Feature Coding Standards and Geodatabase Design

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Introduction

A major goal in many geographic information systems (GIS) is to capture detailed feature descriptions in the GIS database. Some traditional methods for capturing feature descriptions were open-ended, allowing for a variable set of fields to be captured for any feature. This method of capturing geographic knowledge has created some interesting design challenges: How should this knowledge be organized in usable relational databases (tables)? How can such an information system be implemented using GIS to meet multiple purposes, adhere to standards, and be centrally shared with appropriate GIS users across an organization?

There are a number of coding standards in the GIS industry that are designed to give meaning to features independent of any particular data format or product in which the geographic data is stored. Examples of such coding standards include the Digital Geographic Information Exchange Standard (DIGEST) and the United States Geological Survey digital line graphs (DLG). These coding standards follow common patterns in how they assign meaning to features based on combinations of major and minor codes.

Geodatabases that represent features that have meaning defined by these codes must support the use of these standard coding systems to query and report information on these features in terms of these major and minor codes. However, the structure of the coding system does not and should not necessarily dictate the structure of the geodatabase.

This technical paper will discuss the geodatabase data model for feature coding systems that follow this pattern and will focus in on a case study using the DIGEST coding standard as an example. In addition, a sample ArcGIS™ extension and database are described that implement such a geodatabase design. This sample extension and geodatabase are available for download at http://arcobjectsonline.esri.com.

Feature coding standards

The goal of many feature coding standards is to associate meaning to geographic features in a standard, general, and extensible way. Many of these coding standards use a system of major and minor codes. Major codes assign a feature with a category, while minor codes are used to parameterize these major codes.

Major codes would classify a feature as, for example, river, road, demilitarized zone, and so on, while the minor code may specify if a river is intermittent, perennial, or dry and, for roads, whether they are paved or dirt. The use of minor codes to parameterize major codes overcomes the limitations of a single linear or hierarchical coding system.

The application of a coding standard can be independent of a specific data product or specification, and in fact, any geographic feature in any database can be assigned some major and minor codes based on a coding standard. The code is also independent of the representation of a feature in the GIS (as a point, line, or polygon). For example, a school as an image, a school as a point, a school as a polygon, and a school as a row in a table all share the same major and minor codes.

The codes associated with features are important to users of the geographic database. Organizations that assign meaning to their features using coding standards also wish to query their database and assign meaning to their features while editing based on these codes. The requirement for using these codes for working with a geographic database can be summarized as:

Selection: Users need the ability to select features in a feature class, not only by the attributes that describe individual features (such as the name of a road or the volume of a lake) but also in terms of feature classification described by these coding standards. For example, “select all features in the WaterLines feature class that are aqueducts and are suspended above the ground and known to be operational”.

Specifying definition queries: Like making selections, users need the ability to specify a layer definition query on both the attributes that describe individual features and by the feature classification described by the coding standard. For example, “draw only those features from the TransportationLine feature class that represent roads that are paved, have medians, are known to be operational, and whose location is known to be accurate”.

Rendering features: Users need to be able to assign symbols for drawing based on classifications as described in the coding standard. For example, “when drawing the TransportationLines feature class, draw RailRoads with black lines, Roads that are paved with red lines, and Roads that are not paved in dashed red lines”.

Editing and creating new features: When creating new features, users must be able to associate the meaning of the feature in terms of the coding standard. Likewise, when updating an existing feature’s classification, they need to be able to assign relevant codes to the feature. While there are potentially thousands of possible combinations of major and minor codes in any coding system, in reality there is a much smaller subset of valid code combinations that actually exist in the database. Users need to be able to assign major and minor codes to their features but be prevented from assigning invalid code combinations. For example, a user should be able to “create a new road that is paved and has a median” but may not be able to “create a new road that is dirt and has a median”.

Data extraction: The extraction of data from any database is important to provide to other organizations or for use in applications that require data in some particular format. Users need to be able to export features from their database into other formats and carry the feature codes with the features in that exported format.

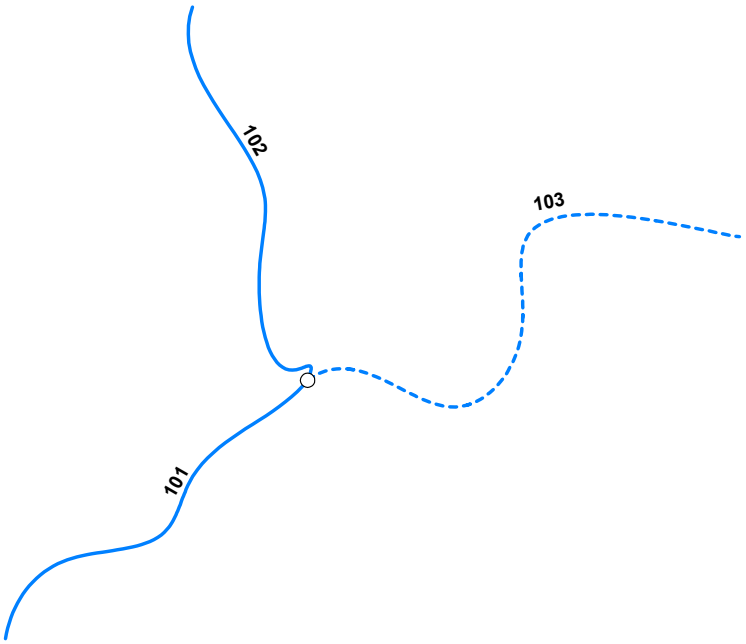
As with any database design, the database must perform well in a multiuser reading and editing environment.

The remainder of this technical paper describes the geodatabase design pattern and ArcGIS application extension to support coding standards, specifically the requirements above. A specific geodatabase design that supports the DIGEST coding standard is used as a case study.

The need for a smart geodatabase design

The classification code describing a feature can be considered as an attribute of the feature. It is a complex attribute because it consists of a major code and one or more minor codes, but it is, logically, a single property. This property value is drawn from a domain of possible values defined in the coding standard. A set of line features, with their code, could be modeled like this:

Id	geometry	code
101	xy...xy	BH140,hyc=6
102	xy...xy	BH140,hyc=8
103	xy...xy	BH020,hyc=8,exs=32
...	...	...



Where, for feature 103, BH020 is the major code, hyc and exs are the minor codes.

In this case, the feature class represents a drainage network of rivers, streams, and canals. Each drainage network element is coded with the appropriate feature code.

As this example illustrates, coding standards define a standard for assigning meaning to features, but they do not dictate any particular organization of features into classes or the actual structure of the geographic data model. *In particular, it is not necessary that the logical or physical schema of a geodatabase design reflect the logical structure of the coding standard.* Major codes do not define feature classes; minor codes do not define

feature class fields. The only requirement is that we can associate a code or description with any feature represented in the database.

One could take the approach where the major codes are mapped to feature classes and the minor code to fields. This leads to a database design that has a large number of feature classes that won't perform well. To reduce the number of feature classes, one might lump major codes with similar minor codes into a single feature class. This results in a feature class containing many features with Null values for those minor code fields that do not apply to the major code.

This is not a good GIS design. Coding standards are only standards for *describing* features; they do not dictate how features are identified or organized in the GIS. In fact, it is a poor idea to let the *descriptive* logic of a coding standard control the spatial or functional logic of the GIS data model. Other aspects, such as the geographic representation of features (lines organized in a network, areas that share topology, etc.), the need to model real-world objects, or the feature extraction specifications, are more important factors to consider in defining feature classes in our geodatabase design. For many datasets in the data model, the descriptive code will be simply irrelevant—for example, bathymetry mass points, military unit overlays, and satellite tracks. For the others, the requirement is simply to be able to get the code for any feature.

The goal is to provide a general mechanism for associating codes with features and use these codes to control map display. This introduces the need for tools to edit the codes, among other things, but the coding standard should not be used to control the data model design.

There are several approaches to such a geodatabase design:

- The direct approach: major codes map to feature classes, while minor codes map to fields. Minor codes vary with subtypes, allowing you to group multiple major codes into a single feature class.

Simple feature class **WaterL**

Geometry *Polyline*
Contains M values *No*
Contains Z values *No*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	OID						
Shape	Geometry	Yes					
FCSUBTYPE	Integer	Yes			0		
GFID	String	Yes					38
VVTID	Integer	Yes			0		
SOURCE	Integer	Yes			0		
NAM	String	Yes					254
OHC	Integer	Yes			0		
WID	Integer	Yes			0		
MaxDepth	Double	Yes			0	0	
F_CODE	String	Yes					6
ACC	Integer	Yes			0	0	2
SLT	Integer	Yes			0	0	2
VDC	Integer	Yes			0	0	2
EXS	Integer	Yes			0	0	2
HYC	Integer	Yes			0	0	2
TID	Integer	Yes			0	0	2
ATC	Integer	Yes			0	0	2
LOC	Integer	Yes			0	0	2
HFC	Integer	Yes			0	0	2
Shape_Length	Double	Yes			0	0	

Major code

Minor codes

- The fully normalized approach: fully normalized attribute model where multiple minor code records for each feature are stored in a related table.

- The enhanced valid value table (VVT) approach: create a table of valid major and minor code combinations representing the actual content of the database (it is not necessary to list all possible combinations of minor and major codes). Build a relationship to associate features with codes through foreign keys into this table.

Simple feature class **WaterLines**

Geometry *Polyline*

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	OID						
VVTID	Integer	Yes			0		
Width	Double	Yes			0	0	
Shape	Geometry	Yes					
Shape_Length	Double	Yes			0	0	

Table **WaterLines_VVT**

Field name	Data type	Allow nulls	Default value	Domain	Precision	Scale	Length
OBJECTID	OID						
FACC	String	Yes					255
Description	String	Yes					250
VVTID	Integer	Yes			0		
ACODES	String	Yes					255

The direct approach is not a good design for the reasons discussed earlier, and the fully normalized model is also not a good design as it would result in too many records in the minor code table and require complex query processing. The VVT approach is a good database design because it best reflects the logic of the coding standard; it compresses the data representation to only deal with valid combinations and supports quality assurance (QA), editing, mapping/query, and multipurpose GIS use.

What are valid value tables?

Valid value tables are tools used to perform quality assurance and to help users who maintain databases assign valid meaning to their features. The VVT contains information as to the valid combinations of major and minor codes for how a particular coding standard is defined for a particular database.

