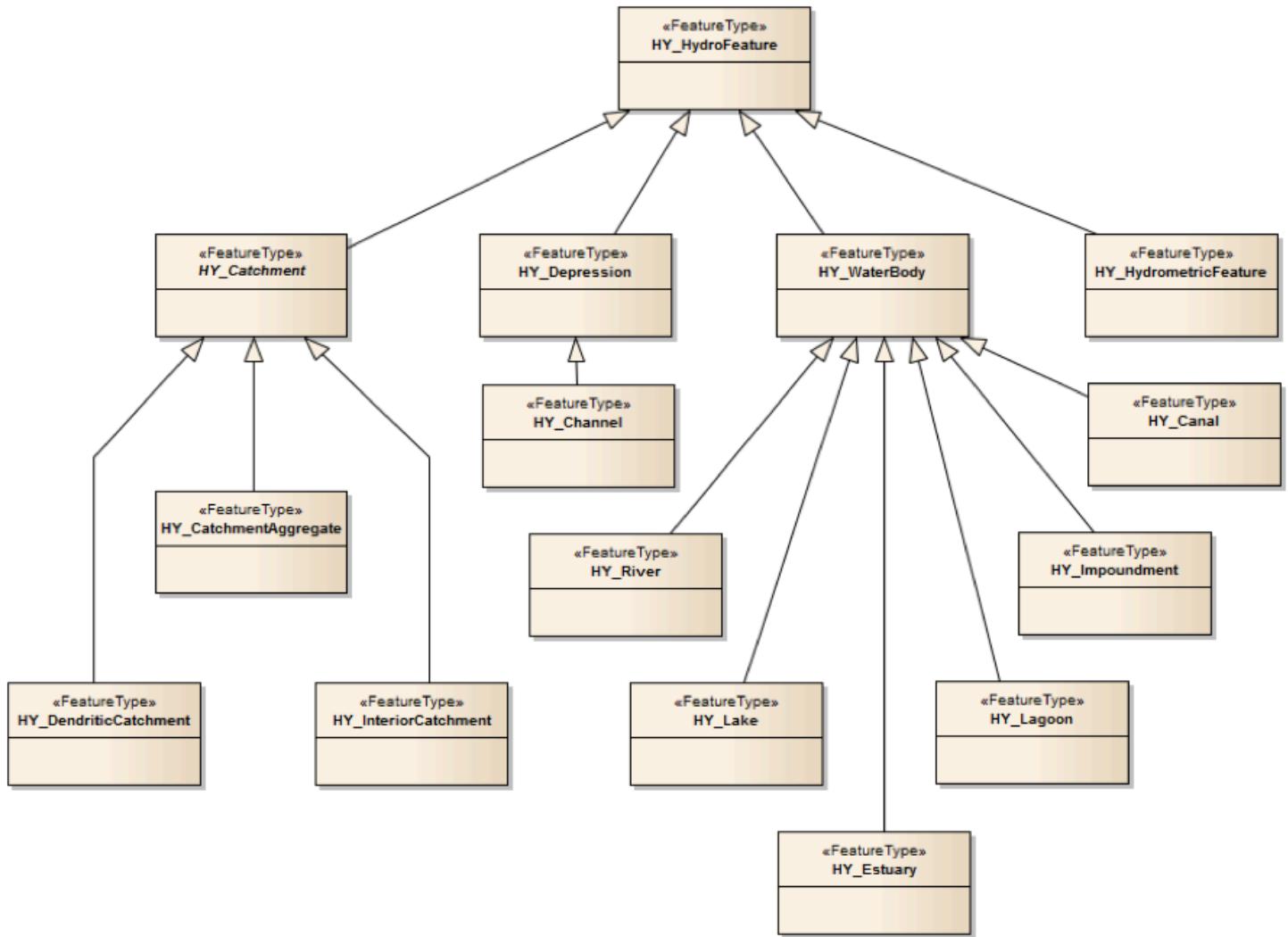
Implementations of HY\_Features SHALL either use common identifiers for instances of Feature Types mapped to the same underlying HY\_Features Feature Type, OR provide a mechanism to match identifiers from different identification schemes.

## 7.4. The Hydro Feature application schema

The Hydro Feature schema provides the core concepts of a named hydrologic feature, of a catchment and its multiple realizations, and of a river positioning using a linear referencing. Hydrologic features are identified by hydrologically significant characteristics and feature topology according to hydrologic rules. Providing a standard terminology for the typical relationships between hydrologic features allows the hydrosphere to be expressed in a consistent way across multiple data products, regardless of various spatial or temporal representations.

Hydrologic features are usually named in cross-jurisdictional and multi-lingual contexts. The Hydro Feature schema provides a concept for a named hydrologic feature which allows the use of multiple names and identifiers without the need for a formal naming model. The named hydrologic feature is further described using various domain-specific feature types, which specify properties of the specializations to define one or more aspects of the hydrology phenomenon (Figure 17).

The Hydro Feature schema provides the core model of catchments and their multiple realizations. The catchment model denotes the hydrologic definition of a catchment by its outlet, conceptualized as HY\_Outfall, and the interaction of catchments through such defined outfalls. This allows division of the hydrosphere into a logically connected network of catchments. Depending on the perspective of a particular study, the logical catchment can be realized in multiple ways by geometric or topologic features. The Hydro Feature schema provides a model to place a catchment's outfall relative to a feature which realizes the logical outfall. The river positioning model provides a river reference system which allows linear referencing of an outfall (typically a monitoring location) using the linear realization of a catchment that corresponds to another outfall (typically a confluence).



*Figure 17. Hydrologic features describing separate aspects of the hydrology phenomenon*

The definitions applied in the Hydro Feature schema are rooted in the definitions given in the WMO Glossary of Hydrology regardless of their application context in respect to the Earth's surface. For the purpose of testing the applicability of the conceptual model in the context of surface water hydrology, the definitions in this standard refer to surface water hydrology. A conceptual model capturing the specifics of features associated with the groundwater domain is developed with reference to the OGC WaterML 2: Part 4 – GroundwaterML2 standard [6].

The Hydro Feature schema contains the leaf packages: NamedFeature, HydroComplex, and RiverPositioningSystem. Figure 18 shows the external dependencies.

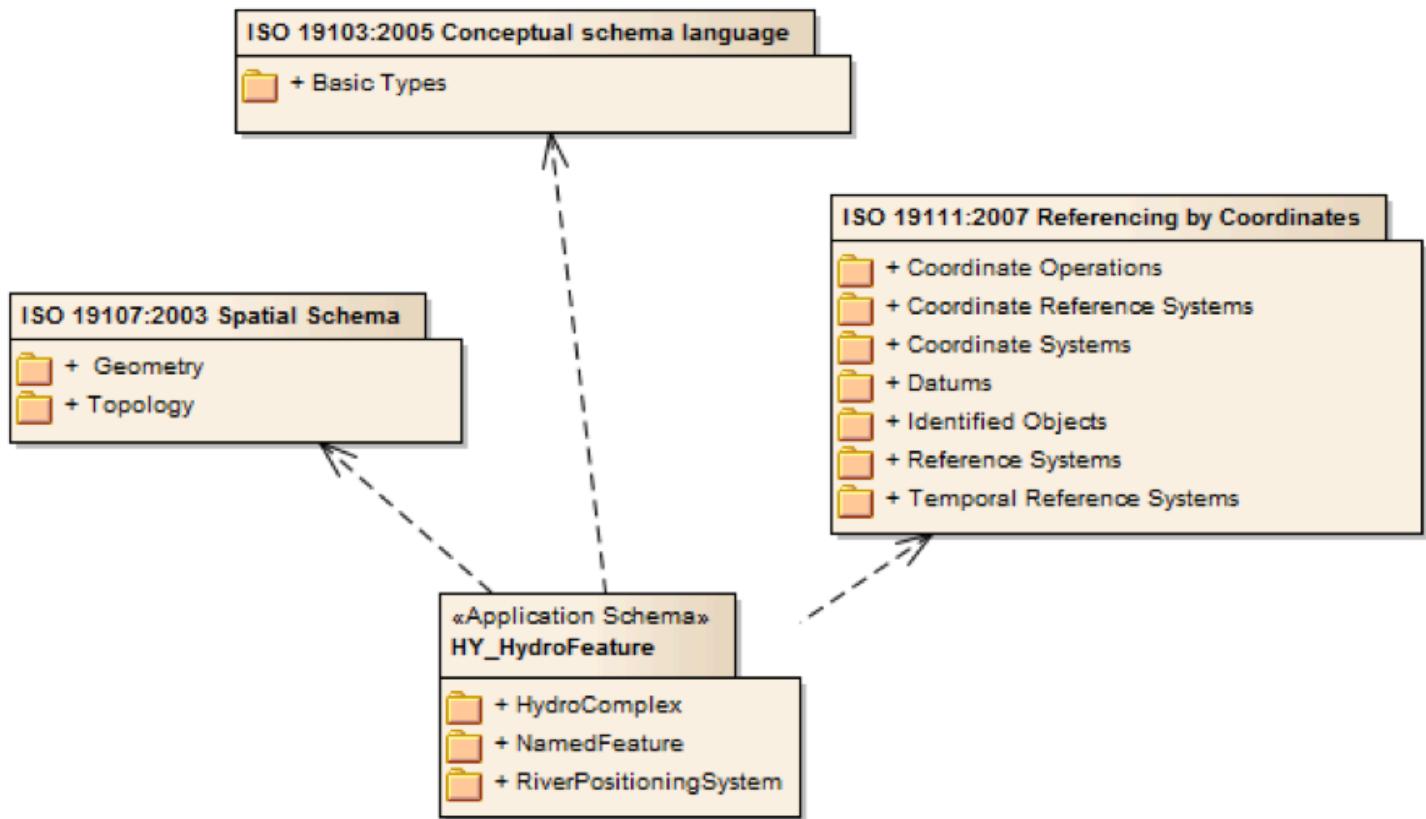


Figure 18. Hydro Feature – external dependencies

## Requirements Class

/req/hy\_hydrofeature/\* ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/))

Target type	Implementation schema
Name	HY_HydroFeature (abstract)
Dependency	/req/hy_features_conceptual_model ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_features_conceptual_model">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_features_conceptual_model</a> )
Dependency	/iso/19103/ ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )
Dependency	/iso/19107/ ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )
Dependency	/iso/19111/ ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )

<b>Requirement</b>	/req/hy_hydrofeature/namedfeature/* ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedfeature/">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedfeature/</a> )
<b>Requirement</b>	/req/hy_hydrofeature/hydrocomplex/* ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/</a> )
<b>Requirement</b>	/req/hy_hydrofeature/positioning/* ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/</a> )

#### 7.4.1. The Named Feature model

The Named Feature model (Figure 19) denotes the abstraction of the hydrology phenomenon as a named hydrologic feature. It provides an approach to identify a named hydrologic feature in cross-jurisdiction and multi-lingual contexts by considering the cultural, political and historical aspects of names assigned to hydrologic features in common usage.

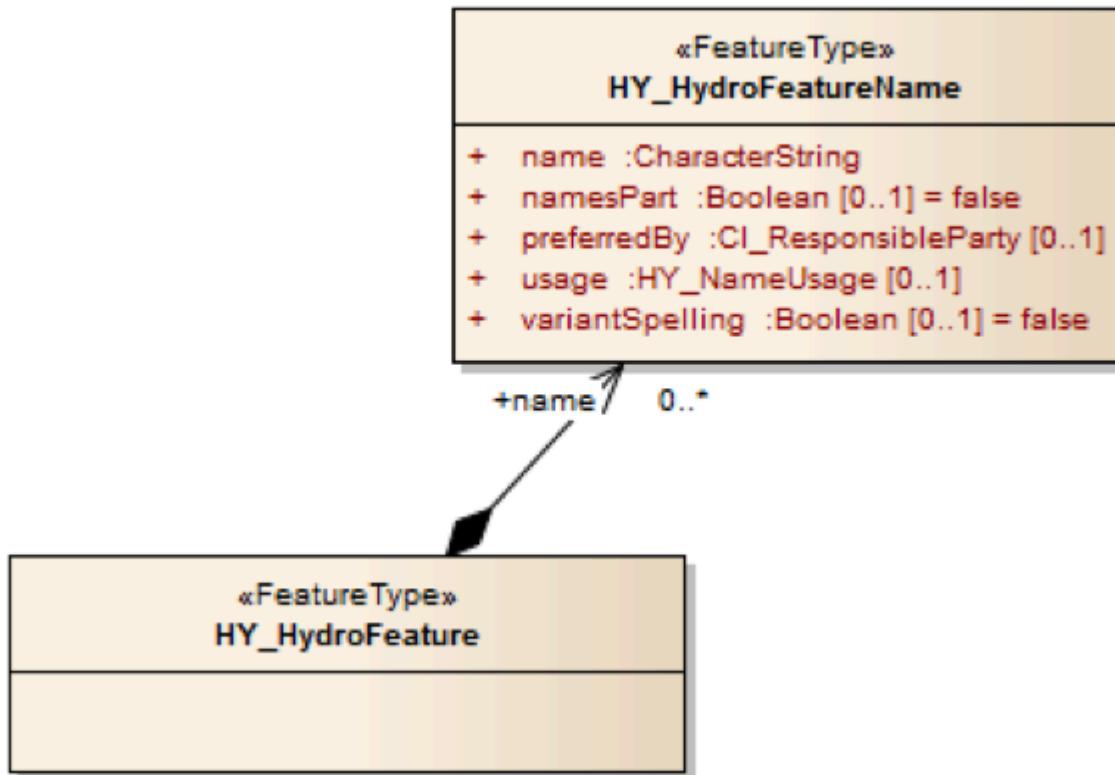


Figure 19. Named Feature (UML class diagram, /req/hy\_hydrofeature/namedFeature/hydrofeature ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/namedFeature/hydrofeature](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature)))

The HY\_HydroFeature feature type is further specialized by separate feature types. Each specialization inherits the properties from generalization; HY\_HydroFeature type has one association: *name*.

The **name** associates a name given to the hydrologic feature in cultural, political or historical context. If required, this association shall be used where names are assigned to a feature instance in cross-jurisdictional and multi-lingual contexts, that may occur with trans-boundary features.

## Requirements Class

/req/hy\_hydrofeature/namedFeature/hydrofeature

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/namedFeature/hydrofeature](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature))

Target type	Implementation schema
Name	HY_HydroFeature
Dependency	<u>/req/hy_hydrofeature/namedFeature/hydrofeaturename</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeaturename">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeaturename</a> )
Dependency	<u>/req/hy_hydrofeature/namedFeature/hydrofeature.name</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.name">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.name</a> )

The HY\_HydroFeatureName feature type provides an abstract pattern to handle cultural, political and historical variability of names. This the assignment of a referencable name for all or part of a hydrologic feature without necessarily have a formal model for naming. HY\_HydroFeatureName has five attributes: *name*, *namesPart*, *preferredBy*, *usage* and *variantSpelling*. If required, an implementation shall use this type to describe the usage of multiple names. The usage type may be identified using the HY\_NameUsage code list described in Annex B.4.

## Requirements Class

/req/hy\_hydrofeature/namedFeature/hydrofeaturename

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/namedFeature/hydrofeaturename](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeaturename))

Target type	Implementation Schema
Name	HY_HydroFeatureName
Dependency	<u>/iso/19103/</u> ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )
Dependency	<u>/iso/19115/</u> ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )

Dependency	<u>/req/hy_hydrofeature/namedFeature/nameusage</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/nameusage">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/nameusage</a> )
<b>Requirement 1</b>	<u>/req/hy_hydrofeature/namedFeature/hydrofeature.name</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.name">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.name</a> )
<b>Requirement 2</b>	<u>/req/hy_hydrofeature/namedFeature/hydrofeature.namespart</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.namespart">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.namespart</a> )
<b>Requirement 3</b>	<u>/req/hy_hydrofeature/namedFeature/hydrofeature.preferredBy</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.preferredby">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.preferredby</a> )
<b>Requirement 4</b>	<u>/req/hy_hydrofeature/namedFeature/hydrofeature.usage</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.usage">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.usage</a> )
<b>Requirement 5</b>	<u>/req/hy_hydrofeature/namedFeature/hydrofeature.variantspelling</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.variantspelling">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature.variantspelling</a> )

#### 7.4.2. The Hydro Complex model

The Hydro Complex model conceptualizes the hydrologic definition of a catchment through an 'outfall' feature with the role of getting flow from a contributing catchment, or providing inflow to a receiving catchment (Figure 20 and Figure 21). Conceptually, each catchment has an outfall, and any outfall has a corresponding catchment, even if catchment and/or outfall may not be present in a particular application. A catchment interacts with upper and lower catchments via associated outfalls, and ultimately contributes flow to the outfall of a containing catchment. The catchment should be understood as the logical link between two outfalls.

The Hydro Complex model implies a collection of hydrologic features that form a hydrologically closed system. The union of a catchment, its inflow and outflow (conceptualized as outfalls) is realized by typical hydrologic features to form a single hydrologic complex. A topological realization of the logical catchment is always of higher topological dimension than the realization of the corresponding outfall in terms of a topological boundary. For example, a linear flowpath realizing a catchment may be understood as an edge between inflow and outflow nodes; the areal realization of a catchment as a face bounded by linear inflow and outflow.

The Hydro Complex model allows the realization of a logical outfall to be any arbitrary location with various realizations of its own. Such a 'real' outfall provides an identifiable reference feature to which alternative catchment realizations may refer. This very general outfall feature supports establishment of topological relationships between hydrographic features, or between hydrographic and hydrometric features. The Hydro Complex model also allows for catchments to be recognized through reference to an outfall even if stream networks, catchment areas or watersheds are not available. It is intended that hydrological reporting applications may use this model without the full complexity and detail of scientific catchment models.

## Catchment

The HY\_Catchment feature type represents a hydrologically determined feature through association an outfall, and the logical network of catchments that form a connected network of smaller catchments and outfalls within the catchment. Each HY\_Catchment may provide association between its many realizations within a hydrologically determined hydrologic complex. These realizations include both geometric and topological realizations such as an edge 'bounded' by inflow and outflow nodes. HY\_Catchment is an abstract class and may be further specialized with respect to catchment interaction.

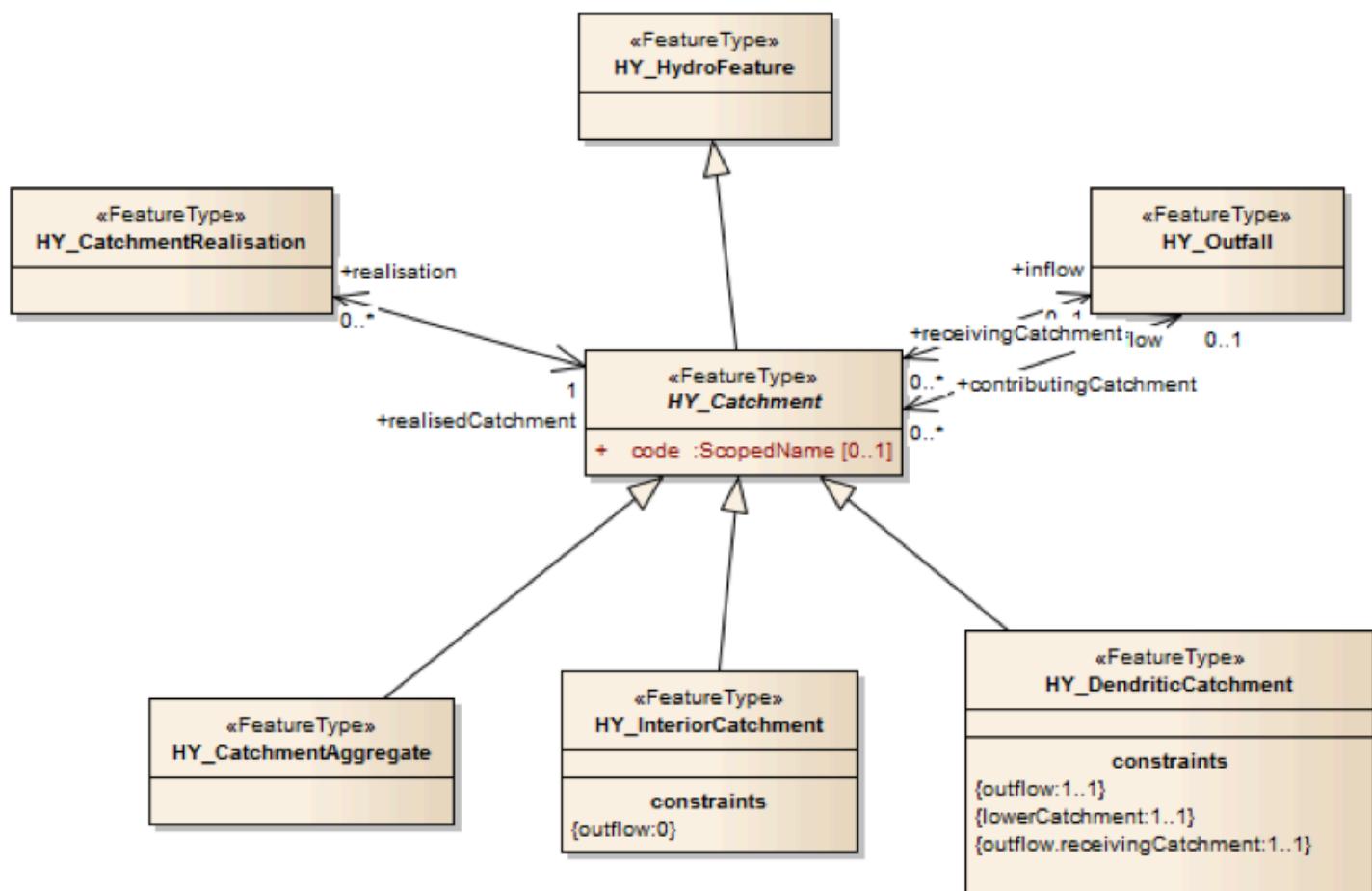


Figure 20. Catchment (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/catchment](#) ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment)))

The HY\_Catchment type (Figure 20) specializes the general HY\_HydroFeature class. Through generalization, HY\_Catchment inherits the name property, and carries the code attribute and the associations: *outflow*, *inflow*, *containingCatchment*, *containedCatchment*, *conjointCatchment*, *upperCatchment*, *lowerCatchment*, *realisation*.

