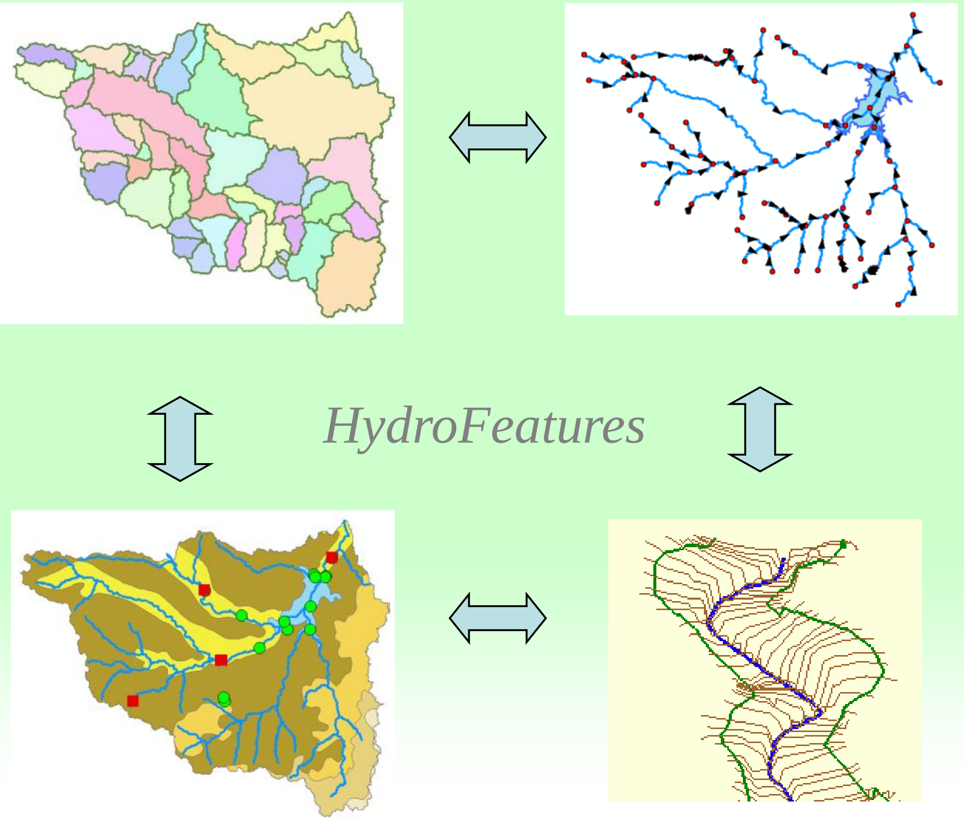


Maidment, D. 2002. *ArcHydro: GIS for Water Resources*, Esri Press

GEOG 482 / 582 : GIS Data Management

Lesson 4: Geodatabase Models for Reference Systems and ArcHydro

Overview

Learning Objective Questions:

1. What are the four components of a geographic coordinate system?
2. What are the four ArcHydro feature datasets?
3. Why identify features with an HydroID domain that spans all feature classes?
4. Why work with multiple drainage scales?
5. Why bother designing Hydro Response Units?
6. What are the types of time series data?

Lesson Preview

Learning objective questions act as the lesson outline.

Questions beg answers.

1. What are the four components of a geographic coordinate system?

Consider each component in next few slides

- Shape of the earth: Spheroid/Ellipsoid/Geoid (mathematical representation as a nonplanar surface in 2D; in 3D it is geoid)
- Datum – reference surface as a collection of horizontal and vertical points of known accuracy to describe earth surface
- Prime Meridian – starting longitudinal line coincident with a selected place on earth (have to start somewhere) in relation to equator
- Units of Measure – degrees or radians
  - degree - angular measurement between two arcs, e.g. long and lat, wherein vertex is center of spheroid
  - radian - length of arc sweep equal to length of radius of a circle

Key terms
Spheroid
Dataum
Meridian

Shape of the earth: Spheroid / Ellipsoid / Geoid

Spheroid – sphere like object

Ellipsoid – take a spheroid and flattened at poles and bulge at equator;
more accurate mathematical representation of the surface of the earth than spheroid

- major (equatorial) axis – extends from equator to equator
  semimajor radius equals ½ (center to equator) of major axis
- minor (polar) axis – extends from pole to pole
  semiminor radius equals ½ (center to pole) of minor

Why are semimajor and semiminor not equal? …flattening at poles and bulging at equator

Spheroid	Semimajor radius	Semiminor radius
Clarke 1866 (Earth)	6378206.4 m	6356583.8 m
GRS 1980 (North America)	6378137 m	6356752.31414 m
WGS 1984 (Earth)	6378137 m	6356752.31424518 m

Geoid – most accurate mathematical representation of earth using piecewise surface for local curvature adjustments

Datum

Collection of horizontal and/or vertical points of known accuracy for measuring earth surface used for georeferencing map data

- North American Datum (NAD) 1983
- European Datum (ED) 1950
- South American Datum (SAD) 1969
- World Geodetic System (WGS) 1984

Datum and Geographic Coordinates in Bellingham Washington

NAD 1927 and NAD 1983 points are approximately 318 feet different.

NAD 1983 and WGS 1984 points are approximately 6 feet different.

Datum	Longitude (decimal degree)	Latitude (decimal degree)
NAD 1927	−122.46690368652	48.7440490722656
NAD 1983	−122.46818353793	48.7438798543649
WGS 1984	−122.46819775227	48.7438850705687

Prime meridian

Royal Observatory, Greenwich England 0° - most popular, but there have been others.

