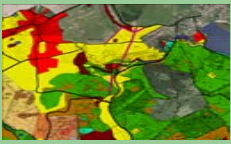




Geospatial analysis in GIS

integrating data
for hydrologic applications
by means of **ArcGIS** software

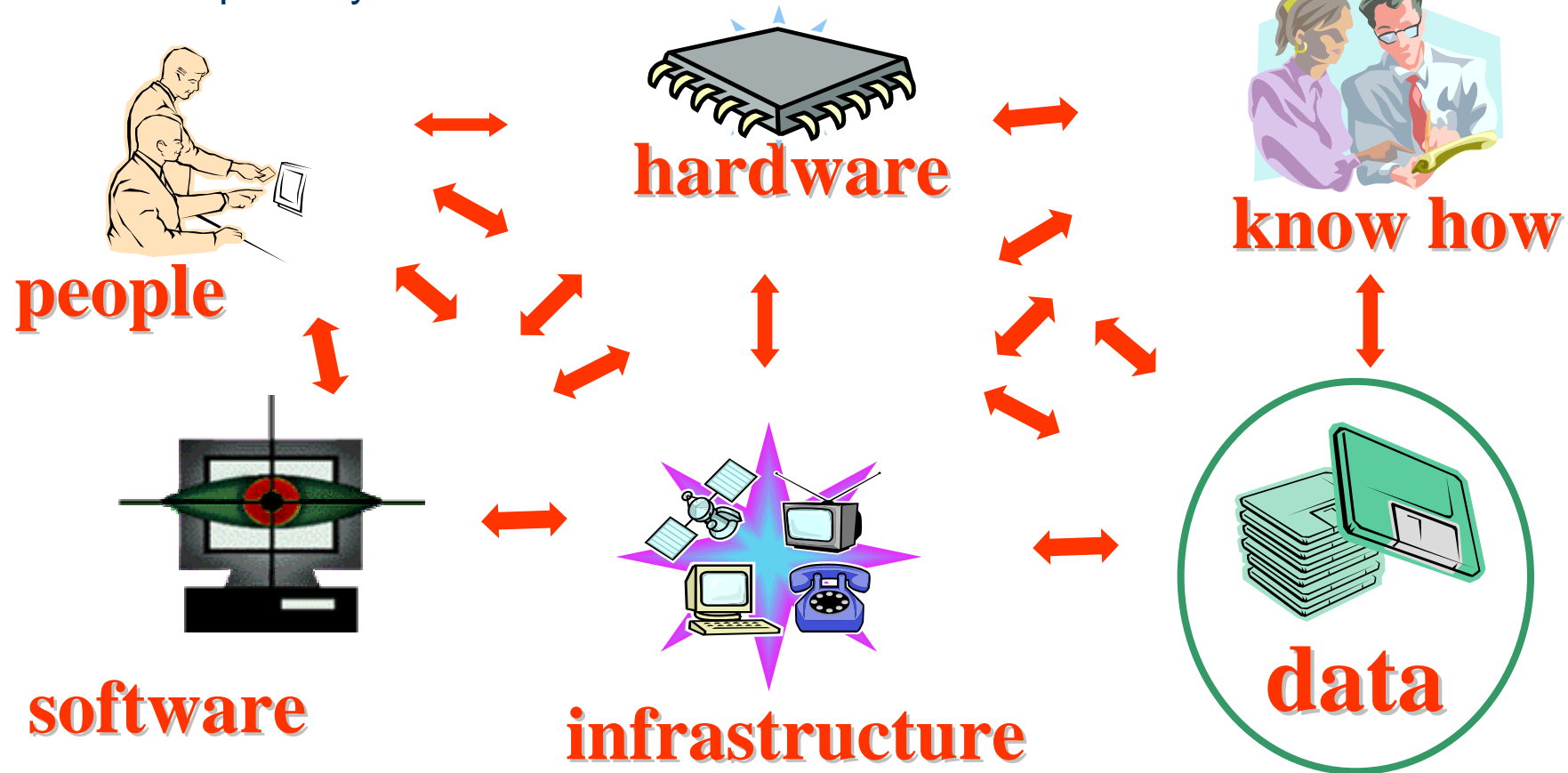


Materials for this lecture are compiled using:

- Arctur, D. & Zeiler, M. 2004. Designing Geodatabases. Case Studies in GIS Data Modeling. ESRI Press, 393 pp
- *ESRI ArcGIS documentation* [manuals of different versions]
- Maidment, D.R. (ed.) 2002. ArcHydro: GIS for Water Resources. ESRI Press, 203 pp. + **CD**
- Roosaare, J. 2004. Geoinformaatika. Kaitseväe Ühendatud Õppeasutuse õppevahend. Tartu, 172 pp. + **CD**

