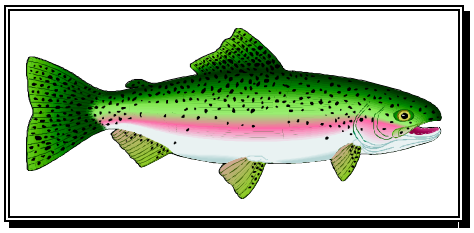
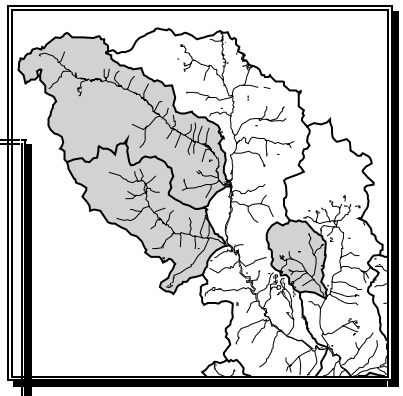
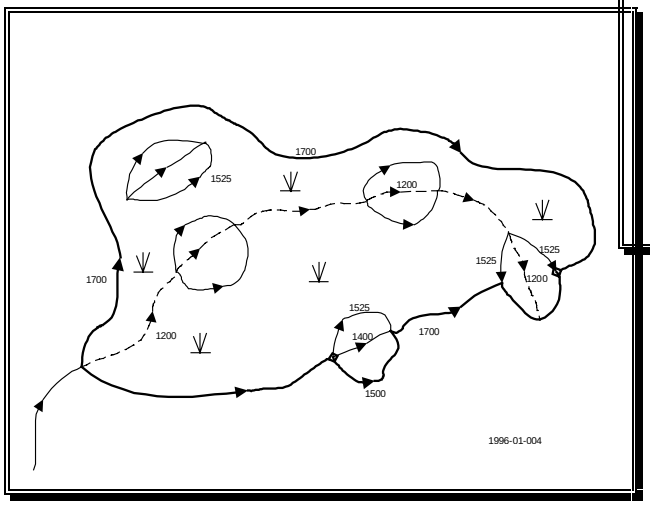
BC Ministry of Environment, Lands and Parks

Fisheries Branch







PHYSICAL DATA MODEL OF THE BRITISH COLUMBIA WATERSHED ATLAS

April 1996

Revision 2.1

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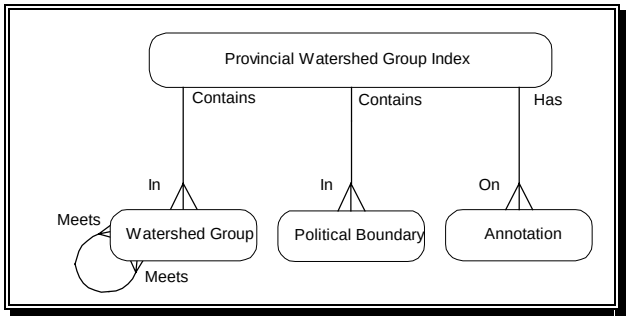

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1. Introduction

The B.C. Watershed Atlas and associated hierarchical coding system is the topologically structured digital map base used by various organizations to geo-reference aquatic-related data. The Atlas consists of all aquatic-related linework (lakes, streams, wetlands) and text as it appears on the NTS 1:50,000 map sheets. In addition, watershed boundaries have been delineated for third order and greater stream systems.

In terms of data management and processing the BC Watershed Atlas is comprised of Watershed Groups which are areas of coverage that approximate natural watershed groupings.

This publication documents the physical data model of the Watershed Atlas. It was written for staff who are responsible for the implementation and maintenance of the GIS spatial data structures of the Atlas. This includes Fisheries Branch staff, Regional GIS Coordinators and Data Conversion Contractors.

The remainder of this document:

- Describes of the various hardcopy and on-line supporting documentation that describe this Atlas;
- Summarizes the key characteristics of the Atlas from a physical GIS database perspective;
- Provides an overview of the spatial data architecture of the Atlas as well as detailed definitions of the arc, point and polygon features;
- Describes the technology context for this dataset including its computer environment, support routines and utilities.

In addition, extensive documentation on the digital GIS processing techniques that were used to produce the Atlas is provided in the Appendices.

2. OVERVIEW OF DOCUMENTATION

This publication is one of many reference documents that can be reviewed. There are three types of documentation that are available: Watershed Atlas Documentation; on-line Meta-Data; and the BC Environment GIS Forum on the World-Wide Web. Each is described below.

2.1 Watershed Atlas Documentation

Two documents have been written specifically for the British Columbia Watershed Atlas:

1. *"Logical Data Model of the British Columbia Watershed Atlas,"* BC Ministry of Environment, Lands, and Parks (First complete draft scheduled for March 1996). This is a non-technical document written for personnel who define spatial data business requirements (i.e. the Users), or staff who must understand the Users' requirements before implementing a solution using GIS (i.e. Regional GIS Coordinators, GIS Analysts, Contractors, etc.);
2. *"Physical Data Model of the British Columbia Watershed Atlas,"* BC Ministry of Environment, Lands, and Parks (First complete draft delivered January 1996). This is a technical document written for personnel who are responsible for the implementation and maintenance of the GIS spatial data structures (i.e. Regional GIS Coordinators).

2.2 On-Line Meta-Data

Each ARC/INFO physical dataset contains a set of INFO tables containing the following meta-data:[1]

- Identification information;
- Data quality;
- Spatial data organization;
- Spatial reference information;
- Entity and attribute information;
- Distribution information;
- Metadata reference information.

These tables are designed to be browsed in a manner similar to any other INFO table. The structure of these meta-data tables follows the standards described *in "Content Standards for Digital Geospatial Metadata,"* Federal Geographic Data Committee, (1994) Washington, D.C. The files are generated by running an AML routine called document.aml.

The meta-data for each file includes both general-purpose meta-data that would be common to all Watershed Atlas datasets (e.g. contact names, descriptions of key entities and their attributes), and special-purpose meta-data that is particular that dataset (e.g. data quality, projection, positional accuracy).

2.3 The BC Environment GIS Forum on the World-Wide Web

The BC Ministry of Environment, Lands and Parks maintains a GIS Forum on the World-Wide Web site. Topics covered include: GIS Glossary; BC Environment Graphical User Interface; BC Environment Standard Projection; ARC/INFO Configuration Guide; ARC/INFO GIS Data Standards; Oracle GIS Data Standards; ARC/INFO Naming Scheme; etc. This is a key source of information for any GIS Analyst who is working with the Watershed Atlas.

[1] Note: At the time of publication of this revision of the document, the meta-data capability was yet to be implemented.

3. KEY PHYSICAL CHARACTERISTICS OF THE WATERSHED ATLAS

The B.C. Watershed Atlas is based on an arc-node, vector topology which defines the structure of all the linework used to represent waterbodies, associated geographic features, and map surround elements. The features represented include streams, lakes, wetlands, man-made waterbodies (e.g. canals and reservoirs), and watershed boundaries. Point features (e.g. obstructions) are also represented in the Atlas. Table 1 summarizes the key physical characteristics.

Table 1 - Key Characteristics of the Watershed Atlas

Multilayer Spatial Dataset: The Atlas represents lakes, rivers, watersheds and other features using a multi-layer approach;
1:50,000 Scale View: The data in this Atlas are compiled from 1:50,000 NTS maps; hence, the positional accuracy and cartographic detail are similar to the standards established for that scale. However, since the Atlas was developed via scanning of the mylar originals of the NTS maps, the positional accuracy is not the same as the source materials;
Source Data Stored On One Layer: The various layers in the Atlas are created from source data maintained on one "parent" layer. Data conversion contractors deliver data to the Ministry in this format;
Most Entities Are Areal or Linear: The majority of the entities represented in the Atlas have either areal or linear spatial characteristics. This allows a user to group linear flow elements in large flow networks, or to combine areal features into larger polygon structures;
Highly Disaggregated: The spatial data is broken down into small component parts. This allows for the data to be regrouped (or aggregated) into larger spatial types. For example, a set of stream and river flow elements can be combined to make a larger drainage entity;
No Map Seams: - Entities in the Atlas cross NTS mapsheet boundaries. Neat lines do not divide up river or watershed entities; coverage extent is based on watershed boundaries.
Large Entities May Be Stored in More Than One Physical Dataset: Even though neat line seams are not an issue, large features such as the Fraser, Nass, Columbia and Skeena systems will be divided by Watershed Group boundaries;
Hierarchical Polygons: The watershed structure is a hierarchical polygon structure in which watersheds of order 'n' are contained by watersheds of order 'n+1'. Compare this concept with a polygon structure describing land ownership parcels in which the polygons are mutually exclusive and do not "contain" each other in a strict hierarchy;
Complex Topology: The Atlas has complex topological rules that must be followed carefully. Data capture requires careful quality assurance to ensure compliance with these rules;
Directionality Rules: For many of the linear features in the dataset, the direction in which a feature is captured has a direct relationship to the direction of flow of water. Similar rules exist for the capture of other entities such as islands, construction lines, etc.;
Watersheds Have Incomplete Geographic Coverage: For a geographic area of interest, the sum total of all the third-order and greater watersheds may not completely represent the Watershed Group. This should be considered carefully when performing area-based calculations;
Tabular Attribute Model: The descriptive attributes that describe feature types, watershed codes, stream identifiers, etc. are stored in a tabular structure. The database is designed to be integrated with a relational DBMS.

4. SPATIAL DATA ARCHITECTURE OF THE WATERSHED ATLAS

4.1 Business View of Entities Contained in the Atlas

The Watershed Atlas provides two main views of the watersheds in the Province. The first view is an overview of British Columbia which shows the boundaries for all of the watershed groups in the Province. The second view is the collection of watershed groups themselves. There are approximately 250 Watershed Groups in all. This "two-view" concept is shown in Figure 1. The overview map can be viewed as a key map which allows a user to index spatially down into the next level of detail. The logical ERD for this view is shown in Figure 2.