Washington, D.C. (77° 3' 2.3” W), see Washington meridian

Rio de Janeiro (43° 10' 19” W)[1]

El Hierro (Ferro), Canary Islands (18° 03' W)

Lisbon (9° 07' 54.862” W)

Madrid (3° 41' 16.58” W)

Paris (2° 20' 14.025” E), see Paris Meridian

Brussels (4° 22' 4.71” E)

Bern (7° 26' 22.5” E)

Pisa, Italy (10°24' E)

Oslo (Kristiania) (10° 43' 22.5” E)

Rome (12° 27' 08.4” E), *meridian of Monte Mario*

Copenhagen (12° 34' 32.25” E) Rundetårn

...and of course more...

See http://en.wikipedia.org/wiki/Prime_meridian

Units of measure

Unit	Description
Meter	Length
Feet	Length
Degrees	Angle

Projected coordinate system defines the following parameters

Central meridian (longitude of origin)

Latitude of origin

Standard parallel 1

Standard parallel 2

Longitude of natural origin

Latitude of natural origin

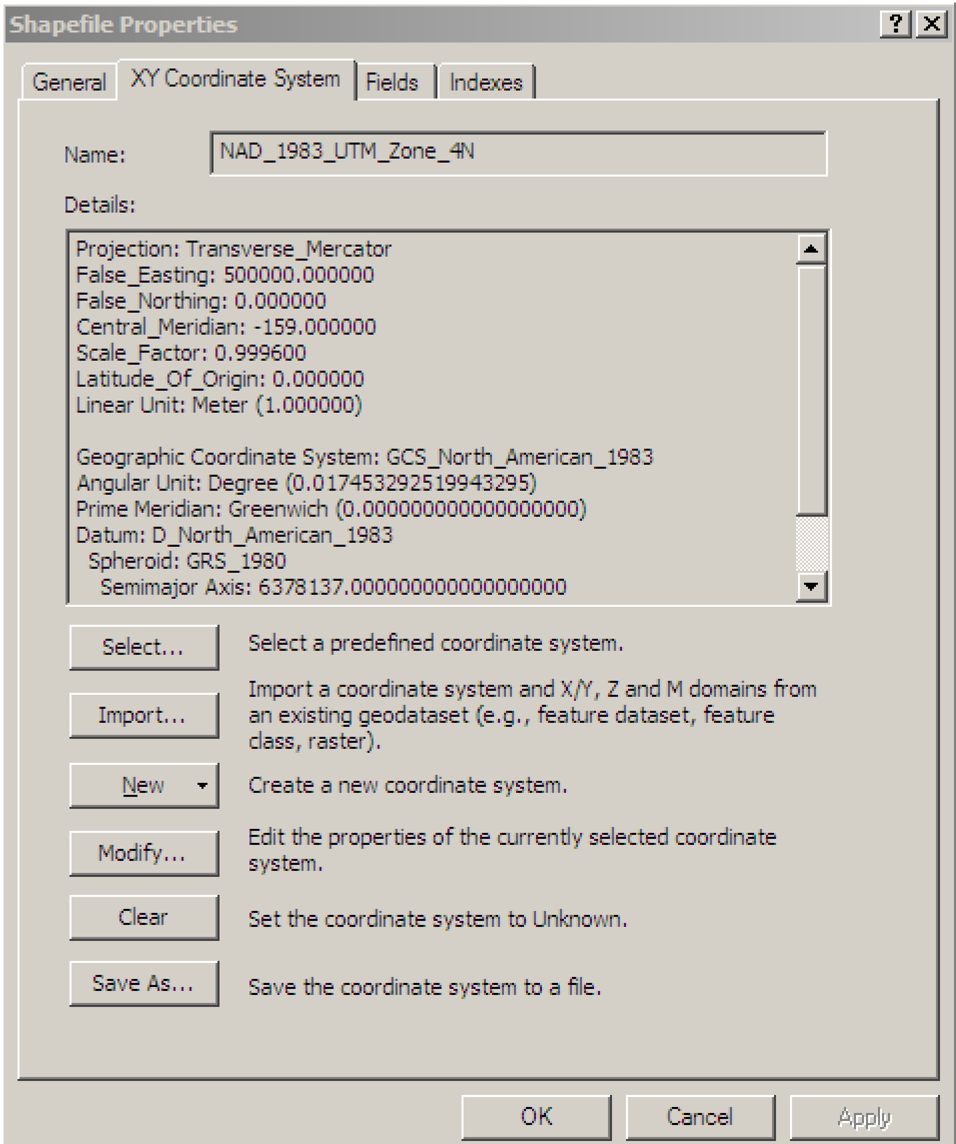
Longitude of second point

Latitude of second point

Azimuth

Rotation angle

Projection properties

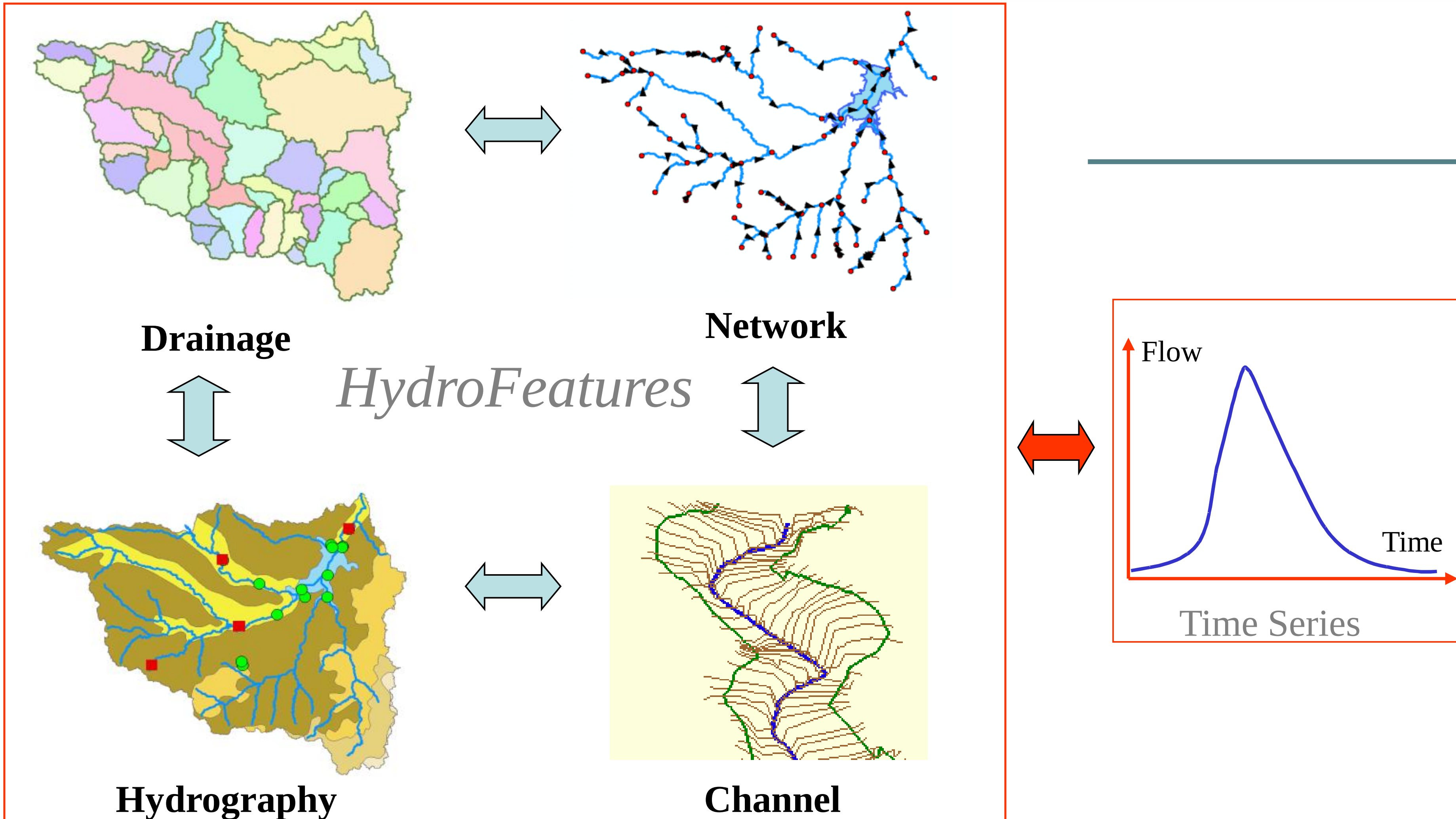