The **code** attribute may be used to assign a unique identifier to the catchment in given context. If required, the code attribute shall be implemented using a controlled classification or coding system. Example: WMO Basin Codes.

The **outflow** and **inflow** associations describe the outfall in terms of outflow or inflow to or from the corresponding catchment. Assuming a dendritic network of catchments, the outflow of a contributing catchment coincides with the inflow to a receiving catchment. This allows description of upstream-downstream relations. If required, this association shall be used to identify the place to which flow is contributed, or where flow is received from.

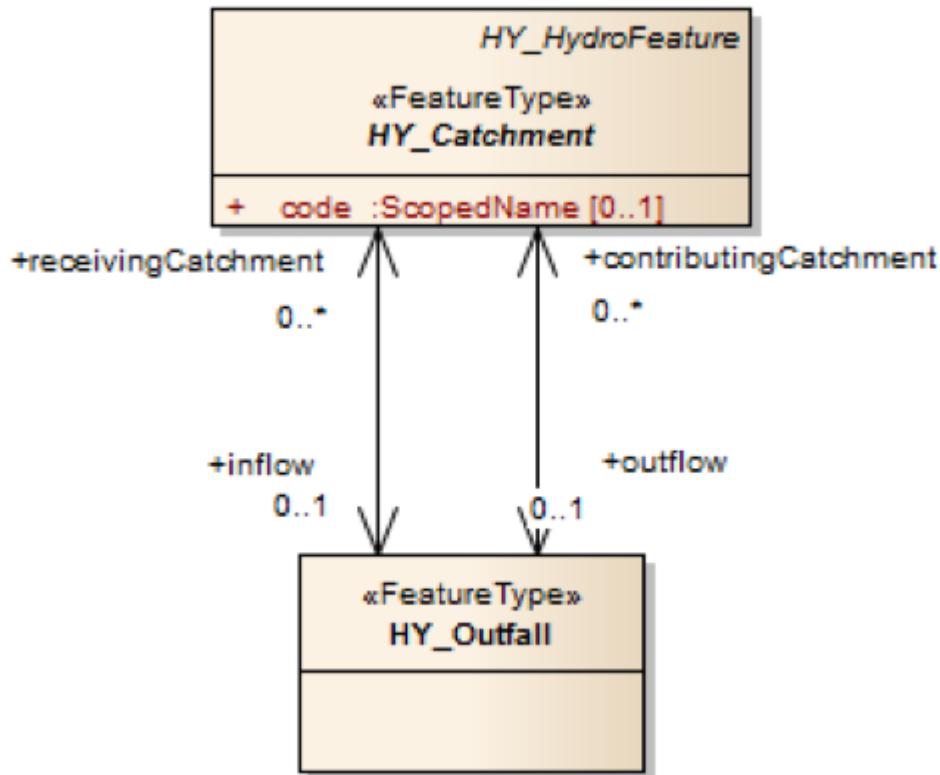


Figure 21. Catchment and outfall (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/catchment.inflow](#) ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment.inflow](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.inflow)), [/req/hy\\_hydrofeature/hydrocomplex/catchment.outflow](#) ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment.outflow](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.outflow)))

The **containingCatchment** and **containedCatchment** associations connect the nesting of catchments in a simple “is-in” containment hierarchy as typically used for high-order organization of management and reporting units. If required, this association shall be used to identify a nesting catchment or the catchments nested therein.

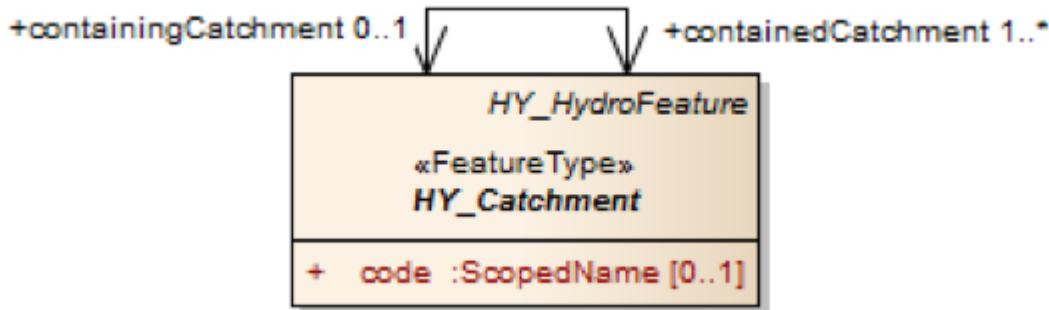


Figure 22. Containing / contained catchment (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/catchment.containingcatchment](#))

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment.containingcatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.containingcatchment))

, [/req/hy\\_hydrofeature/hydrocomplex/catchment.containedcatchment](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment.containedcatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.containedcatchment))

)

The **conjointCatchment** association describes the interaction of a catchment with another catchment crossing an internal boundary line. This line may be a divide separating adjacent catchments, or a diffuse divide between non-delineated sub-catchments within an encompassing catchment, or a fictive line between distant catchments. If required, this association shall be used to identify a catchment contributing with others to a 'joined' outfall. Assuming a dendritic network of catchments, where each catchment is determined by its single outflow, this association may be used to summarize diffuse inflow into an encompassing catchment, as required to describe inflow to headwater catchments.

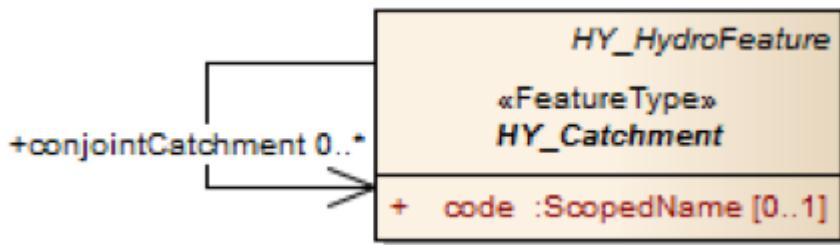
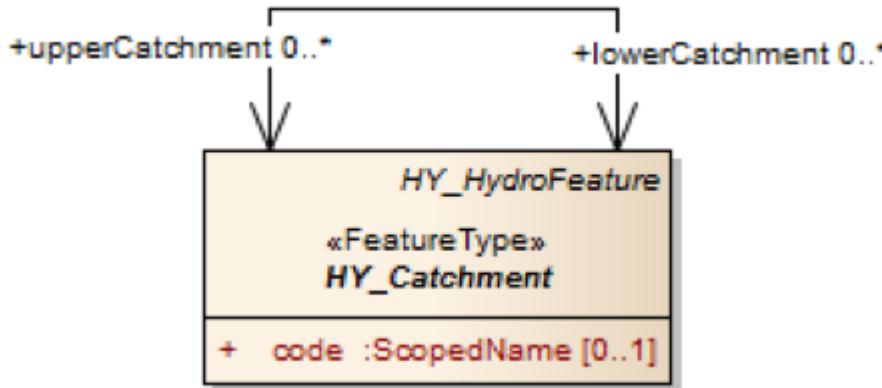


Figure 23. Conjoint catchment (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/catchment.conjointcatchment](#))

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment.conjointcatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.conjointcatchment))

The **upperCatchment** and **lowerCatchment** associations connect the catchment to the adjacent catchment above or below. This allows the description of connected catchments without knowing their inflow or outflow outfalls. If required, this association shall be used to trace the catchment network in upstream direction from mouth to source, or downstream from source to mouth.



*Figure 24. Upper / lower catchment (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/catchment.uppercatchment](#)*

*([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment.uppercatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.uppercatchment))*

*([/req/hy\\_hydrofeature/hydrocomplex/catchment.lowercatchment](#)*

*([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment.lowercatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.lowercatchment))*

The **realisation** association relates the catchment to a feature which realizes the logical catchment. This supports linking multiple realizations of the same catchment. If required, this association shall be used identify a particular realization. In case of a topological realization, the realization of the catchment shall be of higher dimension than the realization of the outfall.

## Requirements Class

[/req/hy\\_hydrofeature/hydrocomplex/catchment](#)

*([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment))*

Target type	Implementation schema
Name	HY_Catchment
Dependency	<a href="#">/iso/19103/</a> ( <a href="https://inspire-twg.jrc.it/svn/iso/">https://inspire-twg.jrc.it/svn/iso/</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/outfall</a> <i>(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall</a>)</i>
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchment</a> <i>(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment</a>)</i>
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a> <i>(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a>)</i>

<b>Requirement 1</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchment.outflow</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.outflow">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.outflow</a> )
<b>Requirement 2</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchment.inflow</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.inflow">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.inflow</a> )
<b>Requirement 3</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchment.containingcatchment</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.containingcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.containingcatchment</a> )
<b>Requirement 4</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchment.containedcatchment</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.containedcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.containedcatchment</a> )
<b>Requirement 5</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchment.conjointcatchment</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.conjointcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.conjointcatchment</a> )
<b>Requirement 6</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchment.uppercatchment</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.uppercatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.uppercatchment</a> )
<b>Requirement 7</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchment.lowercatchment</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.lowercatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.lowercatchment</a> )
<b>Requirement 8</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchment.realisation</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.realisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment.realisation</a> )

## Catchment Aggregate

The HY\_CatchmentAggregate feature type (Figure 25) specializes the HY\_Catchment as a set of non-overlapping dendritic and interior catchments arranged in an encompassing catchment. This allows description of multiple inflows into a catchment aggregate through several hydrologically discrete sub-catchments each with a single inflow, and contributing to a joined outflow of the catchment aggregate, including the 'nillable' outflow of interior catchments. Nillable is meant to signify that the outfall exists, in the form of flow to the subsurface or atmosphere but is unknown in a given implementation. The catchment aggregate may be part of a containing catchment at the

next higher level of hierarchy, which consists of similar-scale neighboring catchments. The catchment aggregate does not necessarily imply a series of nested containing catchments. It primarily allows navigation to the 'highest' level system (total drainage basin) as typically used for reporting purposes.

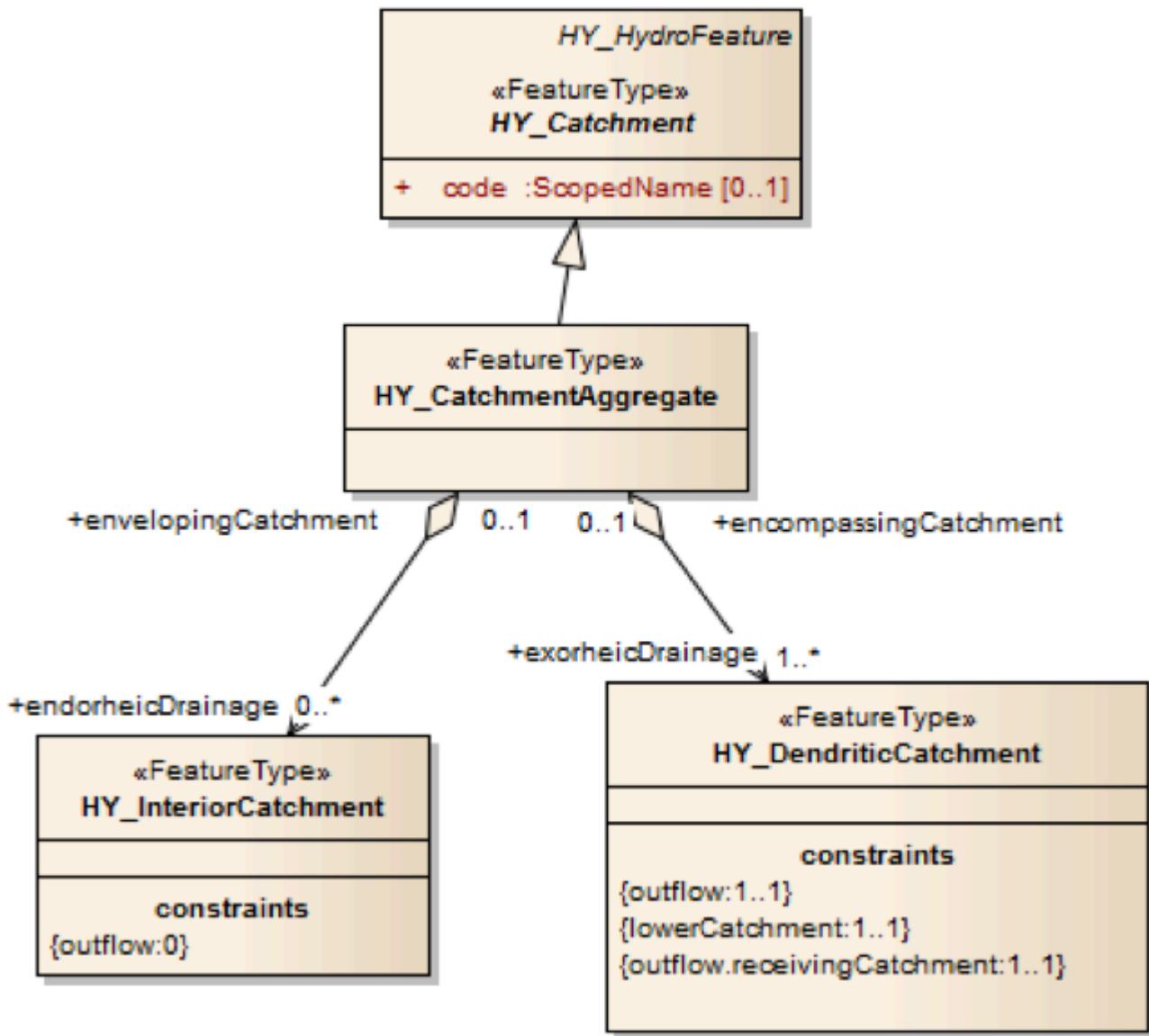


Figure 25. Catchment aggregate (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/catchmentaggregate](#) ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchmentaggregate](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate)))

**HY\_CatchmentAggregate** inherits from generalization the *outflow*, *inflow*, *containingCatchment*, *containedCatchment*, *conjointCatchment*, *upperCatchment*, *lowerCatchment*, and *realisation* properties, and associates the *exorheicDrainage* and *endorheicDrainage*.

The **exorheicDrainage** association references an exorheic drained catchment connected to others in a dendritic network. The **endorheicDrainage** association references an endorheic drained catchment, temporarily connected to the enveloping aggregate. If required, these associations shall be used to identify aggregated catchment parts which permanently or temporarily interact with other catchment parts at the same hierarchy level.

## Requirements Class

/req/hy\_hydrofeature/hydrocomplex/catchmentaggregate

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchmentaggregate](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate))

Target type	Implementation schema
Name	HY_CatchmentAggregate
Dependency	<u>/req/hy_hydrofeature/hydrocomplex/catchment</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment</a> )
Dependency	<u>/req/hy_hydrofeature/hydrocomplex/dendriticcatchment</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/dendriticcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/dendriticcatchment</a> )
Dependency	<u>/req/hy_hydrofeature/hydrocomplex/interiorcatchment</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/interiorcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/interiorcatchment</a> )
<b>Requirement 1</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchmentaggregate.exorheicdrainage</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate.exorheicdrainage">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate.exorheicdrainage</a> )
<b>Requirement 2</b>	<u>/req/hy_hydrofeature/hydrocomplex/catchmentaggregate.endorheicdrainage</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate.endorheicdrainage">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate.endorheicdrainage</a> )

## Dendritic Catchment

The HY\_DendriticCatchment feature type (Figure 26) specializes the general HY\_Catchment class as a catchment which is determined by a single common downstream catchment. It represents the catchment as the topological link between an inflow and an outflow. This allows catchments to be connected in a dendritic network by upstream-downstream relationships without knowing the complex hydrology between inflow and outflow. This concept requires a stable identifier purposefully assigned to the catchment and that catchments are delineated as a simple tree

hierarchy. The dendritic nature of this class is enforced through constraints that the catchment must have one and only one outflow (which can be unknown), must have one and only one lowerCatchment (which may be unknown), and must have an outflow that contributes to only one receiving catchment.

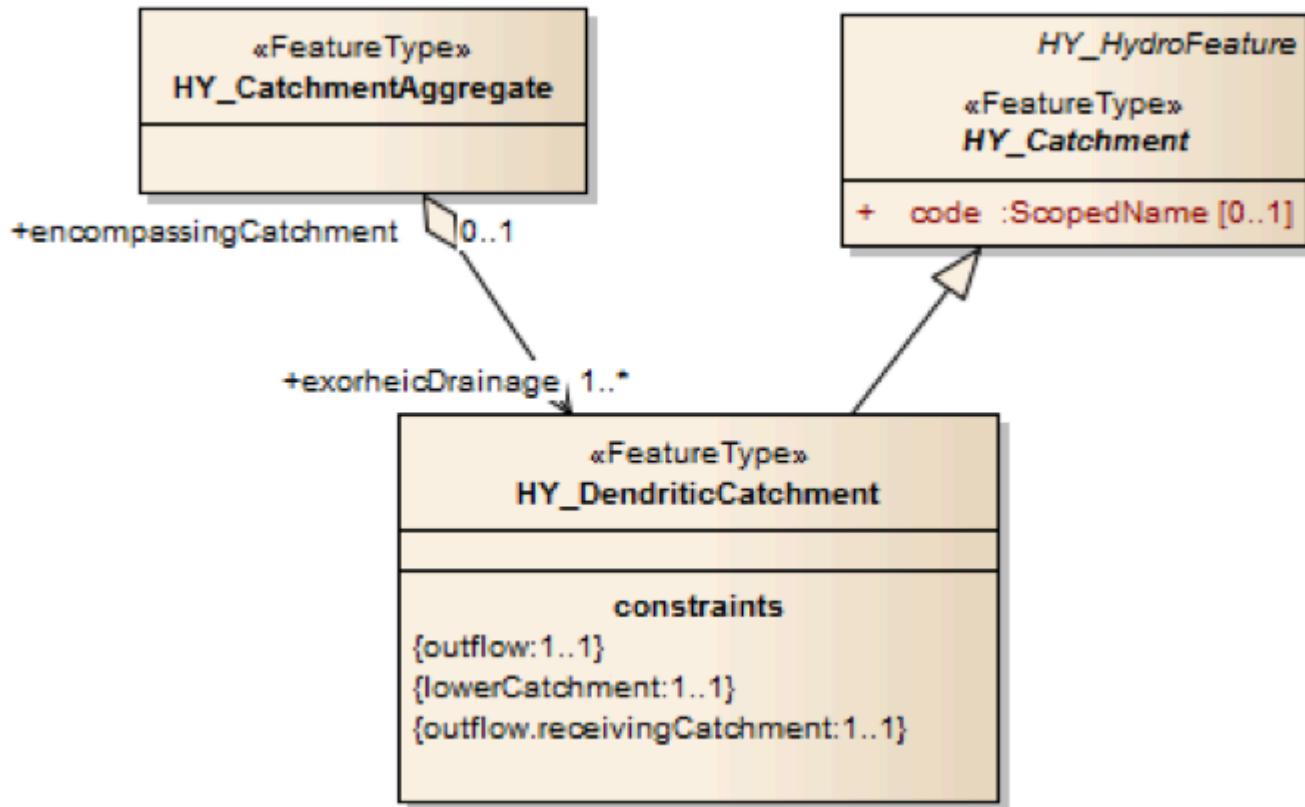


Figure 26. Dendritic catchment (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/dendriticcatchment](#) ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/dendriticcatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/dendriticcatchment)))

**HY\_DendriticCatchment** inherits from generalization the *code*, *outflow*, *inflow*, *containingCatchment*, *containedCatchment*, *conjointCatchment*, *upperCatchment*, *lowerCatchment*, and *realisation* properties, and associates the *encompassingCatchment*.

The **encompassingCatchment** association relates to the dendritic catchment the aggregate encompassing the catchment. If required, this association shall be used to identify the catchment encompassing one or more exorheic or endorheic drained catchments contributing flow to the common outlet, either from a single identified inflow, or in joining with other sub-catchments crossing a divide internal to the encompassing aggregate catchment.

## Requirements Class

[/req/hy\\_hydrofeature/hydrocomplex/dendriticcatchment](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/dendriticcatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/dendriticcatchment))

Target type	Implementation schema
Name	HY_DendriticCatchment
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchment</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchmentaggregate</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate</a> )
Requirement 1	<a href="#">/req/hy_hydrofeature/hydrocomplex/dendriticcatchment.encompassingcatchment</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/dendriticcatchment.encompassingcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/dendriticcatchment.encompassingcatchment</a> )

## Interior Catchment

The HY\_InteriorCatchment feature type (Figure 27) specializes the general HY\_Catchment class as a catchment which is generally not connected to other catchments. This class describes the interior catchment as a catchment enveloped by other catchments to which it may temporarily contribute. While the interior catchment concept precludes flow to neighboring surface catchments, holistically it is a candidate for establishing connections to groundwater or atmospheric systems.