GIS is geospatial INFORMATION SYSTEM

- IS = computer system + its environment

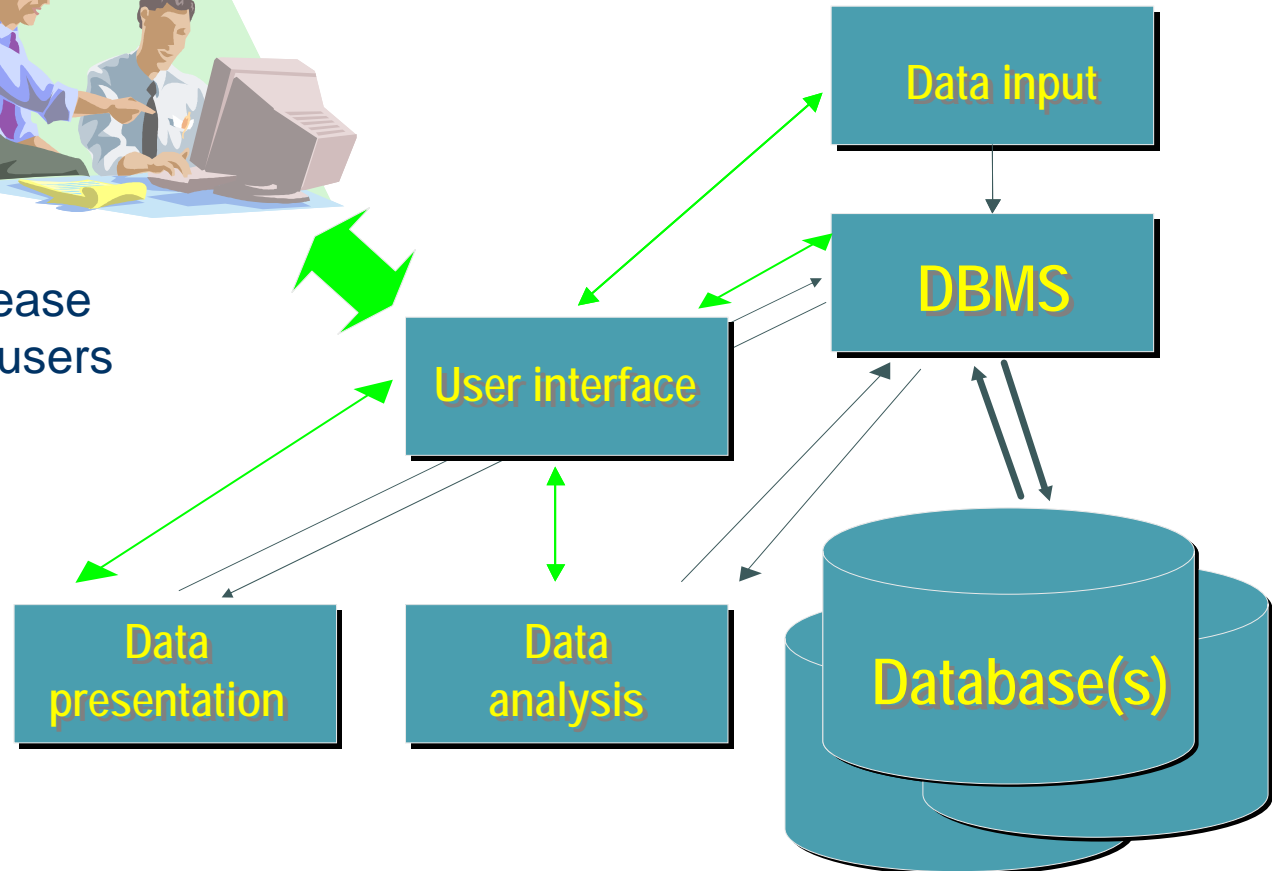


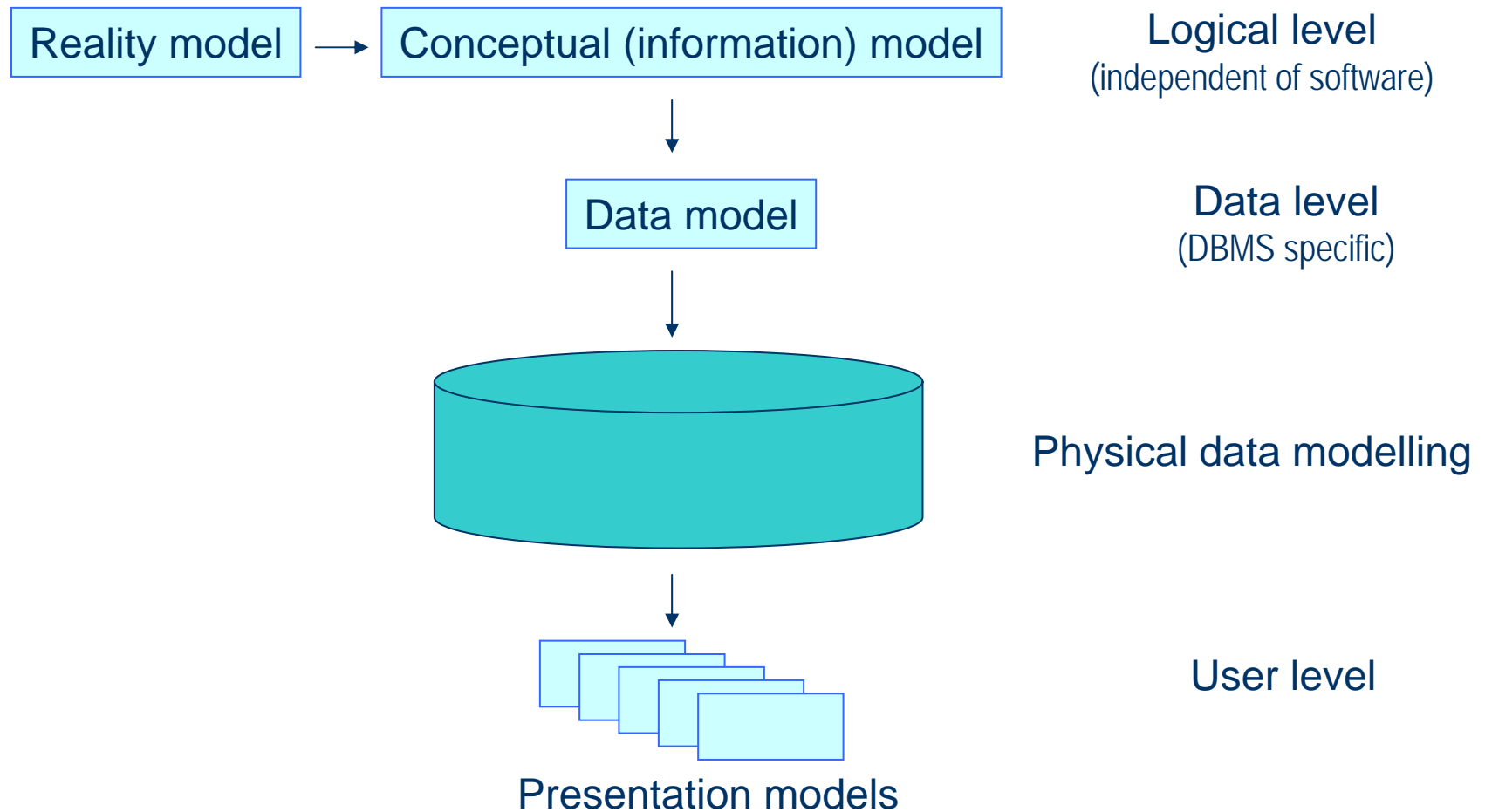
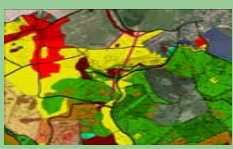
Geospatial analysis in GIS

- **database** is an organised collection of logically related data
- data have to be processed to gather **information**



- in order to increase **knowledge** of users

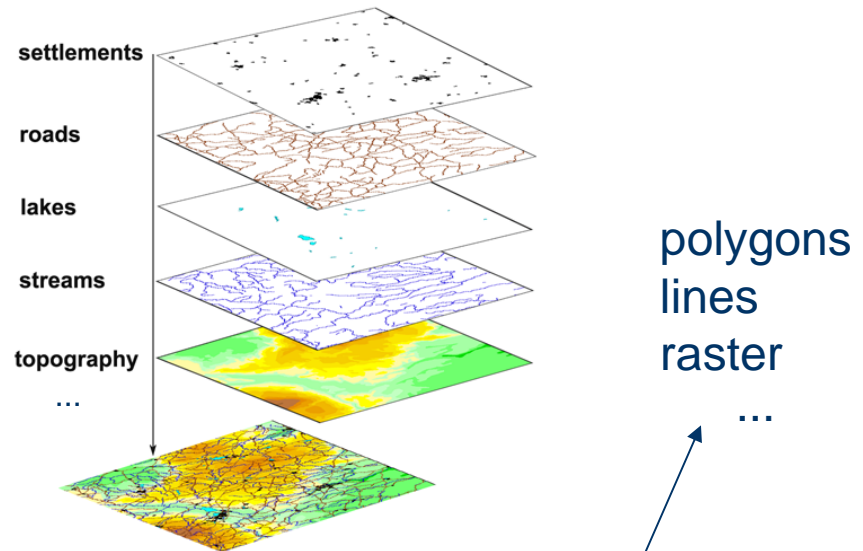






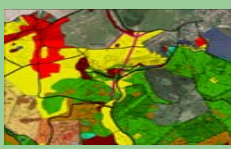
Reality model

Conceptual (information) model



Thematic layers (themes)

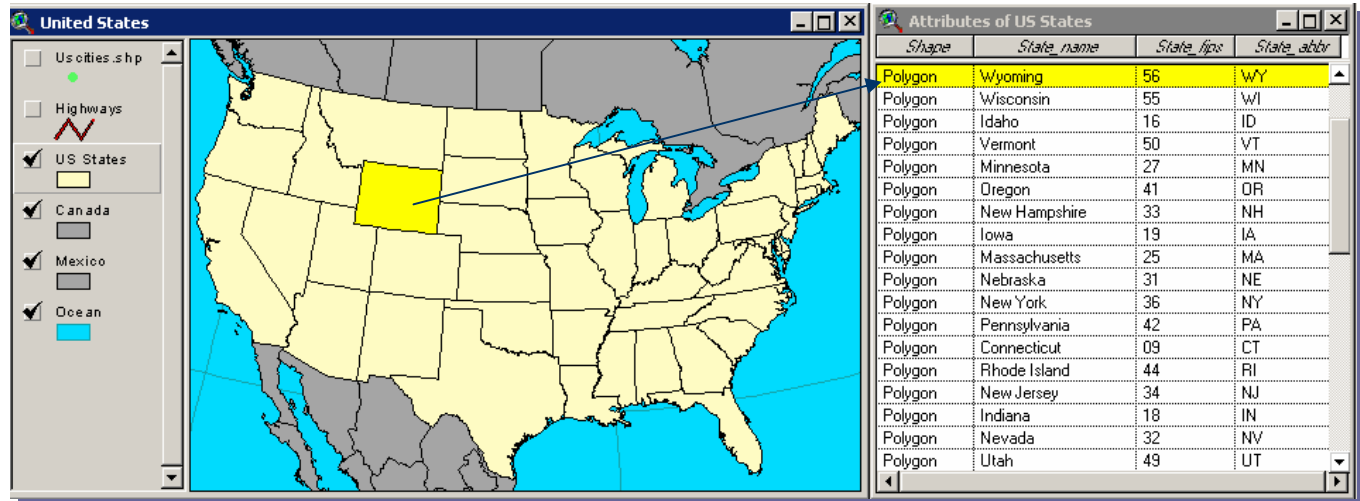
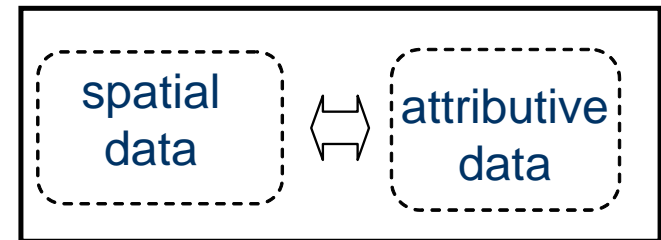
– a key concept in GIS. A thematic layer is a collection of common geographic elements. Each theme may have its own geographic representations.



→ Data model

● georelational data model

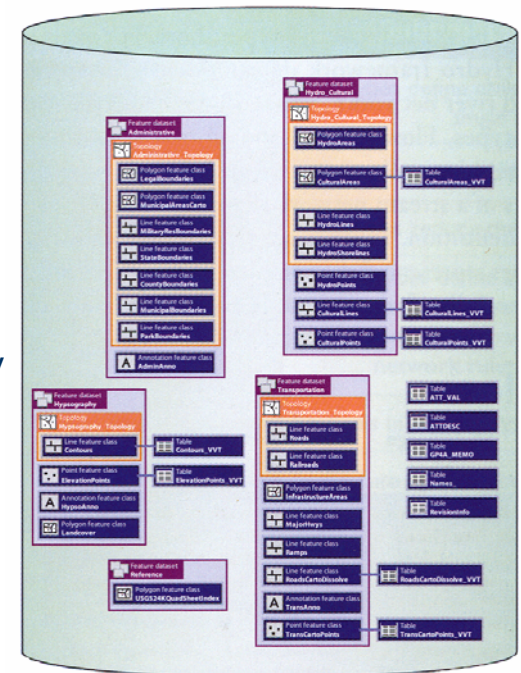
- spatial data and attributive data separately
- e.g. **shapefiles**:
 - vector data for the features in binary files (.shp)
 - attributes in a data table (.dbf)
 - unique identifiers are used to link them to each other.