Key terms
Projection

Water Resources – ArcHydro Data Model

Common Thematic Layers	*Traditionally used for*
Surface terrain:	derive streams and drainage areas
Digital orthophotography:	general backdrop for geographic orientation
Hydrography:	manmade and natural water features
Rainfall response areas:	the way water percolates through surface
Drainage areas:	areas for estimating water flow into rivers
Streams:	stream flow analysis up and downstream
Hydrographic points:	gage stations for monitoring a stream network
Channels:	3D analysis of cross-section profile data

2. What are the four ArcHydro **feature datasets?**



Feature dataset: Drainage

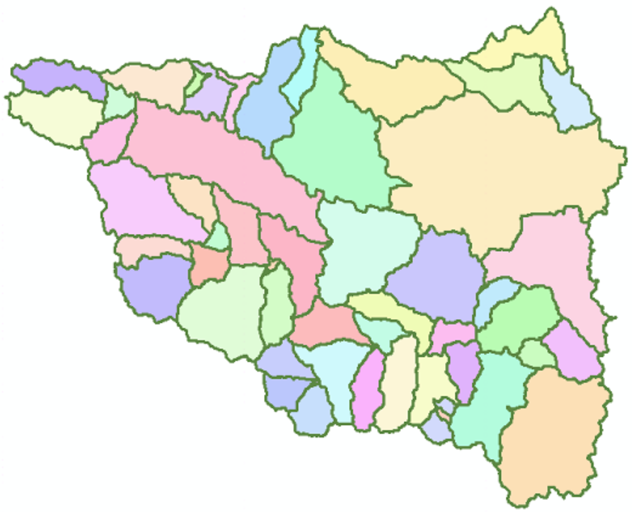
- Basin – polygon feature class
- Watershed – polygon feature class
- Catchment – polygon feature class
- DrainageLine – Line feature class
- DrainagePoint – Point feature class

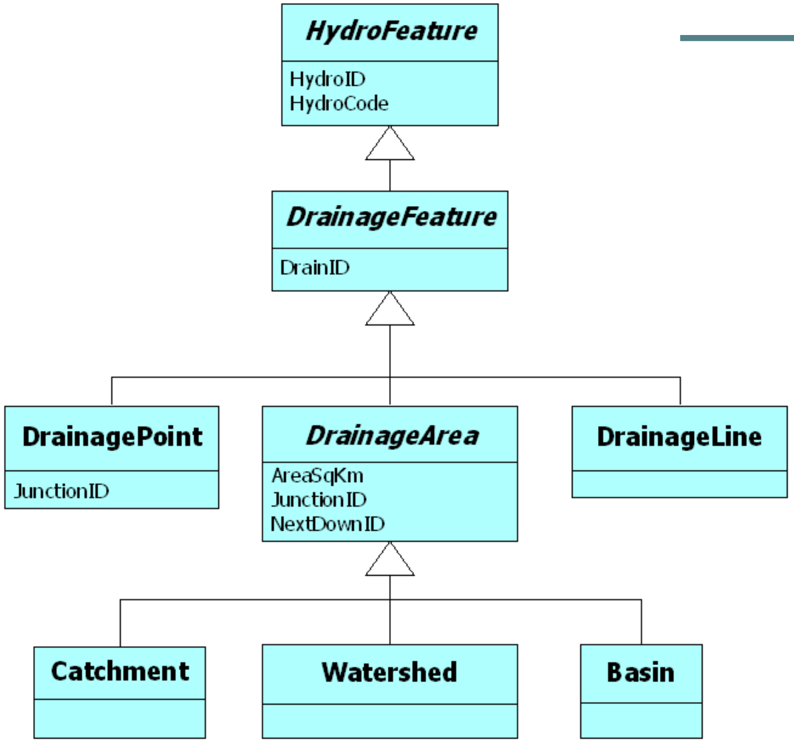
See Table graphic A&Z page 43 for geodatabase diagram