Figure 1 - Relationship of View #1 (Index Map) to View #2 (Watershed Groups)

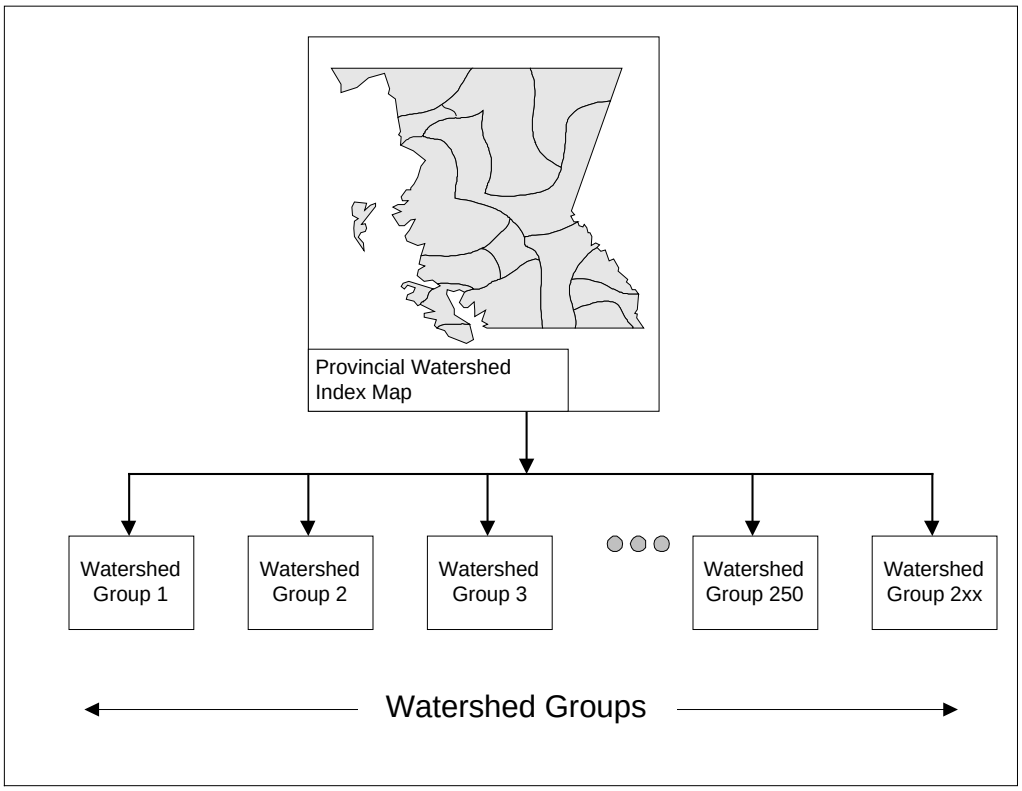
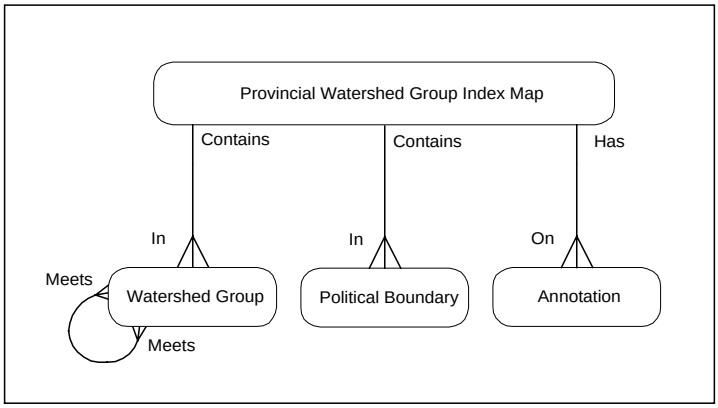
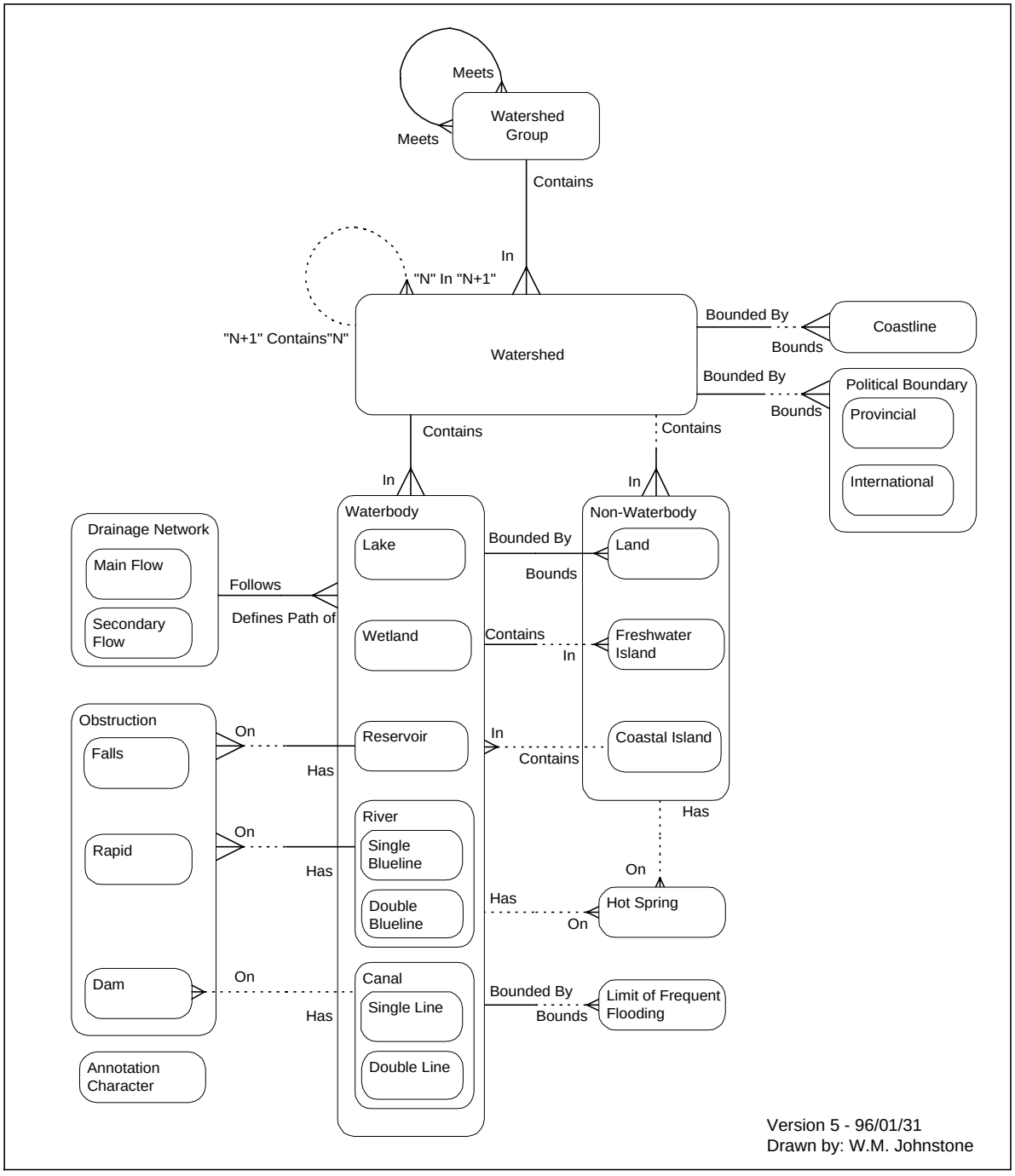


Figure 2 - Logical ERD for Business View #1: Provincial Watershed Group Index Map



Each watershed group describes a number of different business entities that make up the Atlas. Figure 3 presents the logical ERD for this view.[2]

Figure 3 - Logical ERD for Business View #2: Watershed Group



[2] A more detailed description of the business (or user's) view of this Atlas is provided in the companion document "*Logical Data Model of the British Columbia Watershed Atlas*," Fisheries Branch, BC Ministry of Environment, Lands and Parks (1996).

4.2 Physical View of Entities Contained in the Atlas

4.2.1 Mapping of Logical Entities to Physical GIS Entities

Up to now, the business concepts have been discussed independently of GIS considerations. In order to implement the logical model of the Watershed Atlas on a GIS, a physical spatial data model must be designed. A key step in that process is mapping the logical entities discussed in Section 4.1 to the basic physical entities supported by the commercial GIS package. In this case, these "building blocks" are the point, arc and polygon elements supported by ARC/INFO.

Table 2 shows how the logical business entities relate to the GIS entities.

Table 2 - Mapping of Business Entities to Physical GIS Entities

Logical Business Entities	Physical GIS Entities		
	Point	Arc	Polygon
Annotation	X		
Coastline		X	
Drainage Network			
Main flow		X	
Secondary flow		X	
Hot Springs	X		
Limit of Frequent Flooding		X	
Non-Waterbody			
Land			X
Coastal Island			X
Fresh Water Island			X
Obstruction			
Dam	X		
Falls	X		
Rapid	X		
Political Boundary			
International		X	
Provincial		X	
Waterbody			
Lake			X
Reservoir			X
River			
Single Blueline		X	
Double Blueline			X
Canal			
Single Line		X	
Double Line			X
Wetland			X
Watershed			X
Watershed Group			X
Construction Entities	Physical GIS Entities		
	Point	Arc	Polygon
Closure line		X	
Representation line		X	
Connection line		X	
Pseudo node	X		
X = Logical entity can be represented by physical entity.			

At the bottom of the table, a new type of physical GIS entity called the construction entity has been introduced. This is discussed in the next section.

4.2.2 Construction Entities Contained in the Atlas

The overall objective of the Atlas is to create a spatial database that supports high quality cartographic outputs and is topologically structured and feature-coded so as to support and facilitate analyses and information retrieval. Of particular interest is the ability to analyze the data as a continuous network.

To achieve this overall objective, polygon features must be closed to provide identity, computation of area and perimeter, and colour fills. Polygon features such as double-line rivers must be represented as simple lines to support network analyses involving points of interest that are located at various positions along the hydraulic network (e.g. fish distribution zones, macro-reaches).

