INCITS xxxx-Part.6

Date: 2006-01-12

Information Technology – Geographic Information Framework Data Content Standard

Part 6: Hydrography

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Published by:
Information Technology Industry Council
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Washington, DC 20005
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WEB: www.itic.org

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Foreword

Geographic information, also known as geospatial information, both underlies and is the subject of much of the political, economic, environmental, and security activities of the United States. In recognition of this, the United States Office of Management and Budget issued Circular A-16 (revised 2002), which established the Federal Geographic Data Committee (FGDC) as a coordinating organization.

Work on this standard started under the Geospatial One-Stop e-Government initiative. The standard was developed with the support of the member agencies and organizations of the FGDC and aids in fulfilling a primary objective of the National Spatial Data Infrastructure (NSDI), that is, creation of common geographic base data for seven critical data themes. The seven core data themes are considered framework data of critical importance to the spatial data infrastructure.

The increasing need to coordinate collection of new data, identify applicability of existing data, and exchange data at the national level led to the submission of this standard to the ANSI process to become an American National Standard. The national standard contained in this document and its parts was sponsored by Technical Committee L1, Geographic Information Systems, of the InterNational Committee for Information Technology Standards (INCITS), an ANSI-accredited standards development organization.

As the Geographic Information Framework Data Content Standard was developed using public funds, the U.S. Government will be free to publish and distribute its contents to the public, as provided through the Freedom of Information Act (FOIA), Part 5 United States Code, Section 552, as amended by Public Law No. 104-231, “Electronic Freedom of Information Act Amendments of 1996”.

Introduction

The primary purpose of this part of the Framework Data Content Standard is to support the exchange of surface water (hydrography) information. This part also seeks to establish a common baseline for the semantic content of hydrographic databases for public agencies and private enterprises. It seeks to decrease the costs and simplify the exchange of hydrography data among local, Tribal, State, and Federal users and producers. That, in turn, discourages duplicative data collection. Benefits of adopting the part also include the long-term improvement of the geospatial hydrography data through the establishment of Web data services for hydrography data and maps within the community.

This part of the Framework Data Content Sytandard is for the exchange of hydrography data. Framework hydrography describes the geographic locations, interconnectedness, and characteristics of features in the surface water system. The hydrography system includes physical and logical components representing the flow and presence of water within the surface water portion of the environment. This part, and the included UML model, is a result of contributions from a variety of information and systems models. These include: the National Hydrography Dataset (NHD), the Pacific Northwest Framework (PNW), the ArcHydro data model, and the Geographic Names Information System (GNIS). The development of a shared database would be accomplished through “alliances” of data providers.

Framework Data Content Standard – Hydrography

1 Scope, purpose, and application

1.1 Scope

The purpose of Geographic Information Framework Data Content Standard, Part 6: Hydrography is to establish the content requirements for the collection and interchange of hydrography features and to facilitate the maintenance and use of that information by all users of geographic information. The Hydrography part identifies and defines terminology, encoding schema, and the data components required for describing hydrographic features, along with the metadata needed for the hydrography data exchange. This part specifies the content and its organization necessary for the successful interchange of hydrography data. This part does not specify a particular structure for the storage of hydrography data. The scope of this part is limited to the information regarding surface water features and hydrographic networks for the purpose of cartography and network analysis. This part is intended to be applicable at a variety of scales.

1.2 Purpose

The goal of the Hydrography part of the Framework Data Content Standard is to provide common definitions and syntax to enable collaborative development, use, and exchange of hydrography data. This part defines the components of networked and non-networked surface water features, one of seven NSDI framework themes. The primary purpose of the part is to support the exchange of hydrographic feature and network information by general and expert users. It is the intent of the part to set a common baseline of information content for exchange within the hydrographic community that will enhance data sharing and applications development when used with standards-based Web services or file transfer.

The determination of “best-available” hydrography data depends on the usage or organizational requirements and is thus not addressed by the Hydrography part. It is anticipated that multiple representations of hydrographic features will exist within the broader community. Policies have been or will be established for describing, maintaining, and exchanging the various representations of features within specific application communities, such as the NHD. This part will accommodate the exchange of these multiple representations.

While collection criteria could be linked to each feature to give some guidance as to quality characteristics, this part does not specify the criteria by which each feature would be captured (see capture conditions in definitions). Building on the intention to define common community framework content, this part defines a data content model for the exchange of agreed-upon thematic data, rather than the endorsement of a particular native database content design. This part supports the mapping and conversion of native data in any format into a common representation for exchange over the Web or as files. Encoding of hydrography data for transfer, based on the models in this part, is described in the Base Document (Part 0) of the Framework Data Content Standard.

The audience of this part of the standard includes hydrography data users, maintainers, and distributors. The content is intended to support the general requirements of natural resource managers, environmental and water resources agencies, and hydrography applications designers and developers. Specific guidance on the implementation of this part for specific user communities will be made through external guidance or policy documents.

1.3 Capabilities supported by this part of the standard

The development of this part of the Framework Data Content Standard will greatly assist in mitigating the following issues, as determined by the Hydrography Modeling Advisory Team (MAT) – a group of domain experts convened to define a common set of hydrography information content:

- Duplication of data and application development

- Complications exchanging hydrography framework data and related information
- Difficulties integrating data
- Poor framework/support for analytic activities
- Difficulties managing multiple representations of features

1.3.1 Minimize duplications of data and application development

Duplication of data and application development refers to duplicative efforts required, in the absence of a content standard, to store and manage data and develop applications for their use. Parties sharing data who add, edit, or remove features from base data, for example, can be forced to manage duplicate datasets because no dataset conforms to a standard and because there is no agreed upon protocol for replacing or archiving datasets as they are amended. Similarly, applications can be developed and re-developed to meet the same business needs as data models change.

1.3.2 Simplify interchange of hydrography data and related information

The original wording of this objective used the term “share” instead of “exchange.” “Share” was thought to refer to the institutional arrangements and attendant administrative issues required for organizations to provide one another with data. This meaning was deemed outside this part of the standard’s scope, although perhaps appropriate for an informative annex. “Co-managing” (for example, managed by more than one party) was similarly considered for discussion in this part. Because of the significant maintenance arrangements it implies, this topic should be handled as the subject of a separate document. “Interchange” was selected because it was thought to convey the central meanings of giving, taking, and replacing data between individuals or systems.

The phrase “related information” was also added to the original wording to cover situations when hydrography data users exchange fish data, environmental information, point sampling locations, protected status, and so on, along with base hydrography data.

1.3.3 Overcome difficulties in integrating data

The MAT identified four possible meanings of “integrating” which should be addressed by this part of the Framework Data Content Standard:

- Overlapping data of similar content
- Processing adjacent data
- Handling or arbitrating different scale data
- Conflation

It was agreed that to make the data model extensible, this part should tie attribution to an identifier. The measure of this objective would be whether or not users can understand and use the resultant data.

1.3.4 Improve support for analytic activities

The MAT clarified the meaning of this objective as supporting critical uses and meeting the business needs of managers for decision making. By contrast to the other objectives, this objective is broader than objectives pertaining to data and datasets alone.

Participants noted that measuring this objective will be difficult because a standard’s capacity to support analytic activities depends on and varies with data and business needs. It is also important to note that users’ business and decision making needs are too varied and numerous to be equally supported by this part of the standard. The goal of the framework standardization activity is to identify the intersection of information content for exchange that is universally useful within a community. Based on this approach as opposed to a union approach, this part can reasonably be expected to support certain common business and decision-making needs, but not all possible needs.