Key terms
- Basin
- Catchment
- Watershed
- DrainageLine
- DrainagePoint

Feature dataset: Drainage

More general (basic) classes on top, and more specific classes below. The triangle is a symbol for "generalization" class on top, and "specialization" class below.





Above left is a map graphic.
Above right is a "class diagram".
Which language describes database elements more rigorously? Why?

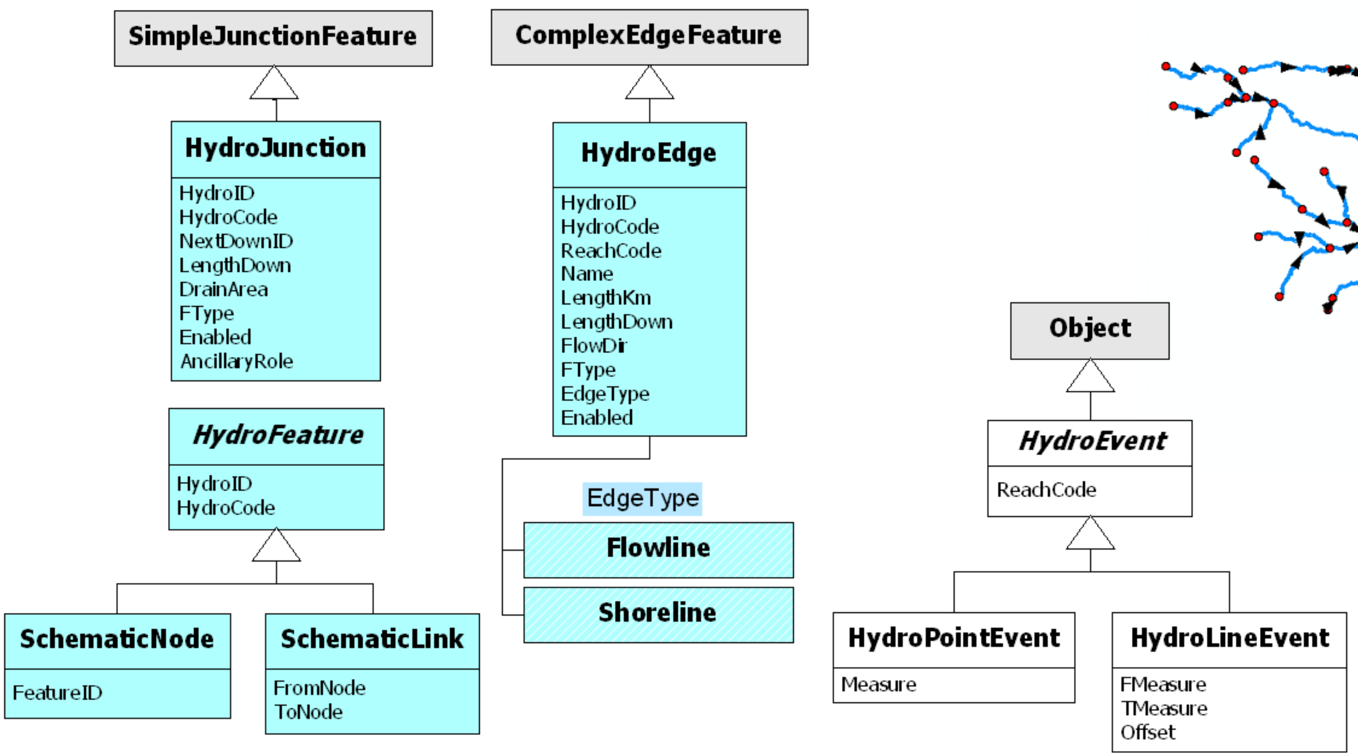
Feature dataset: Network

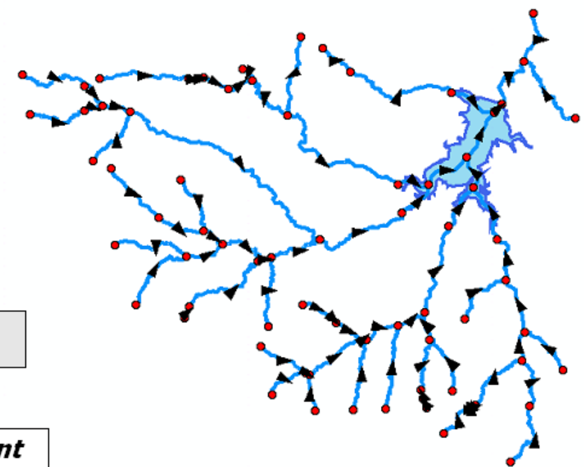
- HydroEdge – complex edge feature class
- HydroJunction – simple junction feature class
- HydroNetwork_Junctions – simple junction feature class
- SchematicLink – Line feature class
- SchematicNode – Point feature class

Key terms
- HydroEdge
- HydroJunction
- HydroNetwork
- SchematicLink
- SchematicNode

Feature dataset: Network

More general (basic) classes on top, and more specific classes below. The triangle is a symbol for "generalization" class on top, and "specialization class below.