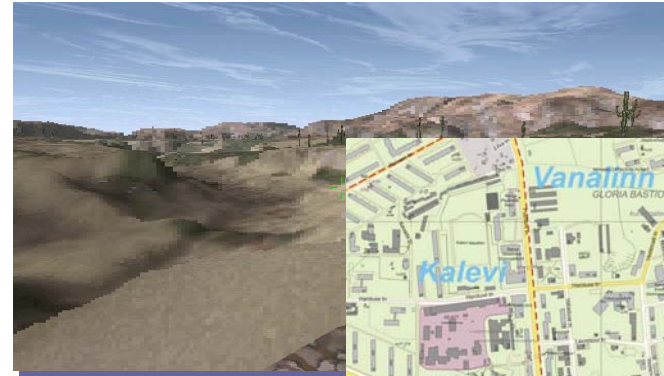




→ Data model

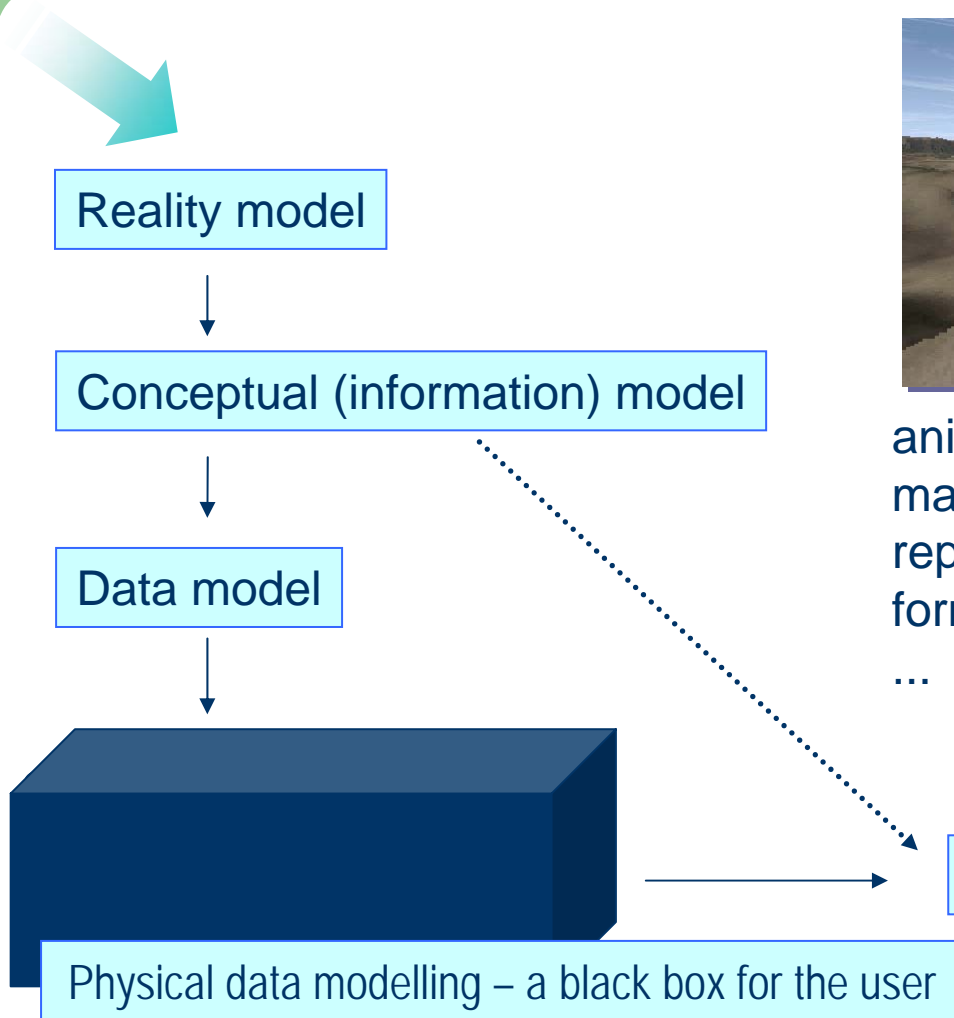
- georelational data model
- **geodatabase data model**
 - all elements are managed in standard DBMS tables using standard SQL data types
 - object-based
 - features, rasters, tables, references etc
 - altogether in a container file (.mdb) as a **database**
 - objects can have built-in behaviour (objects encapsulation)
 - each table stores a feature class
 - each feature is a row in that table
 - spatially large feature classes can be stored seamlessly not tiled.





animations
maps
reports
forms
...


Lageraiaela	
Lagera	
Kuupäev:	
Inventee	
Metsatea	
Maaüksuse nimi:	valida
Kinnistu nr:	5859
Katastri nr:	13328:828:2147
Metsateatise aasta:	2000
Teatatud eraldised:	
Teatatud pindala (ha):	1
Valdav kasvukohatüüp:	Angervaksa
Koosseisu valem:	
Tegelik langi pindala (ha):	1
Raiatud eraldised:	
Uuenenud või uueneva langi (osa) pindala (ha):	1
Kas langil (osal) on teostatud:	Istutus: ja Külv: ei




ArcGIS geodatabase model




- datasets


 **Feature dataset**

Contains spatially related feature classes together with the topology and network objects that bind them. Feature classes in a feature class collection have a common spatial reference.


 **Feature class**

 **Topology**

Integrity rules that define the behavior of geographically integrated features.

 **Network**



Rules for managing connectivity among features in a set of feature classes.



 **Raster dataset**


Contains rasters representing continuous geographic phenomena. Raster data can be stored as either a raster dataset or a multirow raster catalog.

 **Survey dataset**

Comprehensive survey measurements used to manage computation networks. Can be linked to and used to update feature coordinates.

 **Survey points**  **Coordinates**

 **Measurements**  **Computations**

 **Metadata document**

A metadata document can be associated with every dataset in the GIS database.

		XML

ArcGIS geodatabase model



Feature dataset

Contains spatially related feature classes together with the topology and network objects that bind them. Feature classes in a feature class collection have a common spatial reference.

Feature class

A table with a shape field containing point, line, or polygon geometries for geographic features. Each row is a feature.

Predefined fields		User-defined fields		
ObjectID	Shape			

← Features

Subtype	Default	Domain

Subtypes let you discriminate types of features in a feature class to control fine-grained behavior through attribute rules, topology rules, network rules, and relationship rules.

Topology

Integrity rules that define the behavior of geographically integrated features.

Table

A collection of rows, each containing the same fields. Feature classes are tables with shape fields.

Predefined fields		User-defined fields		
ObjectID				

← Rows

Domain ↑ Columns
Defines a set or range of valid values for a field.

Code	Description
0	
1	
2	

Relationship

Associates objects from a feature class or table to objects in another feature class or table. Relationships can have user-defined attributes.

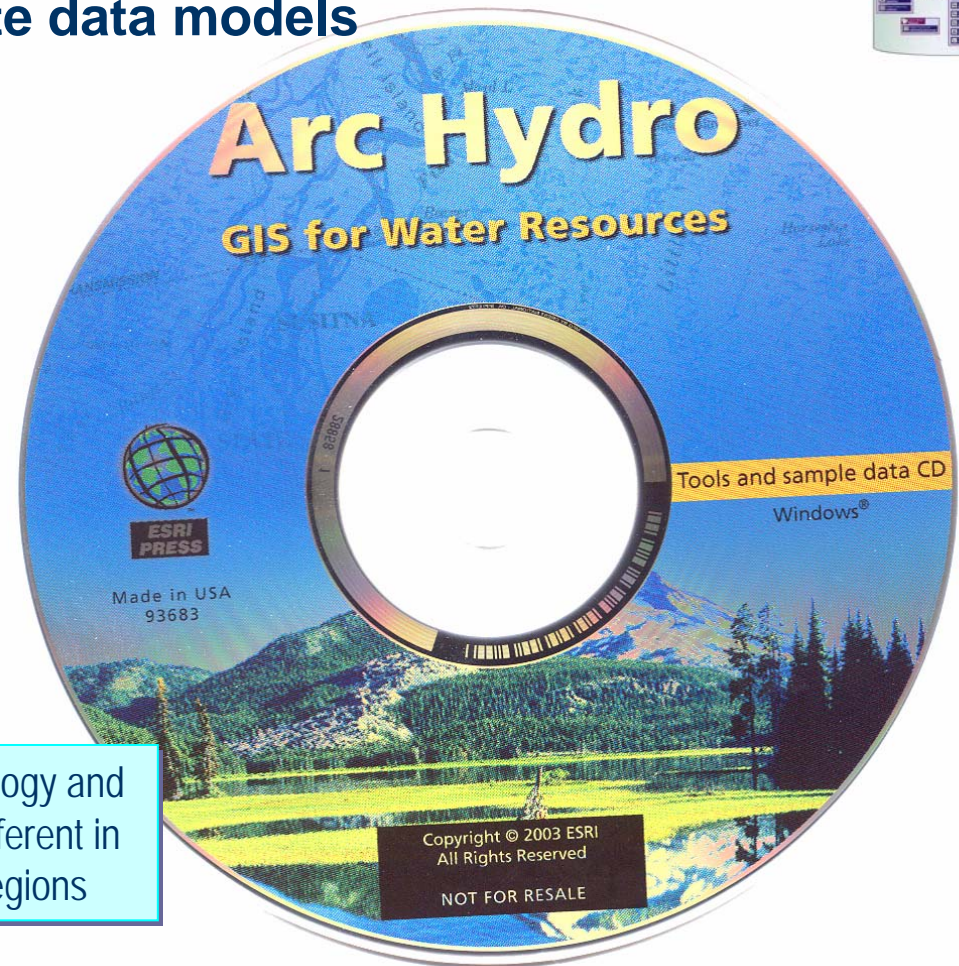
Primary key	Foreign key		

ArcGIS geodatabase model

- ArcGIS has several **template data models**

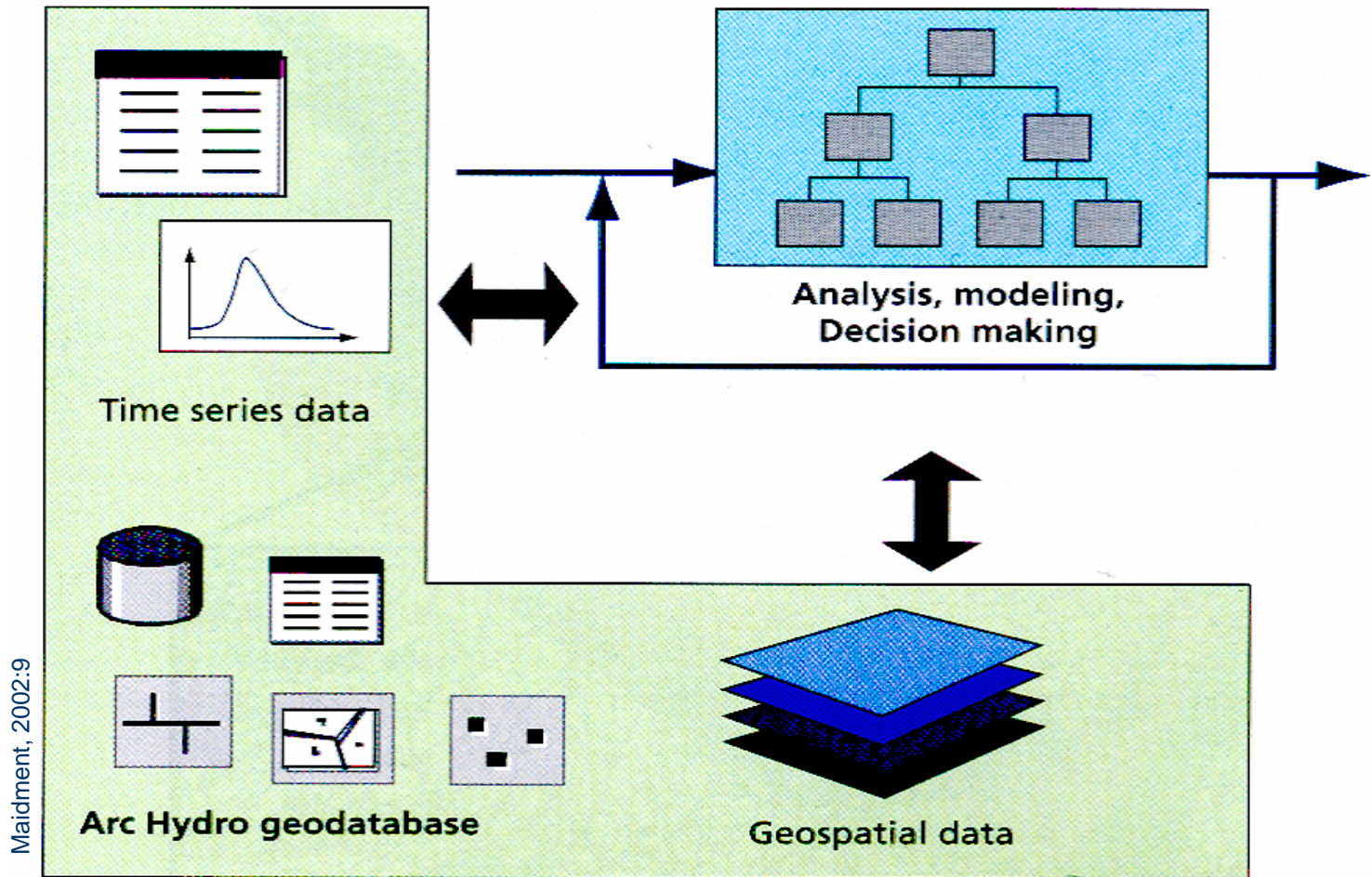
- census units
- addresses and locations
- land cadastre
- transportation networks
- **hydrography**
 - data on water resources
inventory approach
 - water as “blood” of landscape
behavioural approach