The geodatabase design presented here for databases whose features' meanings are defined by feature codes uses the VVT concept in a more direct way: the VVT is not only used as a QA tool but is also used to hold the coding information for the features.

The enhanced VVT design

As discussed at the beginning of this section, the classification code describing a feature can be considered an attribute of the feature. It's a complex attribute as it consists of a major code and one or more minor codes but is logically a single property. The enhanced VVT design uses the VVT itself to store the coding information for the features, while the features themselves hold a foreign key reference to the row in the VVT that contains the major and minor code combination for that feature.

In this design, the codes themselves are treated like an attribute that has a special kind of attribute domain, or a complex domain. The components of a feature's code can be presented to the user by displaying and allowing them to manipulate this foreign key reference attribute as its component parts. The VVT itself contains references to data dictionary tables in the geodatabase that give real, descriptive meaning to the codes.

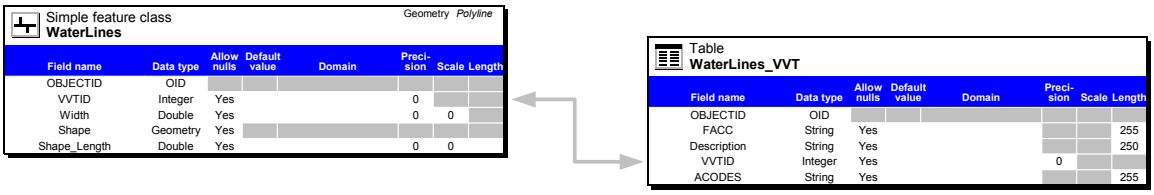
Selection, inspection, and editing of the feature code involve looking up the full code in the VVT and presenting it in a user interface. These user interfaces can present a set of choices based on either (a) picking an existing valid combination or (b) picking individual minor code values. The actual structure of the database is invisible to the end user.

This leads to the question: What is the best VVT design for this purpose? There are a number of possibilities:

- Should there be multiple VVTs (one for each feature class) or a single centralized VVT?
- Represent the structure of the VVTs as:
  - A single table with one column for each minor code.
  - A single table with minor codes appended in a string field.
  - A normalized table with multiple records for each minor code and corresponding valid value property.

In this geodatabase design, a VVT table has been created for each feature class in the database. The VVT contains one field for the major code and one field for the minor codes, which are appended in a string. The approach of a single field containing a string with all the minor code/value pairs simplifies the application logic and queries: each VVT can be queried in a generic way, always returning the same number of fields

regardless of the number of minor codes. The string can then be parsed and analyzed by the application. An example of a feature class in this geodatabase is below:



Each feature class (in this case the WaterLines feature class) has a VVT (in this case WaterLines_VVT), and the two are joined based on the ID of the valid value (VVTID). The major code in the VVT is FACC. The minor codes are held in the ACODES field.

The VVT design and geodatabase data models

ESRI has been actively involved with its user community in the development of a series of ArcGIS data models, which are intended to provide a common design framework for key layers of GIS information. These design efforts have resulted in a series of comprehensive design specifications for a number of thematic layers, including:

- Census and Administrative Units (applied to U.S. Census geography)
- Topographic Base Maps for 1:24,000-Scale Maps
- Hydrography
- Raster Imagery and Elevation Catalogs
- Streets and Comprehensive Address Information
- Transportation (to support linear referencing, navigation, addressing, and cartography)
- Federal Lands and the Public Land Survey System (PLSS) (to support a national database of the legal survey fabric)
- Parcels (to support both U.S. and worldwide systems)
- Water Facilities
- Numerous Other Efforts

Building VVTs for existing data models

The VVT design principles presented here can apply for coding any of these data models or a geodatabase data model that you may design in your organization.

The geodatabase design for VVTs presented in this technical paper centers on the maintenance of a single attribute in any of the feature classes present in the data models listed above or in the data model you have designed based on the GIS requirements of

your organization. The incorporation of feature coding information should be a complement to any of these geodatabase data models, not the basis for a new data model.

The remainder of this technical paper presents a case study and sample geodatabase, including a sample ArcGIS application extension that interprets the feature coding information in the geodatabase and presents that information to the user.

A case study: the DIGEST feature coding standard

The first implementation of this database design on a real coding standard was built to support the DIGEST coding standard. This section of the technical paper will tie the data modeling concepts already discussed into DIGEST coding terms. A sample geodatabase and sample application extension that work with this geodatabase are described in the next section.

Like other coding standards, the DIGEST standard defines a system for associating meaning with geographic features. The standard is based on a set of feature codes, which can then be further modified by other parameters. For example, an intermittent stream would be described as “River/Stream, hydrological category = intermittent” (BH140,hyc=6). A church would be described as “Building, function = house of worship, house of worship type = church” (AL015,bfc=7,hwt=4). In DIGEST, the major code (e.g., BH140) is called the FCODE, while the minor codes are called ACODEs (e.g., hyc=6).

Vector product format (VPF) product designs, such as Vector Map Level 2 (VMap 2) and Topographic Line Map (TLM), were heavily influenced by the DIGEST logical structure. ACODEs were mapped to VPF fields and FCODEs to feature tables. To reduce the number of feature tables, multiple FCODEs that share similar ACODE fields were combined in a single table.

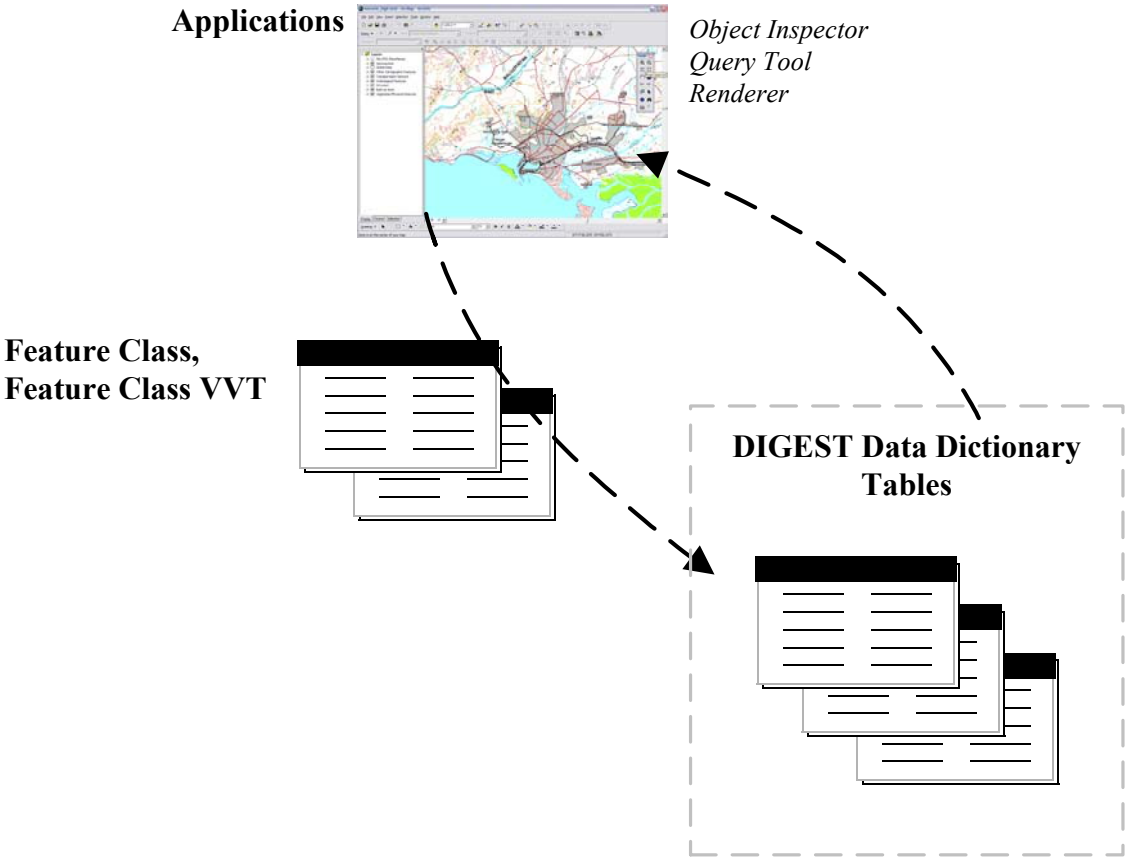
To learn more about the DIGEST coding standard, refer to www.digest.org.

Applying the DIGEST standard to the geodatabase design

The basic design of a geodatabase that supports the DIGEST coding standard, as described in the previous sections of this technical paper, implies that the underlying storage of the coding information is not the user’s view of the data and special tools are required to present and work with the coding information stored in the geodatabase.

Each feature class in this data model contains its geometry, range attributes, and an ID that maps it to a row in a VVT. The contents of this row are the DIGEST attributes for classifying features (FCODE and various ACODEs). The VVT also contains the description of the combination of FCODE and ACODEs. The user-consumable descriptions of these FCODEs and ACODEs are stored in a set of data dictionary tables.

Applications that work with this data model need to understand the structure of the database, navigate the feature class/VVT relationship, and use the data dictionary tables to provide the user with a meaningful representation of the feature codes.