Feature dataset: Hydrography

- Bridge – Point feature class
- Dam – Point feature class
- HydroArea – Polygon feature class
- HydroLine – Line feature class
- HydroPoint – Point feature class
- HydroResponseUnit – Polygon feature class
- MonitoringPoint – Point feature class
- Structure – Point feature class
- UserPoint – Point feature class
- Waterbody – Polygon feature class
- WaterDischarge – Point feature class
- WaterWithdrawl – Point feature class

Key terms

- Bridge
- Dam
- HydroArea
- HydroLine
- HydroPoint
- HydroResponseUnit
- MonitoringPoint
- Structure
- UserPoint
- Waterbody
- WaterDischarge
- WaterWithdrawl

Feature dataset: Hydrography

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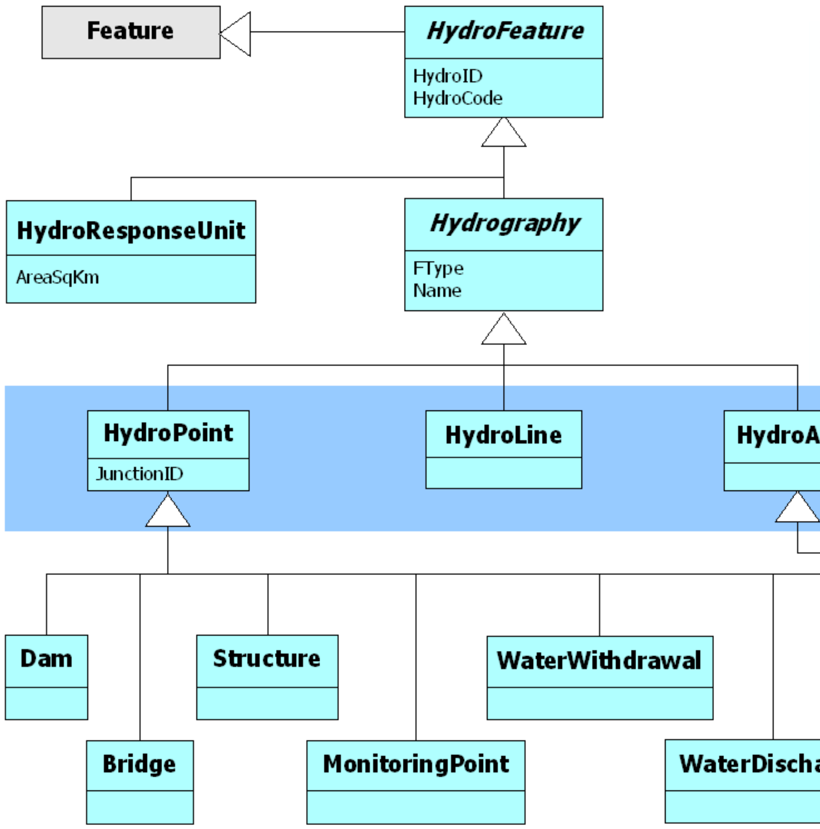
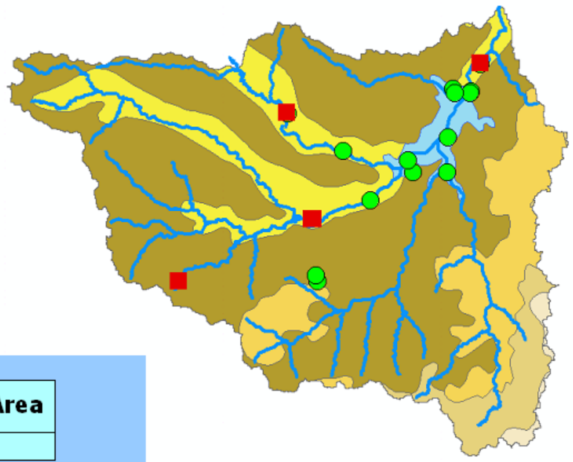