Definitions of hydrology and hydrography are different in different scientific regions



Geospatial analysis in GIS

Hydrologic information system



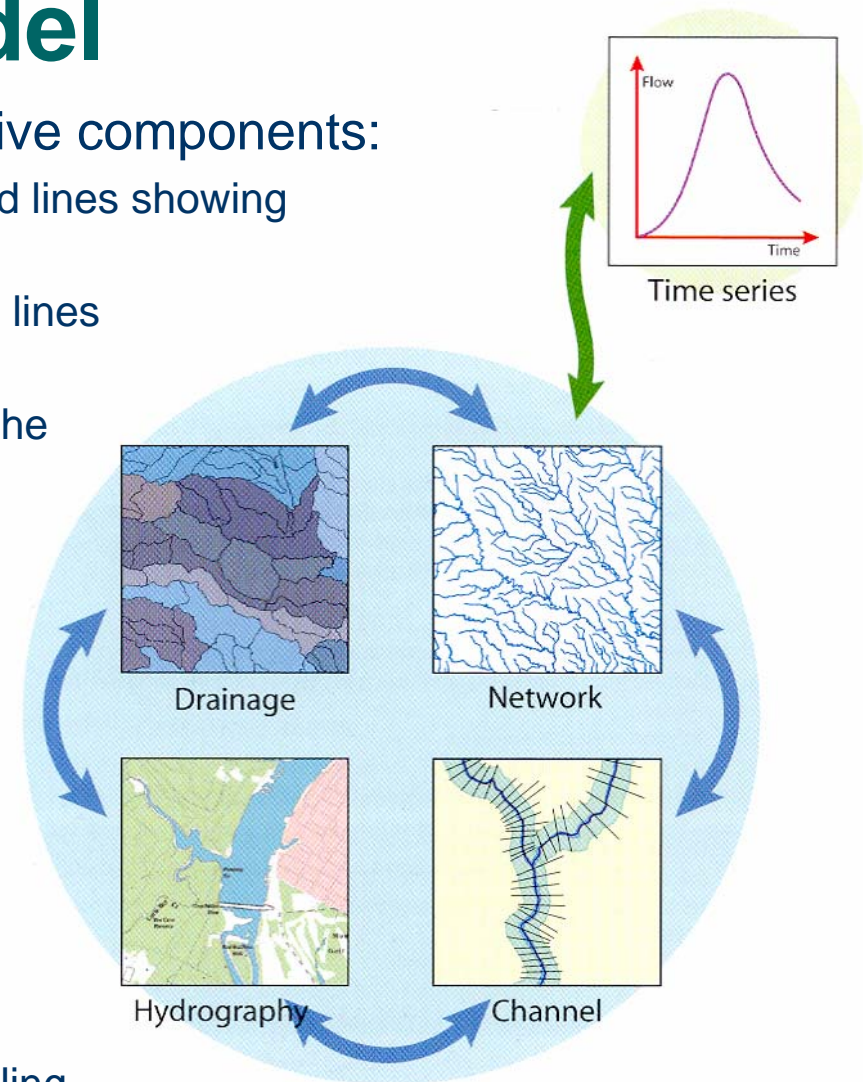
Maidment, 2002:9

A hydrologic information system connects time series and geospatial data with hydrologic analysis and modeling

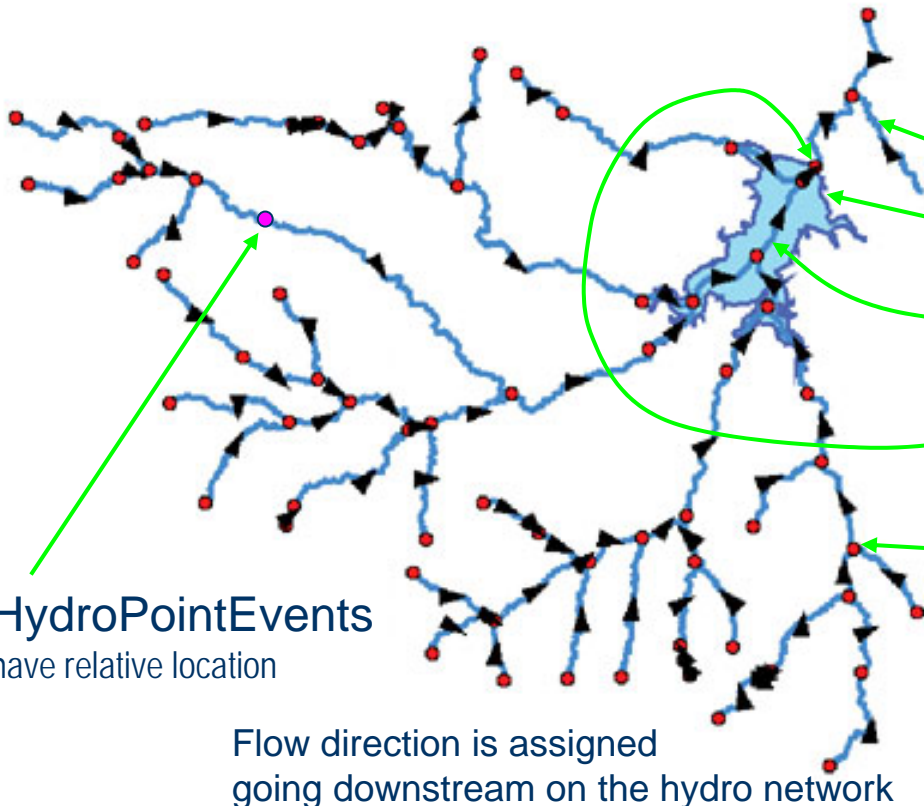
extra topic

Arc Hydro data model

- Divides water resources data into five components:
 - **Network** – connected sets of points and lines showing pathways of water flow.
 - **Drainage** – drainage areas and stream lines defined from surface topography.
 - **Channel** – a 3D line representation of the shape of river and stream channels.
 - **Hydrography** – the base data from topographic maps and tabular data inventories.
 - **Time series** – tabular attribute data describing time-varying water properties for any hydro feature
- Does not describe constructed water pipe systems
- Has an associated set of tools
 - to support hydrologic simulation modelling



Feature dataset *Network*



HydroPointEvents
have relative location

Flow direction is assigned
going downstream on the hydro network

Streams hierarchy may be
ordered in different ways
(Horton's, Strahler's etc.)