To meet these requirements, a set of additional connectivity entities need to be added to the Atlas to provide closure, to represent features in the hydraulic network, and to ensure connectivity of the network. Two types of construction feature have been added to the Atlas: line construction features and point construction features. Each is described below.

4.2.2.1 Line Construction Entities

Construction lines (e.g. through lakes and double-line rivers) are simply lines which are created to provide required topology and connectedness. There are no requirements for positional accuracy, however connection lines for tributary features should attempt to form a ninety (90) degree angle to the flow construction line.

Three types of construction lines are added:

- Closure lines;
- Representation lines;
- Connection lines.

Each is described below.

Closure Lines: Closure lines are added to complete lake shorelines, to complete the coastline, e.g., where double-line river mouths discharge to the ocean, and to identify (and close) major river channels. The objective of these construction lines is to establish identity for river channels that are relatively stable, are of importance, and potentially may have different fisheries or other information than other channels of the same river. Examples would be the North and South Arms of the Fraser River.

Representation Lines: Representation lines are added through the length of "double-line" rivers, lakes and wetlands. Where appropriate, this construction line would connect the main lake/wetland inlet to the main outlet. In rivers, this line would connect the head to the mouth. Construction lines are also required through the length of secondary river channels, i.e. channels that have been given identity through the addition of construction lines to close the feature.

Connection Lines: Connection lines must be added to ensure that tributaries and minor outlets of lakes, wetlands and double-line rivers are connected to the construction line that represents the mainflow through the polygon. This is to ensure connectivity in the hydraulic network. Similarly, construction lines must be added to ensure that river channels are properly connected.

In some cases, order to maintain consistency, there is a need to connect isolated waterbodies that do not have a mapped outlet that is visible at the 1:50,000 scale. A connection line would be used to add a connection to (second case: sinkhole - need to add connection line as well).

4.2.2.2 Point Construction Entities

A point construction entity is also added to the Atlas. In this case, a pseudo-node entity has been added to allow two different types of construction lines to be connected together.

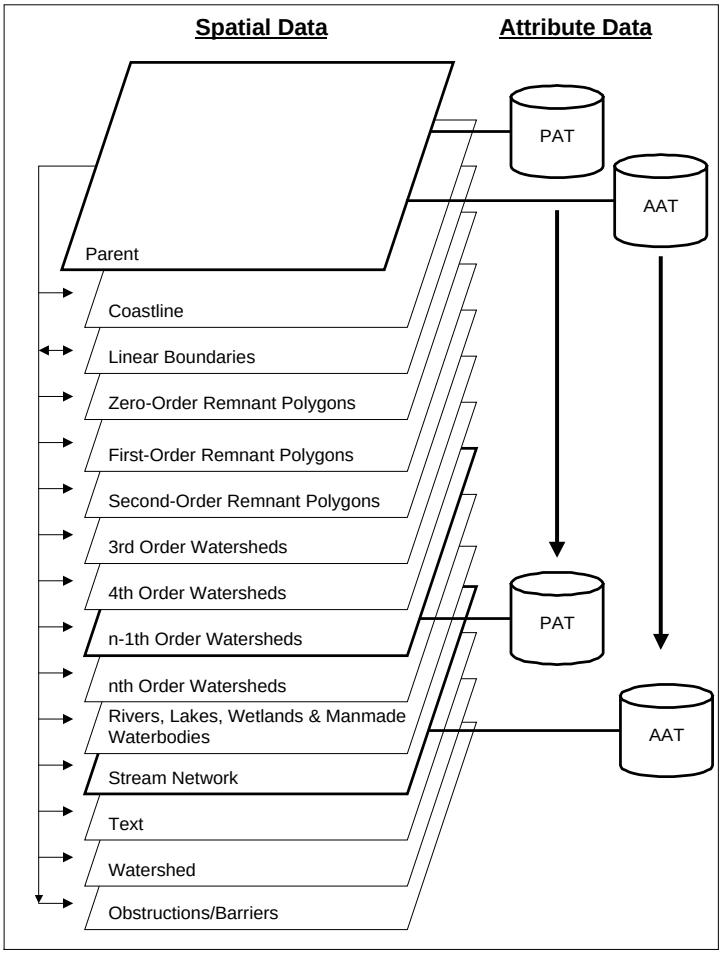
4.2.3 File Structure of Each Watershed Group

Each Watershed Group within the Atlas is organized into thematic layers as shown in Figure 4. The data in each layer is stored as spatial and non-spatial (or attribute) data.

Spatial Data: Each thematic layer represents business entities using an arc-node spatial topological structure. From a data input perspective, the key layer is the parent layer from which all the other thematic layers are built.

Attribute Data: The non-spatial descriptors of each layer are stored in attribute tables. The Watershed Group Parent layer has two attribute tables: the ARC Attribute Table (AAT), and the Polygon Attribute Table (PAT). The AAT contains attributes describing linear features such as streams or coastlines. The PAT describes areal or polygon features such as lakes, wetlands or drainage basins. Each layer has either a PAT or an AAT file but not both, and so contain some or all of the same attributes defined for the parent layer.

Figure 4 - Organization of the Watershed Atlas Into Layers



The figure shows this idea for the n-1th order watershed layer and the stream network layer.

4.2.4 Description of Physical GIS Layers

In addition to mapping logical business entities to points, arcs and polygons, these business entities can also be organized into physical layers or "themes" within the ARC/INFO dataset. For each watershed group, a standard set of thematic layers has been designed.

Table 3 presents the standard thematic layers of the BC Watershed Atlas. Note that the total number of layers for any one Watershed Group is dependent upon the highest order watershed in that group.

Table 3 - Definitions of Watershed Group Layers

Name of Layer	Description[3]
Parent	This layer contains all the spatial and attribute elements defining this watershed group
Coastline	Coastline extracted from the parent layer ***"wsg".***
Linear Boundaries	Linework for all the polygons extracted from the parent layer ***"wsg".***
Zero Order Remnant Polygons	Remnant polygons extracted from the parent layer ***"wsg"*** that have **no streams** within them.
1st Order Remnant Polygons	Remnant polygons extracted from the parent layer ***"wsg"*** that have **only 1st order streams** within them.
2nd Order Remnant Polygons	Remnant polygons extracted from the parent layer ***"wsg"*** that have **a maximum stream order of two**.
3rd Order Watersheds	Watersheds extracted from the parent layer ***"wsg"*** that have **a maximum stream order of three**.
4th Order Watersheds	Watersheds extracted from the parent layer ***"wsg"*** that have **a maximum stream order of four**.
5th Order Watersheds	Watersheds extracted from the parent layer ***"wsg"*** that have **a maximum stream order of five**.
n-1th Order Watersheds	Watersheds extracted from the parent layer ***"wsg"*** that have **a maximum stream order of n-1.**
nth Order Watersheds	Watersheds extracted from the parent layer ***"wsg"*** that have **a maximum stream order of n.**
Rivers, Lakes, Wetlands and Man-Made Waterbodies	This layer contains Rivers, Lakes, Wetlands and Man-made waterbody Features.
Stream Network	Stream flow network. Routes have been built from this layer and are a feature class of this layer.
Text	Annotation for aquatic features.
Watershed	3rd Order watersheds and higher extracted from the parent layer ***"wsg"*** and a summary table of water features.
Obstructions/Barriers	Features which alter the flow of water.

[3] Note: In this table, the letters ***"wsg"*** are generic letters substituted for the actual **four letter** watershed group name eg . **nicl** (nicola lake watershed group), **cown** (cowichan/nanaimo watershed group).

4.2.5 Relationship of Logical Entities to Physical GIS Layers

To complete the translation of the logical business model to a physical GIS model, the entities discussed in Section 4.1 must also be mapped to the physical GIS layers. Table 4 shows how these business entities are represented by the physical layers of each WSG.

Table 4 - Mapping of Business Entities to Watershed Group Layers

	Physical GIS Layers															
Logical Business Entities	Parent	Coastline	Linear Boundaries	Zero Order Remnant Polygons	1st Order Remnant Polygons	2nd Order Remnant Polygons	3rd Order Watersheds	4th Order Watersheds	5th Order Watersheds	n-1th Order Watersheds	nth Order Watersheds	Rivers, Lakes, Wetlands, Canals & Reservoirs	Stream Network	Text	Watershed	Obstructions/Barriers
Annotation	X													X		
Coastline	X	X	X													
Drainage Network																
Main flow	X												X			
Secondary flow	X												X			
Non-Waterbody																
Land	X											X				
Coastal Island	X	X	X									X				
Fresh Water Island	X		X									X				
Obstruction																
Dam																X
Falls																X
Rapid																X
Political Boundary																
International	X		X	X	X	X	X	X	X	X	X				X	
Provincial	X		X	X	X	X	X	X	X	X	X				X	
Waterbody																
Lake	X		X	X	X	X	X	X	X	X	X	X				
Reservoir	X		X	X	X	X	X	X	X	X	X	X				
River																
Single Blueline	X		X										X			
Double Blueline	X		X										X			
Canal																
Single Line	X		X									X	X			
Double Line	X		X									X	X			
Wetland	X		X									X				
Watershed	X		X	X	X	X	X	X	X	X	X				X	
Watershed Group	X		X												X	
Construction Entities																
Closure line	X	X	X									X			X	
Representation line	X												X			
Connection line	X												X			
Pseudo node	X		X										X			

X = Entity is represented on that layer.

NB X's in Lake and Reservoir rows for columns Zero - nth order watersheds should be removed.

5. SPATIAL DATA DICTIONARY

5.1 Point Features

5.1.1 Point Entities

Table 5 presents the entities in the Watershed Atlas that are represented as point features.

Table 5 - List of Point Features

Feature Code	Name
01	Falls
04	Dam
05	Rapid (chute or cascade)
09	Hot Springs

Each entity is described in more detail below.

01 Falls:

Description: The water in a watercourse or a waterbody that follows a perpendicular or a very steep descent.

Topological Rules: -

04 Dam:

Description: A barrier built across a watercourse or waterbody to control the water flow.