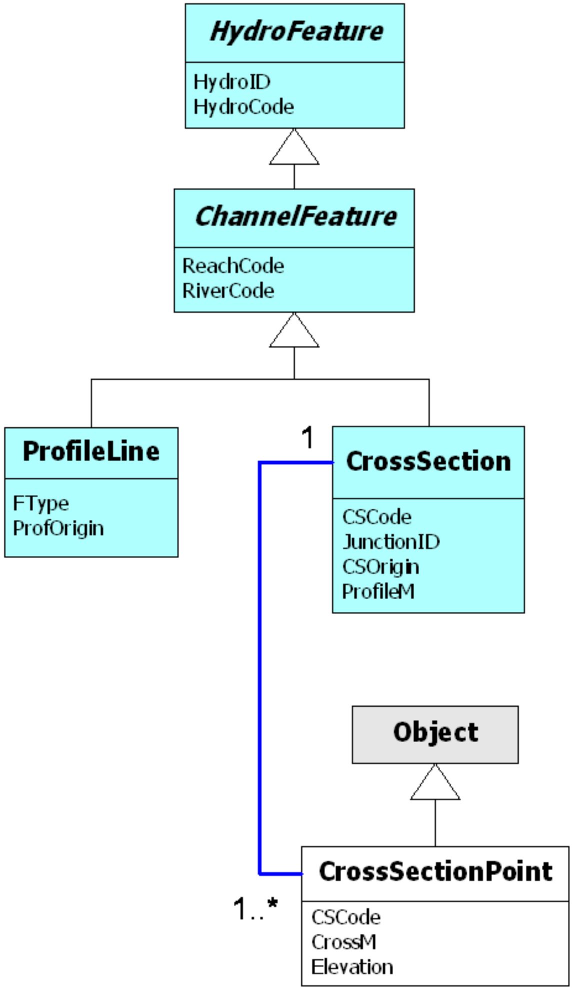
Feature dataset: Channel

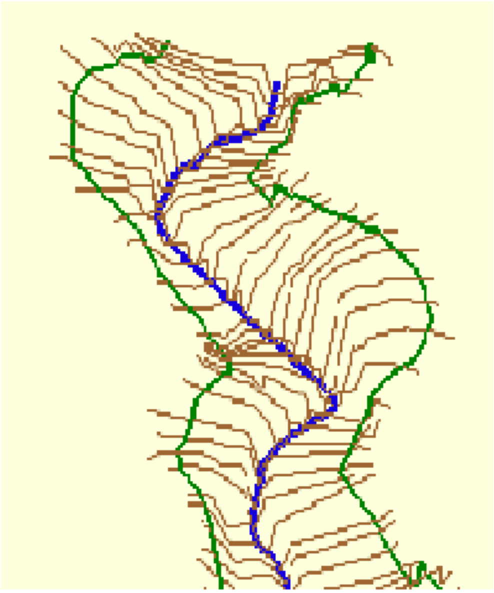
- Contour – Line feature class for elevation
- CrossSection – Line feature class for shape across channel
- ProfileLine – Line feature class for line along channel

Key terms
- Contour
- CrossSection
- ProfileLine

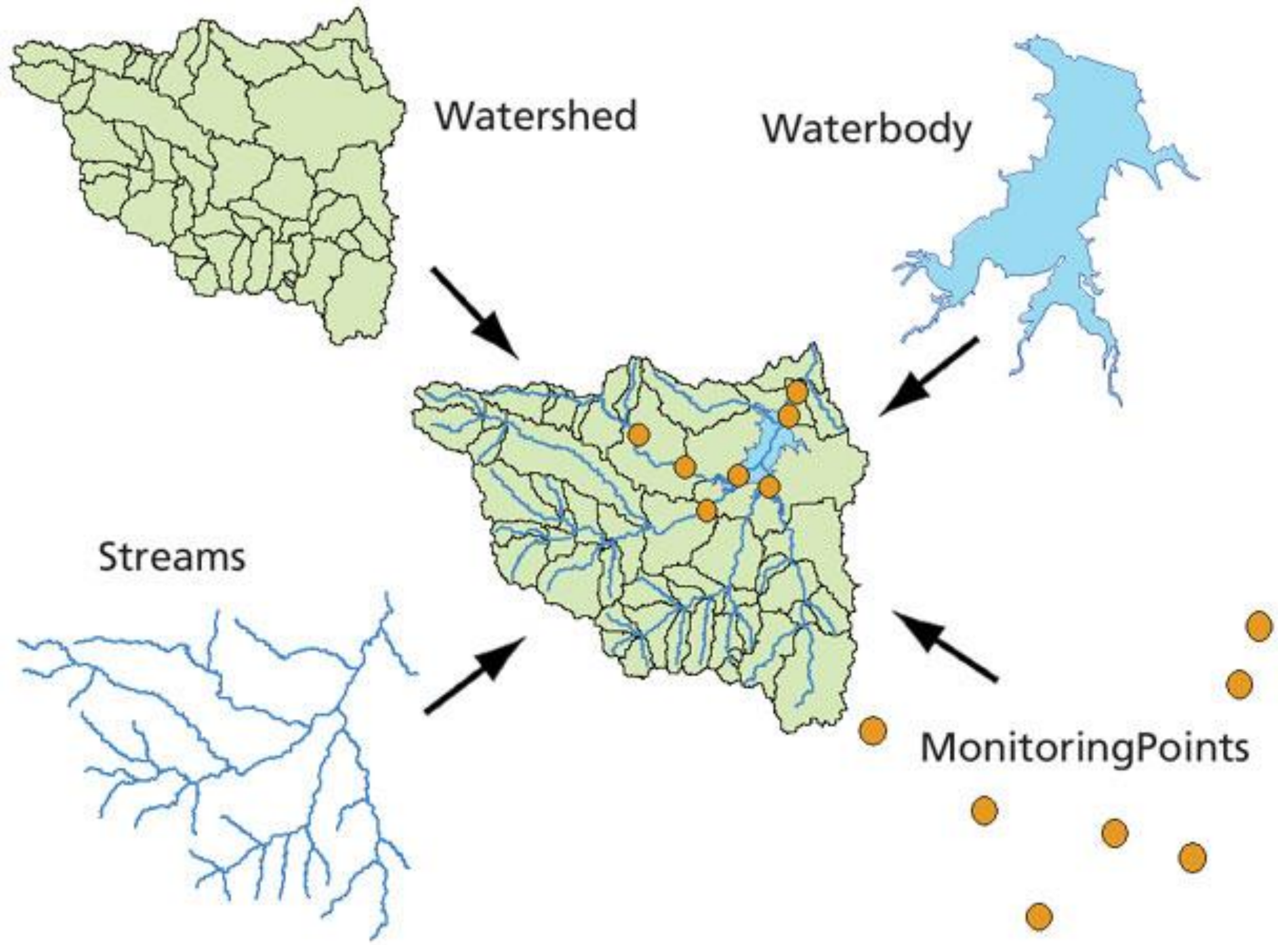
Feature dataset: Channel

More general (basic) classes on top, and more specific classes below. The triangle is a symbol for "generalization" class on top, and "specialization class below.