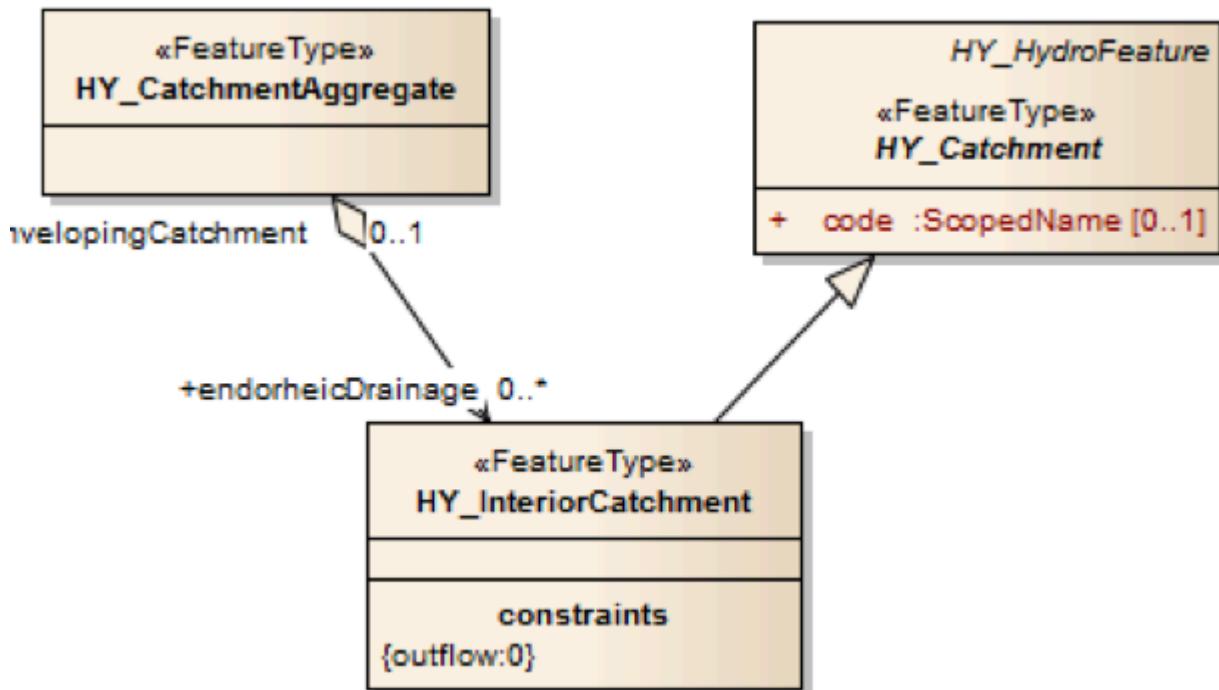


Figure 27. Interior catchment (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/interiorcatchment](#) ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/interiorcatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/interiorcatchment)))

HY\_InteriorCatchment inherits from generalization the code, *outflow*, *inflow*, *containingCatchment*, *containedCatchment*, *conjointCatchment*, *upperCatchment*, *lowerCatchment*, and *realisation* properties, and associates the envelopingCatchment.

The **envelopingCatchment** association relates to the interior catchment the aggregate surrounding the catchment. If required, this association shall be used to identify the catchment enveloping one or more endorheic drained catchments contributing 'nillable' flow to the common outlet.

## Requirements Class

[/req/hy\\_hydrofeature/hydrocomplex/interiorcatchment](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/interiorcatchment](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/interiorcatchment))

Target type	Implementation schema
Name	HY_InteriorCatchment
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchment</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchmentaggregate</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentaggregate</a> )
Requirement 1	<a href="#">/req/hy_hydrofeature/hydrocomplex/interiorcatchment.envelopingcatchment</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/interiorcatchment.envelopingcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/interiorcatchment.envelopingcatchment</a> )

## Outfall

The HY\_Outfall feature type (Figure 28) conceptualizes the hydrologically determined outfall of a corresponding catchment (Figure 21). The logical outfall represents the logical place where a catchment interacts with another catchment, i.e. where the outflow of a contributing catchment becomes inflow into a receiving catchment. A catchment may receive flow from several catchments or contribute flow to several catchments through a single logical outfall. Logically placed in reference to a catchment which links inflow and outflow, an outfall has a position relative to another outfall that is 'fixed' by the catchment. Through unique identity, each outfall feature may associate different outfall realizations within an hydrologic complex given that each realization has the same hydrologic determination. This includes the topological realization as a node in terms of the 'boundary' on a catchment edge.

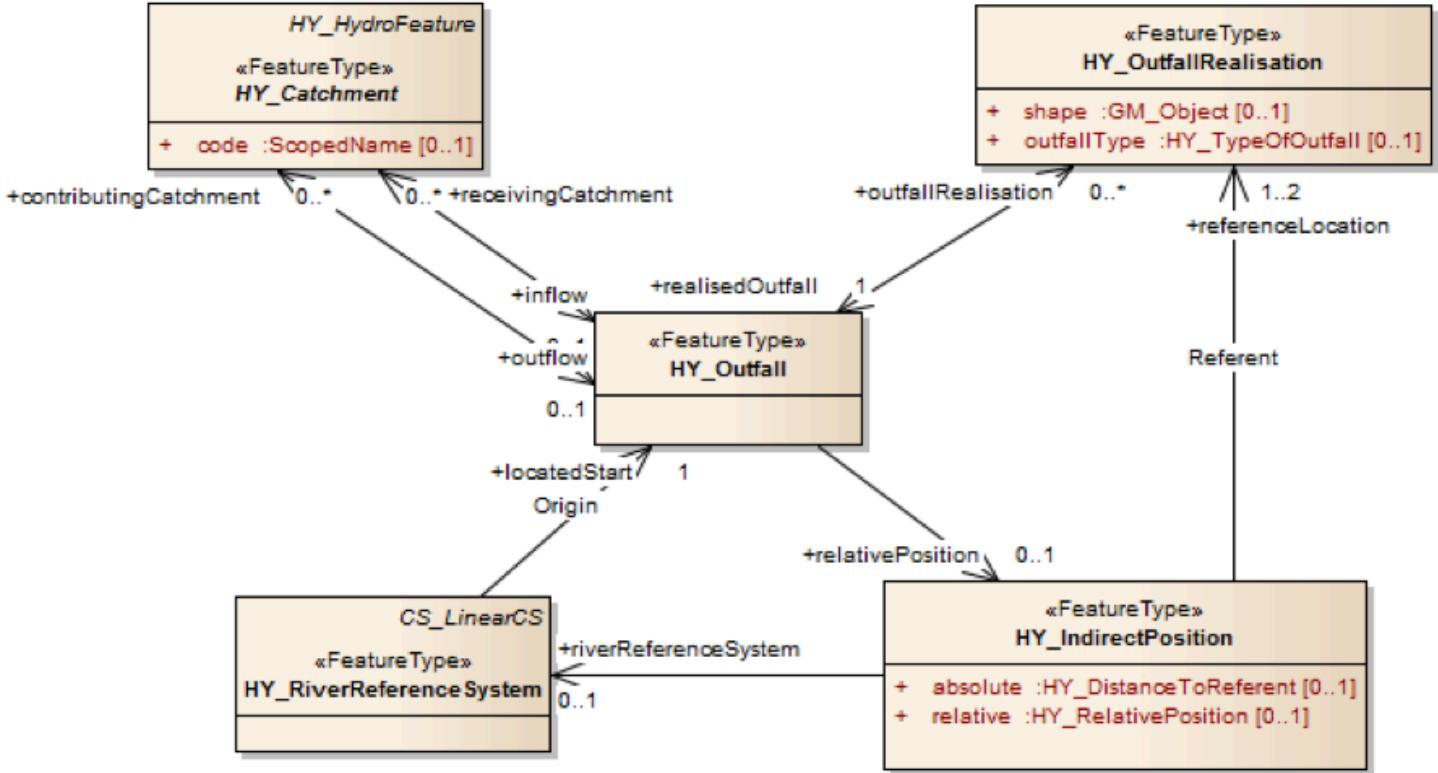


Figure 28. Outfall (UML class diagram, [req/hy\\_hydrofeature/hydrocomplex/outfall](#) ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/outfall](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall)))

HY\_Outfall carries the associations: *contributingCatchment*, *receivingCatchment*, *relativePosition* and *outfallRealisation*.

The **contributingCatchment** association relates the outfall to the catchment that contributes flow to it. This allows relation of a catchment's outflow to an identified inflow and to determine its position through referencing an outfall. If required, this association shall be used to identify the catchment connecting the outfall and an inflow used for reference.

The **receivingCatchment** association relates to the outfall to a catchment that receives flow from it. This allows relation of a catchment's inflow to an identified outflow and to determine its position through referencing an outfall. If required, this association shall be used to identify the catchment connecting the outfall and the outflow used for reference.

The **relativePosition** association assigns a position to the outfall relative to a reference location (typically an outfall realization) fixed in the logical network of catchments. This means that the position of an outfall is determined relative to another realized outfall. If required, this association shall be used to assign a position to an inflow or outflow of a catchment using existing reference location(s). Commonly, this is used to locate an outfall such as at a hydrometric station, to a reference outfall such as a confluence but it can be used to locate any outfall relative to another.

The **outfallRealisation** association relates the outfall to a feature which realizes the logical outfall. If required, this association shall be used to describe the 'real' object considered to be outfall of a catchment. In case of a topological realization, the realization of the outfall shall be of lower dimension than the realization of the corresponding catchment.

## Requirements Class

### req/hy\_hydrofeature/hydrocomplex/outfall

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/outfall](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall))

Target type	Implementation schema
Name	HY_Outfall
Dependency	/req/hy_hydrofeature/hydrocomplex/catchment ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment</a> )
Dependency	/req/hy_hydrofeature/hydrocomplex/indirectposition ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/indirectposition">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/indirectposition</a> )
Dependency	/req/hy_hydrofeature/hydrocomplex/outfallrealisation ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation</a> )
Requirement 1	/req/hy_hydrofeature/hydrocomplex/outfall.contributingcatchment ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall.contributingcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall.contributingcatchment</a> )
Requirement 2	/req/hy_hydrofeature/hydrocomplex/outfall.receivingcatchment ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall.receivingcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall.receivingcatchment</a> )
Requirement 3	/req/hy_hydrofeature/hydrocomplex/outfall.relativeposition ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall.relativeposition">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall.relativeposition</a> )
Requirement 4	/req/hy_hydrofeature/hydrocomplex/outfall.outfallrealisation ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall.outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall.outfallrealisation</a> )

## Catchment Realization

The HY\_CatchmentRealisation feature type (Figure 29) conceptualizes the multiple realization of an 'un-realized', logical catchment, by typical features used to describe a catchment as a unit of study shared across sub-domains and studies. HY\_CatchmentArea, HY\_CatchmentBoundary, HY\_Flowpath and HY\_WaterEdge are special types of catchment realization defined to topologically realize the hydrologically determined logical catchment in terms of face, edge, and node, as well as to reflect the connectivity of catchments by hydrologic features connected in networks. Topologically, the catchment area is a face bounded by catchment boundary and flowpath. Flowpath and water edge are topological edges each bounded by an inflow node and an outflow node. The HY\_HydroNetwork type realizes a logical catchment as a collection of connected network features, the HY\_CartographicRealisation as a set of map layers.

The catchment realization concept implies a hydrologic complex in that, if a catchment realization exists, they are in the same hydrologic complex as the catchment they realize. In this way, any feature realization of a logical catchment has the same hydrologic determination as the realized catchment. If the realized catchment is connected with other catchments via its outfall, possible feature realizations are also connected.

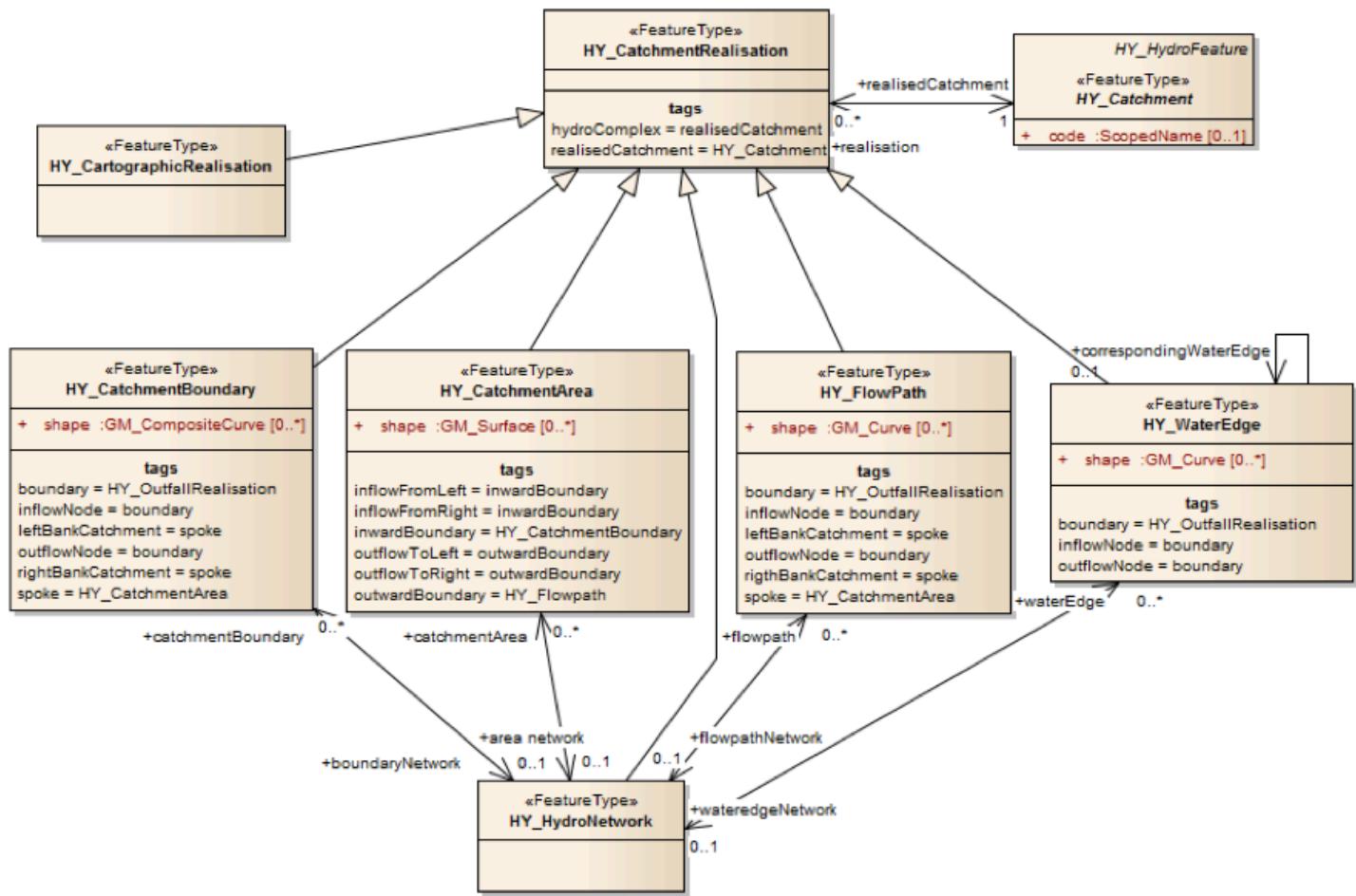


Figure 29. Catchment realization and its specialization (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/catchmentrealisation](#))

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchmentrealisation](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation))

The catchment realization feature types defined in this standard refer to objects on the land surface for the purpose of surface water hydrology. In other contexts, other types of catchment realization may exist. Catchment realizations that do not conform to those defined in this standard, for instance realizations in 3 or 4 dimensional perspectives, may use the general HY\_CatchmentRealisation type.

HY\_CatchmentRealisation carries the *realisedCatchment* association implying the *hydroComplex*. ‘Tagged values’ are used to describe the **hydroComplex** which encompasses a realization feature in the same hydrologic complex as the realized catchment.

The **realisedCatchment** association relates a particular realization with the catchment it realizes. Referencing the hydrologic complex encompassing the catchment and its realizations, allows a catchment’s existence to be recognized and linked to multiple realizations without the complexity and full detail of a scientific model. By referencing the fundamental hydrologically determined catchment, topological relationships can be established and common identifiers assigned. If required, this association shall be used to identify the unit of study realized in a domain-specific feature.

## Requirements Class

[/req/hy\\_hydrofeature/hydrocomplex/catchmentrealisation](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchmentrealisation](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation))

Target type	Implementation schema
Name	HY_CatchmentRealisation
Dependency	<u><a href="#">/req/hy_hydrofeature/hydrocomplex/catchment</a></u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment</a> )
Requirement 1	<u><a href="#">/req/hy_hydrofeature/hydrocomplex/catchmentrealisation.realisedcatchment</a></u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation.realisedcatchment">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation.realisedcatchment</a> )

The HY\_Flowpath feature type specializes HY\_CatchmentRealisation with respect to an implied linear geometric representation including a straight or curved line. Hydrologically, the flowpath is a line describing a moving particle of water. Topologically, the flowpath connects the inflow and outflow of the logical catchment, and is understood as an edge bounded by an inflow node and an outflow node, and corresponding to left-bank and right-bank catchment faces. The ‘boundary’ and ‘spoke’ properties are described by means of ‘tagged values’: the topological ‘boundary’ is of type HY\_OutfallRealisation, the topological ‘spoke’ of type HY\_CatchmentArea.

Through generalization, HY\_Flowpath inherits the *realisedCatchment* association including *hydroComplex*, and carries the properties: *shape*, and *flowpathNetwork*.

The **shape** attribute defines the linear geometric representation. If required, an implementation shall use a geometry type defined in ISO 19107: Spatial Schema, e.g. GM\_Curve type.

The **flowpathNetwork** association defines a network as sequence of connected flowpaths. This concept requires a non-branching 'mainstem' of watercourses, and a single linear representation of each of these. If required, this association may be used to identify the network which realizes as a whole the catchment that contains the catchment realized by the single part.

## Requirements Class

[req/hy\\_hydrofeature/hydrocomplex/flowpath](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/flowpath](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath))

Target type	Implementation schema
Name	HY_Flowpath
Dependency	<a href="#">/iso/19107/</a> ( <a href="https://inspire-twg.jrc.it/svn/iso">https://inspire-twg.jrc.it/svn/iso</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/hydronetw</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetw">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetw</a> )
Requirement 1	<a href="#">/req/hy_hydrofeature/hydrocomplex/flowpath.shape</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.shape">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.shape</a> )
Requirement 2	<a href="#">/req/hy_hydrofeature/hydrocomplex/flowpath.flowpathnetwork</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.flowpathnetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.flowpathnetwork</a> )

The HY\_WaterEdge feature type specializes HY\_CatchmentRealisation with respect to an implied linear geometric representation including a closed line. Hydrologically, the water edge follows the line of intersection between a water body stratum and the confining depression, or channel. Topologically, the water edge realizes the catchment as an edge connecting inflow and outflow realized as nodes fixed at the inflow node and outflow node of the corresponding flowpath. The 'boundary' of type HY\_OutfallRealisation is described by means of 'tagged values'.

Through generalization, HY\_WaterEdge inherits the *realisedCatchment* association including *hydroComplex*, and carries the properties: *shape*, *waterEdgeNetwork*.

The **shape** attribute defines the linear geometric representation. If required, an implementation shall use a geometry type defined in ISO 19107: Spatial Schema, e.g. GM\_Curve type.

The **waterEdgeNetwork** association defines an aggregate of water edges forming a connected network. This concept requires an aggregate of non-overlaying edges, and a single linear representation of each of these. If required, this association may be used to identify the network which realizes as a whole the catchment that contains the catchment realized by the single part.

## Requirements Class

[req/hy\\_hydrofeature/hydrocomplex/wateredge](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/wateredge](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/wateredge))

Target type	Implementation schema
Name	HY_WaterEdge
Dependency	<a href="#">/iso/19107/</a> ( <a href="https://inspire-twg.jrc.it/svn/iso">https://inspire-twg.jrc.it/svn/iso</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/hydronetwork</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwork</a> )
Requirement 1	<a href="#">/req/hy_hydrofeature/hydrocomplex/flowpath.shape</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.shape">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.shape</a> )

## Requirement 2

[/req/hy\\_hydrofeature/hydrocomplex/wateredge.wateredgenetwork](#)  
[\(\[https://github.com/opengeospatial/HY\\\_Features/blob/master/req/hy\\\_hydrofeature/hydrocomplex/wateredge.wateredgenetwork\]\(https://github.com/opengeospatial/HY\_Features/blob/master/req/hy\_hydrofeature/hydrocomplex/wateredge.wateredgenetwork\)\)](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/wateredge.wateredgenetwork)

The HY\_CatchmentBoundary feature type specializes HY\_CatchmentRealisation with respect to an implied linear geometric representation including a single polygon. The catchment boundary connecting the inflow and outflow of the logical catchment, whereby inflow and outflow may overlay. It is topologically understood as an edge bounded by inflow node and outflow nodes, and corresponding to left-bank and right-bank catchment faces inside of the boundary. The 'boundary' and 'spoke' properties are described by means of 'tagged values': the topological 'boundary' is of type HY\_OutfallRealisation; the topological 'spoke' is of type HY\_CatchmentArea. HY\_CatchmentBoundary inherits from generalization the *realisedCatchment* association incl. *hydroComplex*, and carries the properties: *shape*, and *boundaryNetwork*.

The **shape** attribute defines the linear geometric representation. If required, an implementation shall use a geometry type defined in ISO 19107: Spatial Schema, e.g. GM\_CompositeCurve type.