Topological Rules: -

05 Rapids:

Description: A fast-flowing section of a watercourse or waterbody, generally with exposed rocks or boulders. Although many rapids have a linear extent, this feature is coded as a set of independent points. For double-line features, the location of each rapid is clearly delineated by a dashed symbol that spans the feature. A feature point is placed on the construction line at that location. For single-line features, the location of the rapid is placed at the x,y coordinates of the map location.

Topological Rules: -

09 Hot Springs:

Description: A place where hot water naturally flows from the ground.

Topological Rules: -

5.1.2 Pseudo-Nodes

In addition to point entities, the Atlas also makes use of pseudo-nodes to connect different types of construction lines. This facilitates a change in feature type along a linear segment. The two known cases are: (1) Boundary features 5000 and 5100, and (2) Flow features 1050 and 1200 (see Section 5.2 below for descriptions of linear feature codes).

5.2 Arc Features

5.2.1 List of Arc Features

Table 6 presents a list of the arc features contained in the Watershed Atlas. On the following pages, these features are described in more detail.

Table 6 - List of Arc Features

Code	Feature Name	Code	Feature Name
100	Coastline	1600	Island shoreline
150	Construction line, coastline	1625	Island shoreline shared with a wetland
200	Ice Field of Glacier	1700	Wetland shoreline
1000	Single line blueline, main flow	1800	Double line blueline, right bank
1050	Single line blueline, main flow through wetland	1825	Double line blueline, right bank shared with wetland
1100	Single line blueline, secondary flow	1850	Double line blueline, left bank
1150	Single line blueline, secondary flow through wetland	1875	Double line blueline, left bank shared with wetland
1200	Construction line, main flow	1900	Island in river, right bank
1250	Construction line, double line river, main flow	1925	Island in river, right bank shared with wetland
1300	Construction line, secondary flow	1950	Island in river, left bank
1325	Construction line, segment delimiter	1975	Island in river, left bank shared with wetland
1350	Construction line, double line river, secondary flow	2000	Single line, Canal
1375	Construction line, river delimiter	2100	Double line, Canal or Reservoir
1400	Construction line, other flow/inferred connection	2300	Single-line, Canal, secondary flow
1410	Construction line, network connector	4000	Frequent floodplain limit
1425	Construction line, subsurface flow	5000	Major watershed boundary
1450	Construction line, connection	5100	Minor watershed boundary
1455	Construction line, secondary flow connector (downstream)	5200	Trivial watershed boundary
1456	Construction line, secondary flow connector (upstream)	6000	International Boundary
1475	Construction line, lake arm	9000	Map neatlines
1500	Lake shoreline	9999	Undefined
1525	Lake shoreline shared with a wetland		
1550	Construction line, lakeshore		

5.2.2 Description of Arc Features

100 Coastline:
Description: Indicates the interface between land and the ocean.
Topological Rules: -

150 Construction Line, Coastline:
Description: A construction line used when a large waterbody (such as the Fraser River) is connected to the ocean.
Topological Rules: This provides a boundary (separation) between the waterbody and the ocean.

200 Ice Field or Glacier:
Description: A line indicating the boundary of a persistent or semi-permanent area of ice and snow.
Topological Rules: This feature may close on itself, or be attached to other features such as lakes, streams, or watershed boundaries.

1000 Single line blueline, main flow:
Description: The main channel (majority of flow) of a natural river, stream or creek that is represented as a single line at 1:50,000 scale.
Topological Rules: -

1050 Single line blueline, main flow through wetland:
Description: This is used to indicate the **main** channel of a natural river, stream or creek that flows through a wetland, is represented as a single line at 1:50,000 scale and is considered to be the most significant waterbody flowing through that wetland.
Topological Rules: There can only be one 1050 within a wetland polygon, all other lines should be coded as 1100.

1100 Single line blueline, secondary flow:
Description: Any channel that is not the main channel of a natural river, stream or creek that is represented as a single line at 1:50,000 scale.
Topological Rules: -

1150 Single line blueline, secondary flow through wetland:
Description: This is used to indicate a channel of a natural river, stream or creek that flows through a wetland, is represented as a single line at 1:50,000 scale and is considered to be the most significant waterbody flowing through that wetland.
Topological Rules: Similar to 1050, there can only be one 1150 within the wetland polygon. An 1150 can never be located within a wetland polygon that already contains a 1050.

1200 Construction line, main flow:
Description: A construction line through a polygon feature (lake, wetland or man-made waterbody) connecting the main inlet to the main outlet. For waterbodies without inlets and outlets use code 1400 (as there is no flow).
Topological Rules: Where there is no inlet or outlet, the construction line should be from the main outlet to the opposite side/end of the waterbody.

1250 Construction line, double line river, main flow:

Description: A construction line connecting the mouth of a double-line river (a river large enough to be represented as two parallel lines at 1:50,000 scale) to either the head or the point where the river becomes a single line blueline. This construction line should follow the main channel.

Topological Rules: -

1300 Construction line, secondary flow:

Description: A construction line through a polygon feature (lake, wetland or man-made waterbody) indicating a secondary flow. For example, a lake may have a significant outlet and a minor outlet.

Topological Rules: The flow from the main inlet to the significant outlet would be the prominent flow. There would also be a secondary flow line (code = 1300) which connects the main flow line to the minor outlet. Alternately, a lake may be located on a side channel of a river system. In this case the construction line connecting the main inlet to the main outlet is a secondary flow construction line (code = 1300).

1325 Construction line, segment delimiter:

Description: A construction line used to mark the separation of one portion of a polygon feature (typically a double-line river) from another.

Topological Rules: A typical use is to define the boundary between two watershed groups where it should logically be only one large group. This construction line should be digitized from the flow construction line to the river bank.

1350 Construction line, double line river, secondary flow:

Description: A construction line connecting the mouth of a secondary channel (other than the main flow) of a double-line river to either the head (the point where it diverges from the main stem) or the point where the river becomes a single line blueline. This construction line should follow the thalweg (maximum depth of the channel), if known.

Topological Rules: -

1375 Construction line, river delimiter:

Description: A construction line used to mark the separation between two double-line rivers, for example, between a double-line tributary (or man-made waterbody) and a main stem double-line river or between a double-line secondary channel and the main channel.

Topological Rules: In effect this construction line is used to "close the bank" of the more important double-line river or channel.

1400 Construction Line, other flow/inferred connection:

Description: This construction line is used for two purposes: (1) used as a construction line through the major axis of isolated waterbodies (arbitrary direction). This is necessary to represent the waterbody in the link data model. (2) used where linework has been imported from the Intergraph version of the Stream Atlas and a construction line is present that is not within a polygon feature and is not clearly a subsurface flow. Commonly such lines in the Stream Atlas were created as an artifact of the historical requirement for "parent-child" topology when an isolated waterbody was digitized.

Topological Rules: -

1410 Construction line, network connector:

Description: This construction line is used to connect features that would normally be disconnected (e.g. sinkholes, isolated lakes) to the flow model to ensure completeness of the model.

Topological Rules: -

1425 Construction line, subsurface flow:

Description: This construction line is used to indicate a subsurface flow such as ground water flow or storm sewer.

Topological Rules: -

1450 Construction line, connection:

Description: This construction line is used to ensure connectivity between flow lines. For example, it is used to connect a tributary which discharges into a lake to the lake's flow construction line. It is also used to connect secondary flow construction lines to main flow construction lines (*e.g.*, a secondary flow double-line river to the river's main flow construction line).

Topological Rules: Connection lines (code = 1450) are never connected to other connection lines and are only used inside polygon features. Where two connectors are required to "link" a stream flow to the main flow, use a combination of one code 1450 and one code 1410 (i.e. lake within wetland with a tributary into the wetland the code 1450 should be used to connect the main-flow to the lakeshore and a code 1410 used to connect the stream line through the wetland.

1455 Construction line, secondary flow connector (downstream):

Description: [tbd]

Topological Rules: [tbd]

1456 Construction line, secondary flow connector (upstream):

Description: [tbd]

Topological Rules: [tbd]

1475 Construction line, lake arm:

Description: This code exists to allow loading of historical data from the Intergraph version of the Stream Atlas. Linework associated with this code should be replaced where practical. Use of this code to capture new linework is strongly discouraged. The "lake arm" construction line was historically used where there was a limited amount of space available and a requirement to connect a large number of connection lines (code = 1450) to a flow construction line. The "lake arm" is in effect a loop off the construction line which provides more space to attach the connection lines.

Topological Rules: -

1500 Lake Shoreline:

Description: This line is used to indicate the shoreline of a lake except cases where the shoreline of the lake is shared with a wetland (see 1550 below).

Topological Rules: -

1525 Lake shoreline shared with a wetland:

Description: This line is used when a lake shoreline is contiguous with a wetland.

Topological Rules: Examples of where this would be used includes: a lake completely surrounded by wetlands or a wetland which borders on a portion of a lake. In such cases the wetland and the lake are effectively one waterbody and are treated as such. A single construction line would be used to represent both.

1550 Construction line, lakeshore:

Description: This construction line is used to "close" a lake shoreline, for example, providing separation from the lake and a double-line river which discharges into or flows from the lake.

Topological Rules: -

1600 Island Shoreline:

Description: This line indicates the shoreline of an island that is completely contained within a waterbody polygon (*i.e.* is not connected to the outer shoreline of the polygon). For example, an island in a lake is generally code 1600.

Topological Rules: Islands in a river are code 1600 if they are not connected to either the left or right river bank (by a river delimiter, code = 1375). Note that islands in the ocean are code = 100.

1625 Island shoreline shared with a wetland:

Description: This code is used when an isolated island in a river (*i.e.* not connected to the outer shoreline of the river polygon) is a wetland or includes a wetland that borders on the island shoreline. In such cases, the wetland is effectively part of the river and is treated as such.

Topological Rules: There is no construction line added for the wetland. For wetlands on islands in a lake, use code 1525 (lake shoreline shared with a wetland).

1700 Wetland shoreline:

Description: This line indicates the shoreline of a wetland that is not shared with another waterbody. It indicates the boundary between the wetland and dry land.

Topological Rules: A construction line (code 1200, 1300 or 1400 as appropriate) must be added for wetlands that are not contiguous with a lake or river and do not contain a single-line river, stream or creek.