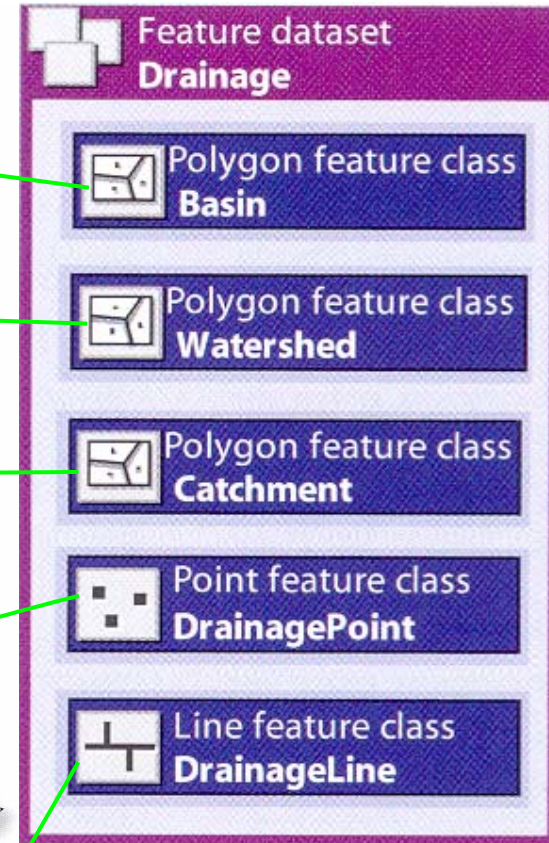
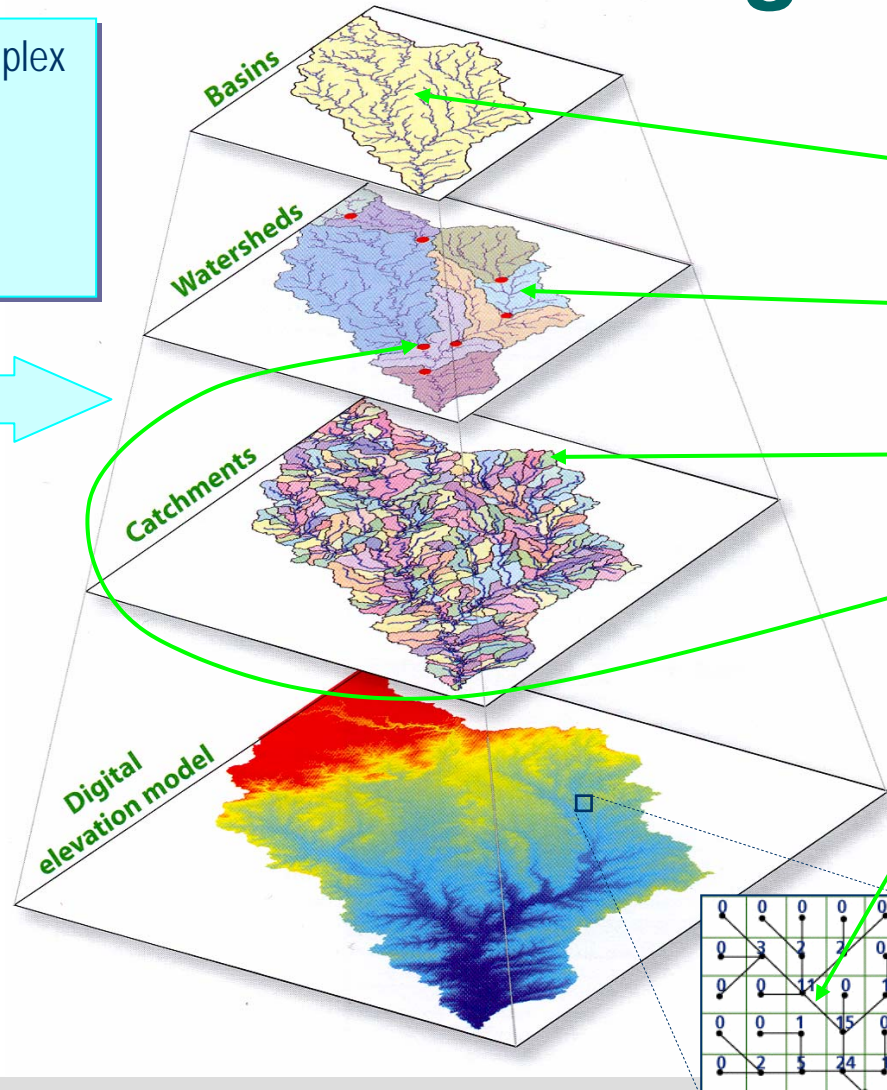
Feature dataset
Network

- Complex edge feature class
HydroEdge
Subtypes: Shoreline, Flowline
- Simple junction feature class
HydroJunction
- Simple junction feature class
HydroNetwork_Junctions
- Line feature class
SchematicLink
- Point feature class
SchematicNode

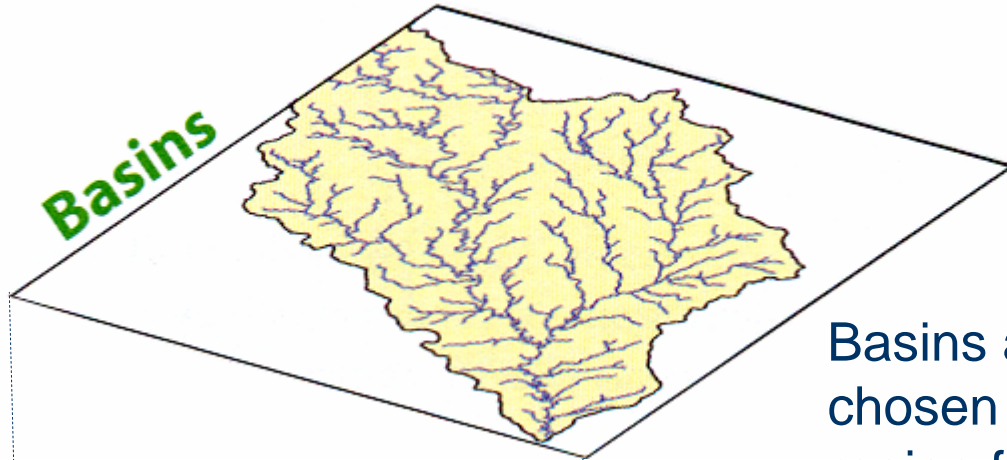
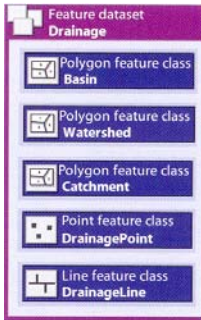
Feature dataset *Drainage*

Drainage areas have complex hierarchy and different definitions

- to simplify
- to standardise

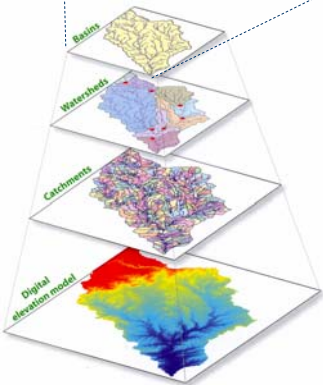


Feature dataset *Drainage*



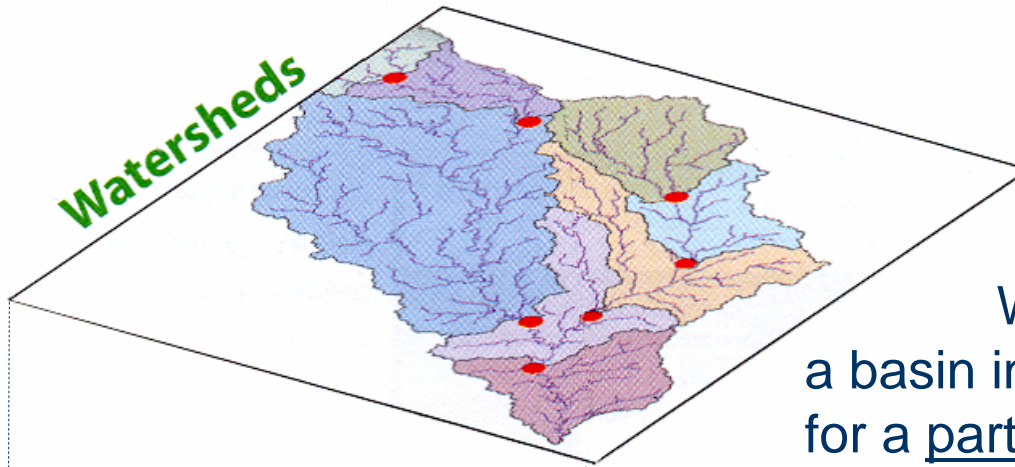
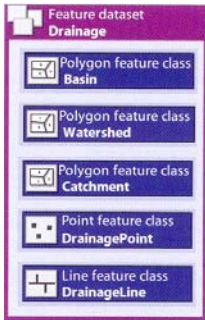
Basins are set of administratively chosen drainage areas that partition a region for purposes of water resources management.

Basins are normally named after the principal rivers and streams of the region.

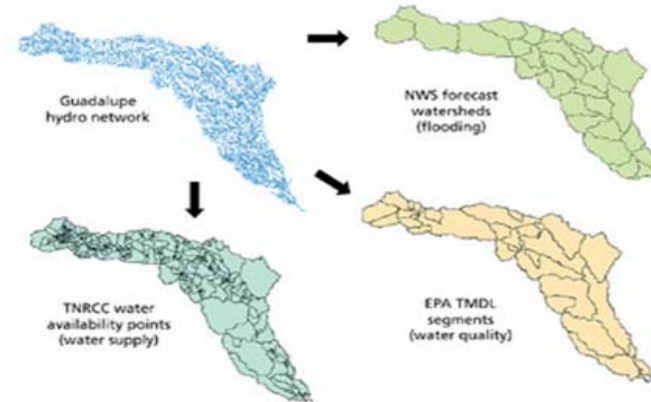


an ArcHydro geodatabase for each basin

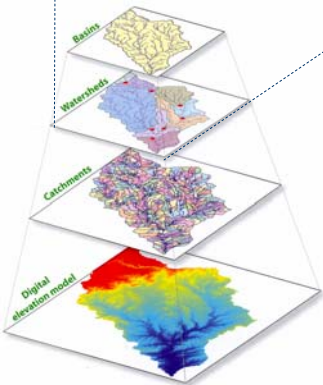
Feature dataset *Drainage*








Watersheds are subdivision of a basin into drainage areas selected for a particular hydrologic purposes.



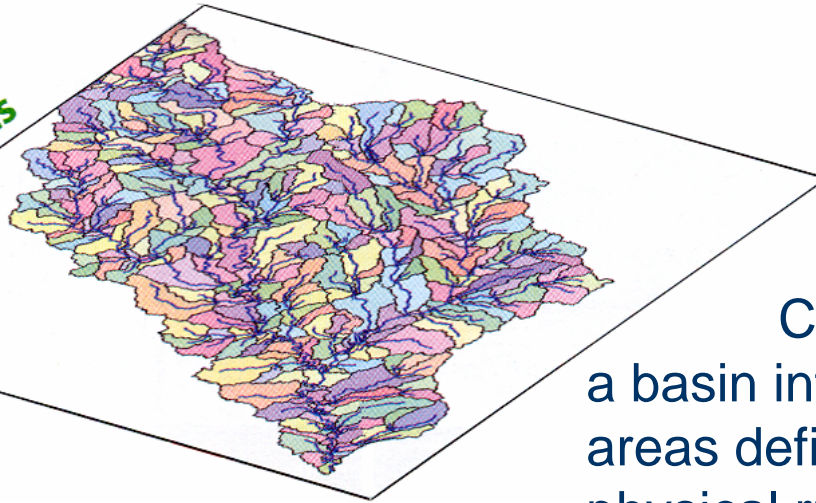
the same network may have different watersheds



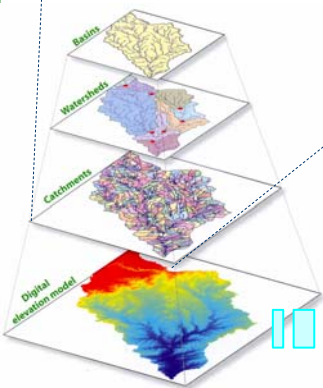
Feature dataset *Drainage*

Feature dataset Drainage	
	Polygon feature class Basin
	Polygon feature class Watershed
	Polygon feature class Catchment
	Point feature class DrainagePoint
	Line feature class DrainageLine