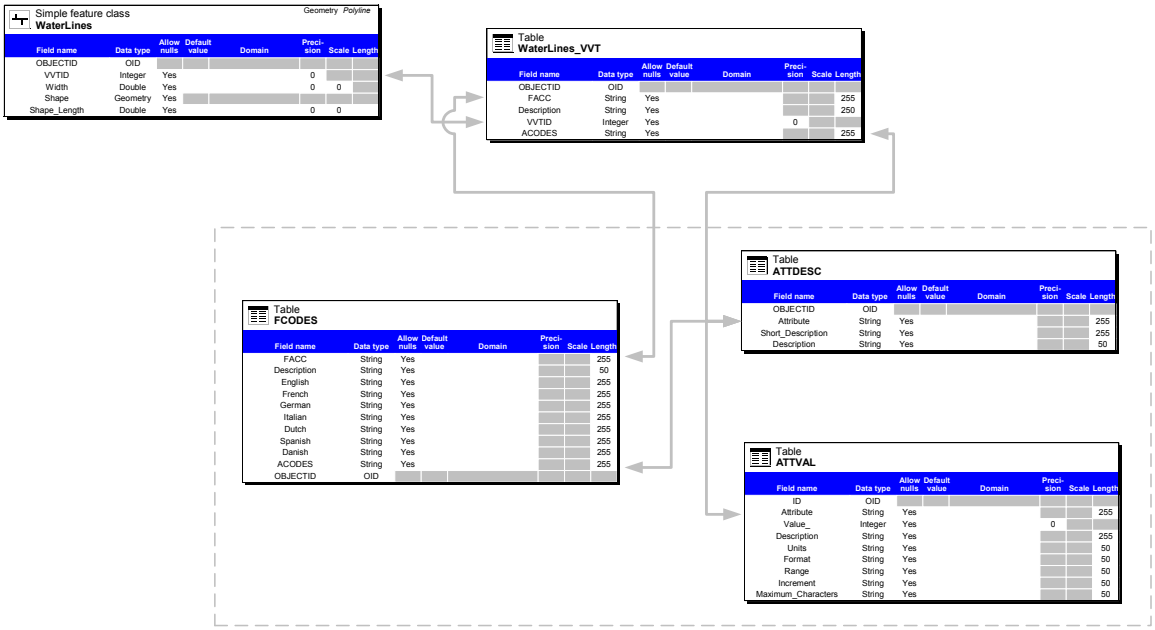
Detailed database design

Each feature class has its own VVT, and there are three data dictionary tables that contain the FCODEs, ACODEs, and their descriptions. The remainder of this section describes the table structure and its contents in more detail.

Each feature class has a corresponding VVT named <Feature Class>_VVT. For example, the WaterL feature class has a VVT called WaterL_VVT. The VVT has a primary key (VVTID), and the feature class has the embedded foreign key (VVTID). These keys are used to determine which DIGEST code combination each feature is associated with in the feature class.

The database also contains a set of tables for which there is a single copy in the database: FCODES, ATTDESC, and ATTVAL. The FCODES table contains information on each FCODE, such as its description, the ACODEs that apply to it, and the allowable values for each ACODE for that FCODE. The primary key is the FCODE, and each VVT has an embedded foreign key called FCODE on which these tables are joined.

The ATTDESC and ATTVAL tables contain descriptions for what each ACODE is as well as descriptions for what each value of each ACODE means, respectively. This structure is illustrated below.



The valid value tables

Each VVT has the same structure: a field that stores the FCODE, a field that stores the ACODEs and their values as a string, and a field that stores the text description of the valid value combination. An example VVT is illustrated below:

Table
WaterLines_VVT

Field name	Data type	Allow nulls	Default value	Domain	Preci-sion	Scale	Length	
OBJECTID	OID							
FACC	String	Yes					255	The name of the FCODE
Description	String	Yes					250	The long description of the valid value combination
VVTID	Integer	Yes			0			The unique ID for the valid value combination
ACODES	String	Yes					255	The ACODEs and their values

Storing the ACODEs and their values in a single field as a string has many advantages: all VVTs can be queried in the same way, regardless of the number of ACODEs associated with the FCODE; the queries are more efficient in that only the same small number of fields is returned each time the VVT is queried. An example of a VVT is shown below:

VVTID	F_CODE	Description	ACODES
1	BA010	Coastline/Shoreline - Definite...	ACC 1|SLT 0|VDC 0|
2	BA010	Coastline/Shoreline - Approximate...	ACC 2|SLT 0|VDC 15|
3	BH020	Canal - Abandoned/Disused...	EXS 6|HYC 0|TID -9|
4	BH020	Canal - Navigable - Perennial...	EXS 32|HYC 8|TID -9|

Application logic is required to interpret this string and to construct queries based on this string format. The details of this are discussed in the next section of this technical paper.

The DIGEST dictionary tables

There are three tables that contain the DIGEST dictionary information: FCODES, ATTDESC, and ATTVAL. These tables are used by the application extension to provide useful, descriptive information for users to interact with.

The FCODES table describes each FCODE and the list of ACODEs and their values that are applicable to the FCODE. The list of applicable ACODEs and their values is important for providing a usable interface for users to define a query on any particular FCODE.

For example, the EXS (existence category) ACODE applies to both the FCODEs BH010 (Canal) and AL240 (Tower); the allowable values for that ACODE differ for these FCODEs, as do the other applicable ACODEs.

Like in the VVT, the ACODEs and their values are stored as strings. An excerpt from the FCODES table is shown below:

F_CODE	Description	ACODES
BA010	Aqueduct	ATC[0,1];EXS[28,5];LOC[0,25,4,8]
BA020	Canal	EXS[6,32];HYC[0,8];TID[-9]
DB170	Sand Dune/Sand Hills	SSC[30,22,0,28,27,26,29]
GB010	Airport Lighting	EXS[-9];LFA[10,26,53,0]

The ATTDESC table contains all of the ACODEs and a text description of their meaning. As with the FCODES table, this information is used to provide a user-friendly interface for queries. An excerpt from the ATTDESC table is shown below:

Attribute	Description
ACC	Accuracy Category
SLT	Shoreline Type Category
EXS	Existence Category
HYC	Hydrological Category

Finally, the ATTVAL table contains all of the ACODE values plus a text description of their meaning. As with the FCODES and ATTDESC tables, this information is used to provide a usable user interface for queries. An excerpt from the ATTVAL table is shown below:

Attribute	Value	Description
ACC	0	Unknown
ACC	1	Accurate
HYC	0	Unknown
HYC	2	Not Applicable

The remainder of this technical paper will focus on a sample ArcGIS application extension that provides the user interface for working with complex feature coding attributes as defined by this geodatabase design. For developers, some key aspects of the implementation are discussed.

Sample ArcGIS application extension

The key element of the application extension is to provide a user interface that presents the feature coding information (in this case DIGEST) in such a way that users can work with that coding information as a special kind of attribute domain. The user interaction is such that this coding information is treated like any other attribute, and the structure of the storage of the coding information (as described in the previous section) is invisible to the end user.

As discussed in earlier sections, the key user tasks for working with geographic data that involve these codes are:

- Selecting features
- Specifying definition queries
- Rendering features
- Editing and creating new features
- Data extraction

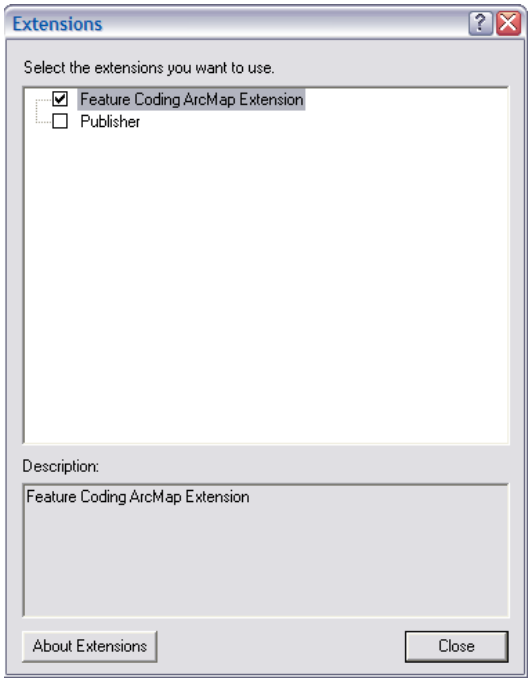
Before discussing each of these parts of the extension, managing the extension itself will be covered.

For developers, some key aspects of the implementation are discussed, including the navigation of the table structure described in the previous sections.

Managing the application extension

Once installed, the extension can be turned on in ArcMap™ like any other ArcGIS extension:

1. On the main menu, click Tools and click Extensions.
2. In the Extensions dialog box, check the Feature Coding Extension to activate it.
3. Click Close to dismiss the dialog box.



Once the map extension is activated, you must tell the extension where your feature code tables are located and some information about which fields in those tables to use to access the data dictionary information.

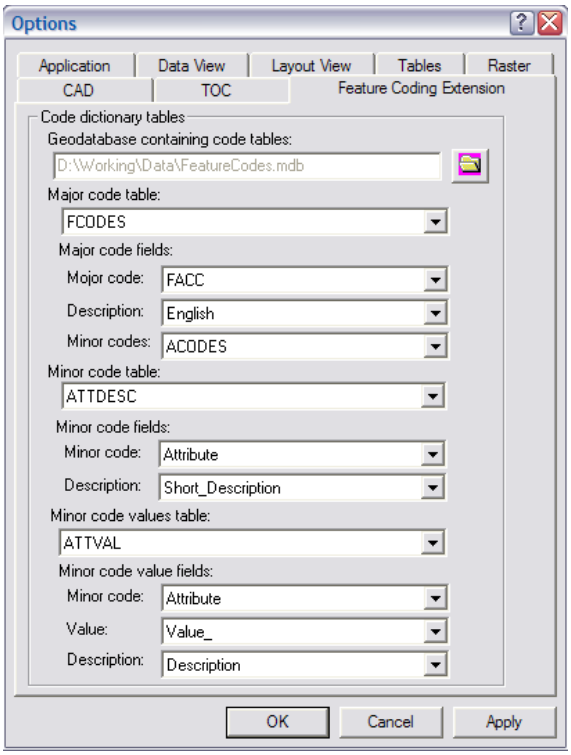
1. On the main menu, click Tools and click Options.

2. In the Options dialog box, check the Feature Coding Extension tab.

3. Click the Browse button to navigate to the geodatabase that contains the data dictionary table (note: the data dictionary tables can be located in a different geodatabase from the feature data).

4. Click the dropdown boxes to specify the tables and their fields that correspond to the various elements of the data dictionary (see the image below to understand which combo boxes are related to which dictionary component).

5. Click OK to apply your changes and close the dialog box.



This information is written to the Windows® registry, so the next time you activate the extension, you won't have to specify this information again.

For developers:

When the information in this dialog box is applied, the application extension does several things:

First, it opens the data dictionary tables specified in the dialog box. Since the minor code table (ATTDESC) and the minor code value table (ATTVAL) are both relatively small, and the information in them is accessed frequently by the extension, the contents of these tables are cached in memory as Visual Basic® dictionary objects. Caching this information allows fast access and greatly reduces the number of queries executed in the database as the user performs a variety of operations.

The information provided in the dialog box is also written to the Windows registry. This allows for these parameters to be persisted across ArcMap sessions and eliminates the need to specify this information each time the extension is activated. This information is persisted in registry as strings for the table and fields names and as a binary registry value for the workspace name object. When the extension is activated, it reads this information from the registry if present.