1.3.5 Manage multiple representations of features

The MAT discussed requirements of framework data for managing multiple representations and data lineage. It was agreed that a framework model should differentiate data states induced by changes over time, scale, or information content. The standard should not require that all versions be available, but a user should be able to know what version of data they are exchanging.

2 Normative references

Annex A of the Base Document (Part 0) lists normative references applicable to two or more parts of the standard. Annex D of the Base Document lists informative references applicable to all of the parts.

3 Maintenance authority

3.1 Level of responsibility

The FGDC is the responsible organization for coordinating work on all parts of the Geographic Information Framework Data Content Standard. The development and maintenance authority for Part 6: Hydrography is held jointly by the U.S. Geological Survey and U.S. Environmental Protection Agency.

The FGDC shall be the sole organization responsible for direct coordination with the InterNational Committee for Information Technology Standards (INCITS) concerning any maintenance or any other requirements mandated by INCITS or ANSI affecting any part of this standard.

3.2 Contact information

Address questions concerning this part of the standard to:

Federal Geographic Data Committee Secretariat
c/o U.S. Geological Survey
590 National Center
Reston, Virginia 20192 USA

Telephone: (703) 648-5514
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Internet (electronic mail): gdc@fgdc.gov
WWW Home Page: http://fgdc.gov

4 Terms and definitions

Definitions applicable to the Hydrography part are listed below. More general terms can be found in the Base Document (Part 0).

4.1
capture conditions

conditions a feature must meet in terms of measurement or other characteristics before it is collected and stored in a dataset

EXAMPLE A headwater stream collected for a 1:100,000-scale dataset is at least 1 mile long, a lake collected for a 1:100,000-scale dataset is at least 6 acres.

4.2
complex feature

feature composed of other features [ISO 19109]

4.3
HydroComplex feature

group of one or more **HydroElement features** having attributes, relationships and events that are independent of the attributes, relationships and events of the participating features

NOTE A HydroComplex feature inherits its geometry from the feature or features that it is composed of.

EXAMPLES reach, watercourse.

4.4
HydroElement feature

instance of a particular hydrography feature type that has geometry that may have attributes, relationships, and events

4.5
feature code

numeric value that encodes the unique combination of hydrography feature type and a set of feature attribute values

NOTE The official five-digit hydrography feature code has two parts: the first three digits encode the feature type; the last two digits encode values for a set of attributes associated with the feature. See Annex A for more information.

4.6
line string

sequence of line segments

4.7
reach

set of one or more hydrographic features grouped into a complex/compound feature that is assigned a permanent, public identifier usually referred to as a **reach code**

NOTE The hydrographic features that compose a reach are selected to maximize their scale independence. The reach code is used to link data to a reach and thereby provide an association to other related data. When reaches are split or merged, a cross-reference of their permanent identifiers is maintained. All linear feature representations of stream/rivers, canal/ditches, pipelines, and all artificial path, connector, shoreline, reservoir, and lake/pond features may compose reaches.

4.8
reach code

permanent identifier assigned to **reaches**

4.9
stream level

level within a stream classification system based on the position of the stream within a drainage network

NOTE Stream level is identified by a numeric code such that streams that terminate in sea/ocean features are assigned to the lowest level (Level 1) and tributaries are incremented based on the level into which they terminate.

EXAMPLES Mississippi River is a Level 1 stream, the Missouri is a Level 2 stream.

4.10
watercourse

HydroComplex feature, made up of one or more hydrography features usually based on a name attribute

NOTE Named path or path based on connectivity. Watercourses may be a permanent feature within a hydrography dataset.

5 Symbols, abbreviated terms, and notations

The following symbols, abbreviations, and notations are applicable to this part of the standard. More symbols, abbreviations, and notations applicable to multiple parts are listed in the Base Document (Part 0).

GNIS – Geographic Names Information System

GUID – Globally Unique Identifiers

ID/IDs – Identifier/Identifiers

NHD – National Hydrography Dataset

PNW – Pacific Northwest Framework

SRS – Spatial Reference System

UUID – Universally Unique Identifiers

6 Requirements

6.1 UML class diagram: a data model for hydrography

Figure 1, below, illustrates the main UML classes and associations for hydrography. These classes, their attributes, and roles are described in detail in the data dictionary (see section 6.2).

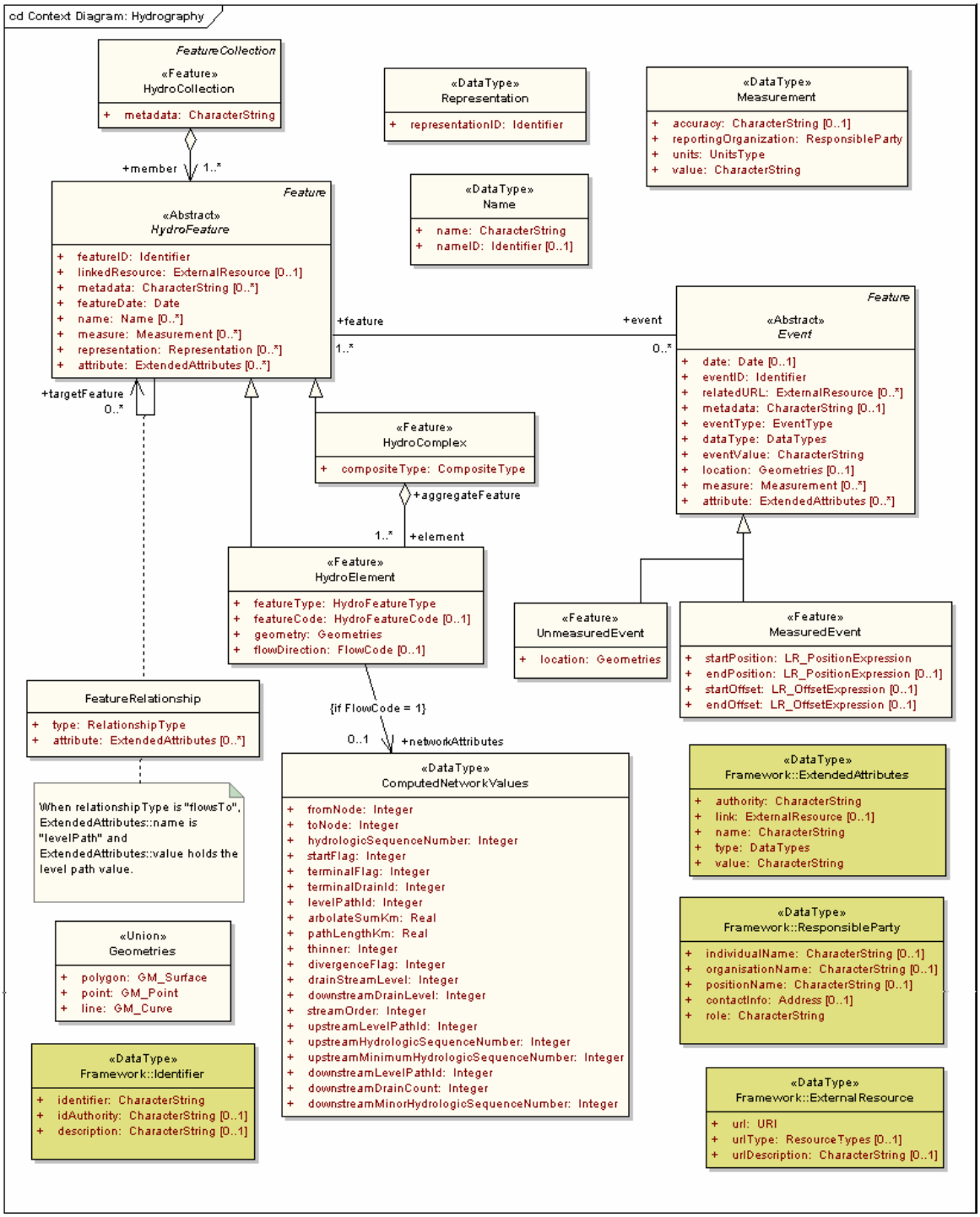


Figure 1 – Main UML classes for hydrography

6.2 UML objects

Each hydrography UML object is described below. Each description includes a narrative for context and understanding, and a table to define the contents.