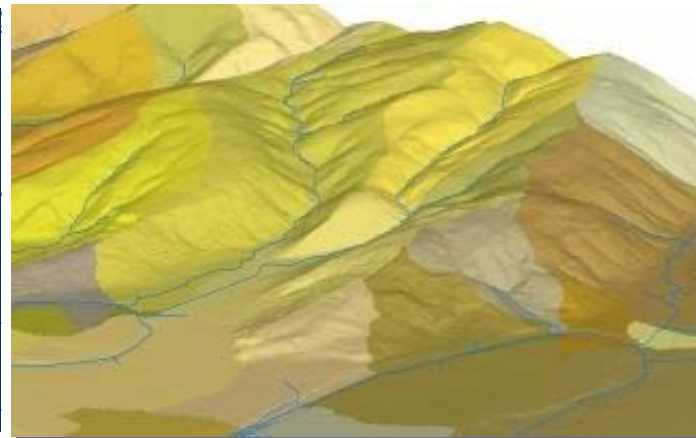
Catchments



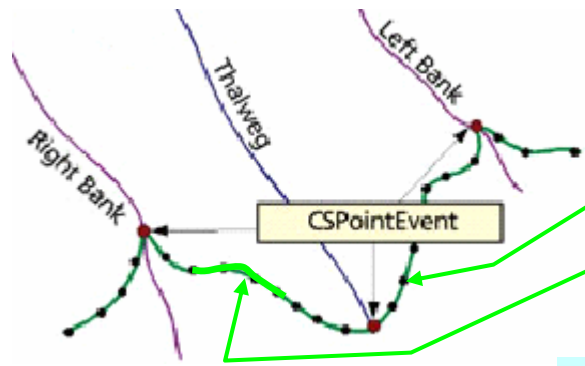
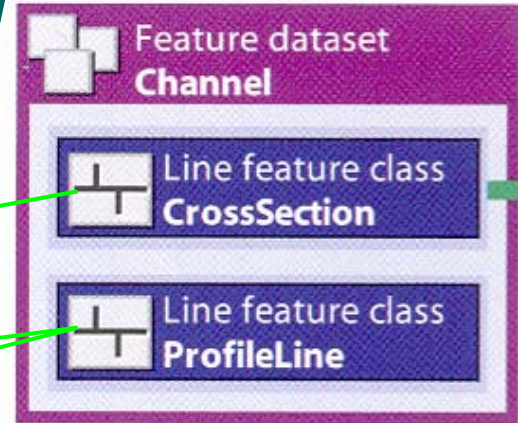
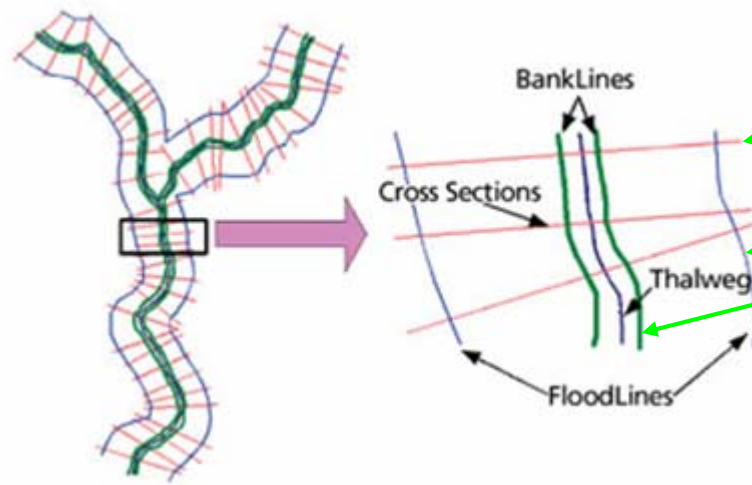
Catchments are subdivision of a basin into **elementary** drainage areas defined by a consistent set of physical rules.



<http://www.dop.co.nz/files/images/GIS/Watershed1.jpg>

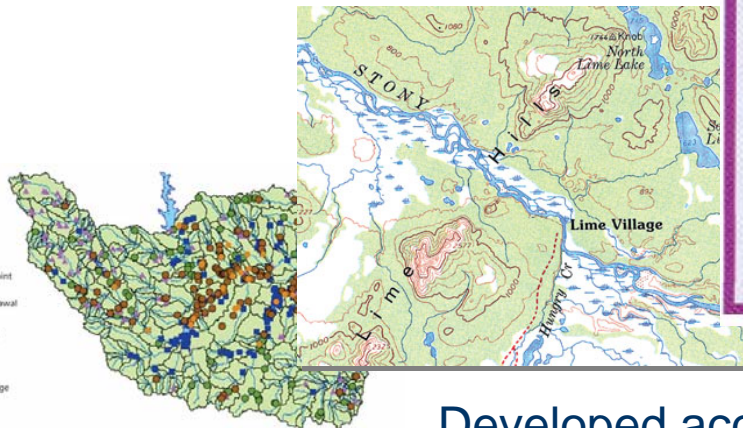
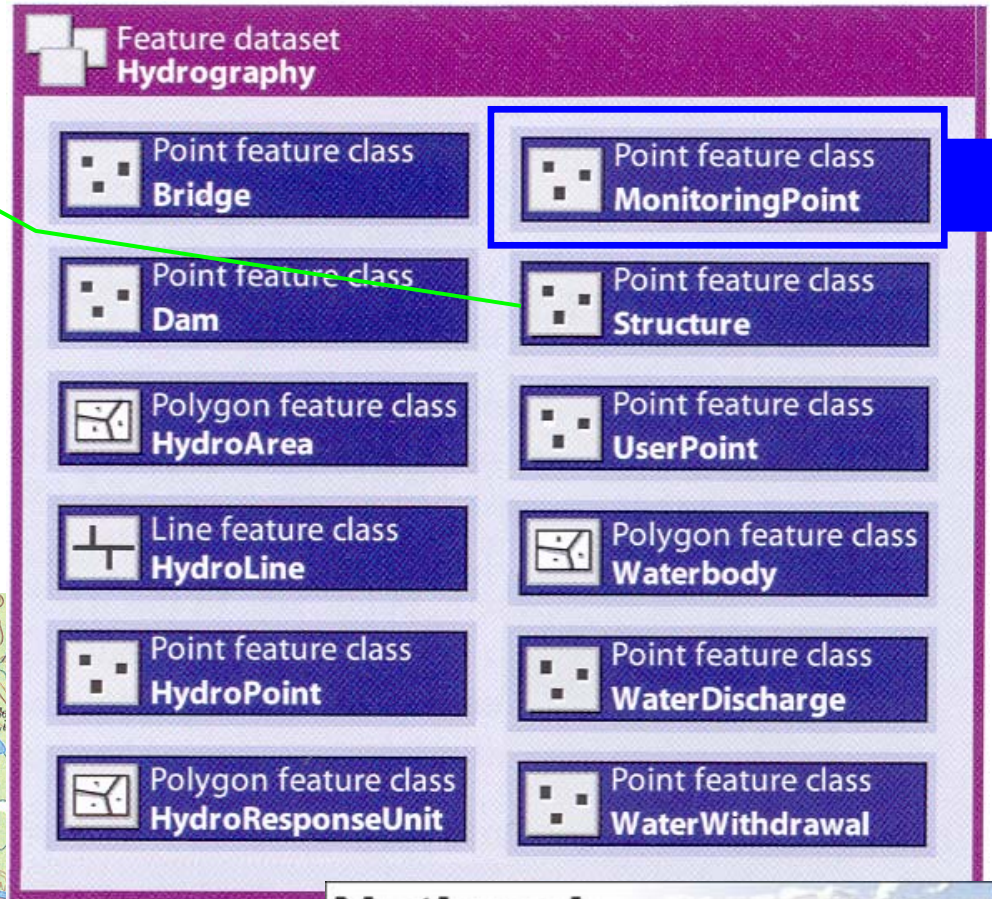


Feature dataset *Channel*



Bridge, Dam, ..., UserPoint

Feature dataset *Hydrography*

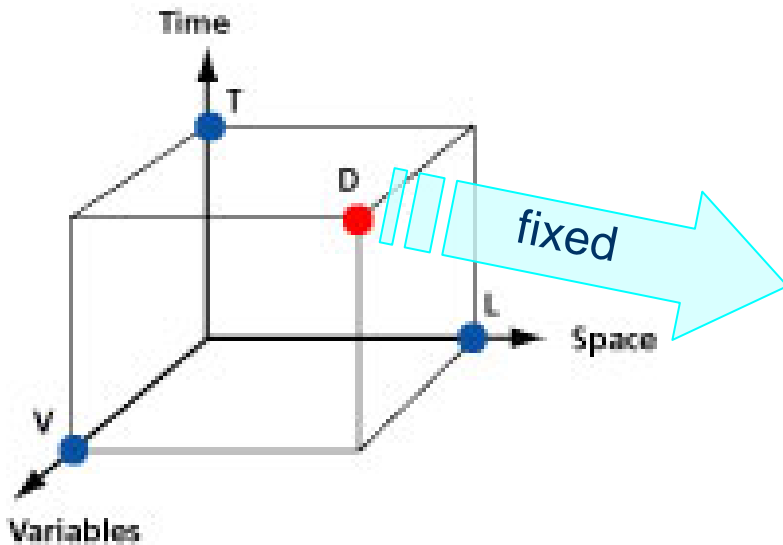
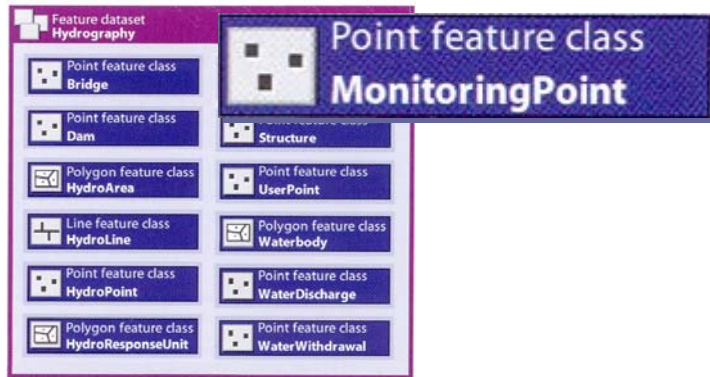