Specifying DIGEST coding criteria for various operations

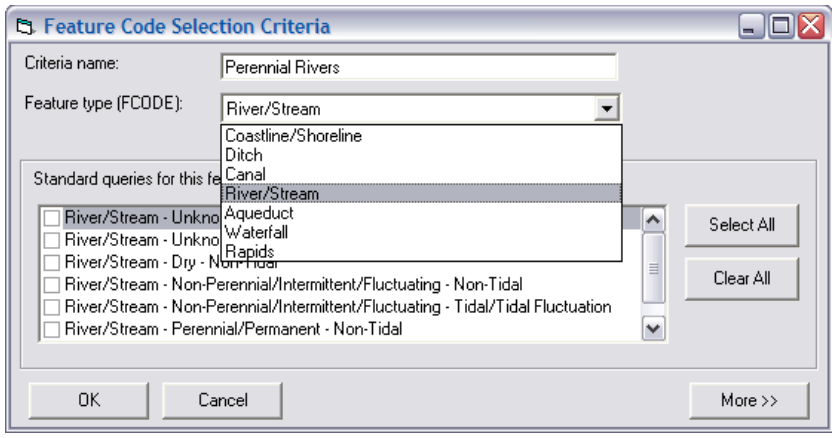
The user interface for selecting, symbolizing, and applying layer definition queries needs to provide a way for users to specify their criteria based on the FCODE and ACODEs that apply to the features in a particular feature class. Since the VVTs hold only those *real* combinations of FCODEs and ACODEs, not all the possible combinations, it is possible to provide a user interface that satisfies this. In addition, those codes must be exposed in a meaningful way with text descriptions rather than cryptic codes that must be looked up by the user. The contents of the DIGEST dictionary tables also make this possible.

To do this, users decide which types of features they want to select, such as WaterL features (a feature class that contains water line features) or River/Stream, which is driven off the FCODE. For each FCODE, there is a set of ACODEs to narrow the selection criteria. Each FCODE potentially has a different set of ACODEs. For example, River/Stream lines have ACODEs: EXS, HYC, and TID, while Rapids have ACODEs: HFC. The user interface that specifies the criteria to select features from a particular class has to be dynamic in terms of which ACODEs it presents to the user, based on the selected FCODE.

For each real FCODE/ACODE combination in a VVT, there exists a description, for example, FCODE=BH140,HYC=3,TID=1 has the description “River/Stream—Dry—Non-Tidal” (see table structure above). One way to specify these criteria is based on the standard feature code sets. Another way is to specify criteria based not on specific combinations of FCODE/ACODE but on variable FCODE/ACODEs combinations.

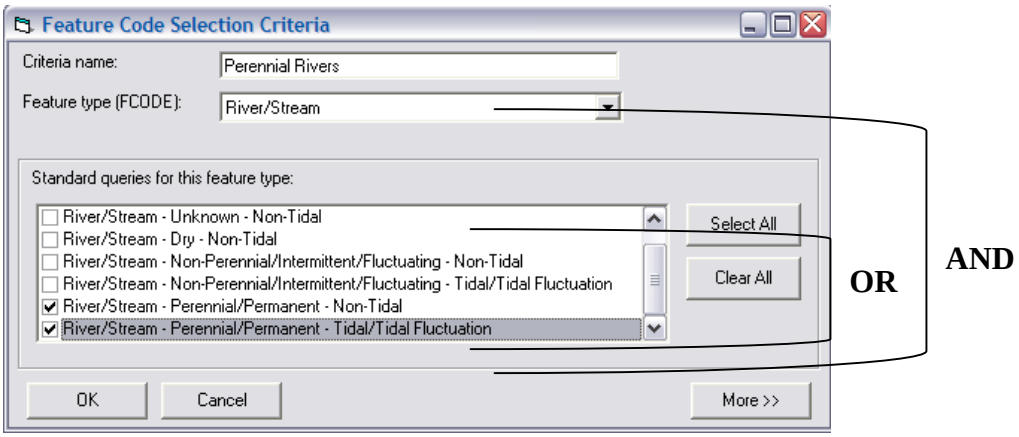
For example, select all rivers/streams that are dry:
FCODE=BH140,HYC=3
This implies any TID code can be used (since it was not a criterion for eliminating features, so there are potentially many FCODE, HYC, TID combinations that satisfy the query).

To facilitate the specification of one of these criteria, the FCODE/ACODE details are presented to the user in a readable/navigable format. The following is an example of specifying criteria for the WaterL feature class. This dialog box will always be presented in the context of specifying criteria for a particular feature class (i.e., select feature from, specify layer definition query for, set symbology for, etc.):

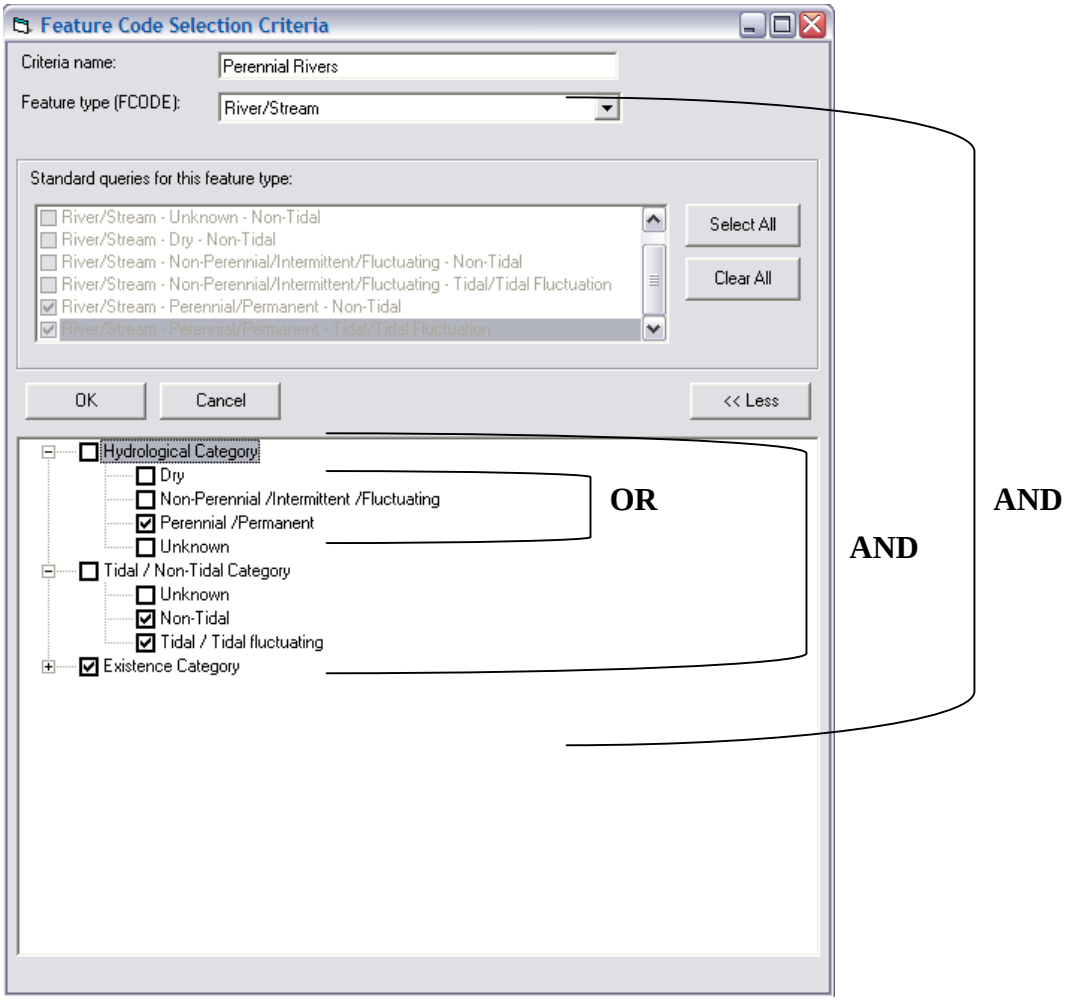


Each criterion is given a name—this allows multiple criteria for a particular operation, such as selection and symbolizing. You can pick the type of feature you want to include in the criterion from the available feature types (i.e., FCODEs) for the feature class (in this case WaterL).

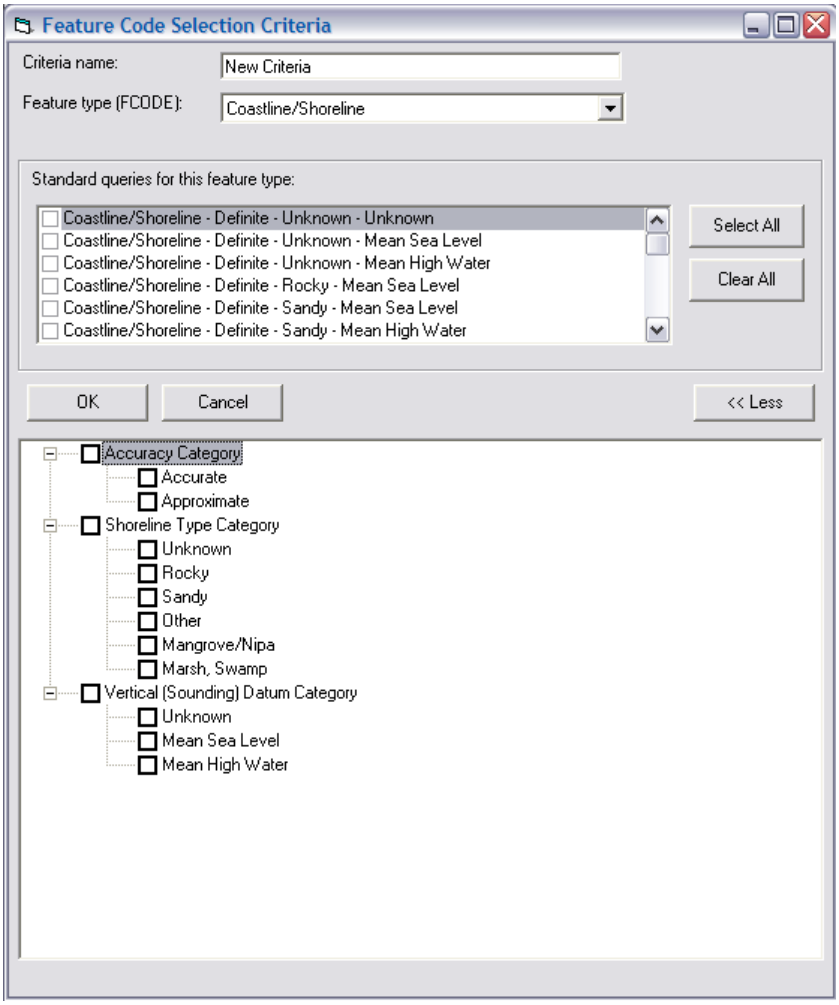
Picking a feature type will populate the standard query list with all the FCODE/ACODE combination descriptions for that FCODE from the VVT. You can use this list and check those valid combinations you wish to include in your criteria:



Alternatively, you can choose to use the ACODEs and their values that apply to that FCODE to specify your criteria. In both these examples, the features whose hydrologic category is Perennial/Permanent will be specified by these criteria (often there will be a large number of choices in the standard query list, which would make the ACODE tree a more desirable way to specify the criteria):



It should be noted that when you change the feature type, the list of standard queries and the applicable ACODE and ACODE values update.