ArcHydro elements for watersheds (using 4 components)



3. Why identify features with an HydroID domain that spans all feature classes?

HydroID - Unique numerical integer identifier

All features within ArcHydro geodatabase carry HydroID

Different than internally generated feature class ID

Spans all feature classes

Take note of HydroID within class diagram (CD) A&Z page 44

HydroID table dispenses all IDs

Let's look at a few of the more important feature classes on the following slides; the most salient feature classes of ArcHydro…

Key terms
HydroID

HydroEdge

HydroEdges compose HydroNetwork

- logical representation of the blue lines on maps defining streams, rivers, and water bodies
- Centerlines can be drawn through all areal features to create a continuous, single-edge network of the river system.

Geodatabase Diagrammer Diagrams (GDD) for HydroEdge on page A&Z p. 46 & 47

- Flowlines, Shorelines, and Flow Direction.
- Subtypes of HydroEdge : Flowline and Shoreline

HydroEdgeType (red in graphics signifies **coded value domain**)

HydroEdge properties, e.g. ReachCode

- reach refers to stream segments
- segment between two confluences
- Confluence is where reaches (flows) combine at a junction

Key terms
HydroEdges
HydroNetwork

Junctions

HydroJunctions

- Significant point locations in the hydro network
- e.g., outlet of lake or location of monitoring station, etc.
- Attribute includes link to next downstream junction
- Strategic locations where other hydro features are attached

HydroNetwork_Junctions

- Intersection of two edges
- Generic junctions wherever two edges meet

See GDD graphics A&Z page 49

Key terms
HydroJunctions
HydroNetwork_Junctions

Hydro Events

HydroPointEvent

Contain measure value (M) to specify where point is located

HydroLineEvent

An attribute or set of attributes associated with a line segment through measure values (M)

M – measure values are created with linear reference system embedded within the 2D (or 3D) coordinate reference system

For example, distance along the stream from the mouth of a lake is a HydroPointEvent like oil spill, or the length of slick HydroLineEvent

Key terms

Hydro events

Drainage system

Water flows on the landscape, into streams and rivers, and eventually to sea.

Land cover and soil control this flow.

Drainage areas are the patchwork of areas used to model flow to hydro network.

Drainage system – GDD graphic on A&Z p. 53 depict scales of representation

Key terms
Drainage system

Feature creation

ArcHydro data model connects drainage (polygonal) areas to hydro network (logical flow lines)

Defined by line of raster cells, and its outlet is defined by a single cell (called a pour point).

Converting from raster to vector structure creates features for
Catchment, DrainageLine, and DrainagePoint

See GDD graphics on page 54
- Catchment – elementary drainage areas delineated for each segment of a stream or river between confluences, several within a watershed.
- DrainageLine – the point to point of input to output.
- DrainagePoint – outfall from DrainageLine

4. Why work with multiple drainage scales?

Different water flow processes operate at different scales. We use different drainage scales to address water management problems.

No specific quantitative measurement for differentiating among basin (marco), watershed (meso), catchment (micro) units (scales).

Catchments are the smallest areas in a drainage system.

Watersheds and basins are broader scale features than catchments

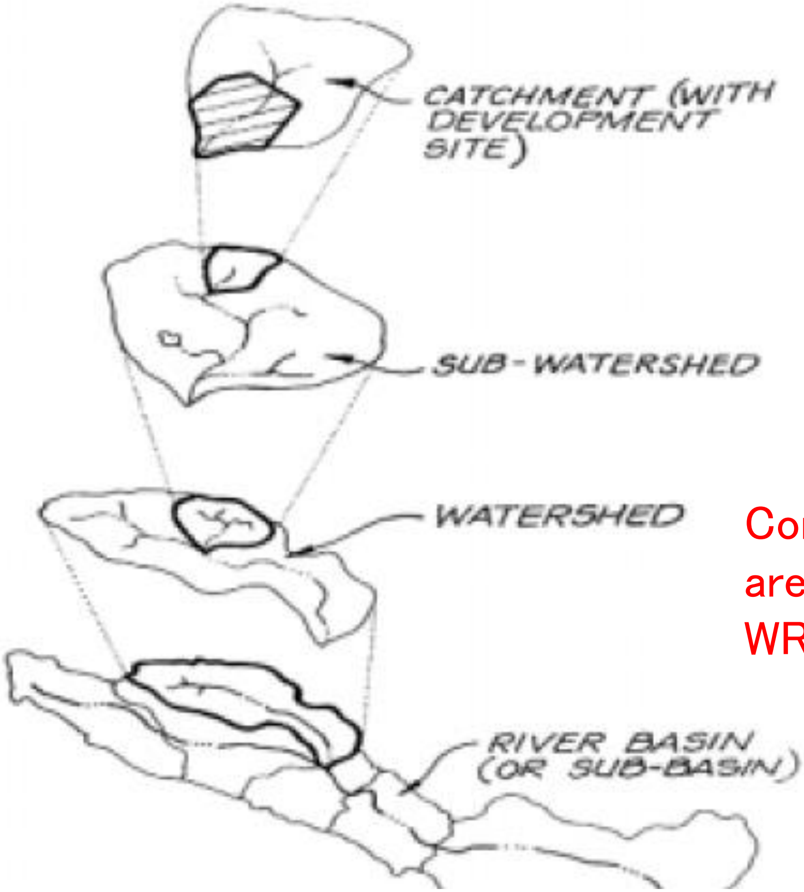
Watershed – subdivision of a landscape embedding catchment, but not always

Basin – the largest scale, often embedding watersheds

See next slide, and GDD graphics on p 55 for Basin & Watershed.