Developed according to US

**National
Hydrography
Dataset**



Time series data



variables

points

time



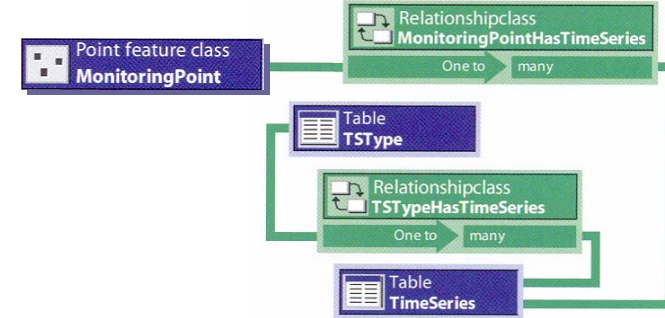
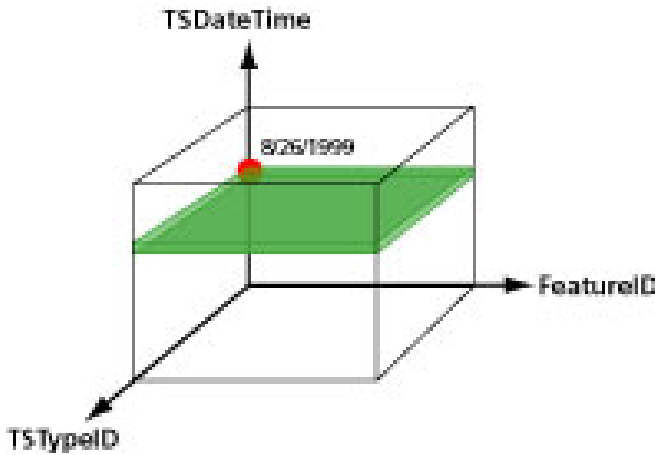
OBJECTID	FEATUREID	TSTYPEID	TSDATETIME	TSVALUE
324537	12000017	1	1/8/26/1999	126
351074	12000019	1	1/8/26/1999	310
403594	12000022	1	1/8/26/1999	140
415132	12000024	1	1/8/26/1999	523
439238	12000026	1	1/8/26/1999	6.9

OBJECTID	FEATUREID	TSTYPEID	TSDATETIME	TSVALUE
324537	12000017	1	1/8/26/1999	126
351074	12000019	1	1/8/26/1999	310
403594	12000022	1	1/8/26/1999	140
415132	12000024	1	1/8/26/1999	523
439238	12000026	1	1/8/26/1999	6.9
485278	12000033	1	1/8/26/1999	762
502625	12000035	1	1/8/26/1999	4.5
504128	12000001	2	2/26/1999	6.9
504425	12000002	2	2/26/1999	5.7
504427	12000003	2	2/26/1999	2.1

OBJECTID	FEATUREID	TSTYPEID	TSDATETIME	TSVALUE
324537	12000017	1	1/8/26/1999	126
351074	12000019	1	1/8/26/1999	310
403594	12000022	1	1/8/26/1999	140
415132	12000024	1	1/8/26/1999	523
439238	12000026	1	1/8/26/1999	6.9
485278	12000033	1	1/8/26/1999	762
502625	12000035	1	1/8/26/1999	4.5
504128	12000001	2	2/26/1999	6.9
504425	12000002	2	2/26/1999	5.7
504427	12000003	2	2/26/1999	2.1



Time series data

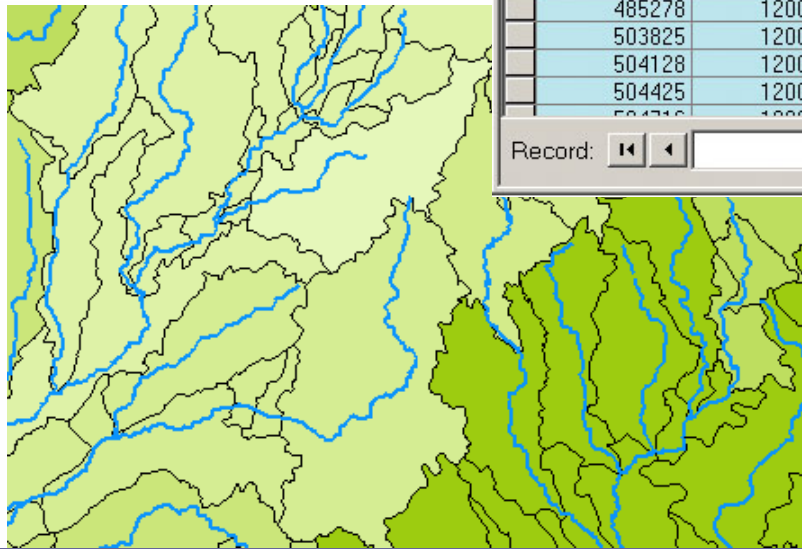


Selected Attributes of TimeSeries

OBJECTID	FEATUREID	TSTYPEID	TSDATETIME	TSVALUE
324537	12000017	1	8/26/1999	126
351074	12000019	1	8/26/1999	310
403594	12000022	1	8/26/1999	140
415132	12000024	1	8/26/1999	523
439236	12000026	1	8/26/1999	6.9
455948	12000030	1	8/26/1999	3.4
485278	12000033	1	8/26/1999	762
503825	12000035	1	8/26/1999	4.5
504128	12000001	2	8/26/1999	6.9
504425	12000002	2	8/26/1999	5.7

Record: 1 Show: All Selected Records (36 out of 12716 Selected.)

- < 10
- 10 - 20
- 20 - 40
- 40 - 60
- 60 - 80
- 80 - 100
- 100 - 150
- 150 - 200
- 200 - 250
- 250 - 300
- 300 - 350
- 350 - 400
- 400 - 450
- 450 - 500
- 500 - 600
- 600 - 700
- 700 - 800

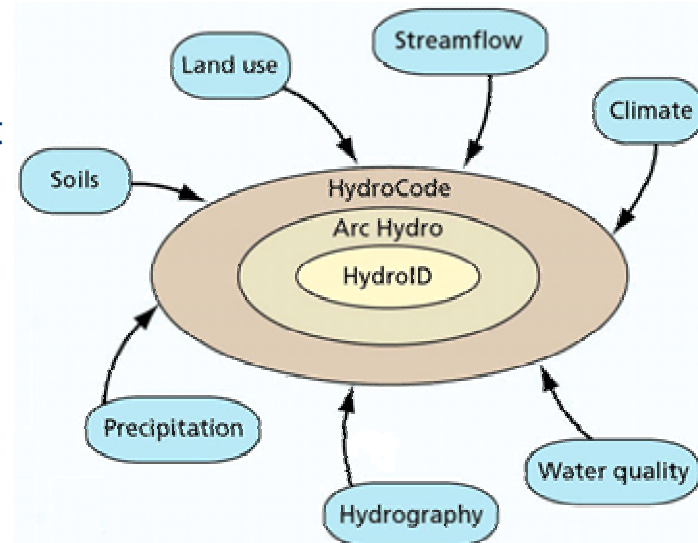


ID-s for features

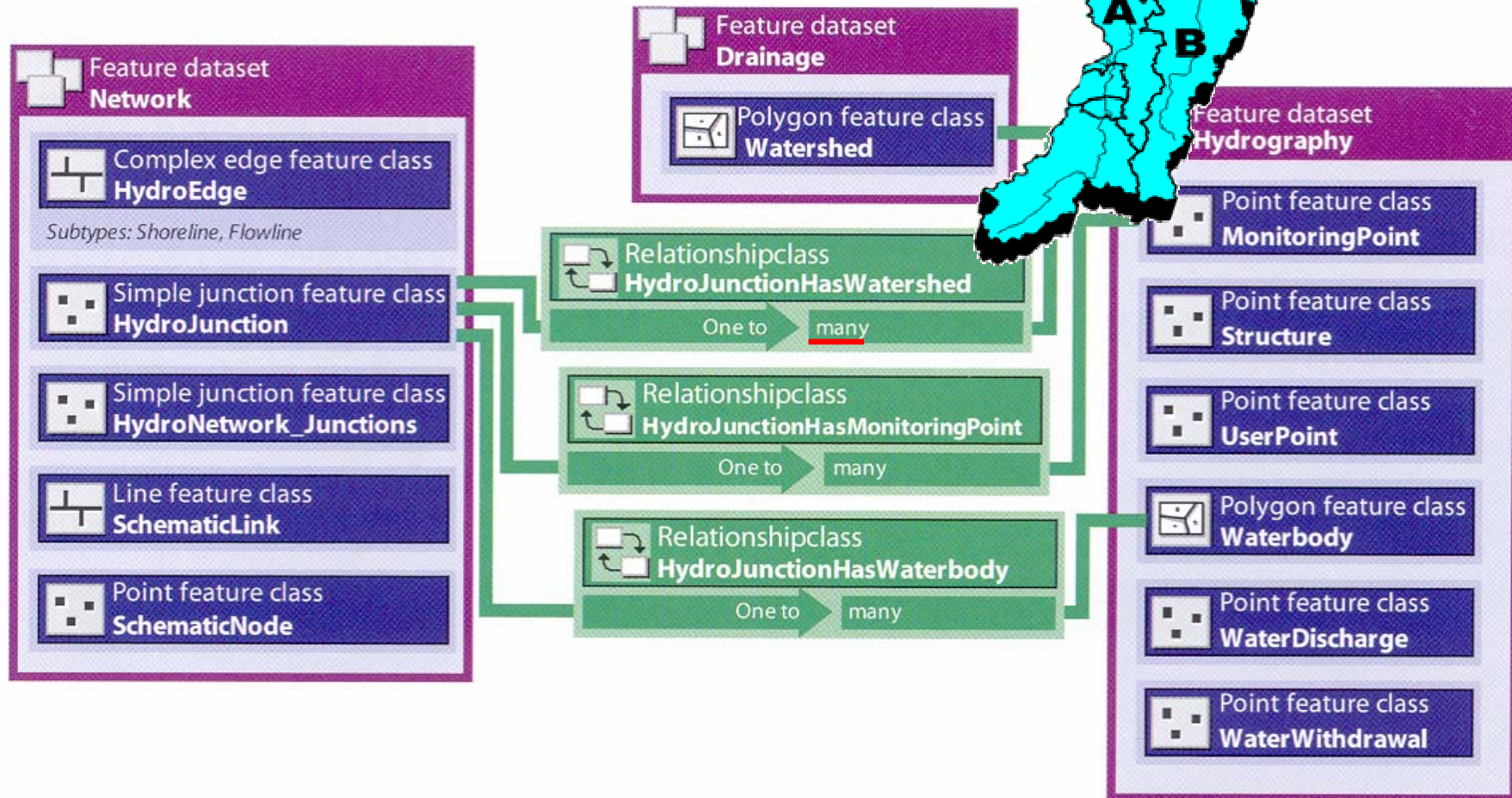
- A data table in relational database must have the **primary key** – a unique **ID**entifier of each row (feature).
- In Arc Hydro, all features are hydro features and therefore have two obligatory attributes:
 - **HydroID** – An *integer* attribute that uniquely identifies the feature in the geodatabase;
 - format for HydroID: <class number><feature number>
 - extended HydroID: <drainage area ID> <class number><feature number>
 - **Assign_HydroID**– a tool to support automatic assignment of IDs
 - **HydroCode** – A *text* attribute that is a permanent public identifier of the feature
 - to link Arc Hydro with other IS-s