When you click the OK button, the information you input is formulated into a query. This query will ultimately be run against the VVT to produce a set of VVTIDs that satisfy the criteria. How these VVTIDs are used is detailed by discussions below about the functional tools that make use of this criteria dialog box and the queries it produces.

Logically, if you specified the criteria by clicking a set of standard queries, these standard queries would be OR'd together and AND'd with the FCODE. If you specified the criteria by the ACODEs, each ACODE is logically AND'd, and each ACODE value is logically OR'd. This is then AND'd with the FCODE (see above).

For developers:

The feature combo box is populated by getting the unique FCODE values from the VVT and looking up their descriptions in the FCODES table. The list of standard queries is populated by querying the VVT for all the descriptions for the specified FCODE.

The list of ACODEs and their values are populated by cracking the ACODEs string from the FCODES table for the specified FCODE. This string contains all the applicable ACODEs and their values for the specified FCODE. This is used to search the cached ACODE information to populate the ACODE tree.

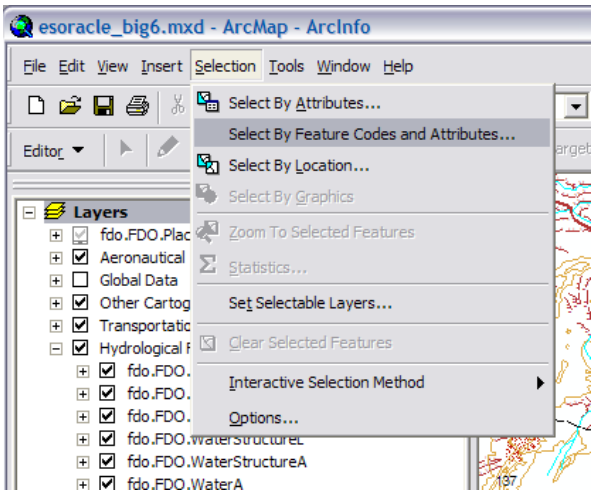
When the user clicks OK, this dialog box takes the input from the user and constructs a query string of an FCODE and an ACODE value string. This query can then be used by whatever function called this dialog box to execute a query against the VVT. This will result in a set of VVTIDs that satisfy the query.

Each part of the user interface that calls this dialog box uses the set of VVTIDs that results from this query to perform some operation. Each case will be described below.

Selecting features

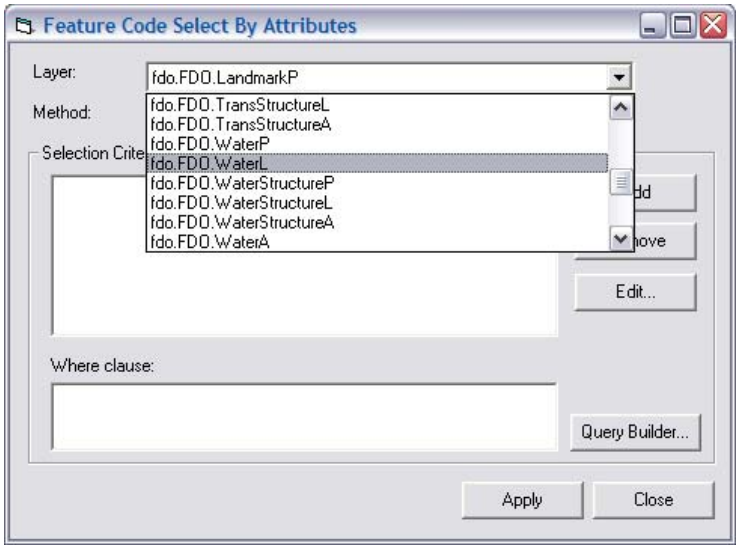
For selecting features in a layer in ArcMap that allows selection criteria based on both the features' attributes and their DIGEST coding information, a new selection command is available.

1. On the main menu, click Selection, then click Select By Feature Codes and Attributes.

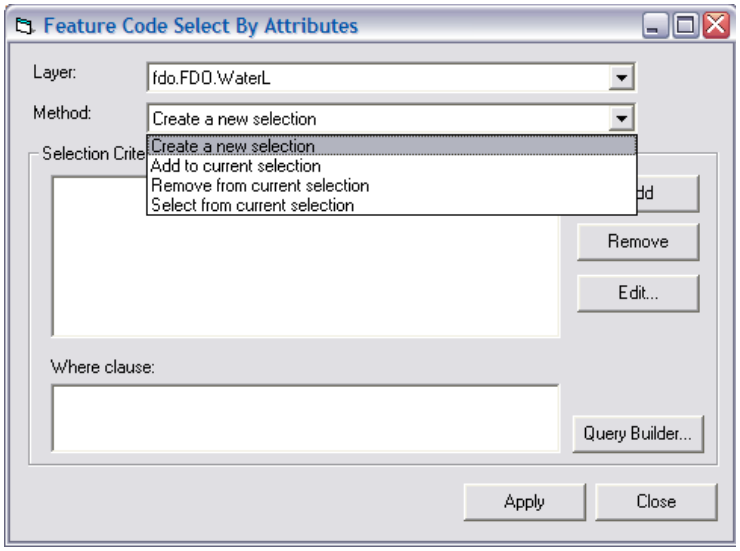


Like the standard ArcMap selection dialog box, the DIGEST selection dialog box applies to all layers in the map that have a corresponding VVT in the database.

2. Select the map layer you wish to select against (only those layers in the map that have a VVT are listed).

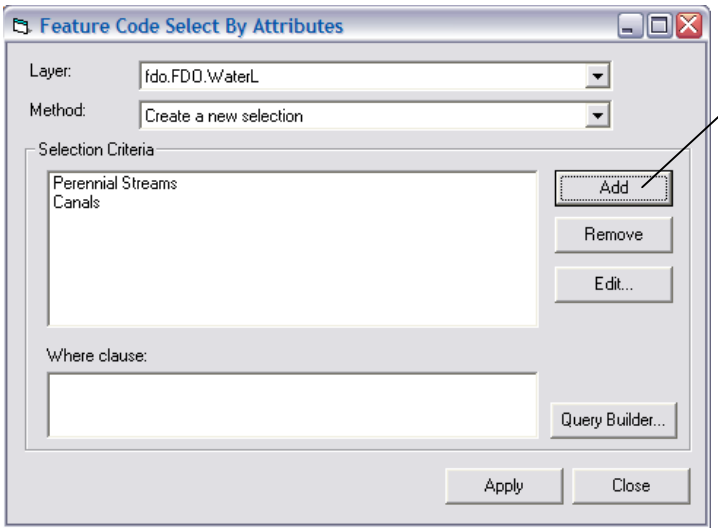


3. Click the selection type. These are the same selection type options that are available from the standard select by attributes dialog box.

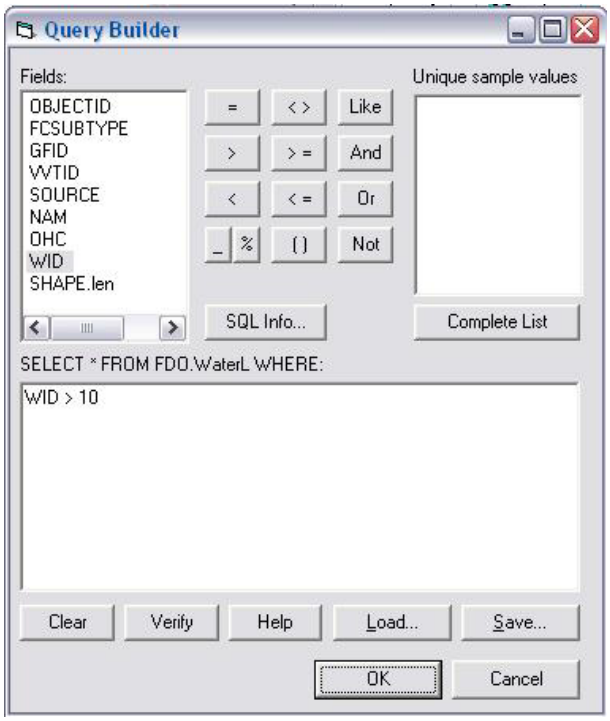


There are two sets of selection criteria. The top list box will contain the selection criteria based on DIGEST codes (see below). The lower list box, labeled “Where clause”, will contain any selection query that is based on the attributes held in the feature class itself. Logically, the DIGEST criteria is AND’d to the where clause criteria.