The **boundaryNetwork** association defines a network as mesh of connected boundaries. This concept requires a mesh of non-overlapping boundary lines, and a single linear representations of each of these. If required, this association may be used to identify the network which realizes as a whole the catchment that contains the catchment realized by the single part.

## Requirements Class

[req/hy\\_hydrofeature/hydrocomplex/catchmentboundary](#)

[\(\[https://github.com/opengeospatial/HY\\\_Features/blob/master/req/hy\\\_hydrofeature/hydrocomplex/catchmentboundary\]\(https://github.com/opengeospatial/HY\_Features/blob/master/req/hy\_hydrofeature/hydrocomplex/catchmentboundary\)\)](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentboundary)

Target type	Implementation schema
Name	HY_CatchmentBoundary
Dependency	<a href="#"><u>/iso/19107/</u></a> ( <a href="https://inspire-twg.jrc.it/svn/iso">https://inspire-twg.jrc.it/svn/iso</a> )
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation">(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a>)</a>
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/hydronetwok</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwok">(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwok">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwok</a>)</a>

<b>Requirement 1</b>	<a href="#">/req/hy_hydrofeature/hydrocomplex/flowpath.shape</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.shape">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.shape</a> )
<b>Requirement 2</b>	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchmentboundary.boundarynetwork</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentboundary.boundarynetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentboundary.boundarynetwork</a> )

The HY\_CatchmentArea feature type specializes HY\_CatchmentRealisation with respect to an implied areal geometric representation including a plane surface. The catchment area connecting the inflow and outflow of the logical catchment, is topologically a face bounded inwards by an inflow edge and outwards by an outflow edge. The 'boundary' is described by means of 'tagged values': the inward directed 'boundary' is of type HY\_CatchmentBoundary, the outward directed 'boundary' of type HY\_Flowpath. A topological 'spoke' is not defined in this standard.

HY\_CatchmentArea inherits from generalization the *realisedCatchment* association incl. *hydroComplex*, and carries the properties: *shape*, and *areaNetwork*.

The **shape** attribute defines the linear geometric representation. If required, an implementation shall use a geometry type defined in ISO 19107: Spatial Schema, e.g. GM\_Surface type.

The **areaNetwork** association defines an aggregate of catchment areas forming a connected network. This concept requires a non-overlapping aggregate of areas, and a single areal representation of each of these. If required, this association may be used to identify the network which realizes as a whole the catchment that contains the catchment realized by the single part.

## Requirements Class

### [req/hy\\_hydrofeature/hydrocomplex/catchmentarea](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/catchmentarea](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentarea))

Target type	Implementation schema
Name	HY_CatchmentArea
Dependency	<a href="#">/iso/19107/</a> ( <a href="https://inspire-twg.jrc.it/svn/iso">https://inspire-twg.jrc.it/svn/iso</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentrealisation</a> )

Dependency	<a href="/req/hy_hydrofeature/hydrocomplex/hydronetw">/req/hy_hydrofeature/hydrocomplex/hydronetw</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetw">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetw</a> )
<b>Requirement 1</b>	<a href="/req/hy_hydrofeature/hydrocomplex/flowpath.shape">/req/hy_hydrofeature/hydrocomplex/flowpath.shape</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.shape">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath.shape</a> )
<b>Requirement 2</b>	<a href="/req/hy_hydrofeature/hydrocomplex/catchmentarea.boundarynetwork">/req/hy_hydrofeature/hydrocomplex/catchmentarea.boundarynetwork</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentarea.areanetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchmentarea.areanetwork</a> )

The HY\_HydroNetwork feature type specializes HY\_CatchmentRealisation with respect to a network of connected hydrologic features. Such a network realizes in the hierarchical network of logically connected catchments contained in a higher-order catchment. It may be a sequence of flowpaths, an aggregate of water edges, an aggregate of catchment areas or a mesh of catchment boundaries. HY\_HydroNetwork inherits the *realisedCatchment* association including *hydroComplex*, and carries the associations *flowpath*, *waterEdge*, *catchmentBoundary* and *catchmentArea*.

The HY\_CartographicRealisation feature type specializes HY\_CatchmentRealisation separate cartographic layers or maps, displaying a network of hydrologic features which may be connected at the representation level, or not. HY\_HydroNetwork inherits from generalization the *realisedCatchment* association including *hydroComplex*.

### Catchment Realization

The HY\_OutfallRealisation feature type (Figure 30) conceptualizes the idea that the an outfall can be realized by practically any feature of interest. Using the outfall to define and reference the hydrologic determination of a catchment, hydrologic features may be associated to a corresponding catchment through reference to the feature that realizes its outfall. Any feature that can be identified as (said to be) the outfall of a catchment may realize the logical outfall. Typically this will be a permanent, stable location that is fixed and/or referenced by coordinates.

Landmarks such as confluences, points corresponding to vertical sections, or the position of a monitoring station on a river are typical outfall realizations. In other than surface water contexts other types may realize a catchment's logical outfall. Other kinds of outfall realizations that don't carry normal surface water characteristics as defined in this standard, e.g. a spring where groundwater enters the surface, an arbitrary point projected onto the surface, or an outfall that collects many disjoint locations may use or specialize the general HY\_OutfallRealisation type.

Topologically, the HY\_OutfallRealisation should be understood to be the boundary of the corresponding catchment, and always of lower topological dimension than the catchment. With respect to the typical topological realization of a catchment as an edge, a 'spoke' property of type HY\_Flowpath is described by means of a 'tagged value' and used

to associate an outfall realization with its upstream and downstream flowpaths. Even though the topological realization of an outfall is typically as a node between catchment edges, an outfall realization may also have any geometric representation, including a single point.

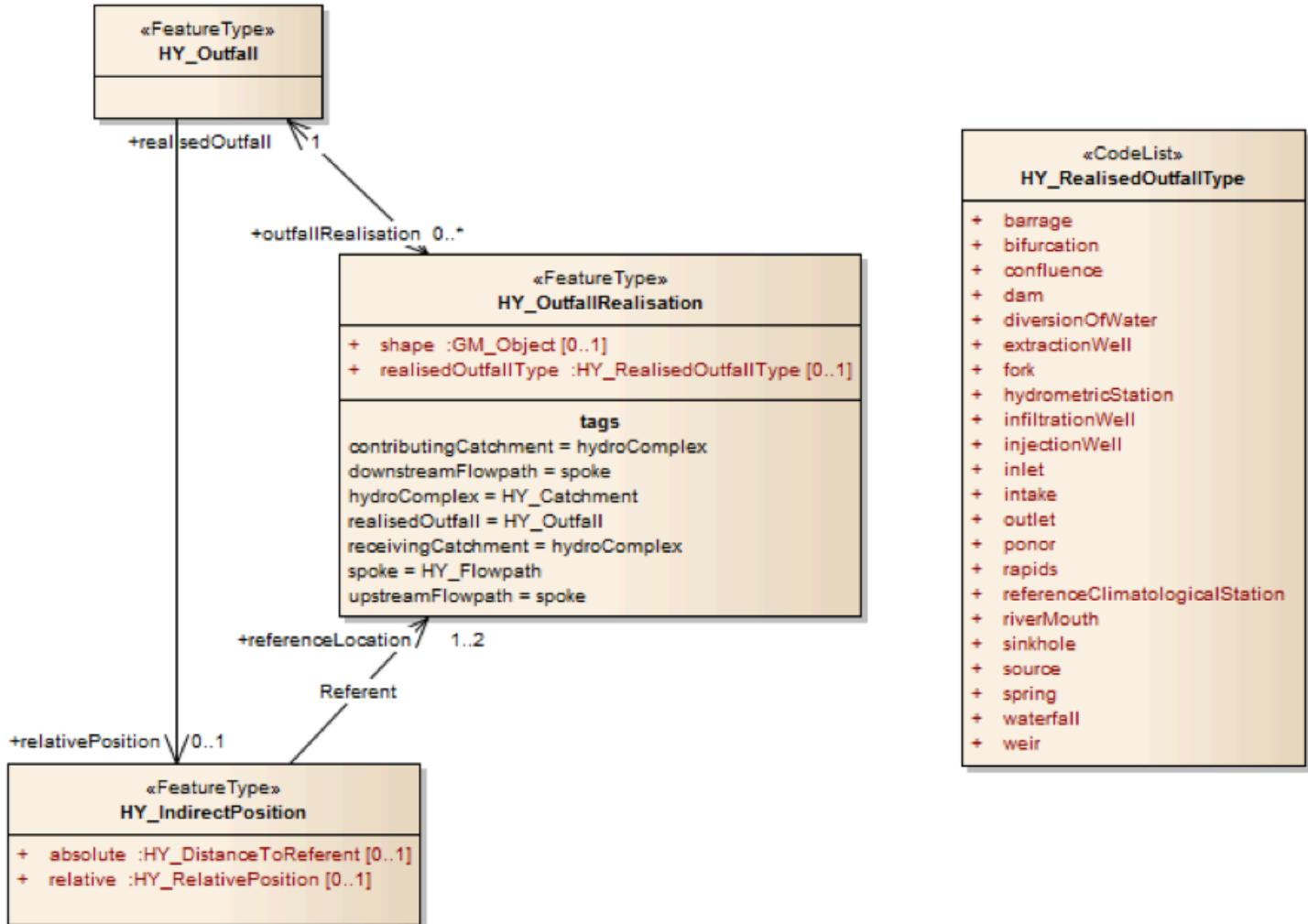


Figure 30. Outfall Realization (UML class diagram, [/req/hy\\_hydrofeature/hydrocomplex/outfallrealisation](#) ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/outfallrealisation](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation)))

**HY\_OutfallRealisation** carries the *realisedOutfall* association implying the *hydroComplex* feature collection, and carries two attributes: *shape* and *realisedOutfallType*.

The **realisedOutfall** association identifies the catchment that contributes to the outfall, or that receives flow from the outfall. This allows identifiers to be assigned to a catchment even if the flowpath, catchment area or stream network are not known or available. If required, this association shall be used to identify the logical outfall which is referenced by the hydrologic feature that realizes the logical catchment.

The **shape** attribute defines the geometric representation of the realized outfall with the option to use a geometry type defined in ISO 19107: Spatial Schema, if required.

The **realisedOutfallType** attribute provides a list of terms in common use to express the type of the realized outfall. If required, an implementation may use a term from the HY\_RealisedOutfallType code list. Note that alternative code lists may be used but should be related to the terms in Annex B.1 using an appropriate formalism.

## Requirements Class

[/req/hy\\_hydrofeature/hydrocomplex/outfallrealisation](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/hydrocomplex/outfallrealisation](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation))

Target type	Implementation schema
Name	HY_CatchmentRealisation
Dependency	<a href="#">/iso/19107/</a> ( <a href="https://inspire-twg.jrc.it/svn/iso">https://inspire-twg.jrc.it/svn/iso</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/outfall</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/typeofoutfall</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/typeofoutfall">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/typeofoutfall</a> )
<b>Requirement 1</b>	<a href="#">/req/hy_hydrofeature/hydrocomplex/outfallrealisation.realisedoutfall</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation.realisedoutfall">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation.realisedoutfall</a> )
<b>Requirement 2</b>	<a href="#">/req/hy_hydrofeature/hydrocomplex/outfallrealisation.shape</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation.shape">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation.shape</a> )
<b>Requirement 3</b>	<a href="#">/req/hy_hydrofeature/hydrocomplex/outfallrealisation.realisedoutfalltype</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation.typeofoutfall">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation.typeofoutfall</a> )

### 7.4.3. The River Positioning System model

The River Positioning System (Figure 31) provides a simple model to place a feature of interest 'on a river' using its topological realization. It introduces the concept of indirect position where a position is determined relative to an already established reference location. This concept uses a linear river reference system whose origin is set at the outfall of a catchment, and whose linear shape is given by a flowpath realizing the catchment between the origin (outfall) and the reference location or another outfall. It is important to note, that each logical catchment has its own reference system, and must have one outfall (origin) and one linear flowpath realization (shape).

The River Positioning System references the topological realization of catchment and outfall within an implied hydrologic complex in such that the origin and referent of the reference system are nodes on the boundary of the flowpath shape. Given that a flowpath realizes a logical catchment between inflow and outflow nodes, the feature of interest being referenced realizes an inflow or outflow node of a catchment that is determined by the corresponding reference location upstream or downstream of an origin outfall. Using reference locations in both directions allows placement of a feature of interest at an interpolated distance between the identified inflow and outflow nodes on a flowpath even if the realized catchment is not explicitly delineated.

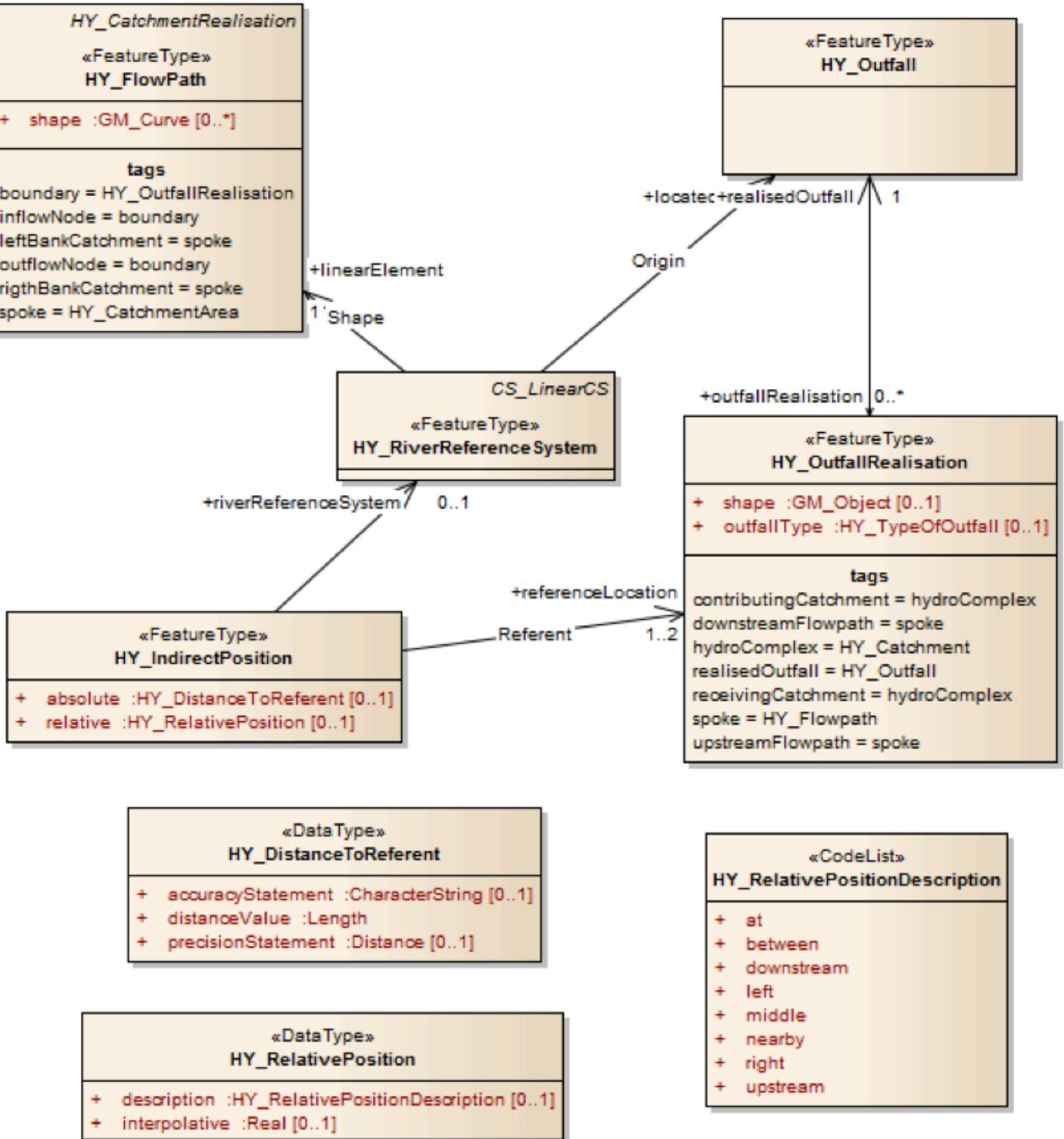


Figure 31. River Positioning System (UML class diagram, /req/hy\_hydrofeature/positioning/indirectposition, /req/hy\_positioning/riverreferencesystem  
[https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/positioning/indirectposition](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition))

The **HY\_IndirectPosition** feature type defines the indirect position, expressed either as the absolute distance along a flowpath to a reference point or the relative distance (percent) along a flowpath (termed interpolative). Indirect position assigns a position to a feature of interest (realizing an outfall) in reference to an existing outfall realization

(or realizations for an interpolative position) using a linear river reference system. HY\_IndirectPosition carries four properties: *absolute*, *relative*, *referenceLocation*, *riverReferenceSystem*. An implementation may use ISO 19148: LinearReferencing with the feature to be placed as an ‘Event’ at a *locating* indirect position in distance to an already located outfall realization, and this distance expressed as a *linear Element* (flowpath) *fromReferent* (origin outfall realization) *towardsReferent* (bounding outfall realization).

The **absolute** attribute provides a distance expressed as an absolute value, including an indication of accuracy and precision of the absolute value; the relative attribute provides an expression for the relative interpolative distance value. If required, an implementation shall use these attributes to express the absolute or relative value using the HY\_DistanceToRefPoint and HY\_RelativePosition data types, or other basic types defined in ISO 19103: Conceptual Schema. To express a relative position verbally, a term from the HY\_RelativePositionDescription code list of terms commonly used in hydrology to describe a spatial relationship between two locations may be used. Note that alternative code lists may be used but should be related to the terms in [Annex B.2](#) using an appropriate formalism.

The **referenceLocation** association describes an existing outfall realization used for reference. If required, this association shall be used to identify a permanent reference location relative to which a position is assigned to an outfall, or the feature of interest realizing the outfall.

The **riverReferenceSystem** association describes the special linear coordinate system applied to assign a position. If required, this association shall be used to identify the origin and shape of a reference system used to locate an outfall or the feature of interest realizing the outfall relative to others. The HY\_IndirectPosition feature type defines an indirect position, either expressed as the distance to a reference point or as a position relative to reference points. HY\_IndirectPosition associates four properties: *absolute*, *relative*, *referenceLocation*, *riverReferenceSystem*.

## Requirements Class

[/req/hy\\_hydrofeature/positioning/indirectposition](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrofeature/positioning/indirectposition](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition))

Target type	Implementation schema
Name	HY_IndirectPosition
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/outfallrealisation</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation</a> )

Dependency	<a href="#"><u>/req/hy_hydrofeature/positioning/distancetorefpoint</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/distancetorefpoint">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/distancetorefpoint</a> )
Dependency	<a href="#"><u>/req/hy_hydrofeature/positioning/relativeposition</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/relativeposition">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/relativeposition</a> )
Dependency	<a href="#"><u>/req/hy_hydrofeature/positioning/riverreferencesystem</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/riverreferencesystem">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/riverreferencesystem</a> )
<b>Requirement 1</b>	<a href="#"><u>/req/hy_hydrofeature/positioning/indirectposition.absolut</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.absolut">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.absolut</a> )
<b>Requirement 2</b>	<a href="#"><u>/req/hy_hydrofeature/positioning/indirectposition.relative</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.relative">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.relative</a> )
<b>Requirement 3</b>	<a href="#"><u>/req/hy_hydrofeature/positioning/indirectposition.referencecelocation</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.referencecelocation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.referencecelocation</a> )
<b>Requirement 4</b>	<a href="#"><u>/req/hy_hydrofeature/positioning/indirectposition.riverreferencesystem</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.riverreferencesystem">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.riverreferencesystem</a> )

The HY\_RiverReferenceSystem feature class specializes the ISO LinearCS feature type for a linear coordinate system using inflow and outflow nodes on the linear flowpath. The origin of the river reference system is set by the located start of the flowpath realizing the catchment between the origin and the reference location. Provided that the located start of the flowpath is at the outfall of the catchment corresponding to the feature to be placed and the end is at an already located outfall upstream or downstream, the position on the flowpath is provided as the distance between its start and end. Alternatively, the position of a feature of interest can be determined as a percentage of the distance between two already located outfalls bounding the flowpath in upstream and downstream direction, whereby the start is located at one of these and the flowpath is directed to the other already located outfall upstream or downstream of the start. HY\_RiverReferenceSystem inherits the axis property, and carries the associations *linearElement* and *locatedStart*.

The **linearElement** association defines the flowpath as the linear shape applied in the river reference system, and the **locatedStart** association defines the outfall as the origin. Bounded by inflow node and outflow node, the flowpath starts at the feature of interest realizing the origin. If required, these associations shall be used to identify the flowpath used as shape, and the start of the flowpath at a realized origin.

## Requirements Class

[/req/hy\\_positioning/riverreferencesystem](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_positioning/indirectposition.riverreferencesystem](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_positioning/indirectposition.riverreferencesystem))

Target type	Implementation schema
Name	HY_RiverReferenceSystem
Dependency	<a href="#"><u>/iso/19111/...</u></a> ( <a href="https://inspire-twg.jrc.it/svn/iso">https://inspire-twg.jrc.it/svn/iso</a> )
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/outfall</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfall</a> )
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/flowpath</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/flowpath</a> )
<b>Requirement 1</b>	<a href="#"><u>/req/hy_hydrofeature/positioning/riverreferencesystem.locatedstart</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.locatedstart">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/indirectposition.locatedstart</a> )
<b>Requirement 2</b>	<a href="#"><u>/req/hy_hydrofeature/positioning/riverreferencesystem.linearelement</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/riverreferencesystem.linearelement">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/positioning/riverreferencesystem.linearelement</a> )

## 7.5. The Surface Hydro Feature application schema

The Surface Hydro Feature application schema provides common concepts of hydrologic features occurring on the land surface and specifies the core concepts defined in the abstract Hydro Feature application schema. This will enable contextually linked information models to build relationships between multiple realizations of the same catchments. Typical realizations of the catchment concept and logical outfalls can be described in a consistent way using standard terminology for the relationships between surface water features defined in this application schema.