1800 Double blueline, right bank:

Description: The outermost right bank of a double-line river (a river large enough to be represented as two parallel lines at 1:50,000 scale) when viewed in a downstream direction.

Topological Rules: Where the right bank of a double-line river is an island's shoreline use code 1900 (see below). The rationale for distinguishing between "river bank" and "island in river, bank" is to allow easy selection of the major outline of a river exclusive of small islands (for example for use on a small scale map). For this reason large islands in rivers, such as Lulu Island in the Fraser River Delta, should not be coded as "island in river, bank". As a guideline, islands which are visible on 1:500,000 scale maps should not be coded as "island in river, bank".

1825 Double line blueline, right bank shared with wetland:

Description: This line is used when the outermost right bank of a double-line river is contiguous with a wetland.

Topological Rules: -

1850 Double line blueline, left bank:

Description: The outermost left bank of a double-line river when viewed in a downstream direction. See discussion of code 1800 above.

Topological Rules: -

1875 Double line blueline, left bank shared with wetland:

Description: This line is used when the outermost left bank of a double-line river is contiguous with a wetland.

Topological Rules: -

1900 Island in river, right bank:

Description: An island shoreline that is the right bank of a channel of a double-line river. See discussion of code 1800 above.

Topological Rules: -

1925 Island in river, right bank shared with wetland:

Description: This is used when an island shoreline that is the right bank of a channel of a double-line river is contiguous with a wetland.

Topological Rules: -

1950 Island in river, left bank:

Description: An island shoreline that is the left bank of a channel of a double-line river. See discussion of code 1800 above.

Topological Rules: -

1975 Island in river, left bank shared with wetland:

Description: This is used when an island shoreline that is the left bank of a channel of a double-line river is contiguous with a wetland.

Topological Rules: -

2000 Single-line, Canal (Man-made waterbody):

Description: A man-made waterbody (such as an irrigation ditch, flume, aquaduct, or raceway) that is represented as a single line at 1:50,000 scale.

Topological Rules: -

2100 Double-line, Canal or Reservoir (Man-made):

Description: A man-made waterbody (such as a reservoir, sewage treatment pond, or log sorting pond) that is sufficiently large as to be represented as a polygon feature at 1:50,000 scale.

Topological Rules: -

2300 Single-line, Canal, secondary flow (Man-made):

Description: A man-made waterbody (such as a canal, irrigation ditch, flume, aquaduct or raceway) that is represented as a single line at 1:50,000 scale, and is considered to be a secondary flow.

Topological Rules: -

4000 Frequent floodplain limit:

Description: A line indicating the boundary of an area that is subject to periodic (possibly seasonal) flooding.

Topological Rules: The area delimited is generally shown on the NTS map as a fine dashed (blue) line delimiting a sand bar (on older editions, referred to as dry river bed).

5000 Major watershed boundary:

Description: A line indicating the boundary of a major watershed as designated by Fisheries Branch, Ministry of Environment, Lands and Parks.

Topological Rules: This should be digitized so that the watershed is to the right of the direction of digitizing. Because GIS coverages normally only include one major watershed, this line usually encloses all data in the coverage.

5100 Minor watershed boundary:

Description: A line indicating the boundary of a minor watershed as designated by Fisheries Branch, Ministry of Environment, Lands and Parks.

Topological Rules: Each major watershed is subdivided into a series of minor watersheds which generally correspond to drainage basins of major tributaries. The direction of digitizing for minor watershed boundaries is arbitrary.

5200 Trivial watershed boundary:

Description: This boundary line is used to provide fine resolution within a larger watershed boundary. For example, a minor watershed may include a small catchment basin (a depression) that may be inappropriate to include in computations of watershed surface area.

Topological Rules: The "trivial watershed boundary" code is provided to allow users to incorporate features such as the depression in the map coverage without interfering with the topology of the major and minor watershed boundaries.

Trivial watershed boundaries may also be added where required because of GIS software limits (for example, to reduce the number of arcs contained in a single polygon, also see feature **1325**).

6000 International or Provincial boundary:

Description: This boundary line is used in the case where there is no aquatic data available on the other side of the line. This occurs at the 49th parallel (Canada-US boundary), the 60th parallel (BC-Yukon boundary), the 120th longitude (BC-Alberta boundary), and the Alaska Panhandle (Canada-US boundary)

Topological Rules: -

9000 Map neatlines:

Description: These are lines which are added, if required, to define the limits of the map coverage.

Topological Rules: Such lines should not be required unless the coverage of a watershed is incomplete. Complete watersheds will include watershed boundaries which provide polygon closure. Neatlines and other map surround elements (braided borders, tic marks, etc.) may be added to the coverage and coded as map neatlines.

9999 Undefined:

Description: This code is used to identify linework that can not currently be coded for whatever reason, pending final resolution of the fate of this linework. It may also be used as temporary coding of a feature that may/should be deleted, pending approval or execution of the deletion.

Topological Rules: -

5.2.3 Description of Arc Attributes

The arc features maintained in the Watershed Atlas have associated attribute data tables that can be used to support query and analysis functions. Definitions of the typical arc attributes maintained for these features are provided below.

Table 7 - Arc Attribute Definitions for the Parent Layer

Attribute	Description	Type	Width
FNODE_	Internal-ID number of the from-node	Numeric	11
TNODE_	Internal-ID number of the to-node	Numeric	11
LPOLY_	Left polygon number	Numeric	11
RPOLY_	Right polygon number	Numeric	11
LENGTH	Length in coverage units	Numeric	13.6
“wsg”_	ARC Internal-ID number. Used for linking to spatial data.	Numeric	11
“wsg”_ID	ARC User-ID.	Numeric	11
GIS_TAG	Province wide unique identifier to link attribute data to spatial data. Combines map name and coverage sequence number. A stream segment or lake shoreline may be composed of several arcs (i.e. lines) each having its own gis_tag identifier. (see Watershed/Waterbody Identifier Project Objectives, Summary and Recommendations - November 21,1994)	Character	15
CODE	The original Numeric code to identify the type of feature represented by the spatial data.	Numeric	6
FCODE	The MOEP standard numeric code to identify the type of feature represented by the spatial data.	Character	10
WS_KEY	Unique Watershed Identifier used by Watershed Atlas programs. A simplified code based upon WS_CODE.	Numeric	9
BL_KEY	Unique Blue Line (stream) identifier used by Watershed Atlas programs. Uniquely identifies a single flow line such that a main channel and a secondary channel with the same watershed code would have different blue line keys.	Numeric	9
WS_CODE	A 45 digit numeric code that uniquely identifies (province wide) the lowest order watershed associated with the stream at its mouth.	Character	45
SEG_PROP	A 4-digit unique “dumb integer” which represents the proportional distance of lakes, wetlands, ponds, etc. and stream segments (working upstream from mouth to headwaters) within a given BL_KEY. (see Watershed/Waterbody Identifier Project Objectives, Summary and Recommendations - November 21,1994).	Character	5
SEG_NO	A sequential numeric code that in combination with the Watershed code uniquely identifies a stream segment (the part of the stream between two stream junctions {nodes}) a lake or wetland.	Numeric	6
WB_KEY	An identifier unique within the watershed group. It is assigned to a group of polygons that make up a single waterbody. These polygons would each be given the same WB_KEY value.	Numeric	6
LAKE_CODE	This is the lake sequence number as derived from the original Intergraph stream atlas. This number increases sequentially from the mouth to the headwaters. This would typically be used as a historical key to link back to existing databases that would have used the older	Character	3

Attribute	Description	Type	Width
	coding scheme.		
GAZE_NAME	Stream Name as it appears in the Gazetteer.	Character	30
ALIAS_1	Local Stream Name.	Character	30
ALIAS_2	Local Stream Name.	Character	30
ALIAS_3	Local Stream Name.	Character	30
WSD_ID	Unique watershed ID based upon the 3rd-order and higher delineations for this layer. (e.g. “wsg”WSDnnnnnnnn”).	Character	15
L_ORDER	The stream order based on 1:50000 scale mapping (after Strahler).	Numeric	4
L_MAGNITUD	Stream magnitude based on 1:50000 scale mapping (see Chapter 2 of Knighton, David. 1984. *Fluvial Forms and Processes.* London. Edward Arnold.).	Numeric	5
NTS_SHEET	Source NTS 1:50000 scale map sheet	Character	8
EDITION	The NTS 1:50000 map sheet edition.	Numeric	3
SOURCE	The nature of the manuscript document from which the atlas was digitized.	Character	10
OLD_WS_COD	The 37 digit watershed code used in the previous version of this dataset called the Stream Atlas.	Character	37
XREF_WS_CO	The old 37 digit watershed code of a feature. This is used in cases where a stream course has changed due to digital re-processing or the interpretation of the flow has changed between editions of the source NTS sheets.	Character	37
WB_KEY_WG	This key, in conjunction with the 45-digit watershed, provides a linking key to the Oracle database. It is formed by taking the WB_KEY and combining it with the four-letter watershed code. It is used to provide a unique waterbody identifier for the Province.	Character	9
DS_WSD_ID	Unique downstream watershed ID based upon the 3rd-order and higher delineations for this layer. (e.g. “wsg”WSDnnnnnnnn”).	Character	15
DS_WS_CODE	Downstream watershed code.	Character	45

5.2.4 Mapping of Arc Features to Linear Business Entities

Although these arc features, as individual elements, can provide useful information to users, they can also be grouped together to build linear business entities such as linear features, boundaries and networks. Table 8 shows how this can be done.