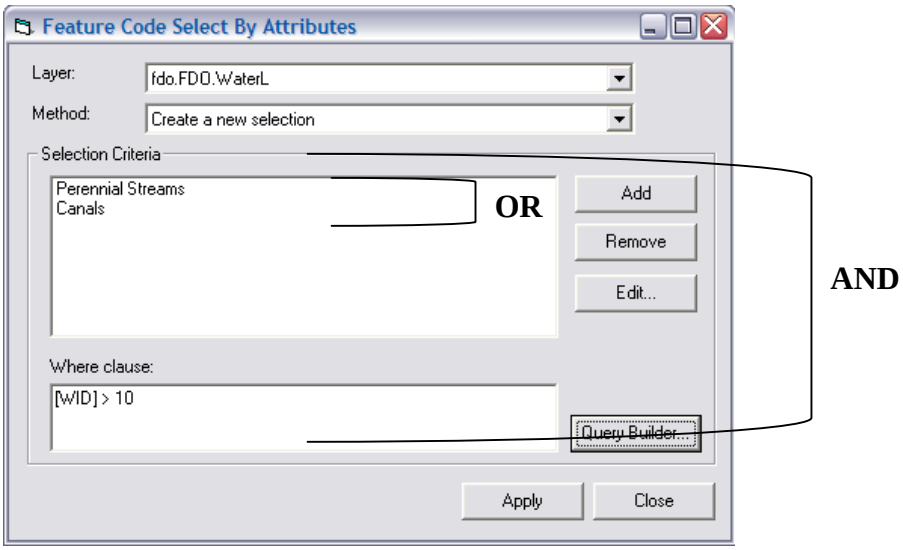
4. To add FCODE/ACODE criteria to the selection, click Add. This will open the criteria builder dialog box discussed above where you can interactively specify new selection criteria. You can add any number of criteria to the selection by clicking Add. The Remove button removes criteria from the list, and the Edit button allows you to modify the criteria.



5. Click Query Builder to open the attribute query dialog box (see below) and add a query that is based on the attributes that are stored on the feature class itself (things such as width, name).



6. Once you have added all the criteria and the where clause is defined (if applicable), then click Apply to create the selection. Note that, like the standard selection dialog box, these criteria do not persist anywhere, and the next time the Select By Feature Codes and Attributes dialog box is opened it is blank.



For developers:

When the Apply button is clicked, the query string for each criterion supplied by the user via the Feature Code Criteria dialog box is OR'd together. This is then used to query the VVT table to get a list of VVTIDs that satisfy the criteria. This list of VVTIDs is then used to construct another query to which the where clause is AND'd (if present) to be executed against the feature class.

The results of the query alter the selection based on the selection type specified in the Select By Feature Codes and Attributes dialog box.

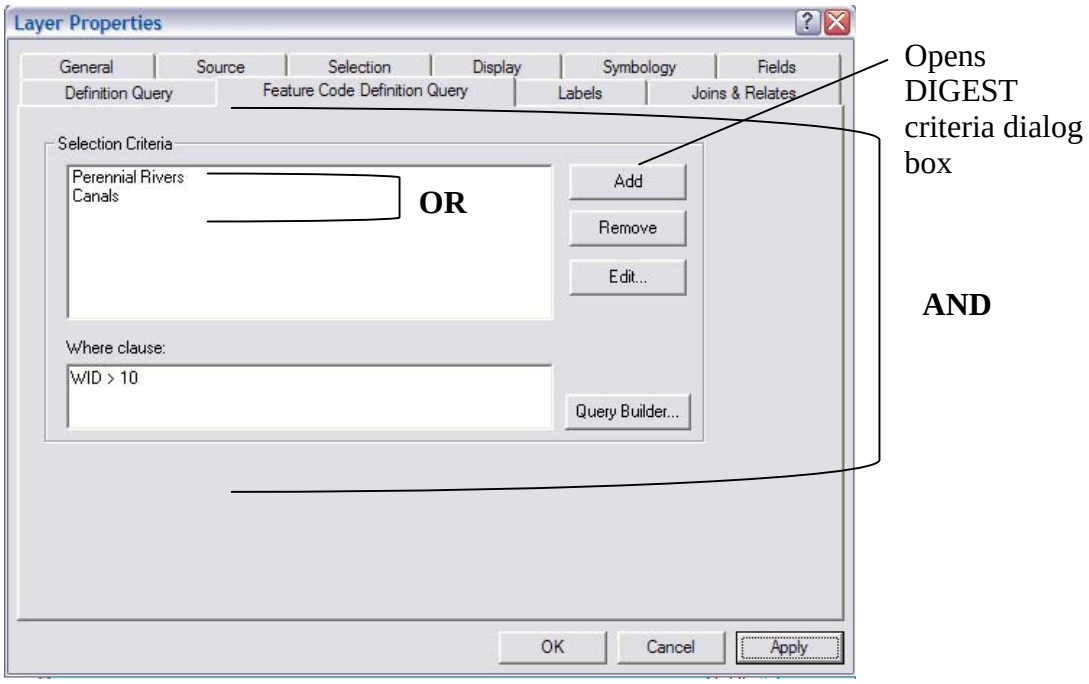
Layer definition queries

To specify layer definition queries for a layer in ArcMap that includes criteria based on both the features' attributes and their DIGEST coding information, a new definition query interface is available. This uses the same criteria as used for creating selections to specify layer definition queries for layers based on feature classes with VVTs.

1. Right-click on the layer you want to define a definition query for and click Properties.

2. Click the Feature Code Definition Query tab.

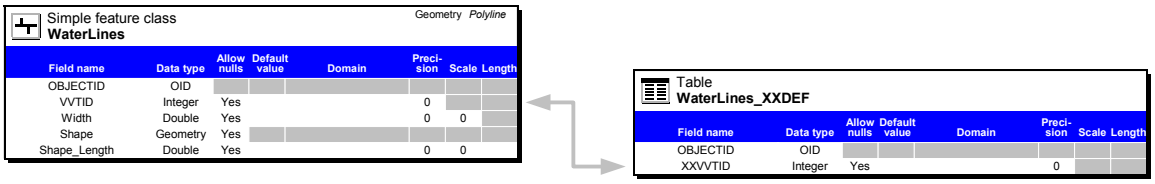
The definition query dialog box shown uses the same basic user interface as the selection dialog box. Here, the Add, Remove, Edit, and Query Builder buttons will open the same dialog boxes as the selection user interface example above.



3. Once you have defined your layer definition criteria, click OK, and only those features that satisfy the criteria will be drawn.

For developers:

As with the selection process, the net result of performing a query based on the FCODE/ACODE combinations is to arrive at a list of VVTID values that satisfy the query. Unlike the selection case, this set of VVTIDs is used to create a scratch table of the selected VVTIDs, which is then used to do an inner join to the feature class, which would eliminate features that do not have matching records in the join table:



This joined feature layer then has the attribute query (WID = 0 in this example) applied to the layer definition if present. This is done because an inner join is much faster than using the list of VVTIDs as a direct query by an “in” statement on the feature class.

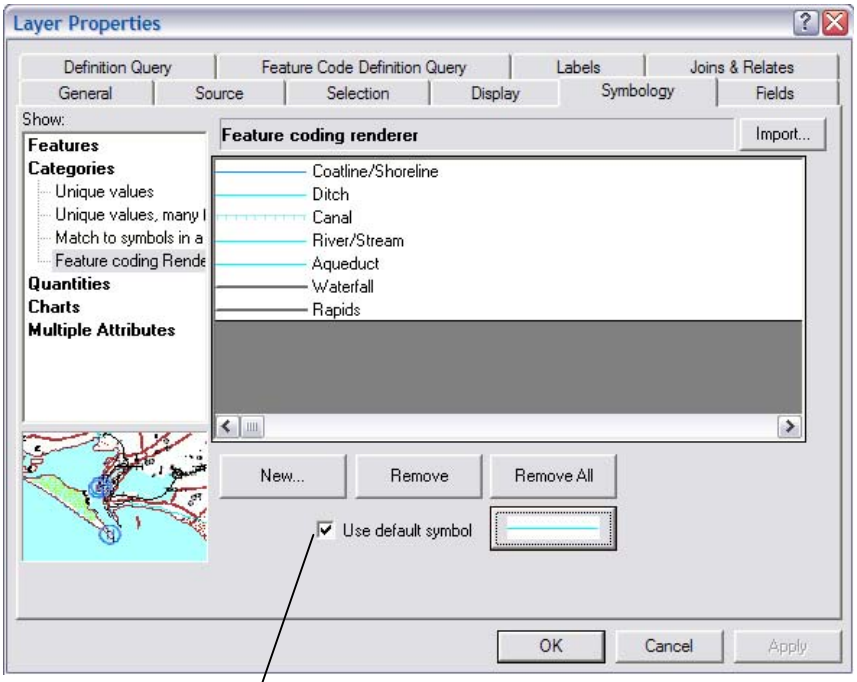
Unlike the selection case, the query used to define the layer definition needs to be persisted such that the user can always refer back to the layer properties to see the layer definition. This is done using a custom layer extension. The layer extension allows you to store any property set with a layer. This property set is persisted with the layer, so the layer definition is saved and can be retrieved.

Rendering features

As with selections and layer definitions queries, you need to be able to assign symbols for drawing features based on both standard FCODE/ACODE combinations and other general FCODE/ACODE criteria. The same logical method used for specifying criteria when selecting and defining layer definitions is also used for assigning symbols to groups of features:

1. Right-click on the layer you want to define symbology for and click Properties.
2. Click the Feature Symbology tab.
3. Under Categories, click Feature coding Renderer.
4. Click New to add a new criterion to assign to a symbol. Here, the New button will open the same dialog box as the selection and layer definition user interface examples above for specifying DIGEST code criteria.
5. Click Remove to remove the selected criteria and symbols.
6. Click Remove All to remove all the symbols.
7. The Use default symbol check box, when checked, indicates that a default symbol is used to symbolize all features that do not match one of the criteria specified in the list. The default symbol can be changed by clicking the button next to the check box.
8. Symbols for each criterion can be changed by double-clicking them in the list.

9. When finished defining the criteria and symbology, click OK to apply the renderer to your feature layer.



For developers:

Since the ultimate result of the criteria specified is a set of VVTIDs, a custom renderer is not required. Instead, the standard unique value renderer can be used. This dialog box is a custom renderer property page that allows the user to specify the VVTID value groups. The user can use the custom property page to make categories with the same dialog boxes and logic used to select features and specify definition queries.

Once Apply is clicked, the unique value renderer is applied to the layer. As the unique value sets are based on the VVTIDs, no join needs to happen during the drawing of the layer. The performance is comparable to any unique value renderer established with the standard unique value renderer property page.

Creating and editing features

A special editing experience for feature classes whose features are based on FCODE/ACODE VVT descriptions is required for both assigning VVTIDs to new features and for editing an existing feature's VVTID.