6.2.1 HydroCollection

HydroCollection is the container for the features packaged in an exchange of hydrographic information.

Table 1 – UML class - HydroCollection

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
1	HydroCollection	Group of features in the exchange	M	1	<<Feature>>	Lines 2-3
2	metadata	Set of formal structured properties that pertain to the collection of features being exchanged	M	1	CharacterString	A valid block of descriptive text or URL as hyperlink to external metadata document
3	Role name: member	Defines the composition relationship of HydroFeatures within a HydroCollection	M	*	<<Abstract>> HydroFeature	HydroElement, HydroComplex

6.2.2 HydroFeature

HydroFeature is an abstract class that captures the characteristics of the hydrographic feature. As the core component of the model, HydroFeature has several significant associations to other classes. HydroFeature has HydroElement and HydroComplex subclasses.

Table 2 – UML class – HydroFeature

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
4	HydroFeature				<<Abstract>>	Lines 5-14
5	featureID	Unique identifier of feature	M	1	<<DataType>>	Unrestricted

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
					Framework::Identifier	
6	linkedResource	Information related to this feature by URL reference	O	1	<<DataType>> Framework:: ExternalResource	Unrestricted
7	metadata	Descriptive information associated with this feature instance	O	*	CharacterString	Text or URL
8	featureDate	Date feature was last modified	M	1	Date	Unrestricted
9	name	Name and naming authority of feature	O	*	Name	Unrestricted
10	measure	Associated calculated measurements of length, height, and area	O	*	<<DataType>> Measurement	Unrestricted
11	representation	Version of the geometric representation	O	*	<<DataType>> Representation	Unrestricted
12	attribute	Extended unofficial attributes	O	*	<<DataType>> Framework::Extended Attributes	Unrestricted
13	Role name: targetFeature	Pair association with other feature instance	O	*	FeatureRelationship	HydroElement or HydroFeature instances
14	Role name: event	Association to maintain properties on partial Hydrofeatures	O	*	<<Abstract>> Event	Unrestricted

6.2.3 HydroElement

Basic hydrographic features with explicit geometry. HydroElement inherits all properties (generalizes) from the abstract parent class, HydroFeature. These properties are not included in the table below.

Table 3 – UML class - HydroElement

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
15	HydroElement	Basic hydrographic feature with explicit geometry			<<Feature>>	Lines 16-20
16	featureType	Classification of feature type based on a list of community-defined hydrographic features	M	1	<<CodeList>> HydroFeatureType	Restricted to the values in the code list HydroFeatureType
17	featureCode	Numeric code defining feature types and properties	O	1	HydroFeatureCode	Unrestricted
18	geometry	Coordinate representation of the feature	M	1	<<Union>> Geometries	GM_Point, GM_Curve, or GM_Surface
19	flowDirection	Direction of flow, where known, relative to coordinate ordering	O	1	<<Enumeration>> FlowCode	0 = not applicable 1 = flows with 2 = flows opposite 3 = unknown 4 = bidirectional
20	Role name: networkAttributes	Conditional set of computed hydrologic network values	C – if FlowCode = 1 (within hydrologic network)	1	<<DataType>> ComputedNetworkValues	Integer or Real

6.2.4 HydroComplex

HydroComplex is an aggregate of HydroElement. The HydroComplex may impose property requirements onto the associated HydroElements. For example, a HydroComplex of Reach requires measure values based on the extent of the Reach, not of the HydroElements that make up the Reach. As an aggregate representation, a HydroComplex is retired if the HydroElements that make up the HydroComplex are retired. The reverse situation does not apply. HydroComplex inherits all properties from the parent abstract class, HydroFeature. These properties are not shown in the table below.

461

462 **Table 4 – UML class – HydroComplex**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
21	HydroComplex	Feature composed of HydroElements that does not have its own geometry			<<Feature>>	Lines 22-23
22	compositeType	Description of HydroComplex type	M	1	<<CodeList>> CompositeType	Restricted to the values in the code list CompositeType
23	Role name: element	Aggregation relationship to gather hydrography elements into grouped features such as watercourses	M	*	HydroElement	Unrestricted

463

464 ### 6.2.5 FeatureRelationship

465 FeatureRelationship describes binary relationships between feature instances. The order of the elements in the relationship is explicit and is
466 represented using a self-association in the UML model. The RelationshipAttribute qualifier will have relevance to a specific RelationshipType.

467

468 **Table 5 – UML association – FeatureRelationship**

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
24	FeatureRelationship	Association between feature instances			Association	Lines 25-26
25	type	Code for valid relationship type	M	1	<<CodeList>> RelationshipType	Restricted to the values in the code list RelationshipType
26	attribute	Extended unofficial attribute to describe relationship	O	*	<<DataType>> Framework:: ExtendedAttributes	Unrestricted

6.2.6 Event

An Event object supports the linking of external attribute information to a portion of a HydroFeature, either HydroElement or HydroComplex. Events can be of two types: MeasuredEvent or UnmeasuredEvent. MeasuredEvents are those that reference portions of features that participate in the linear reference model. UnmeasuredEvents are those that reference portions of features that do not participate in the linear reference model.

Table 6 – UML class – Event

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
27	Event	Property whose location falls on or across one or more features			<<Abstract>>	Lines 28-38
28	date	Date that provides a reference or version for an event	O	1	Date	ISO8601
29	eventID	Unique identifier for event	M	1	<<DataType>> Framework::Identifier	Unrestricted
30	relatedURL	URL and context for additional information about this property	O	*	<<DataType>> Framework:: ExternalResource	Unrestricted
31	metadata	Descriptive, structured information about this event	O	1	CharacterString	Unrestricted
32	eventType	Type of the event	M	1	<<Codelist>> EventType	Restricted to the values in the code list EventType
33	dataType	Data type for the information stored in event value	M	1	<<DataType>> Framework::DataTypes	Unrestricted
34	eventValue	Value being associated with the event	M	1	CharacterString	Constrained by Datatypes
35	location	Geometric location of event that is not dependent on related feature location	O	1	<<Union>> Geometries	GM_Surface, GM_Point, or GM_Curve

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
36	measure	Associated calculated measurements of length, height, and area	O	*	Measurement	Unrestricted
37	attribute	Extended unofficial attribute	O	*	<<DataType>> Framework:: ExtendedAttributes	Unrestricted
38	Role name: feature	Identity of the feature(s) on which this event occurs	M	*	<<Abstract>> HydroFeature	Unrestricted

6.2.7 MeasuredEvent

A MeasuredEvent represents a point or span along a linear feature. In order to have MeasuredEvents, a linear feature must participate in the linear reference model. A MeasuredEvent always has a StartMeasure and, if it represents a span along a feature, it also has an EndMeasure. The measures specifies the exact location of the event relative to the addresses/measures along the referenced feature. A MeasuredEvent may also have a geometric representation (inherits "location") which provides an independent location for the event. MeasureEvent inherits all properties from the parent class, Event. These properties are not shown in the table below.