Table 8 - Mapping of Arc Features to Linear Business Entities

		Logical Features - Arc Entities							
		Coastline	Drainage - Main	Drainage - Secondary	Limit of Frequent Flooding	Political B'dary - International	Political B'dary - Provincial	Wbdy - River - Single Blueline	Wbdy - Canal - Single Line
Feature Code	Physical Feature								
100	Coastline	X							
150	Construction line, coastline	X							
1000	Single line blueline, main flow		X					X	
1050	Single line blueline, main flow through wetland		X					X	
1100	Single line blueline, secondary flow			X				X	
1150	Single line blueline, secondary flow through wetland			X				X	
1200	Construction line, main flow		X						
1250	Construction line, double line river, main flow		X						
1300	Construction line, secondary flow			X					
1350	Construction line, double line river, secondary flow			X					
1400	Construction line, other flow/inferred connection		X						
1410	Construction line, network connector		X						
1425	Construction line, subsurface flow		X						
1450	Construction line, connection		X						
1455	Construction line, secondary flow connector (downstream)			X					
1456	Construction line, secondary flow connector (upstream)			X					
2000	Single line, man-made waterbody		X						X
2300	Single line, man-made waterbody, secondary flow			X					
4000	Limit of Frequent Flooding				X				
6000	International or Provincial boundary					X	X		

X = Denotes the physical feature can represent a linear segment of the logical feature.

5.3 Polygon Features

5.3.1 List of Polygon Features

Table 9 presents a list of the polygon features contained in the Watershed Atlas. On the following pages, these features are described in more detail.

Table 9 - List of Polygon Features

Feature Code	Name
L	Lake
M	Land
O	Outside study area
R	River
U	Undefined type
W	Wetland
X	Man-made waterbody (e.g. Canal or Reservoir)

5.3.2 Description of Polygon Features

L Lake:

Description: A substantial body of water. The area cutoff for the mapping of lakes was determined by the NTS 1:50,000 standard.

Topological Rules: -

M Land:

Description: An area of the Province not covered by a lake, river or wetland.

Topological Rules: -

O Outside study area:

Description: Geographic area not covered by other areas. Rarely used.

Topological Rules: -

R River:

Description: The course followed by the natural flow of water on the earth's surface, draining an area or another body of water.

Topological Rules: -

U Undefined:

Description: An area currently not coded as one of the other candidate area types. Rarely used.

Topological Rules: -

W Wetland:

Description: A water-saturated area, intermittently or permanently water-covered, having cattails, rushes or grasslike vegetation (marsh) and/or shrub and tree-type vegetation (swamp).

Topological Rules: -

X Man-made waterbody:

Description: A canal or reservoir.

Topological Rules: -

5.3.3 Description of Polygon Attributes

The polygon features maintained in the Watershed Atlas have associated attribute data tables that can be used to support query and analysis functions. Definitions of the typical polygon attributes maintained for these features are provided below.

Table 10 - Polygon Attribute Definitions for the Parent Layer

Attribute	Description	Type	Width
AREA	Area of polygon in coverage units.	Numeric	[tbd]
PERIMETER	Perimeter in coverage units.	Numeric	[tbd]
"wsg"_	ARC Internal-ID number. Used for linking to spatial data.	Numeric	11
"wsg"_ID	ARC User-ID.	Numeric	11
WS_KEY	Unique Watershed Identifier used by Watershed Atlas programs	Numeric	9
BL_KEY	Unique Blue Line (stream) identifier used by Watershed Atlas programs. Uniquely identifies a single flow line such that a main channel and a secondary channel with the same watershed code would have different blue line keys.	Numeric	9
WS_CODE	A 45 digit numeric code that uniquely identifies (province wide) the lowest order watershed associated with the stream at its mouth.	Character	45
GAZE_NAME	Stream Name as it appears in the Gazetteer.	Character	30
ALIAS_1	Local Stream Name.	Character	30
ALIAS_2	Local Stream Name.	Character	30
ALIAS_3	Local Stream Name.	Character	30
TYPE	An area feature identifier that indicates whether the polygon is a lake, wetland, river, man-made waterbody, land, or outside the watershed. See Table 9 for list of valid values.	Character	1
WSD_ID	Unique watershed polygon identifier based upon a combination of the four-letter watershed group name ("wsg") and an integer unique to the watershed group.	Character	15
SEG_PROP	See definition of SEG_PROP in Table 7.	Character	5
SEG_NO	See definition of SEG_PROP in Table 7.	Numeric	6
LAKE_CODE	See definition of LAKE_CODE in Table 7.	Character	3
OLD_WS_COD	See definition of OLD_WS_CO in Table 7.	Character	37
XREF_WS_CO	See definition of XS_WS_CO in Table 7.	Character	37
GIS_TAG	Province wide unique identifier to link attribute data to spatial data. Combines "wsg" and coverage sequence number. A stream segment or lake shoreline may be composed of several arcs (i.e. lines) each having its own gis_tag identifier. (see Watershed/Waterbody Identifier Project Objectives, Summary and Recommendations - November 21,1994)	Character	15

5.3.4 Mapping of Arc Features to Areal Business Entities

The areal business features listed in this section are actually built using the arc features described in Section 5.2. Table 11 shows how this can be done.

Table 11 - Mapping of Arc Features to Areal Business Entities

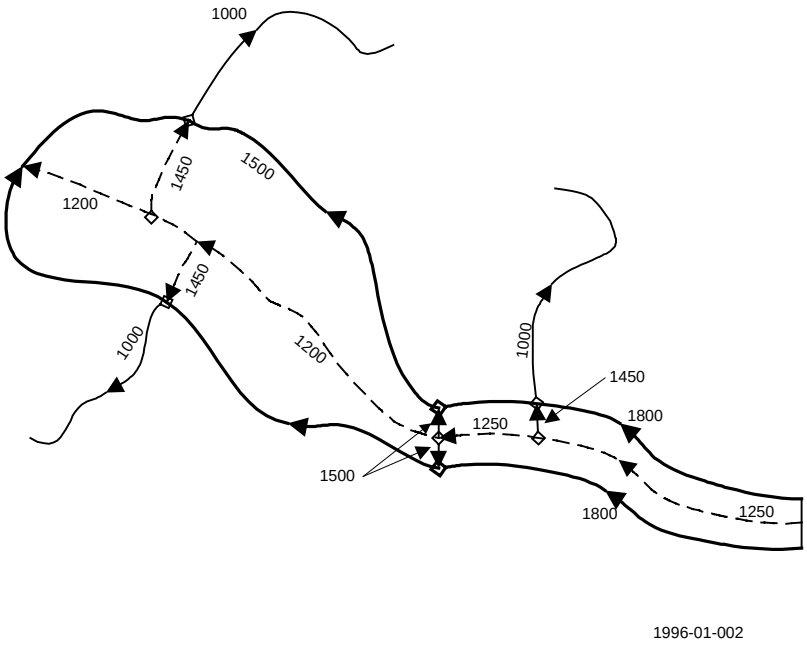
		Logical Features - Polygon Entities										
		Non-waterbody - Land	Non-waterbody - Coastal Island	Non-waterbody - Fresh Water Island	Waterbody - Lake	Waterbody - Reservoir	Waterbody - River - Double Blueline	Waterbody - Canal	Waterbody - Wetland	Watershed	Watershed Group	Area of Frequent Flooding *
Feature Code	Physical Feature											
100	Coastline	X	X							X	X	X
150	Construction line, coastline		X				X	X		X	X	
1325	Construction line, segment delimiter				X		X	X			X	
1375	Construction line, river delimiter				X		X					
1475	Construction line, lake arm				X							
1500	Lake shoreline	X			X							X
1525	Lake shoreline shared with a wetland				X				X			X
1550	Construction line, lakeshore				X		X	X				
1600	Island shoreline			X	X							X
1625	Island shoreline shared with a wetland			X					X			X
1700	Wetland shoreline	X							X			X
1800	Double line blueline, right bank	X					X					X
1825	Double line blueline, right bank shared with wetland						X		X			X
1850	Double line blueline, left bank	X					X					X
1875	Double line blueline, left bank shared with wetland						X		X			X
1900	Island in river, right bank			X								X
1925	Island in river, right bank shared with wetland			X					X			X
1950	Island in river, left bank			X								X
1975	Island in river, left bank shared with wetland			X					X			X
2100	Double line, man-made waterbody	X				X		X				
2300	Secondary, man-made waterbody					X						
4000	Frequent floodplain limit											X
5000	Major watershed boundary	X								X	X	
5100	Minor watershed boundary	X								X	X	
5200	Trivial watershed boundary	X								X	X	
6000	International or Provincial boundary	X								X	X	

X = Denotes the physical feature can represent a boundary segment of the logical feature.
* = "Area of Frequent Flooding" is a special layer that can be generated, but it is not in the Atlas itself.

6. Examples of Feature Coding and Topological Rules

Perhaps the best way to understand the Watershed Atlas from a physical data modeling perspective is to review a set of real-world examples. This section provides a set of cases which show how the features are used to represent business data, and how the topological rules are applied.

Example 1 - Lake Drained by a Double Line River



Detailed Description: This shows a lake which is drained by a double-line river. The lake has two single-line tributaries. The double-line river has one single-line tributary.

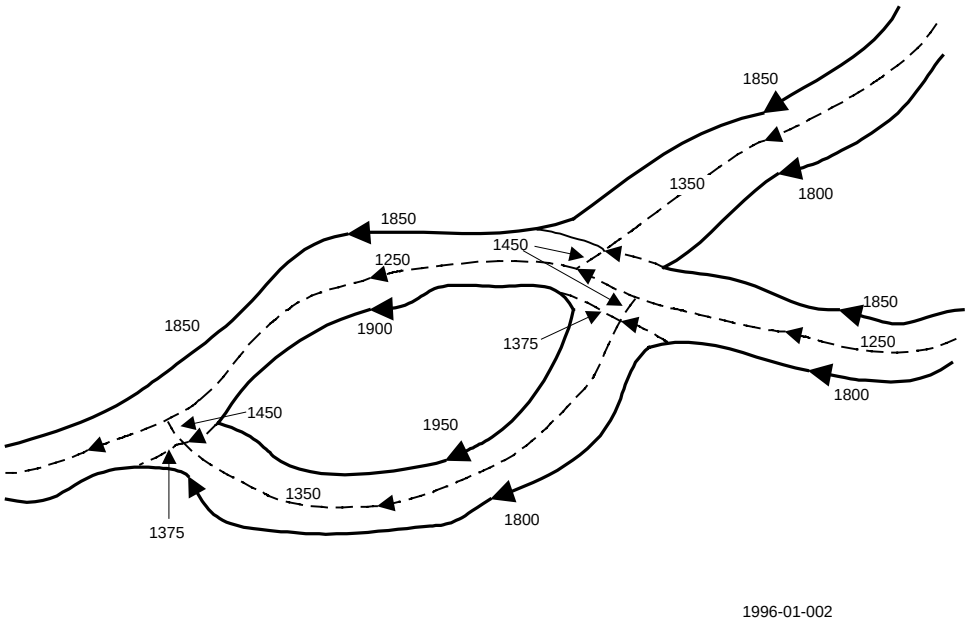
Direction of digitizing is shown by arrows in the figure. A flow construction line is shown following the centre of the double-line river (Code = 1250) and continuing to the end of the lake (Code = 1200). This indicates that the lake is considered to be a continuation of the river. The 1200 and 1250 codes indicate that this lake/double-line river is a main flow.