Creating new features

Each feature class's VVT contains a finite number of valid FCODE/ACODE combinations. When creating a new feature, you must specify one of these combinations to assign a VVTID to a new feature. To do this, the application extension contains a helper dialog box that allows you to:

1. Specify which type of feature you are creating (e.g., WaterL feature).
2. Specify the feature type (FCODE).
3. Based on the FCODE selected, choose one of the standard FCODE/ACODE combinations or manually specify the ACODEs for the feature.
4. Digitize the geometry.

The extension will then assign the correct VVTID to the feature based on what you specified in steps 1–3.

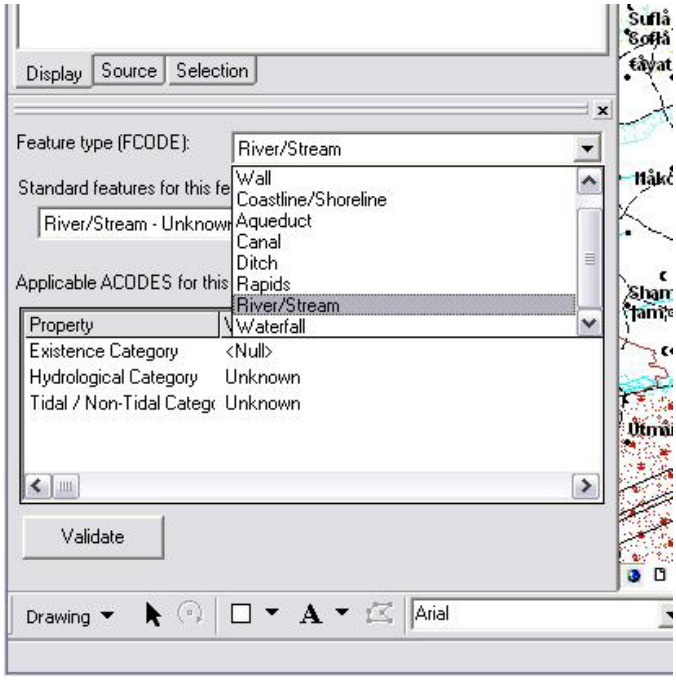
There are two alternative work flows for creating a new feature. The first is based on using standard FCODE/ACODE combinations to specify the correct VVTID for the new feature. The second involves using the ACODE values to specify the correct VVTID for the new feature.

Alternative 1:

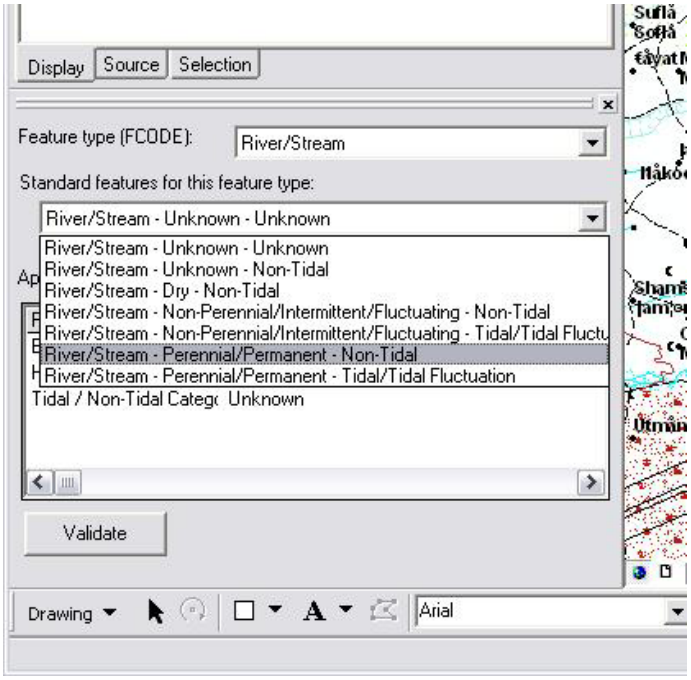
1. On the Editor menu, click Start Editing. The editor helper dialog box appears.

2. On the Editor toolbar, set your target layer. If the target layer has an associated VVT, the feature type combo box in the helper dialog box lists the feature types (FCODEs) for the target layer.

3. Click the Feature type (FCODE) dropdown arrow and specify the type of feature you want to create—for example, a new River/Stream feature.



4. Click the Standard features list to select one of the standard FCODE/ACODE combinations based on the descriptions from the VVT for that FCODE.



5. On the Editor toolbar, click the sketch and digitize a new feature. This feature is created in the target feature class, and the VVTID corresponding to the standard feature type is assigned to the new feature when the sketch is complete.

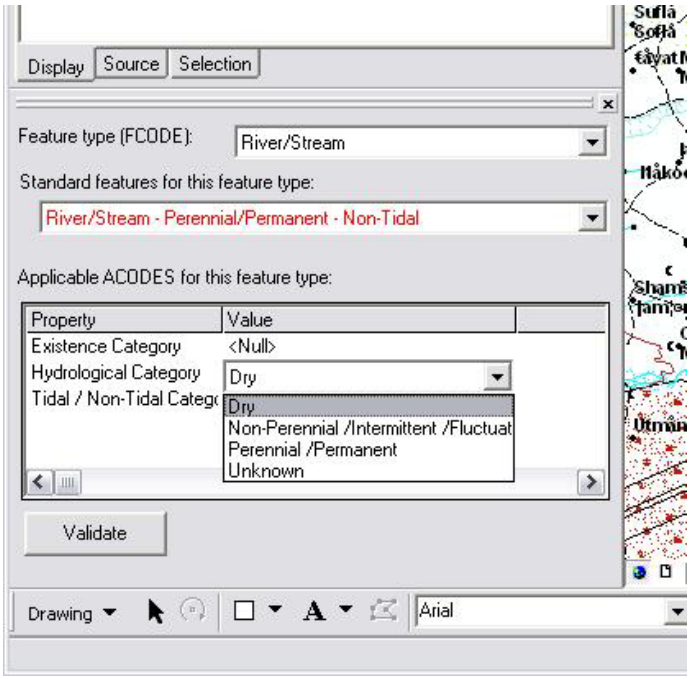
Alternative 2:

1. On the Editor menu, click Start Editing. The editor helper dialog box appears.

2. On the Editor toolbar, set your target layer. If the target layer has an associated VVT, the feature type combo box in the helper dialog box lists the feature types (FCODEs) for the target layer.

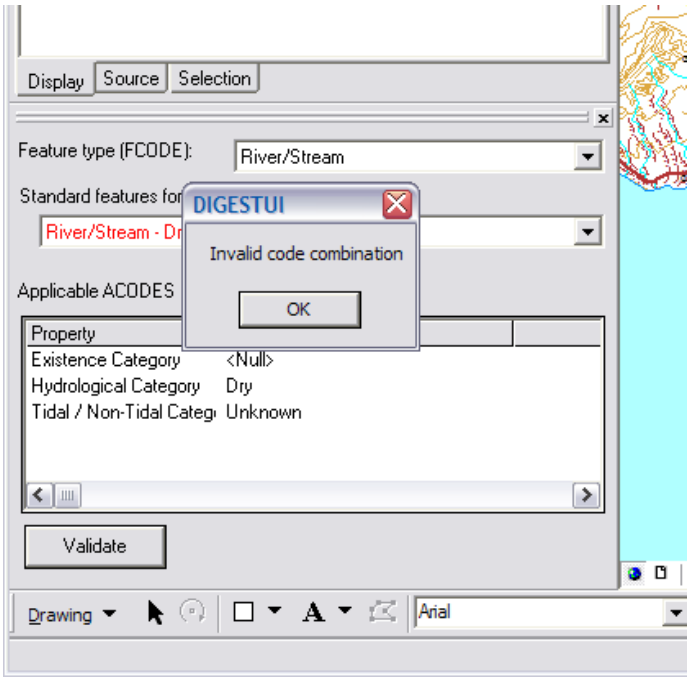
3. Click the Feature type (FCODE) dropdown arrow and specify the type of feature you want to create—for example, a new River/Stream feature.

4. Click the value lists for each ACODE to specify the value for each ACODE that applies to the selected FCODE to describe the feature you want to create. This causes the standard feature type to turn red, indicating that it no longer matches the ACODE values displayed (since you changed them).



5. You can use the editor sketch tools to digitize a feature. When the sketch is finished, the ACODE values will be used to find the row in the VVT that corresponds to that combination (with the selected FCODE). If no row is found, then you will get an error indicating you supplied an invalid ACODE combination for that FCODE.

Alternatively, you can click the Validate button to validate the ACODE value combination you supplied before attempting to add a new feature. If the combination is valid (i.e., it corresponds to a VVTID), then the standard feature will be resolved to show the description corresponding to that combination. If the combination is not valid, you will get an error message.



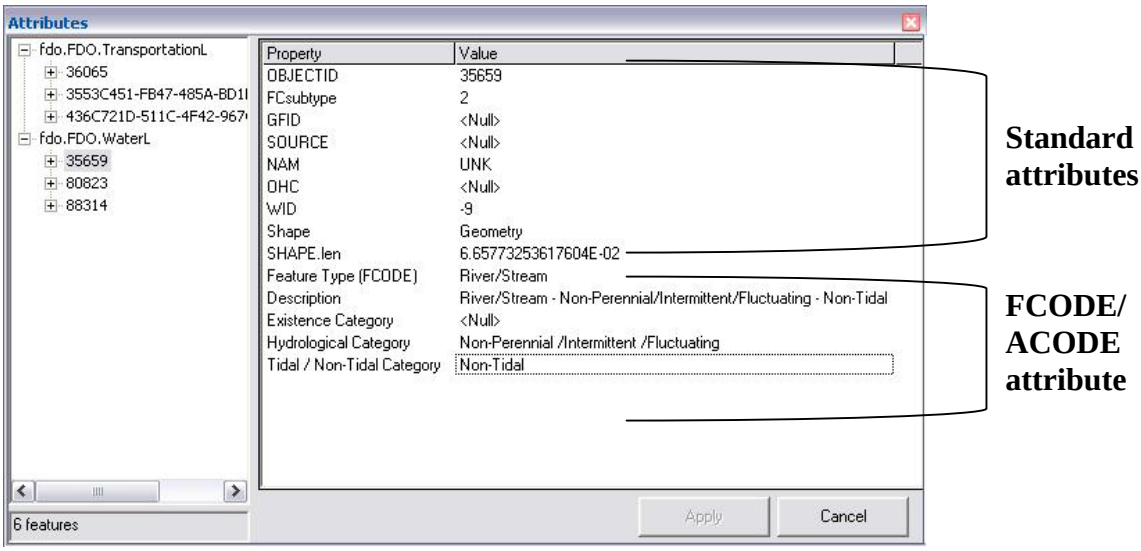
For developers:

When the user clicks Validate, the FCODE and ACODE values are used to build a query that is executed against the VVT. If no rows are returned by the query, then the code combination is invalid (has no associated VVTID), and the user is presented with an error message indicating they supplied an invalid code combination.