Table 7 – UML class – MeasuredEvent

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
39	MeasuredEvent	Property occuring at a point or along a span of one or more linear features			<<Feature>>	Lines 40-43
40	startPosition	Measure along linear feature at which the measured event begins	M	1	<<Type>> LinearReferenceSystems:: LR_PositionExpression	Defined in ISO 19133
41	endPosition	Measure along linear feature at which the measured event ends	C – Mandatory for EventType = Linear	1	<<Type>> LinearReferenceSystems:: LR_PositionExpression	Defined in ISO 19133

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
42	startOffset	Offset distance in current SRS units perpendicular to a linear feature where event starting point begins. Positive offsets are to the right of the feature looking upstream	O	1	<<Type>> LinearReferenceSystems:: LR_OffsetExpression	Defined in ISO 19133
43	endOffset	Offset distance in current SRS units perpendicular to a linear feature ending point	O	1	<<Type>> LinearReferenceSystems:: LR_OffsetExpression	Defined in ISO 19133

6.2.8 UnmeasuredEvent

The UnmeasuredEvent may be linked to any feature that does not participate in the linear reference model. The referenced feature may be a zero-dimensional, one-dimensional, or two-dimensional feature and may be either an HydroElement or HydroComplex feature. UnmeasuredEvents must have a location (geometry) that specifies the location of the event independent of the geometry of the referenced feature. The geometry may be of point, line, or polygon as declared in the Geometries Union class. UnmeasuredEvent inherits all properties from the parent class, Event. These properties are not shown in the table below.

Table 8 – UML class – UnmeasuredEvent

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
44	UnmeasuredEvent	Event occuring on non-networked features			<<Feature>>	Line 45
45	location	Geometric location of event that is not dependent on related feature location	M	1	<<Union>> Geometries	GM_Surface, GM_Point, or GM_Curve

6.2.9 Name

The Name object holds feature names that are managed by a naming authority. The authority may be a recognized authority such as the Board of Geographic Names or an un-recognized authority such as a local hydrography maintainer. An ExchangeCollection may contain names from different authorities. Feature names are linked to HydroFeatures, both HydroElement and HydroComplex, in a many-to-many relationship. This

permits a given feature to have names from different authorities. It also permits a single name to be linked to HydroFeature instances that represent parts of a named feature.

Table 9 – UML class – Name

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
46	Name	Name and identifier construct within a namespace			<<DataType>>	Lines 47-48
47	name	The text name of the feature	M	1	CharacterString	Unrestricted
48	nameID	Identifier and naming authority	O	1	<<DataType>> Framework::Identifier	Unrestricted

6.2.10 Representation

Features, both HydroElement and HydroComplex, will have more than one representation in the hydrography community. A representation is one instance combination of feature attributes and geometry – variation in one characteristic constitutes a new representation. Each HydroFeature instance within a given ExchangeCollection will have a single representation and the Representation object describes which representation is being exchanged. If the ExchangeCollection contains more than one representation for a given HydroFeature, there will be a feature instance (with unique identifier) for each representation in the ExchangeCollection.

Table 10 – UML class – Representation

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
49	Representation	Identification of geometric representation used			<<DataType>>	Line 50
50	representationID	Unique identifier for the representation	M	1	<<DataType>> Framework::Identifier	Unrestricted

6.2.11 Measurement

Measurement is used to store empirical measurements of features such as real-world reported elevation, length, area, and depth – typically of values portrayed on topographical maps. HydroElement, HydroComplex, and Event features may have one or more ReportedMeasurements.

Table 11 – UML class – Measurement

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
51	Measurement	Reported area, length, depth, elevation, or height of hydrographic feature			<<DataType>>	Lines 52-55
52	accuracy	Textual accuracy statement of the area measurement	O	1	CharacterString	Unrestricted
53	reportingOrganization	Identity of the party reporting the measurement	M	1	<<DataType>> Framework:: ResponsibleParty	Unrestricted
54	units	A code describing the parameter and units of measure	M	1	<<CodeList>> UnitsType	Restricted to the values in the code list UnitsType
55	value	Value of the reported measurement	M	1	CharacterString	Unrestricted

6.2.12 ComputedNetworkValues

The National Hydro Dataset (NHD) includes a number of computed values for hydrographic features (HydroElements) with basic geometries. These properties are only calculated for features that participate in the network for which flow direction is known or inferred.

Table 12 – UML class – ComputedNetworkValues

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
56	ComputedNetworkValues	Group of computed values for features participating in the flow	C – participates in flow network	*	<<DataType>>	Lines 57-76

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
		network	(FlowCode = 1)			
57	fromNode	Nationally unique ID for the “from” node (upstream node) endpoint	C – computed	1	Integer	Unrestricted
58	toNode	Nationally unique ID for the “to” node (downstream node) endpoint	C – computed	1	Integer	Unrestricted
59	hydrologicSequenceNumber	Nationally unique sequence number for the current reach	C – computed	1	Integer	Unrestricted
60	startFlag	Code to mark headwater features	C – computed	1	Integer	0 = not headwater 1 = headwater
61	terminalFlag	Code to mark features that terminate in the ocean, the Great Lakes, Canada, Mexico or in closed basins	C – computed	1	Integer	0 = not terminal 1 = terminal
62	terminalDrainId	Hydrologic sequence number for the terminal reach to which this drain flows	C – computed	1	Integer	Unrestricted
63	levelPathId	Hydrologic sequence number of the most downstream reach that is on the same level path	C – computed	1	Integer	Unrestricted
64	arbolateSumKm	Sum of the lengths, in kilometers, of all the reaches that drain to the downstream end of the current reach	C – computed	1	Real	Positive
65	pathLengthKm	Distance from this reach’s downstream end to the terminal reach downstream end	C – computed	1	Real	Positive
66	thinner	Ordinal value to allow selection of progressively more dense networks; least dense network	C – computed	1	Integer	Positive

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
		is where thinner = 1				
67	divergenceFlag	Code signifying if reach is part of a flow divergence	C – computed	1	Integer	0 = not divergent 1 = main divergent channel 2 = minor divergent channel
68	drainStreamLevel	Current stream level; supports upstream mainstream navigation	C – computed	1	Integer	Positive
69	downstreamDrainLevel	Stream level of downstream mainstem reach; supports downstream navigation	C – computed	1	Integer	Positive
70	streamOrder	Strahler stream order number for the reach	C – computed	1	Integer	Positive
71	upstreamLevelPathId	Level path identifier of the immediately upstream mainstem reach; supports navigation traversals through SQL queries	C – computed	1	Integer	Positive
72	upstreamHydrologicSequenceNumber	Hydrologic sequence number of the immediately upstream mainstem	C – computed	1	Integer	Positive
73	upstreamMinimumHydrologicSequenceNumber	Minimum hydrologic sequence number of all immediately upstream reaches	C – computed	1	Integer	Positive
74	downstreamLevelPathId	Level path identifier of downstream reach	C – computed	1	Integer	Positive
75	downstreamDrainCount	Number of drains immediately downstream	C – computed	1	Integer	Positive
76	downstreamMinorHydrologicSequenceNumber	At a divergence, the Hydrologic	C – computed	1	Integer	Positive

Line	Name/Role Name	Definition	Obligation/ Condition	Maximum Occurrence	Data Type	Domain
		Sequence Number of the immediately downstream minor path reach				

525

6.2.13 Common framework classes

Four classes are shown in this figure that are included from the Base Document (Part 0) for completeness. These classes are shown in dark grey and include ExtendedAttributes, ResponsibleParty, Identifier, and ExternalReference. The ExtendedAttribute object, described in Part 0, provides the ability to link additional attributes to HydroFeature instances, both HydroElement and HydroComplex. The ExtendedAttribute must have an authority which is documented with an authority (ResponsibleParty). The ExtendedAttribute may be documented through a URL to an ExternalResource object instance. The fuller description of this behavior is provided in the Part 0 but the classes are only shown here for convenience.