Connection lines (Code = 1450) are used to connect the three single-line tributaries to the flow construction lines of the lake and double-line river.

Lakeshore construction lines (Code = 1550) are used to "close" the lake, thus indicating the separation between the lake area and the double-line river area. The arcs making up the lakeshore (Code 1500 and 1550) are digitized in the same direction as the lake's flow construction line (Code = 1200).

The river's banks are digitized in the same direction as the river's flow construction line (Code = 1250). The "right" bank (Code = 1800) is to the right of the river flow line when viewed in a downstream direction.

Example 2 - Double-Line River Dividing a Small Island



Detailed Description: A double-line river divides around a small island, re-converges then divides again.

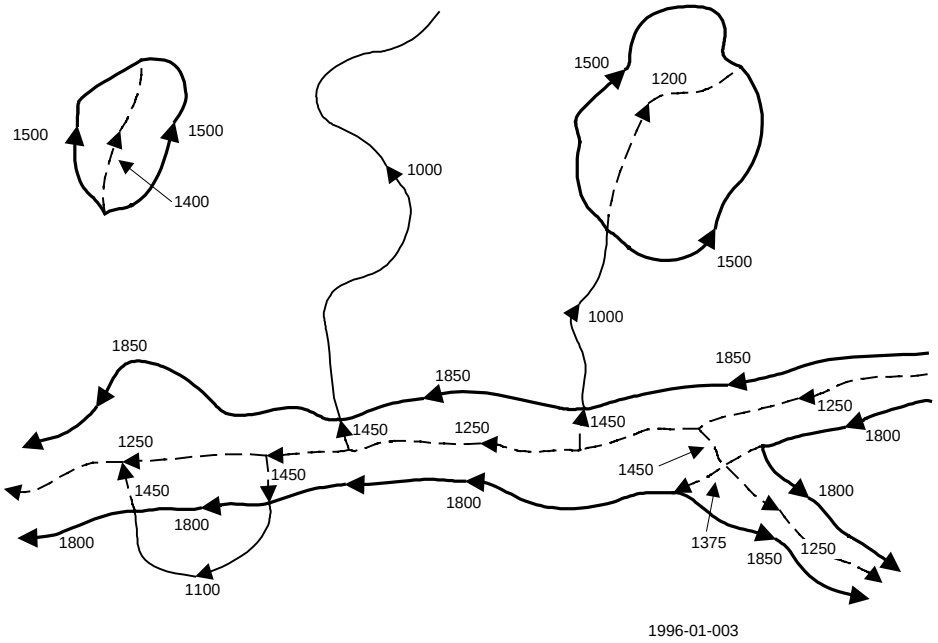
Direction of flow is from left to right. Direction of digitizing is shown by arrows in the figure. The main flow of the double-line river is shown to the north (above) the small island (Code = 1250) and to the south (bottom) at the second branching.

River delimiters (Code = 1375) are used to "close" the main channel banks, thus indicating the separation between the main channel area and the secondary channel areas. These river delimiters are digitized in the same direction as the main channel river banks (upstream).

Connection lines (Code = 1450) are used to connect the secondary flow line with the main flow line as the river diverges and converges around the small island and at the second branching. These connection lines are digitized in upstream direction.

The shoreline of the small island makes up the right bank of the main channel (Code = 1900) and the left bank of the secondary channel (Code = 1950).

Example 3 - Double-Line River, Secondary Flows, Single-Line Tributaries



Detailed Description: A double-line river flows from left to right of the page. There is a single-line secondary flow (bottom left) and an isolated lake (upper left). A single-line tributary (upper centre), a single-line tributary draining a lake (upper right), and a double-line tributary (bottom right) drain into this double line river.

The single-line secondary flow (Code = 1100) is linked by two connection arcs (Code = 1450) to the main flow construction line. These are digitized in an upstream direction.

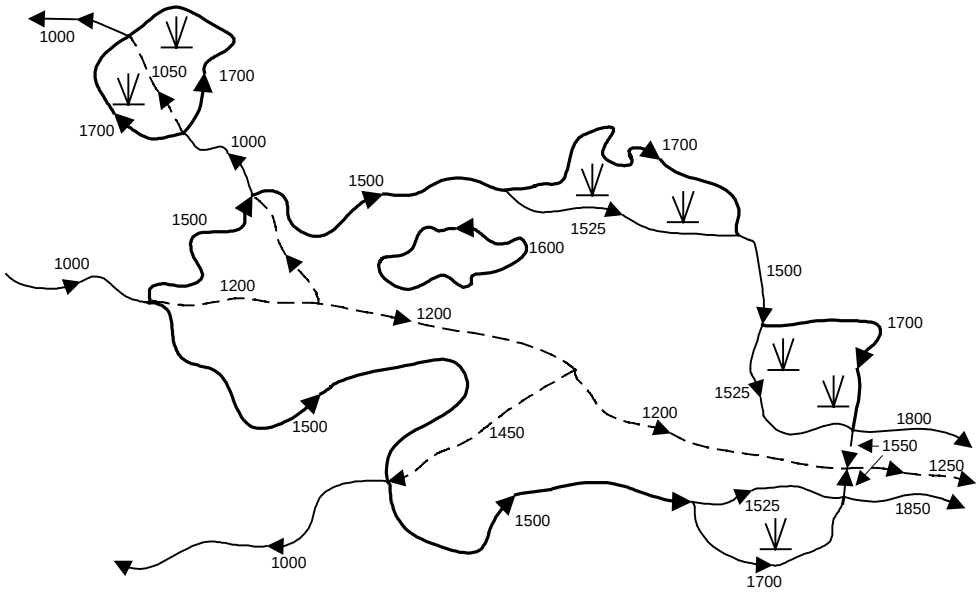
An arbitrary construction line (Code = 1400) is shown through the length of the isolated lake digitized in an arbitrary direction. Shorelines of the isolated lake (Code = 1500) are digitized in the same direction as the construction line.

The single-line tributaries are linked to the double-line river construction line by connector lines (Code = 1450). A construction line (Code = 1200) "continues" the single-line tributary to the end of the lake.

The double-line tributary is separated from the double-line main stem by river delimiters (Code = 1375). This pair of river delimiters "close" the banks of the main stem and therefore are digitized in the same direction as the main stem. Again, a connector line (Code = 1450) links the double-line tributary to the main flow construction line.

Note that the left bank of the double-line tributary (as viewed downstream, Code = 1850) is connected to the right bank of the main stem. This is appropriate since the double-line tributary joins the main stem from the right.

Example 4 - Double-Line River Flowing Into a Lake, Bordering Wetlands, Wetland Flow



Detailed Description: A double-line river flows into a lake (at right) and flows from the lake as a single-line river (at left). The lake includes a small island and part of the lakeshore is bordered by wetlands. Two single-line tributaries flow into the lake, one of which flows through a wetland.

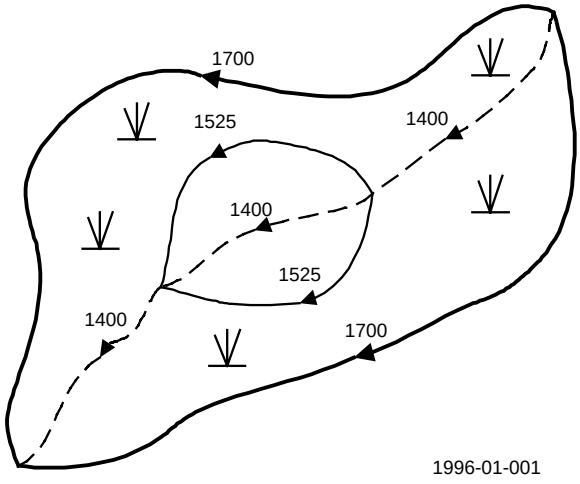
The main flow is show by the construction lines through the double-line river (Code = 1250) into the lake (Code = 1200) and then draining from the lake as a single-line river (Code = 1000).

Lakeshore construction lines (Code = 1550) are used to "close" the lake and separate the lake area from the double-line river area. A small island is present without obvious flow on both sides and therefore is given Code = 1600. Because there is no flow line associated with this small island, right-hand rule applies. Therefore the island shoreline is digitized counter-clockwise with water to the right.

Three areas of wetlands are shown bordering on the lake. These are viewed as being part of the same waterbody as the lake. In effect, they represent areas where the lake shoreline (Code = 1525) is indefinite and the lake is shallow with substantial vegetation. Water would exchange between the wetland and lake without evidence of a distinct flow. For this reason flow construction lines are not shown for these wetlands.