The Surface Hydro Feature schema conceptualizes the accumulation of water on the land surface in water bodies, each made unique by its origin, size, or movement. With respect to the management and storage of water resources, a concept of water storage is provided and allows any water body type to be considered a managed reservoir.

Relying on a conceptual separation of water body and container, the Surface Hydro Feature schema defines a network of potentially connected depressions and channels on the land surface which periodically or continuously contain water. Separate from the hydrographic network of permanent or temporary water bodies, the channel network can be used as the connecting system.

The definitions in this schema are rooted in the definitions given in the WMO Glossary of Hydrology which defines a network of watercourse regardless of the location in respect to the Earth's surface. The conceptual model defined here has been vetted in the context of surface water hydrology. In other words, in this standard, 'channel network' and 'hydrographic network' refer to surface channels or other containers for surface water bodies. The Surface Hydro Feature application schema contains the leaf packages: Channel Network, Hydrographic Network, Water Body Types and Storage. Figure 32 shows the external and internal dependencies.

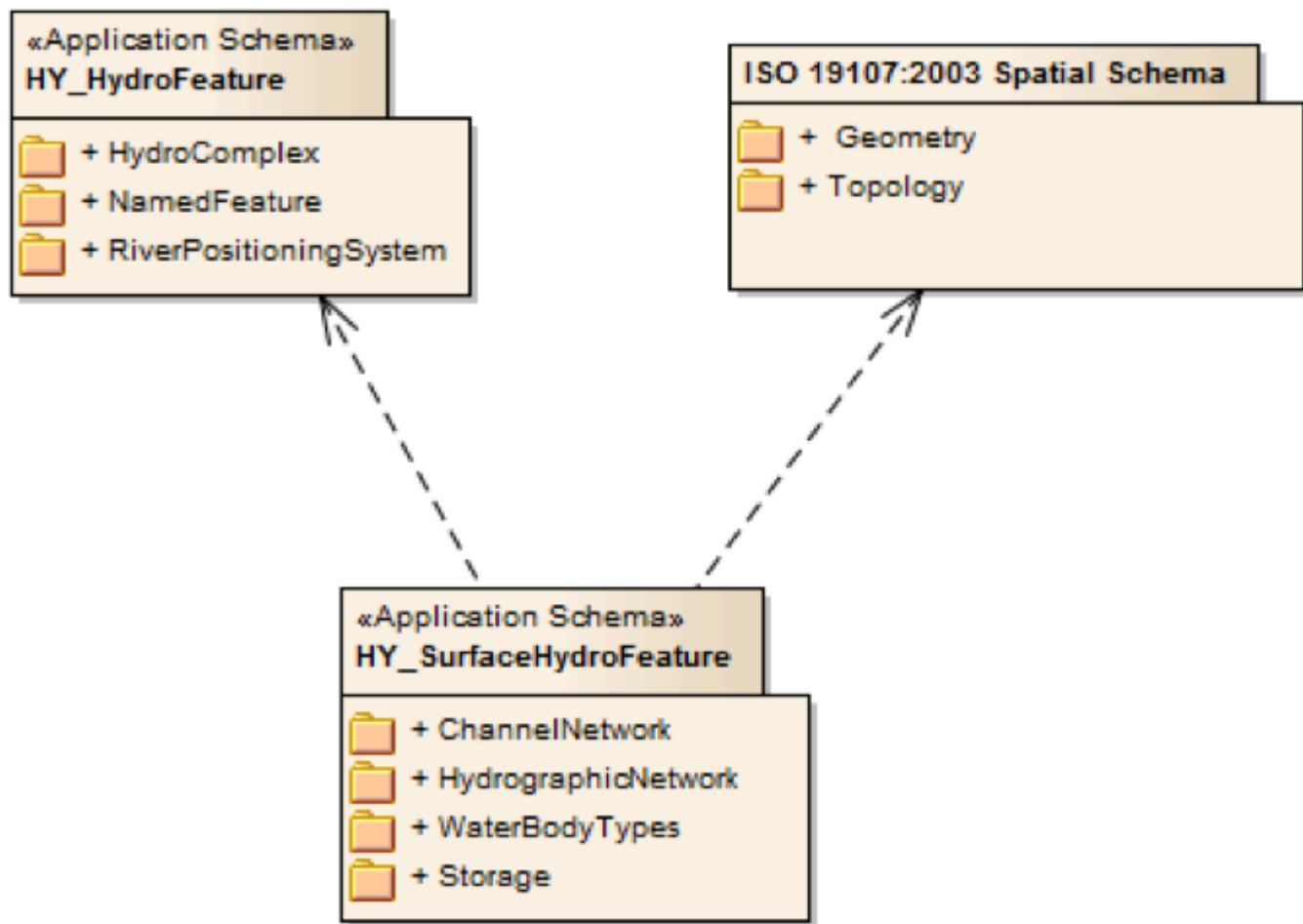


Figure 32. Surface Hydro Feature - dependencies

### 7.5.1. The Channel Network model

The Channel Network model defines a network of connected depressions and channels which, in its entirety, can realize a logical catchment (Figure 32). Usually this is a network of linear flowpaths and/or water edges realizing catchments connected to each other within the containing catchment realized by the entire network. This allows representation of the drainage pattern even if logically connected features may or may not be connected in the context of a particular representation.

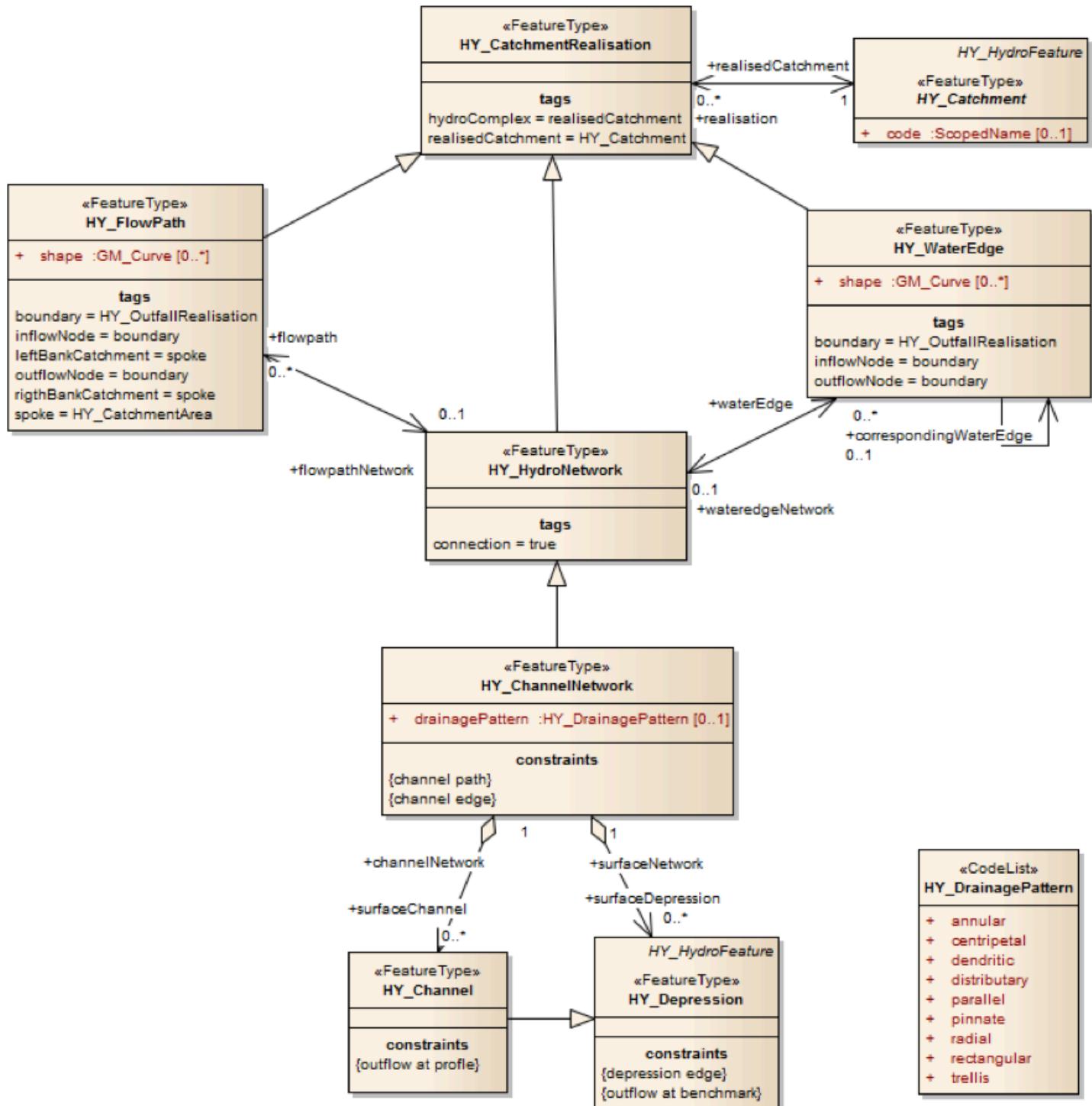


Figure 33. Channel Network realizing the catchment (UML class diagram, /req/hy\_surfacehydrofeature/)

## channelnetwork/channelnetwork

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydro/channelnetwork/channelnetwork](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydro/channelnetwork/channelnetwork))

The channel network is defined independent of the hydrographic network. This separates the concerns of hydraulics, focused on the analysis and design of channels and conduits, from the concerns of hydrology, focused on the occurrence and movement of water over land and in water bodies. It allows a logical catchment to be realized as a network of connected channels and depressions, regardless of water is contained therein or not.

A single depression or channel may realize the logical catchment, either as part of the network (Figure 33) or via a reference feature which realizes the conceptual outfall of the catchment (Figure 34). For example, a point at an associated cross or longitudinal section may be considered to realize the outflow of the catchment which is realized by the channel expressed as a flowpath.

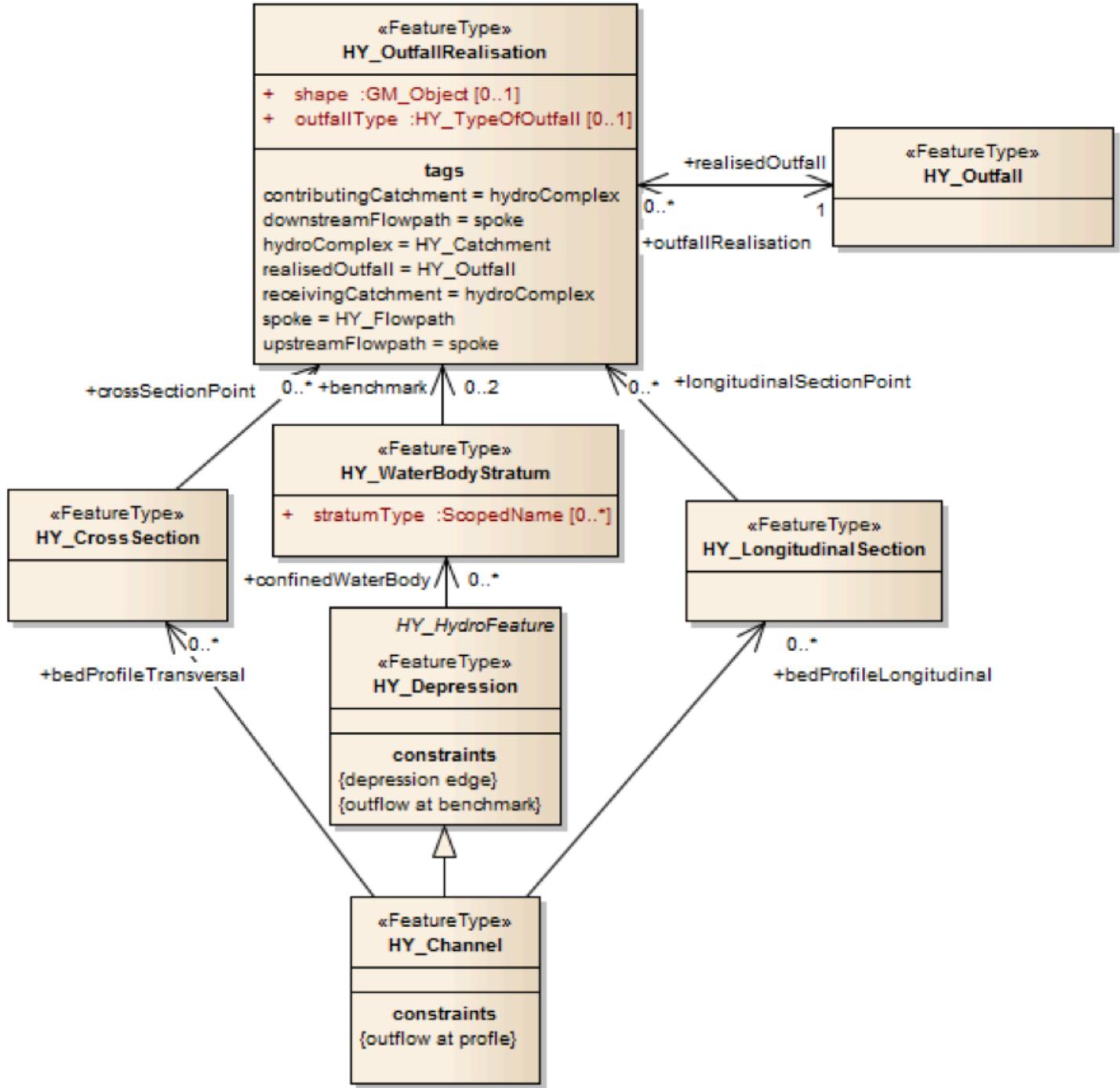


Figure 34. Depression and Channel realizing the outfall (UML class diagram, [/req/hy\\_surfacehydrofeature/channelnetwork/depression](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/channelnetwork/depression](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression)), [/req/hy\\_surfacehydrofeature/channelnetwork/channel](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/channelnetwork/channel](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel))

### 7.5.2. Channel Network

The **HY\_ChannelNetwork** feature type specializes the **HY\_HydroNetwork** realization defined in the core model, specifically as an aggregate of surface depressions and surface channels which continuously or periodically contain water, without imposing a particular drainage pattern. This allows to represent the network, even if logically

connected features may or may not be connected at the representation level. If the realized catchment is connected with other catchments via outfall, the channel network is considered connected to the channel network realizing these catchments. If required, an application focused on the structures containing a water body may use the defined relationships to describe the realization of a catchment by the channel network, or network parts associated with the hydrographic network.

HY\_ChannelNetwork associates the *surfaceDepression* and *surfaceChannel*, and carries a *drainagePattern* attribute; it inherits from generalization the *realisedCatchment*, *flowpath* and *waterEdge*, as well as *catchmentBoundary* and *catchmentArea* associations. Depending on the application, the channel network and the related features may be described by suitable attributes. A *channel path* constraint is defined such that whenever the channel network is a network of flowpaths, a depression or channel is of type HY\_Flowpath, and a *channel edge* constraint such that depression or channel is of type HY\_WaterEdge whenever the channel network is a network of water edges.

The **drainagePattern** attribute describes in general the drainage pattern. If required, an implementation may use a term from the HY\_DrainagePattern code list. Note that alternative code lists may be used but should be related to the terms in Annex B.3 using an appropriate formalism.

The **surfaceDepression** association relates a depression which may contain stagnant water or not to the channel network. If required, this association shall be used to identify a depression which realizes the logical catchment either separately, or as part of the channel network.

The **surfaceChannel** association relates a channel which may contain moving water or not to the channel network. If required, this association shall be used to identify a surface channel which realizes the logical catchment either separately, or as part of the channel network.

## Requirements Class

/req/hy\_surfacehydrofeature/channelnetwork/channelnetwork

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydro/channelnetwork/channelnetwork](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydro/channelnetwork/channelnetwork))

Target type	Implementation schema
Name	HY_ChannelNetwork
Dependency	<u>/req/hy_hydrofeature/hydrocomplex/hydronetwork</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwork</a> )

Dependency	<u>/req/hy_surfacehydrofeature/channelnetwork/drainagepattern</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/drainagepattern)</u>
Dependency	<u>/req/hy_surfacehydrofeature/channelnetwork/depression</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression)</u>
Dependency	<u>/req/hy_surfacehydrofeature/channelnetwork/channel</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel)</u>
<b>Requirement 1</b>	<u>/req/hy_surfacehydrofeature/channelnetwork/channelnetwork.drainagepattern</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channelnetwork.drainagepattern)</u>
<b>Requirement 2</b>	<u>/req/hy_surfacehydrofeature/channelnetwork/channelnetwork.surfacedepression</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channelnetwork.surfacedepression)</u>
<b>Requirement 3</b>	<u>/req/hy_surfacehydrofeature/channelnetwork/channelnetwork.surfacechannel</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channelnetwork.surfacechannel)</u>

### 7.5.3. Depression

The HY\_Depression feature type specializes the general HY\_HydroFeature class. It describes land lower than the surrounding land as container for standing water. A depression is part of the network of channels and depressions forming the connecting system for the wherein water bodies stand as parts of hydrographic network.

HY\_Depression inherits from generalization the name property, and the *channel path* and *channel* edge constraints. It associates the *surfaceNetwork* in which it participates, a body of *standingWater* and a *confinedWaterBody*. A *depression edge* constraint is defined such that whenever the depression is part of the surface network, the confined water body is of type HY\_WaterEdge. An *outflow* at *benchmark* constraint is defined such that the outflow of the catchment which is realized by the channel network is of type HY\_OutfallRealisation whenever an outfall is realized on a water body stratum.

The **standingWater** association relates a body of stagnant water to a containing pool. This allows to establish a relationship to a water body carrying a permanent reference location which realizes the outfall of the catchment realized by the associated water body. If required, this association shall be used to identify the water body contained in the depression.

The **confinedWaterBody** association relates a stratum of the contained water body to the depression. If required, this association shall be used to identify the horizontal layer carrying a permanent reference location which realizes the outfall of the catchment which is realized by the depression.

## Requirements Class

[/req/hy\\_surfacehydrofeature/channelnetwork/depression](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/channelnetwork/depression](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression))

Target type	Implementation schema
Name	HY_Depression
Dependency	<a href="#">/req/hy_hydrofeature/namedfeature/hydrofeature</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedfeature/hydrofeature">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedfeature/hydrofeature</a> )
Dependency	<a href="#">/req/hy_surfacehydrofeature/channelnetwork/channelnetwork</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channelnetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channelnetwork</a> )
Dependency	<a href="#">/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</a> )
Dependency	<a href="#">/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum</a> )
<b>Requirement 1</b>	<a href="#">/req/hy_surfacehydrofeature/channelnetwork/depression.surfacenetwork</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression.surfacenetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression.surfacenetwork</a> )
<b>Requirement 2</b>	<a href="#">/req/hy_surfacehydrofeature/channelnetwork/depression.standingwater</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression.standingwater">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression.standingwater</a> )
<b>Requirement 3</b>	<a href="#">/req/hy_surfacehydrofeature/channelnetwork/depression.confinedwaterbody</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression.confinedwaterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression.confinedwaterbody</a> )

#### 7.5.4. Channel

The HY\_Channel feature type specializes the general HY\_HydroFeature class with respect to a natural or man-made, open or closed channel through or along which water may flow, or not. A channel is part of the network of channels and depressions which form the connecting system for the hydrographic network; a channel may have vertical sections at right angles to the main (average) direction of flow or along its centreline.

HY\_Channel associates the channelNetwork in which it participates. It carries the associations: stream, bedProfileTransversal and bedProfileLongitudinal. HY\_Channel inherits from generalization the confinedWaterBody association and the constraints depression edge and outflow at benchmark. An outflow at profile constraint is defined such that whenever an outfall is realized at a bed profile, the outflow of the catchment realized by the channel network is of type HY\_OutfallRealisation.

The **stream** association relates to the channel a water body periodically or continuously flowing in the channel. This allows to establish a relationship to a water body carrying a permanent reference location which realizes the outfall of the catchment realized by the water body. If required, this association shall be used to identify the water body contained in the channel.

The **bedProfileTransversal** and **bedProfileLongitudinal** associations relate to the channel a transversal or longitudinal vertical shape. If required, this association shall be used to identify the vertical section carrying a permanent reference location which realizes the outfall of the catchment which is realized by the channel.