Key terms
Drainage scales

Drainage area nesting (embedding)



Comparable to water resource inventory area (WRIA) scale in lab assignment 1; WRIA 9 has about 100 sub-watersheds

Key terms
Embedding

Nesting of drainage units, each having a different label to help with water management scale (Center for Watershed Protection 1998)

Stream (drainage) Order in the US;
another way to consider drainage area scale

US National Stream and River Mileage (Adapted from Strahler 1957)

Stream Order*	Number of Streams	Total Length of Stream (miles)	Mean Drainage Area (square miles)**
1	1,570,000	1,570,000	1
2	350,000	810,000	4.7
3	80,000	420,000	23
4	18,000	220,000	109
5	4,200	116,000	518
6	950	61,000	2,460
7	200	30,000	11,700
8	41	14,000	55,600
9	8	6,200	264,000
10	1	1,800	1,250,000
Total	2,023,400	3,250,000	N/A

* stream order based on Strahler (1957) method, analyzing maps at a scale of 1:24,000

** cumulative drainage area, including tributaries

Key terms
Stream order

Drainage Topology Rules

A tessellation is a complex covering of an area using a geometry unit

Generally,

- catchments tessellate basins (and usually watersheds)
- watersheds tessellate basins

Drainage points must be coincident with drainage line

Tessellate rule is a compound rule, expressed in three separate rules

- Features must not have gaps
- Features must not overlap other features of the same class
- Features must be covered by a single feature of the feature class it tessellates

See table of rules A&Z page 56
See GDD graphic rendering of rules A&Z page 57

Key terms
Topology Rules

Schematic network representation

Schematic networks provide means of defining connectivity between features without overhead of maintaining full geometry

Simpler network, usually for analysis purpose

Schematic (data) values operationalize the structure for analysis

Schematic behavior

- Analysis behavior of the model – hydrologic modeling

Key terms
Schematic network

Channel cross sections and profile lines

Channel cross sections – shape (of channel traverse) across the channel

Channel profile lines – boundaries of stream channel,
e.g. three ProfileLineTypes
See GDD graphic A&Z p. 61

- Floodline – outer profile line (see slide 19 graphic)
- Bankline – side of stream (not on slide 19 graphic)
- Thalweb – centerline of stream (see slide 19 graphic)

Linear measure (m-coordinate) – measurement from mouth of stream

Key terms
Channel

Hydrographic features – Points

HydroPoint, e.g. gage, well, or spring

Bridge, Dam, Structure

WaterWithdrawl, waterDischarge

MonitoringPoint, UserPoint

See GDD graphics A&Z pages 64 – 67.

Key terms
HydroPoint
MonitoringPoint

Hydrographic features – Lines

Hydroline – lines important for display, not represented by HydroEdge

HydroArea – zones important display purposes, not represented by Waterbody

Waterbody – any significant pond or lake

See GDD graphic A&Z p. 69

Key terms

5. Why bother designing Hydro Response Units?

Polygon/grid features that combine data for rainfall, land cover, soil into a 'unit of water behavior' called Hydro Response Unit (HRU)

Units linking atmospheric and surface processes

Units linking surface and subsurface processes

Rainfall is characterized using Nexrad Doppler Radar data in grid form
Nexrad sites: http://www.roc.noaa.gov/WSR88D/Maps.aspx
For longer term precip (climate) See PRISM at Oregon State U

See GDD graphic A&Z p. 70 for HRU characterization

Unit response can depend upon

Land cover/use and soil type influence permeability

Soil Conservation Service Curve Numbers parameterize response

Soil permeability reduces runoff

Impervious surface increases runoff

Key terms
Unit response

6. What are the types of time series?

Six types of time series, particularly in relation to HRU's

1. Instantaneous data – condition at a given instant in time
2. Cumulative data – accumulated amount since the beginning of keeping the time
3. Incremental data - difference in beginning and ending vales within an interval
4. Average data – Average rate over a time interval; calculated as incremental value divided by duration of data interval.
5. Maximum data – Maximum value of a variable within the time interval
6. Minimum data - Minimum value of a variable within the time interval

Key terms
Time series

Time Series – three main aspects of every time series

Location in space (space)

Location in time (time)

Classification of type of observation (attribute)

See GDD graphic A&Z p. 73

- Purple signifies a feature type (akin to feature class)
- Green signifies a relationship between Types
- Red signifies coded value domain

Time Series Software Tools

- ArcHydro Tools – available for download from Texas Water Resources Institute (TWRI)

- ArcGIS Tracking Analyst tool can track nexrad data and water quality data

- Danish Hydrographic Institute (DHI) – ArcHydro tools to analyze watershed flow

Maidment's Group at TWRI provides many lessons learned for various series.

Time series – sequence of time and attribute observations

Attribute series – sequence for a specific feature

Feature series - feature changes geometry over time

Raster series – for raster and time attributes (Raster Catalog)

Key terms
Time Series
Attribute Series
Feature Series
Raster Series

Temporal geoprocessing – flood inundation

Times series for a specific location on the ground, with such locations being affected by a temporal event (stormwater)

Attribute series - Perform spatial interpolation across all values, given the time increments

Raster series - Raster classification and conversion to **feature series** polygons (shape, value, time)

Zonal statistics calculations (Depths and extremes)

See GDD graphic A&Z p. 77

Key terms
Temporal geoprocessing

Summary

In this lesson, you learned about…

1. Four components of a geographic coordinate system
2. Four ArcHydro feature datasets
3. Identifying features with an HydroID domain that spans all feature classes
4. Working with multiple drainage scales
5. Designing hydro response units
6. Types of time series data

Contact me at nyerges@uw.edu if you have questions or comments about this lesson.

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END Lesson 4: Geodatabase Models for Reference Systems and ArcHydro