The ExternalResource object provides the ability to link Internet URLs to HydroFeatures, both HydroElement and HydroComplex, to Events, to Authorities, and to ExtendedAttributes. There are a number of different types of ExternalResources as enumerated in the ResourceType codelist.

Identifier stores a set of related properties required for the management of information within a namespace. The identifier, a description, and a reference to an assigning authority are provided.

The ResponsibleParty class is modeled after the ISO 19115 metadata concept of the same name but is implemented here to simplify the possible associations and recursion in the data model. ResponsibleParty provides descriptive details of an organization to which one can go and get additional contextual information.

6.2.14 External packages

Several UML packages of structured information are used or referenced from ISO sources in this part of the standard. These include geometry and linear referencing constructs from other ISO standards [GM_Object from ISO19107, CharacterString and Date from ISO/TS 19103]. The inclusion of these packages of information complements the model.

6.2.15 Code lists and enumerations

The code lists presented in Figure 2 represent known values that are encouraged to promote interoperability. Code lists, by their nature are not closed enumerations and are not intended to be exhaustive. In fact, they might be placed online and would support controlled update by the community. In implementation, strict validation may include tests for the presence of these codes, whereas lax validation may permit these and additional code values.

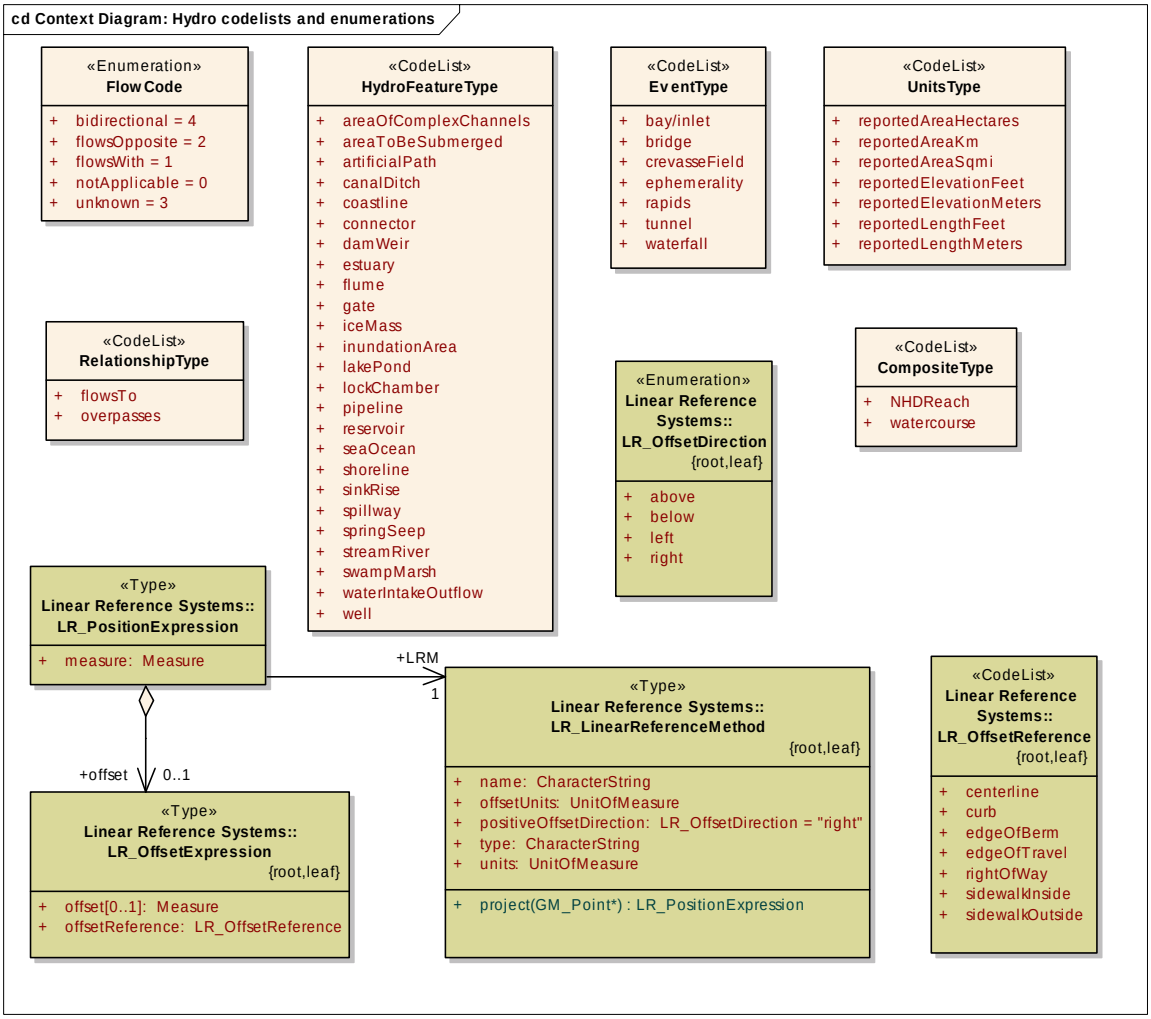
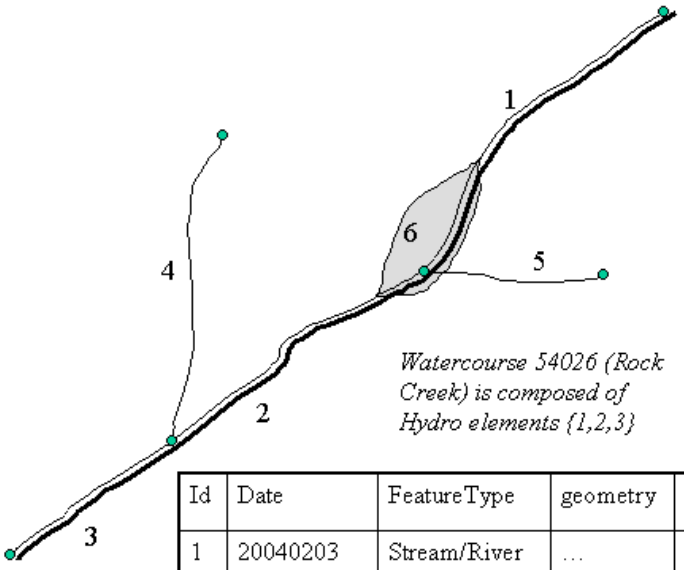


Figure 2 – Hydrography UML class code lists and enumerations

6.3 Example hydrography data

Figure 3 below represents a small collection of hydrography features, their attributes, and relationships. Only selected characteristics are shown to illustrate a basic network of hydrographic features. These notional representations can be translated into the logical UML model as well as implementation models such as relational databases.



elementA	elementB	relation
1	6	flowsTo
5	6	flowsTo
6	2	flowsTo
2	3	flowsTo
4	3	flowsTo

Id	Date	FeatureType	geometry	name	nameID	idAuthority
1	20040203	Stream/River	…	Rock Creek	54026	GNIS
2	20040203	Stream/River	…	Rock Creek	54026	GNIS
3	20040203	Stream/River	…	Rock Creek	54026	GNIS
4	20040203	Stream/River	…	Tin Draw	36223	GNIS
5	20040203	Stream/River	…			
6	20040203	Lake/Pond	…	Willow Pond	74383	GNIS

Figure 3 – Example basic hydrographic data

Annex A
(normative)
Feature codes, code lists, and enumerations

A.1 Common hydrography feature and feature codes

The following table includes common coded combinations of properties, or feature codes, associated with hydrographic features as used in the National Hydrography Dataset. These codes are intended to simplify association and classification of features for applications and symbology. A hydrography feature code is the numeric value used that encodes the unique combination of hydrography feature type and a set of feature attribute values. The official five-digit hydrography feature code has two parts: the first three digits encode the feature type; the last two digits encode values for a set of attributes associated with the feature.