If the query does return a row, then the standard features list is updated to reflect the standard feature description for that VVTID.

Modifying existing features

To modify existing features, a custom property inspector is used. This custom property inspector looks and behaves like the standard property inspector, except it handles the complex FCODE/ACODE attribute domain.



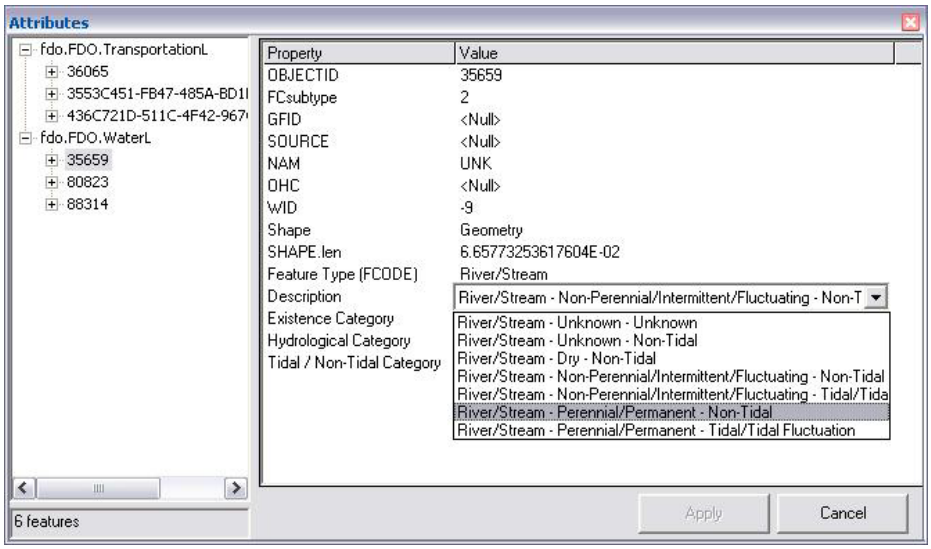
This property inspector is used for two key functions:

- Update the standard attributes for the feature on the feature class.
- Update the VVTID of the feature based on the FCODE/ACODE information in the VVT.

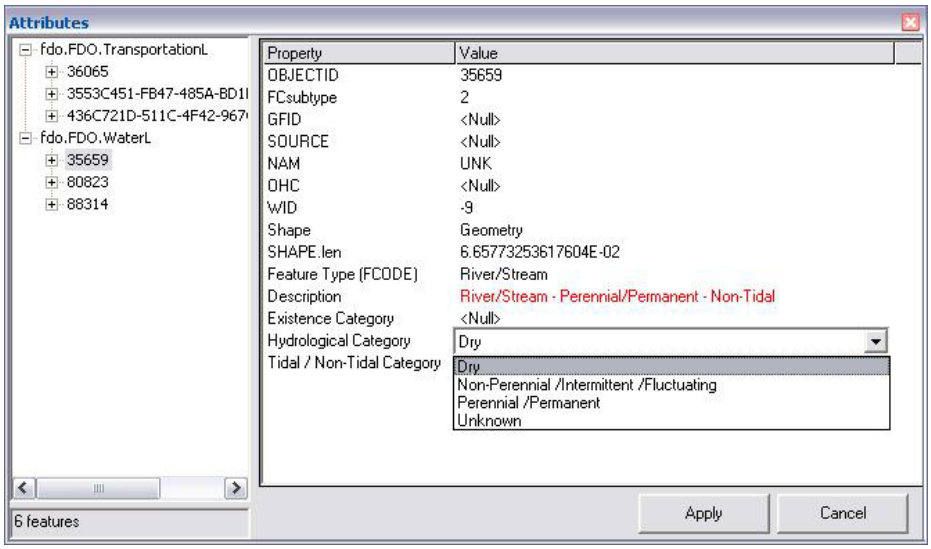
To modify the properties of a feature:

1. Select the feature type (FCODE) from a list of valid feature types for that class.

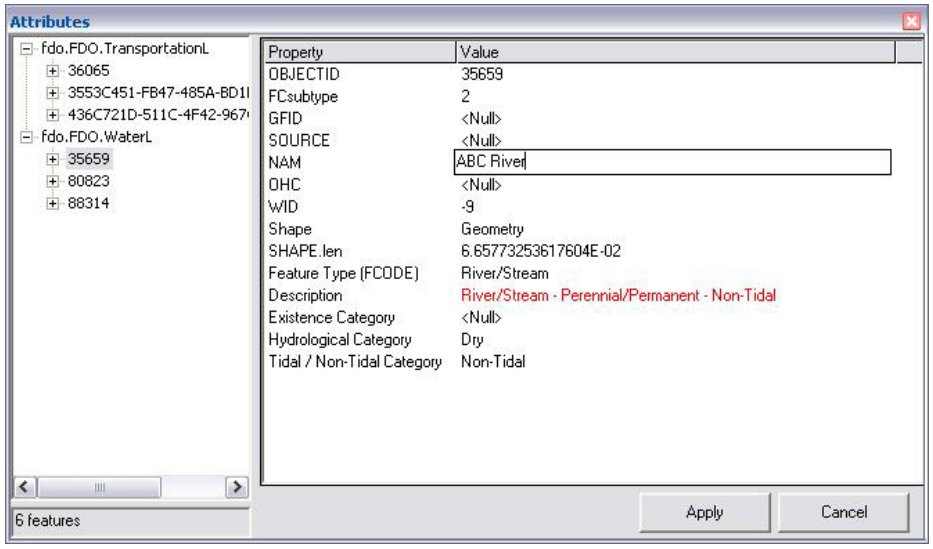
2. Alternatively, select from a list of standard feature types for the FCODE (these are the descriptions in the VVT for that FCODE).



Or you may specify values for each ACODE. Once an ACODE value is changed, the standard description turns red to indicate that it no longer applies to the specified ACODE values.



3. To update standard attributes, you can interact with the property inspector in the same way as the standard property inspector.



4. Once you have made your changes, click Apply to update the feature. If you supplied an invalid FCODE/ACODE combination, you will get an error message.

For developers:

When the user clicks Apply, the FCODE and ACODE values are used to build a query that is executed against the VVT. If no rows are returned by the query, then the code combination is invalid (has no associated VVTID), the edit operation is aborted, and the user is presented with an error message indicating they supplied an invalid code combination.

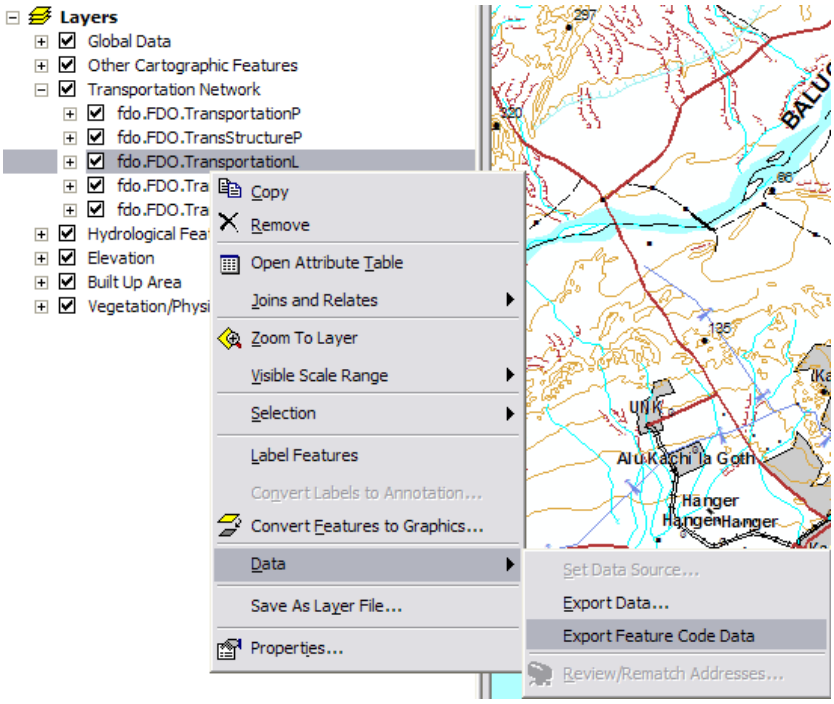
If the query does return a row, then the feature's VVTID is set as the VVTID associated with that row.

Exporting features

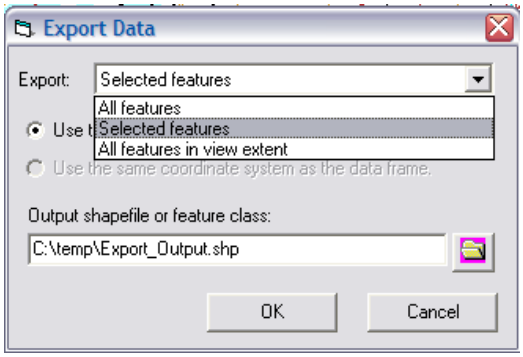
As with any database, it's often required that portions of the data be exported in a format that can be shared with other users and systems. This format can require the feature codes to be denormalized and stored on the feature table of the exported data. This allows sharing the data with users who do require features with codes expressed as fields in feature tables.

The application extension contains an export command that exports data in a layer to a shapefile or a geodatabase feature class with the major and minor codes (FCODE/ACODE) stored as values in fields. To use this command:

1. Right-click on the layer whose data you want to export.
2. Click Data and click Export Feature Code Data.



3. On the export dialog box, click the Export list to specify what data you will export.
4. Browse for the shapefile or feature class to export to.
5. Click OK to export the data.



For developers:

To determine the set of fields to be included on the output shapefile or feature class, the VVT associated with the class is used as the template. A field for the FCODE and fields for each ACODE that is associated with the set of FCODEs in the VVT are created in the output shapefile.

For each feature, the VVT is queried for the FCODE, ACODEs, and ACODE values and is inserted into the fields associated with each in the output.