#### Requirements Class

/req/hy\_surfacehydrofeature/channelnetwork/channel

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/channelnetwork/channel](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel))

Target type	Implementation schema
Name	HY_Channel
Dependency	<u>/req/hy_surfacehydrofeature/channelnetwork/channelnetwork</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channelnetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channelnetwork</a> )
Dependency	<u>/req/hy_surfacehydrofeature/channelnetwork/depression</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression</a> )

Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody)</u></a>
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection)</u></a>
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection)</u></a>
<b>Requirement 1</b>	<a href="#"><u>/req/hy_surfacehydrofeature/channelnetwork/channel.channelnetwork</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel.channelnetwork"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel.channelnetwork)</u></a>
<b>Requirement 2</b>	<a href="#"><u>/req/hy_surfacehydrofeature/channelnetwork/channel.stream</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel.stream"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel.stream)</u></a>
<b>Requirement 3</b>	<a href="#"><u>/req/hy_surfacehydrofeature/channelnetwork/channel.bedprofiletransversal</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel.bedprofiletransversal"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel.bedprofiletransversal)</u></a>
<b>Requirement 4</b>	<a href="#"><u>/req/hy_surfacehydrofeature/channelnetwork/channel.bedprofilelongitudinal</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel.bedprofilelongitudinal"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel.bedprofilelongitudinal)</u></a>

#### 7.5.5. The Hydrographic Network model

The Hydrographic Network model defines a logical network of water bodies which in its entirety realizes a logical catchment (Figure 34), usually as a network of linear flowpaths and/or water edges realizing catchments connected to each other within a containing catchment that is realized by the entire network. This allows to represent the network of ‘blue lines’, even if logically connected features may or may not be connected at the representation level.

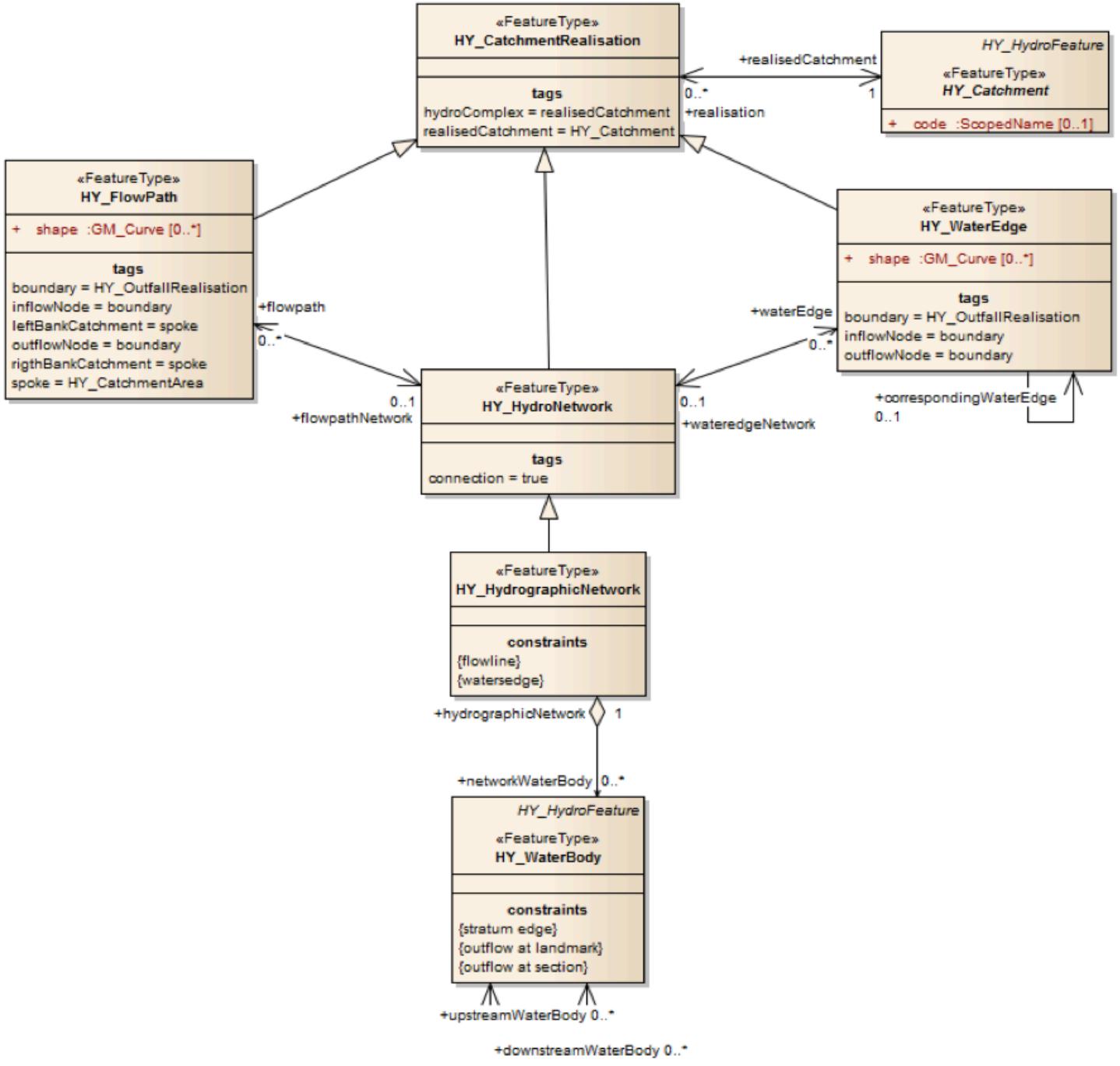


Figure 35. Hydrographic Network realizing the catchment (UML class diagram, /req/hy\_surfacehydro/ hydrographicnetwork/hydrographicnetwork  
([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrographicnetwork/hydrographicnetwork](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrographicnetwork/hydrographicnetwork)))

The hydrographic network is defined independent of the channel network. This conceptual separation references to the specific concerns of hydrology studying the occurrence, accumulation, and circulation of water. It allows to realize the logical catchment as a network of moving or standing water bodies, regardless of the channel wherein it may move, or not.

A single water body realizes the logical catchment either as part of the hydrographic network (Figure 35), or via a reference location which realizes the conceptual outfall of the catchment realized by the water body (Figure 36). For example, a fixed landmark, or a point at an associated cross or longitudinal section is considered to realize the outflow of the catchment which is realized by the channel expressed as a flowpath.

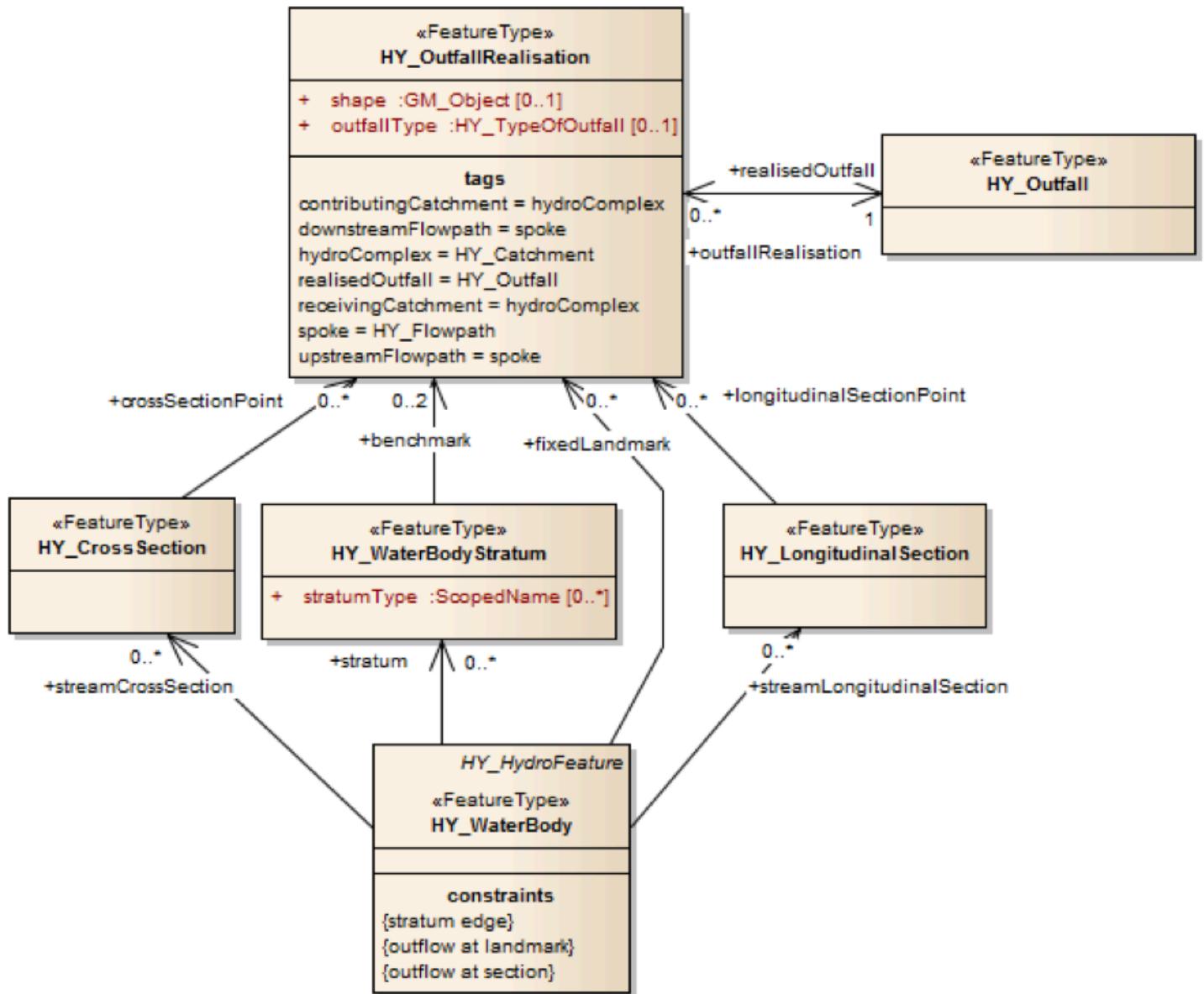


Figure 36. Water Body realizing the outfall (UML class diagram, /req/hy\_surfacehydro/hydrographicnetwork/waterbody ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrographicnetwork/waterbody](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrographicnetwork/waterbody)))

## Hydrographic Network

The HY\_HydrographicNetwork feature type specializes the HY\_HydroNetwork realization defined in the core model, specifically as aggregate of permanent or temporary bodies of water standing in depressions or moving in channels. If the realized catchment is connected with other catchments via outfall, the hydrographic network is considered connected to the network realizing these catchments. This allows to represent the network, even if logically connected features may or may not be connected at the representation level. If required, an application

focused on surface water bodies contained in channels or depressions may use the defined relationships to describe the realization of a catchment by the hydrographic network, or network parts associated with the channel network. HY\_HydrographicNetwork inherits from generalization the *realisedCatchment*, *flowpath* and *waterEdge*, as well as *catchmentBoundary* and *catchmentArea* associations, and associates a *networkWaterBody*. A flowline constraint is defined such that whenever the hydrographic network is a network of flowpaths, the network water body is of type HY\_Flowpath, and a *watersedge* constraint such that the network water body is of type HY\_WaterEdge whenever the hydrographic network is a network of water edges.

The **networkWaterBody** association relates a surface water body to the hydrographic network. If required, this association shall be used to identify a water body which realizes the logical catchment either separately, or as part of the network.

## Requirements Class

[/req/hy\\_surfacehydro/hydrographicnetwork/hydrographicnetwork](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrographicnetwork/hydrographicnetwork](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrographicnetwork/hydrographicnetwork))

Target type	Implementation schema
Name	HY_HydrographicNetwork
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/hydronetwork</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwork</a> )
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</a> )
<b>Requirement 1</b>	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork.hydrographicnetwork.networkwaterbody</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork.hydrographicnetwork.networkwaterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork.hydrographicnetwork.networkwaterbody</a> )

## WaterBody

The HY\_WaterBody feature type specializes the general HY\_HydroFeature class. The water body as part of the hydrographic network, either standing in a water pool, or flowing as stream in a watercourse, which are parts of the channel network. A water body may be segmented in vertical sections at right angles to the main (average) direction of flow or along its centerline, and horizontal strata. Conceptually, each water body, or a stratum, is understood as a reservoir used for storage, regulation or control of water resources.

HY\_WaterBody inherits from generalization the name property, and the flow line and water edge constraints. It associates the *hydrographicNetwork* in which it participates, the containing *waterpool* and watercourse, the vertical *streamCrossSection*, *streamLongitudinalSection*, a horizontal *stratum*, and a reservoir for *storage* of water. A *stratum edge* constraint is defined such that whenever the water body is part of the hydrographic network, the confined stratum is of type HY\_WaterEdge. An *outflow at section* and an *outflow at landmark* constraint are defined such that the outflow of the catchment which is realized by the hydrographic network is of type HY\_OutfallRealisation whenever an outfall is realized at a fixed landmark, a cross or longitudinal section.

The **waterpool** association relates to a water body the natural or artificial depression wherein water may stand, incl. large interstices in the ground, such as cave, cavern or a group of these. If required, this association shall be used to identify the pool which continuously or periodically contains standing water.

The **watercourse** association relates to a water body the natural or man-made channel through or along which water may flow, incl. large interstices in the ground, such as cave, cavern or a group of these. If required, this association shall be used to identify the watercourse which continuously or periodically contains moving water.

The **upstreamWaterBody** and **downstreamWaterBody** associations relate to a water body another water body immediately up or downstream. If required, these associations shall be used to identify a water body to trace the hydrographic network without knowing the inflow or outflow of the catchment realized by the water body.

The **fixedLandmark** association relates to the water body permanent reference location. If required, this association shall be used to identify a fixed landmark which realizes the conceptual outfall of the catchment realized by the water body.

The **stratum** association relates a horizontal stratum. If required, this association shall be used to identify a layer of consistent characteristics, or a storage zone of a reservoir, carrying a permanent reference location which realizes the outfall of the catchment which is realized by the water body.

The **streamCrossSection** and **streamLongitudinalSection** associations relate to the water body a vertical section either at right angles to the main (average) direction of flow, or along a centre line. If required, this association shall be used to identify the vertical section carrying a permanent reference location which realizes the outfall of the catchment which is realized by the water body.

The **storage** association associates to the water body a reservoir storing water as a resource for future use. If required, this association shall be used to describe storage characteristics of the water body participating in the hydrographic network.

## Requirements Class

[/req/hy\\_surfacehydro/hydrographicnetwork/waterbody](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrographicnetwork/waterbody](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrographicnetwork/waterbody))

Target type	Implementation schema
Name	HY_WaterBody
Dependency	<a href="#"><u>/req/hy_hydrofeature/namedFeature/hydrofeature</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/namedFeature/hydrofeature</a> )
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/outfallrealisation</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation</a> )
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/channelnetwork/channel</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/channel</a> )
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/channelnetwork/depression</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/channelnetwork/depression</a> )
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/hydrographicnetwork</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/hydrographicnetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/hydrographicnetwork</a> )
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</a> )
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/stratum</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/stratum">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/stratum</a> )
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection</a> )
Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection</a> )

<b>Requirement</b> 1	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.fixedlandmark</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.fixedlandmark)</u>
<b>Requirement</b> 2	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.waterpool</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.waterpool)</u>
<b>Requirement</b> 3	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.watercourse</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.watercourse)</u>
<b>Requirement</b> 4	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.hydrographicnetwork</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.hydrographicnetwork)</u>
<b>Requirement</b> 5	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.upstreamwaterbody</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.upstreamwaterbody)</u>
<b>Requirement</b> 6	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.downstreamwaterbody</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.downstreamwaterbody)</u>
<b>Requirement</b> 7	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.stratum</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.stratum)</u>
<b>Requirement</b> 8	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.streamcrosssection</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.streamcrosssection)</u>
<b>Requirement</b> 9	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.streamlongitudinalsection</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody.streamlongitudinalsection)</u>

## Water Body Stratum

The HY\_WaterBodyStratum feature type describes a horizontal layer in a stratified water body determined by differences in thermal or salinity characteristics or by oxygen or nutrient content, or by virtual storage zones of a reservoir. HY\_WaterBodyStratum carries the properties: *stratumType* and *benchmark*.

The **stratumType** attribute characterizes in general the stratum using a term from a controlled vocabulary. If required, an implementation may use the Scoped Name type defined in the ISO 19103: Conceptual Schema.

The **benchmark** association relates to the water body permanent reference location. If required, this association shall be used to identify a benchmark which realizes the conceptual outfall of the catchment realized by the water body.

## Requirements Class

[/req/hy\\_surfacehydrofeature/hydrographicnetwork/waterbodystratum](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/hydrographicnetwork/waterbodystratum](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum))

Target type	Implementation schema
Name	HY_WaterBodyStratum
Dependency	<a href="#">/iso/19103/</a> ( <a href="https://inspire-twg.jrc.it/svn/iso">https://inspire-twg.jrc.it/svn/iso</a> )
Dependency	<a href="#">/req/hy_hydrofeature/hydrocomplex/outfallrealisation</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation</a> )
Requirement 1	<a href="#">/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum.benchmark</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum.benchmark">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum.benchmark</a> )
Requirement 2	<a href="#">/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum.stratumtype</a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum.benchmark">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum.benchmark</a> )

## Cross-Section and Longitudinal Section

The HY\_CrossSection and HY\_LongitudinalSection feature types conceptualize the segmentation of a water body or a containing channel through vertical sections. Taking into account the conceptual separation of a watercourse, the cross section concept refers to both the cross section of a water body orthogonal to the direction of flow, and to the transversal bed profile of a channel.

Both types of vertical section associate permanent reference locations: *crossSectionPoint* and *longitudinalSectionPoint*. If required, this associations shall be used to identify a reference location at a vertical section which realizes the conceptual outfall of the catchment realized by the associated channel or water body.

## Requirements Class

[/req/hy\\_surfacehydrofeature/hydrographicnetwork/crosssection](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/hydrographicnetwork/crosssection](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection))

Target type	Implementation schema
Name	HY_CrossSection
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/catchment/outfallrealisation</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment/outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment/outfallrealisation</a> )
<b>Requirement 1</b>	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection.crosssectionpoint</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection.crosssectionpoint">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/crosssection.crosssectionpoint</a> )

## Requirements Class

[/req/hy\\_surfacehydrofeature/hydrographicnetwork/longitudinalsection](#)

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/hydrographicnetwork/longitudinalsection](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection))

Target type	Implementation schema
Name	HY_LongitudinalSection
Dependency	<a href="#"><u>/req/hy_hydrofeature/hydrocomplex/catchment/outfallrealisation</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment/outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/catchment/outfallrealisation</a> )
<b>Requirement 1</b>	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection.longitudinalsectionpoint</u></a> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection.longitudinalsectionpoint">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/longitudinalsection.longitudinalsectionpoint</a> )

## Water-LiquidPhase and Water-SolidPhase

The HY\_Water\_LiquidPhase and HY\_Water\_SolidPhase feature types provide simple concepts of the accumulation of water in water bodies. This definition refers to the matter accumulated to a mass of water. In its liquid form water is considered accumulated in water bodies; in its solid phase water may be accumulated after melting, or as a layer of ice or snow on an open water body. The accumulation of water in the atmosphere or below the land surface, e.g.

rain, soil moisture or groundwater, is not in scope of this standard, as well as the accumulation of snow and ice in glaciers which is subject of glaciology science. Contextually related information models may use the HY\_Water\_LiquidPhase and HY\_Water\_SolidPhase feature types to build relationships to an accumulating water body, and ultimately to the catchment realized either by the water body or by the network of which the water body is part.

HY\_Water\_LiquidPhase carries the association *accumulatingWaterBody*; HY\_Water\_SolidPhase associates two properties: *snowmelt* and *coveredWaterBody*. If required, these associations shall be used to identify the water body (part of the network) where liquid water as a material is accumulated.

## Requirements Class

/req/hy\_surfacehydrofeature/hydrographicnetwork/waterliquidphase

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/hydrographicnetwork/waterliquidphase](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterliquidphase))

Target type	Implementation schema
Name	HY_WaterLiquidPhase
Dependency	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbodystratum</a> )
<b>Requirement 1</b>	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterliquidphase.accumulatingwaterbody</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterliquidphase.accumulatingwaterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterliquidphase.accumulatingwaterbody</a> )

## Requirements Class

/req/hy\_surfacehydrofeature/hydrographicnetwork/watersolidphase

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/hydrographicnetwork/watersolidphase](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/watersolidphase))

Target type	Implementation schema
Name	HY_WaterSolidPhase
Dependency	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</a> )

Dependency	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterliquidphase</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterliquidphase"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterliquidphase)</u></a>
<b>Requirement 1</b>	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/watersolidphase.coveredwaterbody</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/watersolidphase.coveredwaterbody"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/watersolidphase.coveredwaterbody)</u></a>
<b>Requirement 2</b>	<a href="#"><u>/req/hy_surfacehydrofeature/hydrographicnetwork/watersolidphase.snowmelt</u></a> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/watersolidphase.snowmelt"><u>(https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/watersolidphase.snowmelt)</u></a>

#### 7.5.6. The Surface Water Body types

The Surface Water model defines typical specializations of a water body on the land surface. Being a specialization of the HY\_WaterBody class each subtypes inherits the *stratum*, *waterpool*, *watercourse*, *upstreamWaterBody*, *downstreamWaterBody*, *fixedLandmark*, *streamCrossSection* and *streamLongitudinalSection* properties. From the general HY\_HydroFeature class the special water bodies inherit the name property, which allows to handle names given to them in cross-jurisdiction and multi-lingual contexts. Each specialization is understood to be part of the hydrographic network. In other contexts other specializations, or a typical segmentation may exist, that not conforms to the types defined in this standard.

The HY\_River feature type defines the existence of body of surface water, participating in a hydrographic network, special due to its property to permanently or temporarily flow.

The HY\_Canal feature type defines the existence of body of surface water, participating in a hydrographic network, special due to its artificial origin (man-made).

The HY\_Lake feature type defines the existence of body of surface water, participating in a hydrographic network, special due to its considerable size.