Table A.1 – Common feature codes

FCode	Description
53700	Area of Complex Channels
30700	Area to be Submerged
55800	Artificial Path
33600	Canal/Ditch
33601	Canal/Ditch: Canal/Ditch Type = Aqueduct
56600	Coastline
33400	Connector
34300	Dam/Weir
34305	Dam/Weir: Construction Material = Earthen
34306	Dam/Weir: Construction Material = Nonearthen
49300	Estuary
36200	Flume
36900	Gate
37800	Ice Mass
40300	Inundation Area
40308	Inundation Area: Inundation Control Status = Controlled
40309	Inundation Area: Inundation Control Status = Controlled; Stage = Flood Elevation
40307	Inundation Area: Inundation Control Status = Not Controlled
39000	Lake/Pond
39001	Lake/Pond: Hydrographic Category = Intermittent
39006	Lake/Pond: Hydrographic Category = Intermittent; Stage = Date of Photography

FCode	Description
39005	Lake/Pond: Hydrographic Category = Intermittent; Stage = High Water Elevation
39004	Lake/Pond: Hydrographic Category = Perennial
39009	Lake/Pond: Hydrographic Category = Perennial; Stage = Average Water Elevation
39011	Lake/Pond: Hydrographic Category = Perennial; Stage = Date of Photography
39010	Lake/Pond: Hydrographic Category = Perennial; Stage = Normal Pool
39012	Lake/Pond: Hydrographic Category = Perennial; Stage = Spillway Elevation
39800	Lock Chamber
42800	Pipeline
42816	Pipeline: Pipeline Type = Aqueduct
42801	Pipeline: Pipeline Type = Aqueduct; Relationship to Surface = At or Near
42802	Pipeline: Pipeline Type = Aqueduct; Relationship to Surface = Elevated
42803	Pipeline: Pipeline Type = Aqueduct; Relationship to Surface = Underground
42804	Pipeline: Pipeline Type = Aqueduct; Relationship to Surface = Underwater
42814	Pipeline: Pipeline Type = General Case
42805	Pipeline: Pipeline Type = General Case; Relationship to Surface = At or Near
42806	Pipeline: Pipeline Type = General Case; Relationship to Surface = Elevated
42807	Pipeline: Pipeline Type = General Case; Relationship to Surface = Underground
42808	Pipeline: Pipeline Type = General Case; Relationship to Surface = Underwater
42815	Pipeline: Pipeline Type = Penstock
42809	Pipeline: Pipeline Type = Penstock; Relationship to Surface = At or Near
42810	Pipeline: Pipeline Type = Penstock; Relationship to Surface = Elevated
42811	Pipeline: Pipeline Type = Penstock; Relationship to Surface = Underground
42812	Pipeline: Pipeline Type = Penstock; Relationship to Surface = Underwater
42813	Pipeline: Pipeline Type = Siphon
43600	Reservoir
43618	Reservoir: Construction Material = Earthen
43619	Reservoir: Construction Material = Nonearthen
43601	Reservoir: Reservoir Type = Aquaculture
43609	Reservoir: Reservoir Type = Cooling Pond
43603	Reservoir: Reservoir Type = Decorative Pool
43606	Reservoir: Reservoir Type = Disposal
43625	Reservoir: Reservoir Type = Disposal; Construction Material = Earthen

FCode	Description
43626	Reservoir: Reservoir Type = Disposal; Construction Material = Nonearthen
43607	Reservoir: Reservoir Type = Evaporator
43623	Reservoir: Reservoir Type = Evaporator; Construction Material = Earthen
43610	Reservoir: Reservoir Type = Filtration Pond
43611	Reservoir: Reservoir Type = Settling Pond
43612	Reservoir: Reservoir Type = Sewage Treatment Pond
43608	Reservoir: Reservoir Type = Swimming Pool
43605	Reservoir: Reservoir Type = Tailings Pond
43604	Reservoir: Reservoir Type = Tailings Pond; Construction Material = Earthen
43617	Reservoir: Reservoir Type = Water Storage
43613	Reservoir: Reservoir Type = Water Storage; Construction Material = Nonearthen
43614	Reservoir: Reservoir Type = Water Storage; Construction Material = Earthen; Hydrographic Category = Intermittent
43615	Reservoir: Reservoir Type = Water Storage; Construction Material = Earthen; Hydrographic Category = Perennial
43621	Reservoir: Reservoir Type = Water Storage; Hydrographic Category = Perennial
43624	Reservoir; Reservoir Type = Treatment
44500	Sea/Ocean
56700	Shoreline
45000	Sink/Rise
45500	Spillway
45800	Spring/Seep
46000	Stream/River
46003	Stream/River: Hydrographic Category = Intermittent
46006	Stream/River: Hydrographic Category = Perennial
46600	Swamp/Marsh
48500	Water Intake/Outflow
48800	Well

A.2 Feature code lists and enumerations

The following tables represent consolidated code lists and enumerations of recognized feature types for water features. In general, landmark or non-water features were omitted from this list. Where possible, potential or identified alternate names (aliases) are presented. Some consolidation occurred where what used to be a feature type was recognized to be, in fact, a modifier or property on some other feature type. In these cases, the column of "characteristics" reflects possible modifiers.

A.2.1 Feature code lists

A.2.1.1 CompositeType code list

CompositeType is a non-exhaustive CodeList of values for the attribute compositeType.

Table A.2 – CodeList for CompositeType

Value Name	Feature Name	Definition	Characteristics	Aliases	Definition Source
NHDReach	NHDReach	A complex feature that is scale-independent and carries a publicly recognized permanent identifier			NHD, 1999
watercourse	Watercourse	A HydroComplex feature, made up of one or more features usually based on a name attribute			NHD, 1999

A.2.1.2 EventType code list

In the NHD, the contact between land and coastal features is captured as Coastline. The NHD does not support the shoreline feature type. Most shorelines could be derived for the purpose of exchange from existing bounded water area features. The provision of shoreline features (or any other feature type) is not mandatory, but supported by the Hydrography part of the Framework Data Content Standard.

- Bridges and tunnels are properties of canal/ditches and pipelines
- Crevasse field is an attribute of an ice mass
- Foreshores are the area between high and low water but are problematic. Should really be defined by NOAA coastal shorelines – it is derivable

- Hazard zone is a property of general water features, not a first order feature
- Islands are not water features but may be landmark features. Out of scope in this part but may be supported in some exchanges
- A Reach is not a first-order feature but rather is a characteristic (Reach identity) used to group kindred feature instances. The community may consider a replacement term for "reach"
- Sand and gravel bar is more like an island and is excluded
- Sounding datum line (tidal datum) is like edge of foreshore. It seems out of context
- Special use zone and special use zone limit are really properties of any area water feature. These are not shown in the current feature type table, above, but may be revealed in the FCODE enumeration

EventType is a non-exhaustive CodeList of values for the attribute eventType.