2112000033

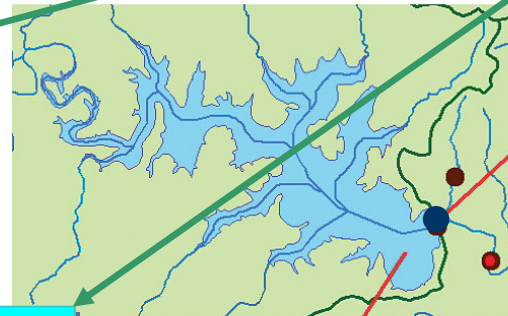
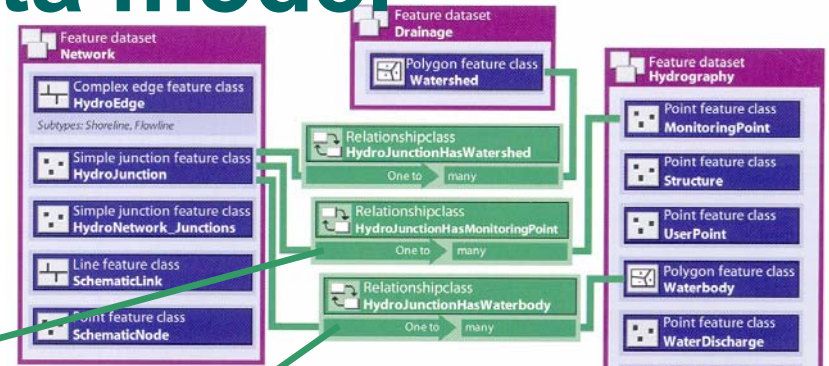
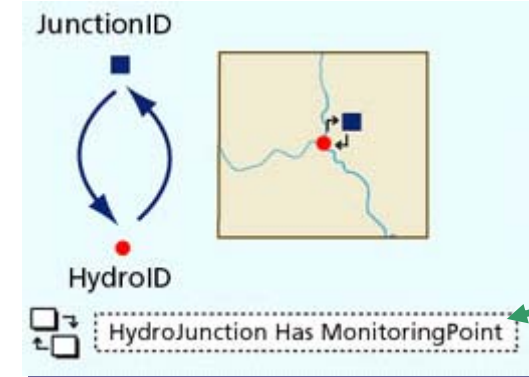
drainage area ID feature class feature number



Relationships in data model



Relationships in data model



Identify Results

Layers: <Top-most layer>

- HydroJunction
 - 3753
 - Waterbody
 - 92
 - Watershed
 - MonitoringPoint
 - 3843

Field	Value
OBJECTID_1	3753
Shape	Point
Enabled	True
AncillaryRole	None
HydroID	3003753
NextDownID	3003843

Location: (-212103.938458)

HydroJunction has Waterbody

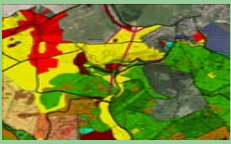
Identify Results

Layers: <Top-most layer>

- Waterbody
 - 92
 - HydroJunction
 - 3753
 - Watershed
 - MonitoringPoint

Field	Value
OBJECTID	92
Shape	Polygon
Shape_Length	112730.616328
Shape_Area	32572280.427557
HydroID	6000092
JunctionID	3003753

Location: (-216525.249559; 757773.567619)



Arc Hydro Tools

- description the drainage patterns of a catchment
- drainage analysis on a terrain model
- development of attributes that can be useful in hydrologic modelling
- comprehensive documentation (Overview, Tutorial, online Help) attached





Arc Hydro Tools

Terrain Preprocessing

Watershed Processing

Attribute Tools

Network Tools

ApUtilities



Data Management

DEM Reconditioning

Fill Sinks

Flow Direction

Flow Accumulation

Stream Definition

Stream Segmentation

Catchment Grid Delineation

Catchment Polygon Processing

Drainage Line Processing

Adjoint Catchment Processing

Drainage Point Processing

Slope

Slope greater than 30

Slope greater than 30 and facing North

- Tools in this menu deal with processing of Digital Elevation Model (DEM). They are mostly used once in order to prepare spatial information for later use.



Arc Hydro Tools

Terrain Preprocessing ▾ Watershed Processing ▾ Attribute Tools ▾ Network Tools ▾ ApUtilities ▾ 

- These tools provide functionality for generation of some of the key attributes (fields) in the Arc Hydro data model. Some of the tools require existence of a geometric network.

Data Management

Assign HydroID

Generate From/To Node for Lines

Find Next Downstream Line

Calculate Length Downstream for Edges

Calculate Length Downstream for Junctions

Find Next Downstream Junction

Store Area Outlets...

Consolidate Attributes


Accumulate Attributes

Display Time Series

Get Parameters



Arc Hydro Tools

Terrain Preprocessing ▾ Watershed Processing ▾ Attribute Tools ▾ Network Tools ▾ ApUtilities ▾ 

- These tools generate or manipulate properties of geometric (hydro) network.

Data Management

Hydro Network Generation


Node/Link Schema Generation

Store Flow Direction

Set Flow Direction...



Arc Hydro Tools

Terrain Preprocessing ▾ Watershed Processing ▾ Attribute Tools ▾ Network Tools ▾ ApUtilities ▾ 

- These are tools for management of Arc Hydro project properties. In general, they will be seldom used.

List Maps

Add New Map

Set Target Locations...

XML Manager...

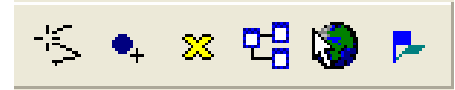
Load/Merge Config XML

HydroID Tables Manager...

Arc Hydro Help

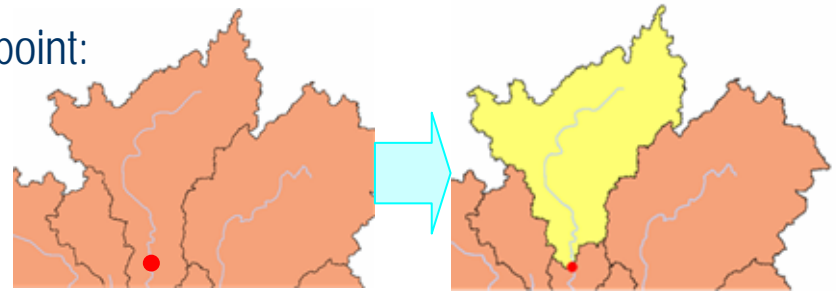


Arc Hydro buttons




 tracing flow path from the selected point to the outlet following the steepest descent

 delineation of watershed for a selected point:



 batch point generation (as input for watershed batch processing)

 assigning related IDentifier

 global point delineation – merges the resulting in delineation local watershed with the Catalog Units (e.g. EDNA) polygons located upstream

 tracing upstream, downstream or in both directions (e.g. to display the catchments located upstream and/or downstream from a specific junction)



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Hydro Data Model

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ESRI has developed models for Water Resources and has focused on surface water with input from key state, national, and international contributors. The ArcGIS Hydro model is available for review and download. We are also supporting a groundwater data model initiative and will eventually consider the full hydrologic cycle as part of the Hydro effort.

ArchHydro Training Classes!
The instructor-led training classes provide an introduction to the Arc Hydro data model and associated software tools supporting hydrologic and hydraulic analysis with GIS. Two courses; ArchHydro GIS for Water Resources, and Hydrologic and Hydraulic Analysis can be found by searching the [ESRI Instructor-Led Training site](#).

If you are interested in downloading the most recent version of the ArchHydro tools please contact: Archhydro@esri.com

Data Model User Group

Join the [data model user group](#) if you are an existing ArcGIS customer and want to learn more about design and architecture of personal or enterprise Geodatabase and become a part of ESRI's growing data model community.

We invite user group members to participate in a series of instructional web casts. Please fill out the [data model survey](#) to give us feedback on what web casts you would like to see.

contact: Archhydro@esri.com

User Forums

Visit the [ESRI data model discussion](#) questions with other users.

Downloads - Case Studies

These Case Studies are a good start discipline. These project examples documentation.

- [San Marcos Basin Case Study G](#)
28490kb (submitted 02/21/2003)
- [Hydro Data Model Poster](#) ArcGIS
(submitted 06/30/2003)
- [ArchHydro GIS for Water Resource](#)
- [Hydrologic and Hydraulic Analysis](#)
08/31/2004)

Downloads - Design Templates

The Design Templates are the rest general concepts and terms for th to create a template data model a

- [Arc Hydro Data Model Template](#)
09/26/2002)
- [Framework Microsoft Repository](#)
11/19/2002)
- [Hydro Microsoft Repository](#) Micro
11/19/2002)
- [Visio 2002 Update](#) Visio 2002 - zi
- [Tips and Tricks for Data Models](#)
- [Arc Hydro Tools version 1.1 Fina](#)
txt - zip format, 19802kb (submitte
- [Arc Hydro Tools version 1.1 Fina](#)
msi, mso, txt - zip format, 18819kb



Thank you!