The HY\_Impoundment feature type defines the existence of body of surface water, participating in a hydrographic network, special due to be formed by collecting water, as by a dam.

The HY\_Lagoon feature type defines the existence of body of surface water, participating in a hydrographic network, special due to its shallow depth and interaction with the open sea.

The HY\_Estuary feature type defines the existence of body of surface water, participating in a hydrographic network, special due to branching and its interaction with the open sea.

### 7.5.7. The Storage Model

The Storage model (Figure 37) provides a concept to describe any water body, in terms of a reservoir storing water for future use. The separate storage model allows to describe the hydrographic network without the details of storage capacities that a water body may have, and vice versa storage reservoirs to be referenced independent of their role within the hydrographic network.

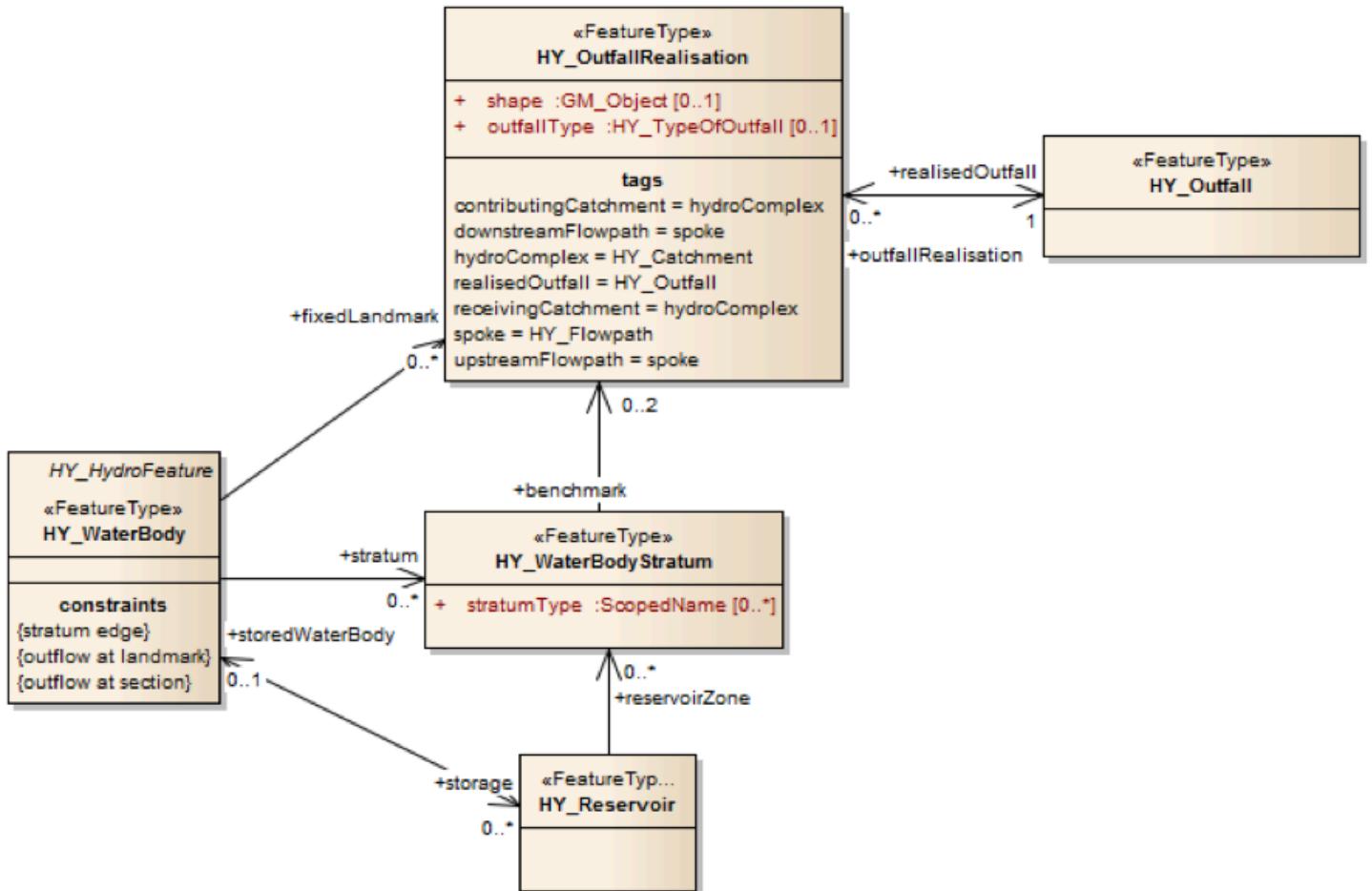


Figure 37. Reservoir realizing an outfall (UML class diagram, /req/hy\_surfacehydrofeature/storage/reservoir ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/storage/reservoir](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/storage/reservoir)))

The HY\_Reservoir feature type describes the water body, either natural or man-made, used for storage, regulation and control of water resources. The reservoir concept refers to a volume of water managed in zones between operating levels. HY\_Reservoir associates to a reservoir the *storedWaterBody* and a *reservoirZone*.

#### Requirements Class

/req/hy\_surfacehydrofeature/storage/reservoir

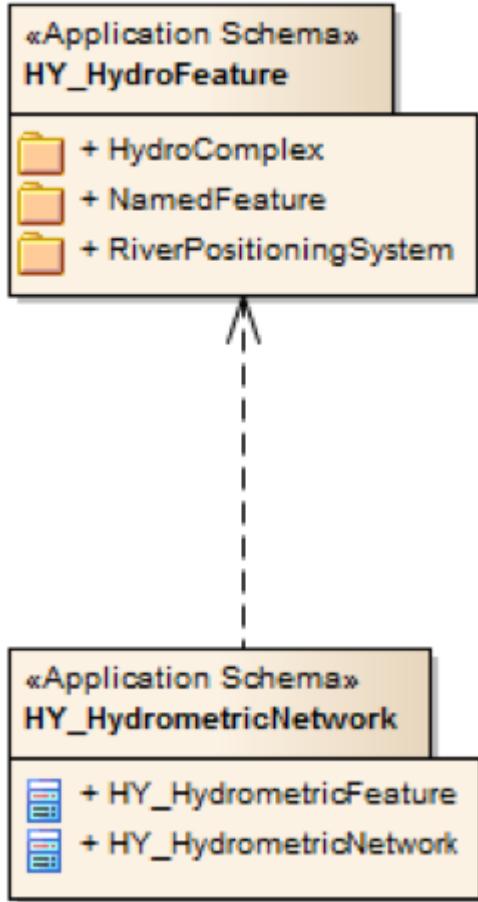
([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_surfacehydrofeature/storage/reservoir](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/storage/reservoir))

Target type	Implementation schema
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Name	HY_Reservoir
Dependency	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</u> <u>(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</a>)</u>
Dependency	<u>/req/hy_surfacehydrofeature/hydrocomplex/outfallrealisation</u> <u>(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrocomplex/outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrocomplex/outfallrealisation</a>)</u>
<b>Requirement 1</b>	<u>/req/hy_surfacehydrofeature/storage/reservoir.storedwaterbody</u> <u>(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/storage/reservoir.storedwaterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/storage/reservoir.storedwaterbody</a>)</u>
<b>Requirement 2</b>	<u>/req/hy_surfacehydrofeature/storage/reservoir.reservoirzone</u> <u>(<a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/storage/reservoir.reservoirzone">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/storage/reservoir.reservoirzone</a>)</u>

## 7.6. The Hydrometric Network application schema

The Hydrometric Network schema (Figure 39) defines a logical model to take into account a network of hydrometric stations as a specific realization of the catchment in the perspective of hydrologic observation, without the detail of an observation strategy. The Hydrometric Network specifies the core concepts defined in the abstract Hydro Feature application schema (Figure 38). The general concept is that of a network of logically connected hydrometric stations realizing as a whole the catchment. This enables contextually related information models to relate monitoring stations and observing posts to hydrologic features, finally to the realized catchment, as usually required in the context of environmental reporting or when interpreting, comprising and processing observation results.



*Figure 38. Hydrometric Network – dependencies*

The hydrometric network model introduces the concept of a 'position on river' which allows an hydrologic station, even free from position, to be the realization of the logical outfall. This supports to establish upstream-downstream relationships between hydrometric features, to assign a position relative to a 'fixed' outfall, or to place a feature of interest relative to the hydrometric station.

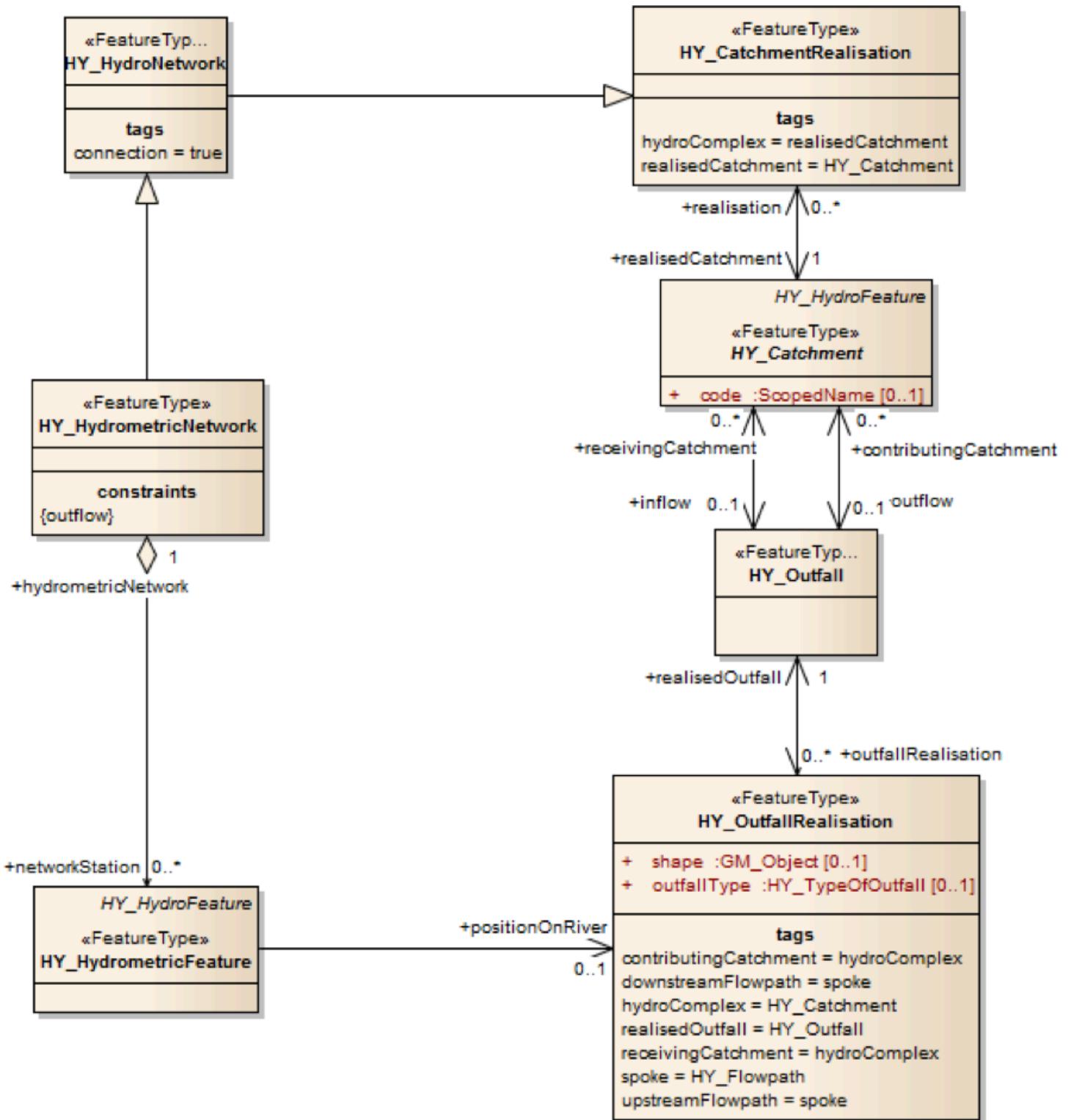


Figure 39. Hydrometric network model (UML class diagram, /req/hy\_hydrometricfeature/hydrometricnetwork ([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrometricfeature/hydrometricnetwork](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricfeature/hydrometricnetwork)))

The HY\_HydrometricNetwork feature type specializes the HY\_HydroNetwork realization defined in the core model specifically as an aggregate of hydrometric features. HY\_HydrographicNetwork inherits from generalization the *realisedCatchment*, *flowpath* and *waterEdge*, as well as *catchmentBoundary* and *catchmentArea* associations. The

**networkStation** association relates a monitoring station at which data on water are obtained. If required, this association shall be used to identify the hydrometric station, which realizes the logical catchment either separately, or as part of the hydrometric network.

The HY\_HydrometricFeature associates the *hydrometricNetwork* in which it participates and a *positionOnRiver*.

The **positionOnRiver** association relates the hydrometric feature to a permanent reference location. If required, this association shall be used to identify a reference location which realizes the conceptual outfall of the catchment corresponding to the hydrometric feature.

## Requirements Class

/req/hy\_hydrometricfeature/hydrometricnetwork

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrometricfeature/hydrometricnetwork](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricfeature/hydrometricnetwork))

Target type	Implementation schema
Name	HY_HydrometricNetwork
Dependency	<u>/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_surfacehydrofeature/hydrographicnetwork/waterbody</a> )
Dependency	<u>/req/hy_hydrofeature/hydrocomplex/hydronetwok</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwok">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwok</a> )
Dependency	<u>/req/hy_hydrometricfeature/hydrometricfeature</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricfeature/hydrometricfeature">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricfeature/hydrometricfeature</a> )
<b>Requirement 1</b>	<u>/req/hy_hydrometricfeature/hydrometricnetwork.networkstation</u> ( <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricfeature/hydrometricnetwork.networkstation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricfeature/hydrometricnetwork.networkstation</a> )

## Requirements Class

/req/hy\_hydrometricnetwork/hydrometricfeature

([https://github.com/opengeospatial/HY\\_Features/blob/master/req/hy\\_hydrometricnetwork/hydrometricfeature](https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricnetwork/hydrometricfeature))

Target type	Implementation schema
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Name	HY_HydrometricFeature
Dependency	<u>/req/hy_hydrofeature/hydrocomplex/outfallrealisation</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/outfallrealisation</a>
Dependency	<u>/req/hy_hydrofeature/hydrocomplex/hydronetwok</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwok">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrofeature/hydrocomplex/hydronetwok</a>
Dependency	<u>/req/hy_hydrometricfeature/hydrometricnetwork</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricfeature/hydrometricnetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricfeature/hydrometricnetwork</a>
<b>Requirement 1</b>	<u>/req/hy_hydrometricnetwork/hydrometricfeature.positiononriver</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricnetwork/hydrometricfeature.positiononriver">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricnetwork/hydrometricfeature.positiononriver</a>
<b>Requirement 2</b>	<u>/req/hy_hydrometricnetwork/hydrometricfeature.hydrometricnetwork</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricnetwork/hydrometricfeature.hydrometricnetwork">https://github.com/opengeospatial/HY_Features/blob/master/req/hy_hydrometricnetwork/hydrometricfeature.hydrometricnetwork</a>

## 8. Media Types for any data encoding(s)

A section describing the MIME-types to be used is mandatory for any standard involving data encodings. If no suitable MIME type exists in <http://www.iana.org/assignments/media-types/index.html> then this section may be used to define a new MIME type for registration with IANA.

# Annex A: Conformance Class Abstract Test Suite (Normative)

## NOTE

Ensure that there is a conformance class for each requirements class and a test for each requirement (identified by requirement name and number)

## A.1. Introduction

These test suites ascertain the compliance of the conformance targets for the HY\_Features specification with the specification itself. Each instance of hydrologic feature data is encoded according to a specific interchange schema, so the role of conformance with the abstract specification is that such an implementation schema can be related to the common definitions of HY\_Features. An implementation schema conforming to HY\_Features SHALL provide a formal mapping from one or more Feature Types present in the implementation schema to Feature Types defined in this standard specification, including all mandatory properties defined by the realized HY\_Features concept. Default values to be assumed must be specified in this mapping.

## A.2. Conformance Class: HY\_HydroFeature application schema equivalence

<b>Conformance Class</b>	<u>/spec/hydrology/hydrofeature/1.0/conf/hy_hydrofeature</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/spec/hydrology/hydrofeature/1.0/conf/hy_hydrofeature)</u>
<b>Test id:</b>	<u>/conf/uml_hydrofeature/namedfeature/*</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_hydrofeature/namedfeature/)</u>
<b>Test id:</b>	<u>/conf/uml_hydrofeature/hydrocomplex/*</u> <u>(https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_hydrofeature/hydrocomplex/)</u>
<b>Test id:</b>	<u>/conf/uml_hydrofeature/positioning/*</u> ( <u>https://conf/uml_hydrofeature/positioning/</u> )
<b>Requirement:</b>	All relevant elements of a data exchange schema including hydrologic features are mapped to equivalent HY_Features elements.
<b>Test purpose:</b>	All relevant elements of a data exchange schema including hydrologic features are mapped to equivalent HY_Features elements.
<b>Test method:</b>	Inspect the mapping between the data exchange schema and the HY_Features model to determine that all relevant schema elements are mapped to HY_Features equivalents.
<b>Test Type</b>	Capability

## A.3. Conformance Class: HY\_SurfaceHydroFeature application schema equivalence

<b>Conformance Class</b>	<a href="https://github.com/opengeospatial/HY_Features/blob/master/spec/hydrology/surfacehydrofeature/1.0/conf/hy_surfacehydrofeature[/spec/hydrology/surfacehydrofeature/1.0/conf/hy_surfacehydrofeature]">https://github.com/opengeospatial/HY_Features/blob/master/spec/hydrology/surfacehydrofeature/1.0/conf/hy_surfacehydrofeature[/spec/hydrology/surfacehydrofeature/1.0/conf/hy_surfacehydrofeature]</a>
<b>Test id:</b>	<u>/conf/uml_surfacehydrofeature/channelnetwork/*</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_surfacehydrofeature/channelnetwork/">(https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_surfacehydrofeature/channelnetwork/)</a>
<b>Test id:</b>	<u>/conf/uml_surfacehydrofeature/hydrographicnetwork/*</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_surfacehydrofeature/hydrographicnetwork/">(https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_surfacehydrofeature/hydrographicnetwork/)</a>
<b>Test id:</b>	<u>/conf/uml_surfacehydrofeature/surfacewaterbodies/*</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_surfacehydrofeature/surfacewaterbodies/">(https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_surfacehydrofeature/surfacewaterbodies/)</a>
<b>Test id:</b>	<u>/conf/uml_surfacehydrofeature/storage/*</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_surfacehydrofeature/storage/">(https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_surfacehydrofeature/storage/)</a>
<b>Requirement:</b>	All relevant elements of a data exchange schema including hydrologic features are mapped to equivalent HY_Features elements.
<b>Test purpose:</b>	All relevant elements of a data exchange schema including hydrologic features are mapped to equivalent HY_Features elements.
<b>Test method:</b>	Inspect the mapping between the data exchange schema and the HY_Features model to determine that all relevant schema elements are mapped to HY_Features equivalents.
<b>Test Type</b>	Capability

## A.4. Conformance Class: HY\_HydrometricFeature application schema equivalence

<b>Conformance Class</b>	<a href="https://github.com/opengeospatial/HY_Features/blob/master/spec/hydrology/hydrometricfeature/1.0/conf/hy_hydrometricfeature[/spec/hydrology/hydrometricfeature/1.0/conf/hy_hydrometricfeature]">https://github.com/opengeospatial/HY_Features/blob/master/spec/hydrology/hydrometricfeature/1.0/conf/hy_hydrometricfeature[/spec/hydrology/hydrometricfeature/1.0/conf/hy_hydrometricfeature]</a>
<b>Test id:</b>	<u>/conf/uml_hydrometricfeature/hydrometricfeature/*</u> <a href="https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_hydrometricfeature/hydrometricfeature/">(https://github.com/opengeospatial/HY_Features/blob/master/conf/uml_hydrometricfeature/hydrometricfeature/)</a>

<b>Requirement:</b>	All relevant elements of a data exchange schema including hydrologic features are mapped to equivalent HY_Features elements.
<b>Test purpose:</b>	All relevant elements of a data exchange schema including hydrologic features are mapped to equivalent HY_Features elements.
<b>Test method:</b>	Inspect the mapping between the data exchange schema and the HY_Features model to determine that all relevant schema elements are mapped to HY_Features equivalents.
<b>Test Type</b>	Capability

## Annex B: Code lists for the HY\_Features model

### B.1. Terms identifying a fixed landmark determined to realize the conceptual outfall

Code list	Realized Outfall Type
<b>barrage</b>	barrier across a stream provided with a series of gates or other control mechanisms to control the water-surface level upstream, to regulate the flow or to divert water supplies into a canal.
<b>bifurcation</b>	division of a stream into two branches
<b>confluence</b>	joining, or the place of junction, of two or more streams.
<b>dam</b>	barrier constructed across a valley for impounding water or creating a reservoir.
<b>diversion of water</b>	transfer of water from one watercourse to another, such watercourses being either natural or man-made.
<b>fork</b>	(1) place where two or more streams flow together to form a larger stream. (2) place where a stream divides into two or more streams.
<b>hydrometric station</b>	station at which data on water in rivers, lakes or reservoirs are obtained on one or more of the following elements: stage, streamflow, sediment transport and deposition, water temperature and other physical properties of water, characteristics of ice cover and chemical properties of water.
<b>inlet</b>	structure admitting water supplies from the source or through an intake structure built upstream.
<b>intake</b>	structure or site, the purpose of which is to control, regulate, divert, and admit water directly from the source, through an inlet built upstream.
<b>outlet</b>	opening through which water flows out or is extracted from a reservoir or stream.
<b>ponor</b>	hole or opening in the bottom or side of a depression where a surface stream or lake flows either partially or completely underground into a karst groundwater system.