Table A.3 – CodeList for EventType

Value Name	Characteristic	Definition	Reference Feature	Definition Source
bay/inlet	Bay/Inlet	A water area that is an opening of the sea/ocean into the land, or of an estuary, lake, or river into its shore. (Implemented as a landmark feature)	Estuary, Lake/Pond, Sea/Ocean, Stream/River	NHD, 1999
bridge	Bridge	Structure spanning and providing passage over a waterway, railroad or other obstacle. For example, a characteristic of a canal/ditch or pipeline with passage over a stream	Canal/Ditch, Pipeline	NHD, 1999
crevasseField	Crevasse Field	Area of deep fissures in the surface of an ice mass caused by breaking or parting	Ice mass	NHD, 1999
ephemerality	Ephemerality	The perennial or intermittent nature of a flowing water feature	Lake/Pond, Stream/River	NHD, 1999
rapids	Rapids	An area of swift current in a stream or river, characterized by standing waves or by boulders and rocks	Stream/River	NHD, 1999
tunnel	Tunnel	An underground or underwater passage	Canal/Ditch, Pipeline	NHD, 1999
waterfall	Waterfall	A vertical or near vertical descent of water over a step or ledge in the bed of a river	Stream/River	NHD, 1999

612 **A.2.1.3 HydroFeatureType code list**

613 HydroFeatureType is a non-exhaustive CodeList of values for the attribute featureType.

614

615 **Table A.4 – CodeList for HydroFeatureType**

Value Name	Feature Name	Definition	Code	Characteristics	Aliases	Definition Source
areaOfComplexChannels	Area of Complex Channels	An area where a stream or river flows in an intricate network of interlacing channels	537			NHD, 1999
areaToBeSubmerged	Area to be Submerged	The known extent of the intended lake that will be created behind a dam under construction	307			NHD, 1999
artificialPath	Artificial path	An abstraction to facilitate hydrologic modeling through open water bodies and along coastal and Great Lakes shorelines and to act as a surrogate for lakes and other water bodies	558			NHD, 1999
canalDitch	Canal/Ditch	An artificial open waterway constructed to transport water, to irrigate or drain land, to connect two or more bodies of water, or to serve as a waterway for watercraft	336	Tunnel	Aqueduct	NHD, 1999
	Coastline	The contact line between land and water along the Atlantic, Pacific, or Arctic Oceans, the Great Lakes, the Gulf of Mexico, or the Caribbean Sea	566			NHD, 2004
connector	Connector	A known, but nonspecific, connection between two nonadjacent network segments	334			NHD, 1999

Value Name	Feature Name	Definition	Code	Characteristics	Aliases	Definition Source
damWeir	Dam/Weir	A barrier constructed to control the flow or raise the level of water	343		Levee	NHD, 1999
estuary	Estuary	The lower end of a river, or a semienclosed coastal body of water with access to the open ocean, which is affected by the tides and where fresh and salt water mix. Should be hydrologically based	493		Bay	NHD, 1999
flume	Flume	An open, inclined, artificial channel constructed of wood, metal, or concrete; generally elevated	362			NHD, 1999
gate	Gate	A structure that may be swung, drawn, or lowered to block an entrance or passageway	369			NHD, 1999
iceMass	Ice Mass	A field of ice, formed in regions of perennial frost	378	Crevasse Field	Glacier, Snowfield	NHD, 1999
inundationArea	Inundation Area	An area of land subject to flooding	403			NHD, 1999
lakePond	Lake/Pond	A standing body of water with a nearly horizontal water surface and a predominantly natural shoreline surrounded by land. May be natural or formed by a dam/weir	390	Gravel Pit/Quarry, Playa		NHD, 1999
lockChamber	Lock Chamber	An enclosure on a waterway used to raise and lower vessels as they pass from one level to another	398			NHD, 1999
pipeline	Pipeline	A closed conduit, with pumps, valves and control devices, for conveying fluids, gases, or	428	Aqueduct (if closed), Siphon,		NHD, 1999

Value Name	Feature Name	Definition	Code	Characteristics	Aliases	Definition Source
		finely divided solids		Tunnel		
reservoir	Reservoir	A constructed basin formed to contain water or other liquids. (Need a more hydrologically sound definition.)	436			NHD, 1999
seaOcean	Sea/Ocean	The great body of salt water that covers much of the Earth	445		Gulf	NHD, 1999
shoreline	Shoreline	The contact line between land and an inland waterbody	567	Coastal, Island, Reservoir, Nonearthen, Stream/River		PNW
sinkRise	Sink/Rise	The place at which a stream disappears underground or reappears at the surface in a karst area	450			NHD, 1999
spillway	Spillway	A constructed passage for surplus water to run over or around a dam	455		Masonry Spillway	NHD, 1999
springSeep	Spring/Seep	A place where water issues from the ground naturally	458	Mudpot, Fumarole, Geyser		NHD, 1999
streamRiver	Stream/River	A body of flowing water	460	Wash	Ephemeral Drain	NHD, 1999
swampMarsh	Swamp/Marsh	A (generally) noncultivated, vegetated area that is inundated or saturated for a significant part of the year. The vegetation is adapted for life in saturated soil conditions	466		Bog, Wetland	NHD, 1999
waterIntakeOutflow	Water Intake/Outflow	A structure through which water enters or exits a conduit	485	Intake, Outflow		NHD, 1999
well	Well	A pit or hole dug or bored into the earth for the extraction of	488			NHD, 1999

Value Name	Feature Name	Definition	Code	Characteristics	Aliases	Definition Source
		water				

A.2.1.4 RelationshipType code list

RelationshipType is a non-exhaustive CodeList of values for the attribute type.

Table A.5 – CodeList for RelationshipType

Name	Definition
flowsTo	
overpass	

A.2.1.5 UnitsType code list

UnitsType is a non-exhaustive CodeList of values for the attribute units.

Table A.6 – CodeList for UnitsType

Name	Definition
reportedAreaHectares	
reportedAreaKm	
reportedAreaSqmi	
reportedElevationFeet	
reportedElevationMeters	
reportedLengthFeet	
reportedLengthMeters	

A.2.2 FlowCode enumeration

FlowCode is an enumeration of values for the attribute flowDirection.

Table A.7 – FlowCode enumeration

Name	Definition
notApplicable (0)	
flowsWith (1)	
flowsOpposite (2)	
unknown (3)	
bidirectionsal (4)	

Annex B
(informative)
Design concepts and design requirements

B.1 Design concepts

Several key design concepts are defined in the Hydrography part, as defined by requirements of water resource applications:

- Core component of this part and model is the feature
- All features have geometry, either directly or through association
- Features are classified by type and further qualified by attributes
- Features may have relationships to other features
- Common definition of features is required for data sharing
- Permanent identifiers on features and on associated data are managed by an authority
- Linear referencing is supported through permanent features, identifiers, and measurement references
- Multiple representations of a feature exist and are managed in a community

B.2 Design requirements

Hydrographic applications have specific data and information needs associated with them. Below is a table of examples of such requirements.

Table B.1 – Design requirements

Uses	Data and Information Needed
Trace pollution upstream and downstream	Permanent features with IDs, information on flow of water through surface water network, feature classification, measurements on the surface water network, water discharge and velocity
Assist recovery of threatened and endangered species	Permanent features with IDs, linear reference system, surface water flow relationships, measurements on the surface water network
Identify withdrawn areas for timber harvesting based on riparian and stream characteristics	Shoreline, surface water flow relationships, linear reference system, measurements on the surface water network, feature classification
Make maps as a reference layer with other data	Feature names, feature classification, attributes for generalizing or symbolization
Landscape analysis: influence of hydrography on landscape and vice versa	Flow relationships, history of features, positional accuracy, quality information, feature classification
Emergency management system for displaying impact areas and model flooding	Permanent features with identifiers (identifies), watersheds
Display and identify the identities/names of water features at a location	Features, IDs, names, geometries
Update local data with most up-to-date hydrography	Permanent feature IDs, representation IDs, metadata

Based on these requirements, this part and model support the concepts described in the data and information needs.