<b>rapids</b>	reach of a stream where the flow is very swift and shooting, and where the surface is usually broken by obstructions, but has no actual waterfall or cascade.
<b>reference climatological station</b>	climatological station the data of which are intended for the purpose of determining climatic trends. This requires long periods (not less than thirty years) of homogeneous records, where man-made environmental changes have been and/or are expected to remain at a minimum. Ideally the records should be of sufficient length to enable the identification of secular changes of climate.
<b>river mouth</b>	place of discharge of a river into a sea or a lake.
<b>sinkhole</b>	place where water disappears underground in a limestone region. It generally implies water loss in a closed depression or blind valley.
<b>source</b>	origin of the river
<b>spring</b>	place where water flows naturally from a rock or soil onto land or into a body of surface water.
<b>waterfall</b>	vertical fall or the very steep descent of a stream of water.
<b>weir</b>	overflow structure which may be used for controlling upstream water level or for measuring discharge or for both.

## B.2. Terms commonly used in hydrology to describe a spatial relation between two points

<b>Code list</b>	<b>Realized Outfall Type</b>
<b>at</b>	located at the (reference) point
<b>between</b>	located between two (reference) points
<b>downstream</b>	located downstream of the (reference) point, e.g. in the direction of the current in a river or stream.
<b>left</b>	located left-hand of the (reference) point when facing downstream.
<b>nearby</b>	located in a short distance to the (reference) point.

<b>right</b>	located right-hand of the (reference) point when facing downstream.
<b>upstream</b>	located upstream of the (reference) point, e.g. in the direction towards the source of a stream.

### B.3. Terms commonly used in hydrology to describe a drainage pattern

<b>Code list</b>	<b>Realized Outfall Type</b>
<b>annular</b>	main rivers have circular pattern with subsidiary channels at right angles.
<b>centripetal</b>	streams flow inward to center.
<b>dendritic</b>	spreading treelike arrangement; no evident orientation of channels (random orientation).
<b>distributary</b>	one main channel divides into many channel-ways ending with many outlets.
<b>parallel</b>	main channels regularly spaced and parallel or sub-parallel to each other; tributaries join at very acute angles.
<b>pinnate</b>	featherlike, closely grouped , short tributaries (fine texture).
<b>radial</b>	streams flow outward from center.
<b>rectangular</b>	drainage forms a perpendicular net with the two directions equally developed.
<b>trellis</b>	a dominant drainage direction with a secondary direction perpendicular to this; primary tributaries join main stream at right angles, secondary tributaries parallel main stem.

### B.4. Terms commonly used in hydrology to describe a drainage pattern

<b>Code list</b>	<b>Realized Outfall Type</b>
<b>conventional</b>	accepted, used, or practiced by most people ('agreed by convention').
<b>historical</b>	restricted to or based on fact in history
<b>official</b>	ordered or allowed by those in authority
<b>vernacular</b>	used in or suitable for speech, usually not used in formal writing

## Annex C: HY\_Features-AHGF Mapping

This is a descriptive mapping for the Australian Hydrological Geospatial Fabric (AHGF) [11]. It is intended to provide an understanding of the basic relationship of HY\_Features concepts and the AHGF hydrologic feature implementation.

### C.1. Catchment Model

HY_Features Name	AHGF Class	Comment
HY_Catchment	ConCatID	Logical features identified via ConCatID with topological relationships defined via ConNodeID (HY_Outfall). Can also be seen as the contributing set of logical features sharing a common ConCatID.
HY_DendriticCatchment	ConCatID	All logical HY_Catchment features are constrained to be dendritic in the Geofabric.
HY_InteriorCatchment	Not represented	All catchment areas defined by a particular DEM are considered to flow to a single common outlet.  Note: Areas not flowing to a common outlet are aggregated with areas that do according to saddle points in the terrain model.
HY_CatchmentAggregate	Collections of ConNodeID	Network following connectivity via ConNodeID encapsulating divergent flows to remain dendritic in nature.
HY_Outfall	ConNodeID	All ConNodeID act in the role of outflow node (To_Node) for one or more ConCatID catchment(s) and most also act in the role of inflow node (From_Node) for a single ConCatID catchment.

HY_Outfallrealization	AHGFNetworkNode	HY_ReferenceLocation can be used as a reference location for any point associated with a feature. In reality this will normally be a realisation of a ConNodeID (with associated coordinates) or the Geofabric realisation of event locations (AHGFNetworkNode::GhostNode) used to register Hydrometric features on the network.
HY_CatchmentRealization	Feature identified by ConCatID	Any feature or collection of features identified by a single ConCatID. Single instances of AHGFCreatedCatchment and AHGFLink as well as collections of AHGFNetworkStream, AHGFNetworkNode, AHGFCatchment (low level sub-catchments) and AHGFWaterbody. Note: features of subtype AHGFCreatedCatchment::NoFlowArea do not have a ConNodeID (i.e. No HY_Outfall)
HY_CatchmentArea	AHGF Contracted Catchment, AHGFCatchment	A single AHGFCreatedCatchment or a collection of AHGFCatchment (both 2D simple surfaces derived from a common Digital Elevation model).
HY_CatchmentBoundary	Not represented	Can be seen as the boundary (or boundaries) of the polygon feature(s) that realise HY_CatchmentArea.
HY_CartographicRealization	AHGMappedStream	AHGMappedStream is a feature class of the Geofabric Surface Cartography product, perhaps all feature classes in this product can be considered as HY_CartographicRealization.

## C.2. Hydrographic Network

HY_Features Name	AHGF Class	Comment
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HY_Hydrographic Network	AHGFNetworkStream	Subset of AHGFNetworkStream features (subtypes: NetworkFlowSegment & NetworkWaterAreaSegment) provides a particular HY_CatchmentRealization. This network realization can be supplemented with its corresponding HY_ChannelNetwork instance.
HY_WaterBody	AHGFNetworkStream	AHGFNetworkStream features (subtypes: NetworkFlowSegment & NetworkWaterAreaSegment).
HY_ChannelNetwork	AHGFNetworkStream	Subset of AHGFNetworkStream:: NetworkArtificialFlowSegment provides a particular HY_CatchmentRealization. This network realization is only complete when combined with the corresponding HY_HydrographicNetwork instance.
HY_Depression	Not represented	—
HY_Channel	AHGFNetworkStream	AHGFNetworkStream features (subtype: NetworkArtificialFlowSegment). For version 3 products AHGFNetworkStream features are related to the relevant logical HY_Catchment via ConCatID.
HY_Reservoir	AHGFWaterbody::Reservoir	Reservoir subtype of AHGFWaterbody.
HY_FlowPath	AHGFLink	Note: Geofabric currently has no FlowPath for headwater (AHGFCContractedCatchment) areas.
HY_WaterEdge	Not represented	—
HY_LongitudinalSection	Not represented	—
HY_WaterBodyStratum	Not represented	—
HY_Water_LiquidPhase	Not represented	—

HY_Water_SolidPhase	Not represented	—
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### C.3. Hydrometric Network

HY_Features Name	AHGF Class	Comment
HY_HydrometricNetwork	Not represented	SPossible future plans to produce a geoschematic representation of the hydrometric features at some stage.
HY_HydrometricFeature	AHGFFeatureNode:: AHGFGhostNode	Ghost Nodes are a representation of Hydrometric features located on a Hydrographic Network representation. Note: Currently, V3 has a separate AHGFGhostNode feature class for ghost nodes. There are plans to include these features as part of the Hydrology Reporting Catchments product forming outfalls for AHGFContractedCatchment (HY_DendriticCatchment) features.
HY_RiverReferenceSystem	Not represented	Measures are not yet explicitly included in AHGF.
HY_IndirectPostition	Not represented	Measures are not yet explicitly included in AHGF.

## Annex D: HY\_Features - NHDPlus Mapping

This is a descriptive mapping for the USGS National Hydrography Dataset Plus (NHDPlus)[10]. It is intended to provide an understanding of the basic relationship of HY\_Features concepts and the NHDPlus hydrologic feature implementation.

### D.1. Catchment Model

HY_Features Name	NHDPlus Name	Comment
HY_Catchment	comid catchment	The comid catchment is the feature that takes part in PlusFlow topology table, has associated accumulated characteristics, etc. Could also be the collection of catchments that contribute to a given reachcode reach, HUC watershed outlet, or other identifiable watershed outlet.
HY_DendriticCatchment	comid catchment	NHDPlus catchments not following any diversions in the flow tables
HY_InteriorCatchment	comid catchment	Including interior catchments and not following diversions in the flow tables
HY_Outfall	fromNode or toNode	NHDPlus nodes are inflow (fromNode) and outflow (toNode) nodes of a given comid catchment.
HY_Outfallrealization	fromNode or toNode location, point location of point events, etc	HY_ReferenceLocation can be used as a reference location for any point associated with a feature. Typically this is for outfalls and monitoring locations, but may be used for many other feature types.
HY_CatchmentRealization	Any entity that is identified by a comid	In NHDPlus, the comid identifier represents an unrealized catchment. Any geometric or topologic data that is referenced to a comid can be said to realize that catchment. This includes upstream aggregations of the network or catchment areas to form complete watersheds.

HY_CatchmentArea	Not Represented	While the polygon representing a catchment might be thought of as an area, the subset of a DEM or another land cover dataset would be more in line with the meaning of CatchmentArea.
HY_CatchmentBoundary	comid catchment polygon	The polygon representing a comid catchment should be thought of as both the catchmentBoundary
HY_CartographicRealization	A map of a catchment	The NHDPlus dataset doesn't include any, but if a map view of a catchment is created at any scale, it could be said to be a cartographic visualization realization of the catchment.

## D.2. Hydrographic Network

HY_Features Name	NHDPlus Name	Comment
HY_Hydrographic Network	collection of flowlines and waterbodies	The collection of perennial and ephemeral flowlines as well as so-called double line streams and on-network lakes within any collection of catchments (an HY_Catchment) can be considered its hydrographic network.
HY_WaterBody	Perennial flowlines and waterbodies	Perennial flowlines are thought to represent water bodies as well as waterbody polygons that represent wide streams and lakes. These features indicate that there is water contained in some channel or other container.
HY_ChannelNetwork	Not represented	—
HY_Depression	Not represented	—
HY_Channel	Ephemeral flowlines.	While NHD doesn't have an explicit channel concept, ephemeral flowlines can be thought of as a channel in that they indicate that water can flow there, but may not be present in the flowline container at all times.
HY_Reservoir	waterbodies that are reservoirs	Any waterbody that can be categorized as a reservoir

HY_FlowPath	flowlines and reaches	A flowline or reach is the linear representation of a catchment. For NHD Events, the reach is the flowpath because it is the linear element used for linear referencing.
HY_WaterEdge	Not represented	—
HY_LongitudinalSection	flowline	For reachcode linear referencing, the reachcode flowpath is made up of a collection of linear segments that are flowlines
HY_WaterBodyStratum	Not represented	—
HY_Water_LiquidPhase	Not represented	—
HY_Water_SolidPhase	Not represented	—

### D.3. Hydrometric Network

HY_Features Name	NHDPlus Name	Comment
HY_HydrometricNetwork	Not Represented	—
HY_HydrometricFeature	event	A hydrometric feature, such as a stream gaging station, is represented as an event.
HY_RiverReferenceSystem	reachcode and measure	A reachcode reach is the river reference system's shape, the origin is the outlet of the reach, and the indirect position is the measure.
HY_IndirectPostition	measure	The measure is an indirect position of type relative position because it is a percent.

## Annex E: HY\_Features-INSPIRE Hydrography Theme

This table assigns core features as defined in the INSPIRE Hydrography theme [2] to HY\_Features core concepts. It also indicates relationship between both terms and potential conditions in which they can be associated.

This table should not be understood in terms of a ‘conceptual mapping’ of clearly defined relationships between two logical concepts, but rather as a simple approach to show compatibility of concepts, based on the meaning expressed in the definitions, and without imposing a particular implementation. Since each dataset that implements the INSPIRE theme will have a different legacy of documentation and information modeling, a conceptual mapping would be expressed differently. Applications implementing the INSPIRE Hydrography theme can use this listing to understand how a particular dataset may relate to the HY\_Features concepts.

### E.1. Catchment Model

<b>HY_Features Name</b>	<b>Relationship between concepts</b>	<b>INSPIRE Hydrography Name + potential condition(s)</b>	<b>Comment</b>

HY_Catchment	Is like	<p>DrainageBasin</p> <p>In case that HY_Catchment is realized by HY_CatchmentArea</p>	<p>Area having a common outlet for its surface runoff.</p> <p>NOTE 1 Regarding the different classifications of drainage basins, no distinction is made between drainage basins / sub-basins since this will vary with application. It is possible to build basins from other basins.</p> <p>NOTE 2 The outlet of a drainage basin may be a canal or a lake.</p> <p>NOTE 3 Synonyms for drainage basin include: catchment; catchment area; drainage area; river basin; watershed</p>
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HY_DendriticCatchment	Is narrower than	DrainageBasin + In case that HY_Catchment is realized by HY_CatchmentArea With one outlet	Area having a common outlet for its surface runoff.  NOTE 1 Regarding the different classifications of drainage basins, no distinction is made between drainage basins / sub-basins since this will vary with application. It is possible to build basins from other basins.  NOTE 2 The outlet of a drainage basin may be a canal or a lake.  NOTE 3 Synonyms for drainage basin include: catchment; catchment area; drainage area; river basin; watershed.
HY_InteriorCatchment	—	Not represented	—
HY_InteriorCatchment	Is Like	RiverBasin In case that HY_Catchment is realized by HY_CatchmentArea	The area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta.

HY_Outfall	Is Like	HydroNode + In case that HY_Catchment is realized by HY_FlowPath	A node within the hydrographic network. NOTE May represent a physical confluence, bifurcation/confluence/vanishing point etc., or it may be associated with a hydrographic point of interest or facility.
HY_OutfallRealization	Is Like	HydroPOI	A natural place where water appears, disappears or changes its flow. EXAMPLE Fluvial points (waterfall, cascade, rapids, breaker), spring/water hole (spring, source, geyser, thermal spring, natural fountain, well, also fumarole, artesian), sinkhole (sinkhole, drainage loss). NOTE A hydro point of interest may create a flow constriction in the network.
HY_CatchmentRealization	—	Not represented	—

HY_CatchmentArea	Is Like	DrainageBasin	<p>Area having a common outlet for its surface runoff.</p> <p>NOTE 1 Regarding the different classifications of drainage basins, no distinction is made between drainage basins / sub-basins since this will vary with application. It is possible to build basins from other basins.</p> <p>NOTE 2 The outlet of a drainage basin may be a canal or a lake.</p> <p>NOTE 3 Synonyms for drainage basin include: catchment; catchment area; drainage area; river basin; watershed.</p>
HY_CatchmentBoundary	—	Not represented	—
HY_CartographicRealization	—	Not represented	—

## E.2. Hydrographic Network Model

HY_Features Name	Relationship between concepts	INSPIRE Hydrography Name + potential condition(s)	Comment

HY_HydrographicNetwork	Is narrower than	WatercourseLinkSequence In case that features of interest are water bodies and not channels. AND In case that network is non branching.	A sequence of watercourse links representing a non-branching path through a hydrographic network.
HY_WaterBody	Is narrower than	WatercourseLink In case that features of interest are water bodies and not channels.	A segment of a watercourse within a hydrographic network. A watercourse link may be fictitious, with no direct correspondence to a real-world object and included only to ensure a closed network.
HY_ChannelNetwork	Is narrower	WatercourseLinkSequence In case that features of interest are channels and not water bodies. AND In case that network is non branching.	A sequence of watercourse links representing a non-branching path through a hydrographic network.

HY_Depression	Is like	<p>StandingWater</p> <p>In case that geometry is surface or point.</p>	<p>Any known inland waterway body.</p> <p>EXAMPLE Lake/pond, reservoir, river/stream, etc.</p> <p>NOTE: May include islands, represented as 'holes' in its geometry. Islands may be surrounded by a shore and / or land-ware boundary.</p>
HY_Channel	Is narrower	<p>WatercourseLink</p> <p>In case that features of interest are channels and not water bodies.</p>	<p>A segment of a watercourse within a hydrographic network.</p> <p>A watercourse link may be fictitious, with no direct correspondence to a real-world object and included only to ensure a closed network.</p>
HY_Reservoir	Is like	<p>StandingWater</p> <p>In case that geometry is surface or point.</p>	<p>Any known inland waterway body.</p> <p>EXAMPLE Lake/pond, reservoir, river/stream, etc.</p> <p>NOTE: May include islands, represented as 'holes' in its geometry. Islands may be surrounded by a shore and / or land-ware boundary.</p>

HY_FlowPath	Is like	WatercourseLink With a fictitious representation	A segment of a watercourse within a hydrographic network. A watercourse link may be fictitious, with no direct correspondence to a real-world object and included only to ensure a closed network.
HY_WaterEdge	Is like	LandWaterBoundary	The line where a land mass is in contact with a body of water.
HY_LongitudinalSection	Is narrower	—	—
HY_CrossSection	Is narrower	—	—
HHY_WaterBodyStratum	Is narrower	—	—
HY_Water_LiquidPhase	Is narrower	—	—
HY_Water_SolidPhase	Is narrower	—	—

## Annex F: HY\_Features- SANDRE Mapping

This is a descriptive mapping for the French National Service for Water Data and Reference-dataset Management (SANDRE) [12]. It is intended to provide an understanding of the basic relationship of HY\_Features concepts and the SANDRE hydrologic feature dictionary for Hydrography.

Please notice that terms for SANDRE are based on French words.

### F.1. Catchment Model

HY_Features Name	SANDRE name	Comment
HY_Catchment	RegionHydro OR SecteurHydro OR SousSecteurHydro OR ZoneHydro	SANDRE make distinction between basins and sub-basins
HY_Catchment	RegionHydro OR SecteurHydro OR SousSecteurHydro OR ZoneHydro	SANDRE: all catchments are dendritic
HY_InteriorCatchment	Not represented	—
HY_CatchmentAggregate	RegionHydro OR SecteurHydro OR SousSecteurHydro	SANDRE: RegionHydro are aggregation of SecteurHydro that are aggregation of SousSecteurHydro that are aggregation of ZoneHydro.
HY_Outfall	NoeudHydrographique	HY_Outfall can be seen as a specific NoeudHydrographique
HY_OutfallRealization	NoeudHydrographique	NoeudHydrographique

HY_CatchmentRealization	Not represented	—
HY_CatchmentArea	RegionHydro OR SecteurHydro OR SousSecteurHydro OR ZoneHydro	While the polygon representing a catchment might be thought of as an area, the subset of a DEM or another land cover dataset would be more in line with the meaning of CatchmentArea.
HY_CatchmentBoundary	LimiteHydroBassin	SANDRE : LimiteHydroBassin is the boundary of a catchment. It has a linear representation
HY_CartographicRealization	Not represented	—

## F.2. Hydrographic Network Model

HY_Features Name	SANDRE Name	Comment
HY_Hydrographic Network	Not Represented	SANDRE focuses on channels, not on water bodies
HY_WaterBody	Not Represented	SANDRE focuses on channels, not on water bodies
HY_ChannelNetwork	CoursEau OR TronconHydrographique	SANDRE: EntiteHydroSurface is an aggregation of EltHydroSurface. Both have a surfacic representation.
HY_Depression	EntiteHydroSurface OR EltHydroSurface	SANDRE: EntiteHydroSurface is an aggregation of EltHydroSurface. Both have a surfacic representation.
HY_Channel	TronconHydrographique OR TronconHydrograElt OR EltHydroSurface	SANDRE: CoursEau is aggregation of TronconHydrographique that is an aggregation of TronconHydrograElt. All of them have a linear representation. EntiteHydroSurface

HY_Reservoir	EntiteHydroSurface OR EltHydroSurface OR PointEauIsole	SANDRE: EntiteHydroSurface is an aggregation of EltHydroSurface. Both have a surfacic representation. PointEauIsole can be used in case that HY_Reservoir is not linked to the hydrographic network and is represented by a point
HY_FlowPath	Not Represented	—
HY_WaterEdge	Not represented	—
HY_LongitudinalSection	Not represented	—
HY_WaterBodyStratum	Not represented	—
HY_Water_LiquidPhase	Not represented	—
HY_Water_SolidPhase	Not represented	—

### F.3. Hydrometric Network

HY_Features Name	AHGF Class	Comment
HY_HydrometricNetwork	Not represented	—
HY_HydrometricFeature	Not Represented	—
HY_RiverReferenceSystem	Not represented	—
HY_IndirectPostition	Not represented	—

## Annex G: Revision History

Date	Release	Editor	Primary clauses modified	Description
08-10-2014	0.1	Irina Dornblut	Initial version	Initial draft in OGC template
12-11-2014	0.1	Irina Dornblut	Section7, Annex D included	Editing requirements classes, Annex D included
15-08-2016	0.3	David Blodgett; Irina Dornblut	Completely revised version	Draft in OGC template
18-08-2016	0.4	Irina Dornblut	Figs7,8,9,10,11,13,14	added
18-31-2016	0.5	David Blodgett, Darren Smith, David Arctur	Entire Document	General edit for clarity and consistency.

## Annex H: Bibliography

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