Features are central to the hydrography model. Other data objects exist in the model through association to the features. A HydroElement feature is a geographic entity that can be classified by consistent type over its extent. A HydroComplex feature is an aggregation of HydroElement features.

This part of the Framework Data Content Standard contains specific feature classifications so that all exchange datasets that conform to it are consistent in terms of form or function, and in terms of minimum attributes of those features. For example, if one creates an exchange dataset according to this part and if that exchange dataset contains features classified as “stream”, then those features would meet the part’s definition of a “stream”. This part contains feature type enumerations and associated specific definitions that represent a set of harmonized types from major stakeholder systems.

Additional classification qualifiers are captured as attributes, also with specific definitions and, where appropriate, with code lists. The code lists should not be considered as bounded – more like an open-ended list – but that these types are the currently recognized ones for information exchange. Different provider-consumer arrangements might require validation against this list, or permit exchange of extended and non-standard feature types.

Characteristics that are less fixed to a permanent location on the ground should not "break" features, but be linked to the core data so as to remain accessible. For example, an application of name is concrete and can be tied explicitly to the feature. However, a classification of hydrographic category (for example, intermittent versus perennial) is less fixed and may be better represented though a time series or a statistical measure, but not by explicit points that "break" the underlying feature.

As a Framework Data Content Standard, the hydrography model emphasizes permanent features with unique permanent IDs to support the community’s uses of hydrography data. Permanent identifiers allow sharing of data in a distributed environment. Permanent identifiers are required to support maintaining entities over time (for example, exchange of updates); to support maintaining entities across multiple representations (for example, scale and/or dimension); to support maintaining associations to linked data; and to describe associations among local and external data entities, such as water quality or ecological surveys.

Any permanent identifier scheme requires an authority to manage the included features.[1] The model also allows assignment of local identifiers to server as temporary identifiers or as cross-walks to permanent identifiers. If a permanent identifier does not exist, the model requires at least a unique temporary identifier be assigned for the purpose of the exchange. All feature identifiers must be unique in the context of the transfer and within an authority’s coding system. The responsibilities of an authority include: recognition as a maintenance authority within the community, ability to assign, update, manage and publish identifiers, and to assure that identifiers are discoverable by users within a reasonable timeframe of their registration.

This part of the standard supports the management of multiple representations of features. A feature instance may have multiple representations reflecting different geometries and attributes due to changes over time, changes in scale, or differing generalization criteria applied in support of user needs. This part does not define a “best available” spatial representation since these differ depending on the application of the data. Data authorities may establish specific data capture requirements to data under their authority. Some feature types, such as reaches and watercourses, do not have direct spatial representation, but instead derive their geographic extent

[1] Recognized authorities include the National Hydrography Dataset co-administered by the U.S. Geological Survey and the U.S. Environmental Protection Agency, and the U.S. Geographic Names Information System in which official place names are stored. Both authorities support unique and persistent identifiers for features under their maintenance.

through association to other feature types that do have spatial representation. A feature extent is defined by stable characteristics that allow for distinct bounds (for example, start, end, location, extent) of the feature instance.

The combination of a specific instance of a feature – all its attributes including a specific geometry – can be identified with a unique representation identifier. Thus a representation identifier denotes a unique, identifiable packaging of a feature, its attributes, and its geometry. This representation identifier provides a unique code to identify the state of the described feature. For example, a change in attribution or geometry preserves the same permanent feature identifier for purposes of linking to references or tracking changes, but would be tagged with a new representation identifier to indicate a change in the representation. When there are multiple persistent representations of a feature, such as those based on scale, then each representation would have its own identifier. Representation identifiers should be derived algorithmically, applying methods like a checksum from attributes and geometry or assignment of truly universally unique identifiers (UUID) or globally unique identifiers (GUID).

Features may have relationships to other features to describe connectivity or association. Relationship types include flow behavior, vertical offsets, and composition. The feature members of the relationship are referenced through their identifiers. The flow connectivity described in these relationships supports development of a linear flow network for flow navigation without the use of geometry. An attribute should be specified to note whether flow direction is one-way, bi-directional, or unknown. The endpoints of segments (nodes, junctions) will not be managed as first order features in this model.

Hydrography features are classified as either elemental (HydroElement) or complex (HydroComplex). HydroElement features, as enumerated in the Annex on HydroFeatureTypes, are of a particular feature type that has geometry and may have attributes, relationships, and events. HydroComplex features exist only as aggregations of HydroElement features and do not have their own explicit geometry. Examples of HydroComplex features are “reach” and named “watercourse”. HydroElement features may not be composed of other HydroElement features. HydroComplex features may be composed of only one set of HydroElement features; for simplicity, the composition relationship is not recursive.

This part of the standard supports a continuous linear representation of the surface water network, although it permits the management and exchange of non-networked features. The network is composed of features that are represented as line strings whose connectivity relationship is known. The logical network is composed of linear representations of hydrography features and centerlines (artificially derived flow paths) within area representations such as reservoirs, rivers, and lakes. A “flows-through” relationship exists between centerlines and the area feature representations through which they flow. The geometric representation of features supported by this part of the standard includes point, line, and area representations only (GM_Point, GM_Curve, GM_Surface).

The Hydrography part contains a reference system that supports both linear and non-linear links to the hydrography data. The reference system is described by a single type of HydroComplex features (for example, reaches or watercourses). The reference system features have an attribute that can be used as the reference key. The reference key attribute contains unique values. External information that is linked to the reference system does so by referring to the reference key. The reference systems features may have any configuration of geometry: point, line, or area. The reference system's linear features may support a linear reference system. The features that make up the linear reference system have an attribute that identifies the features as being part of a linear reference system. Addresses or measures are assigned along the linear features to support linking external information to just a portion of a linear feature. The addresses or measures begin with zero (0) at one end of the feature and terminate with one-hundred (100) at the other end of the feature. Measures are applied to linear features in proportion to their length. The reference system is defined on HydroComplex features, therefore the measures are designated based on the HydroComplex Feature's consolidated geometry which it inherits from its HydroElement features. The measures are stored on the geometry of the HydroElement

features as a measure (that is to say, “m”) value for each geometry coordinate. The coordinates of linear features in the reference system are ordered from upstream to downstream if the direction of flow is known. Measurements increase in the opposite direction of the coordinate order. Therefore, by definition, where direction of flow is known, measure values increase from downstream to upstream. Both linear and non-linear references support an event model whereby the events are associated to the feature through its reference key and, optionally, to locations along the feature defined by the feature's measures. Measurements along shorelines should have a well-known starting location, such as the point of major outflow or other reference point.

Management of feature names is a core requirement for the Hydrography part, including the ability to manage multiple names of the same feature in an exchange. Names are provided in the context of a naming authority, such as the GNIS. To differentiate among different named features that are identically named – for example, all the “Mill Creeks” – a unique identifier is assigned by an authority to each named feature instance.

Metadata can be managed for the entire data exchange collection (feature collection), for a feature, or for an event. Although either FGDC or ISO 19115 metadata can be associated with these hydrography data, ISO 19115 is especially suited to describing characteristics on collections, datasets, and features. This part of the Framework Data Content Standard requires data history/lineage to be reported in metadata so users understand the context for data exchanged. It does not impose constraints on metadata; it requires that metadata be reported using FGDC or ISO 19115 schemes as part of the data transfer.