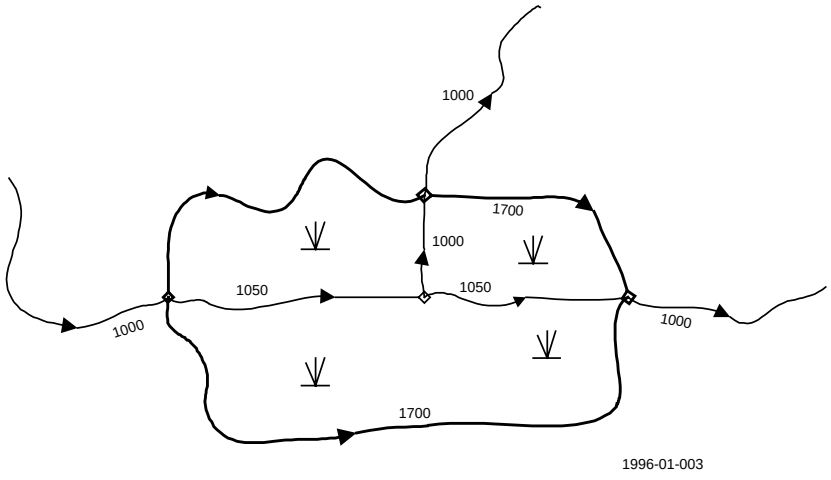
Note that the tributary to the lake that flows through a wetland is shown as Code = 1050 where it flows through the wetland. This indicates that a conspicuous channel that should be shown as a single-line blueline flows through the wetland. The 1050 Code indicates that this wetland is considered to be associated with this single-line river.

Example 5 - Isolated Lake Surrounded by Wetland



Detailed Description: An arbitrary construction line (code = 1400) is shown through the length of both the lake area and the wetland area, digitized in an arbitrary direction. Shorelines of the lake and wetland are digitized in the same direction as the construction line. The wetland is viewed as being part of the same waterbody as the lake.

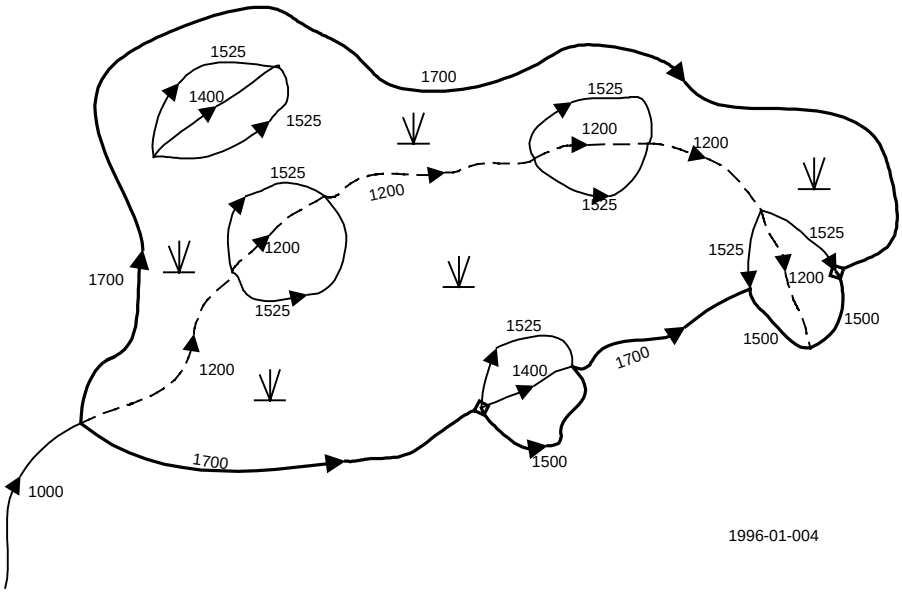
Example 6 - Single-Line Tributary Through Wetland



Detailed Description: The main tributary flowing through the wetland is shown (Code = 1050) indicating that it is a conspicuous channel that should appear as a single-line blueline on the NTS mapsheet and mylar. The wetland is considered to be associated with this single-line river.

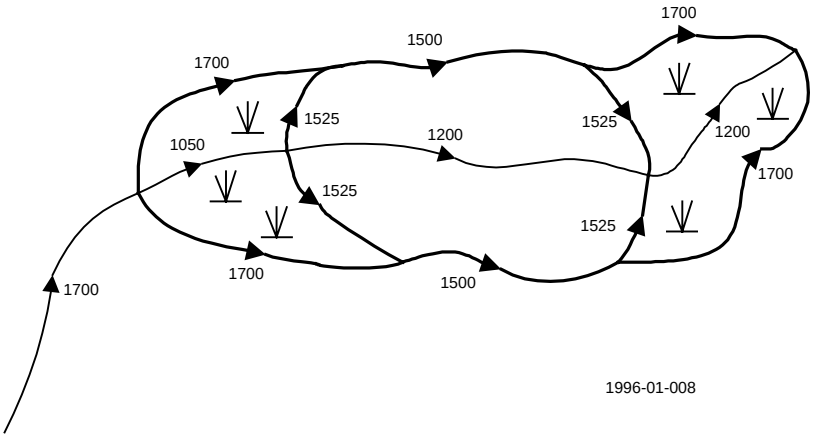
The second tributary also forms a channel when it enters the wetland. This channel would also appear as a single-line blueline on the NTS map and mylar, the Code = 1000 indicates that it is secondary and not associated with the wetland. Arcs are digitized in an upstream direction.

Example 7 - Single-Line Tributary Through Wetland Joined by Single-Line Tributary Within Wetland



Detailed Description: The mainflow is shown by the construction line (Code = 1200) drawn to encompass the majority of the individual lakes. All shorelines are digitized in an upstream direction, as is the construction line. The two isolated lakes that are not connected to the mainflow construction line have arbitrary construction lines (Code = 1400). The entire area is viewed as being the same waterbody that is the headwater of the single-line river.

Example 8 - Single-Line River Through Wetland and Lake



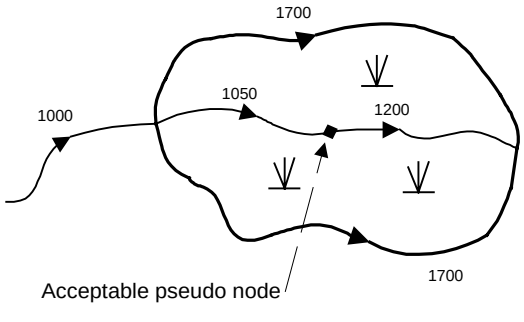
Detailed Description: A single-line river passes through a wetland as it drains a lake. A second wetland occurs at the upstream end of the lake with no conspicuous channel.

The single-line river is code = 1050 where it flows through the wetland. This indicates that it is a conspicuous channel that should be shown as a single-line blueline on the NTS map and mylar. The mainflow is shown by the construction lines (code = 1200) through the length of the lake and second wetland.

All lines are digitized in an upstream direction.

Both wetlands and the lake are considered to be part of the same waterbody.

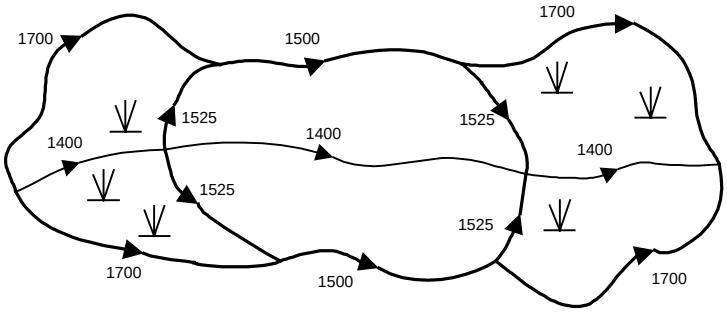
Example 9 - Single-Line River Originating From A Wetland



Detailed Description: The channel (code = 1050) through the wetland appears as a single-line blueline on the NTS map and mylar. The mainflow is continued to the end of the wetland with a construction line (code = 1200).

All lines are digitized in an upstream direction.

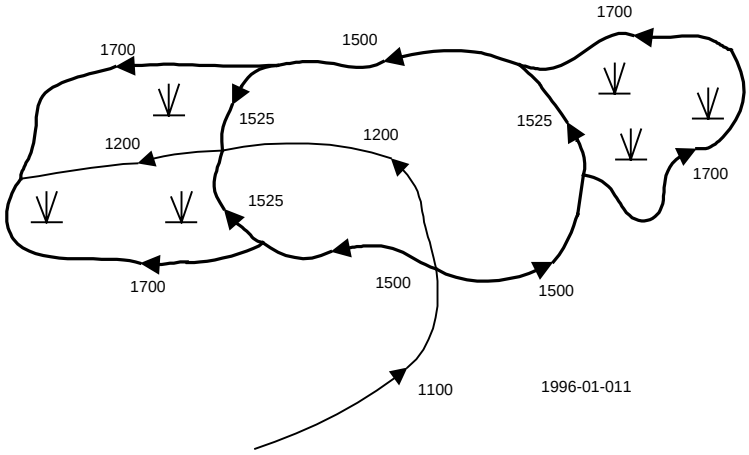
Example 10 - Isolated Lake With Associated Wetland Area



1996-01-010

Detailed Description: Construction line (code = 1400) runs to the end through both wetlands and the lake. All arcs are digitized in an upstream direction, according to contour lines on the NTS map or the operators arbitrary decision, ensuring that the most significant waterbody (always a lake over a wetland) is "closed."

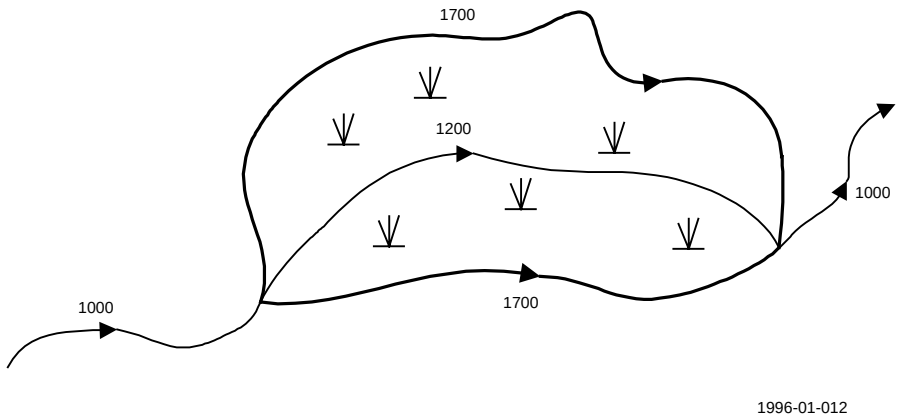
Example 11 - River Draining A Lake With Associated Wetland



1996-01-011

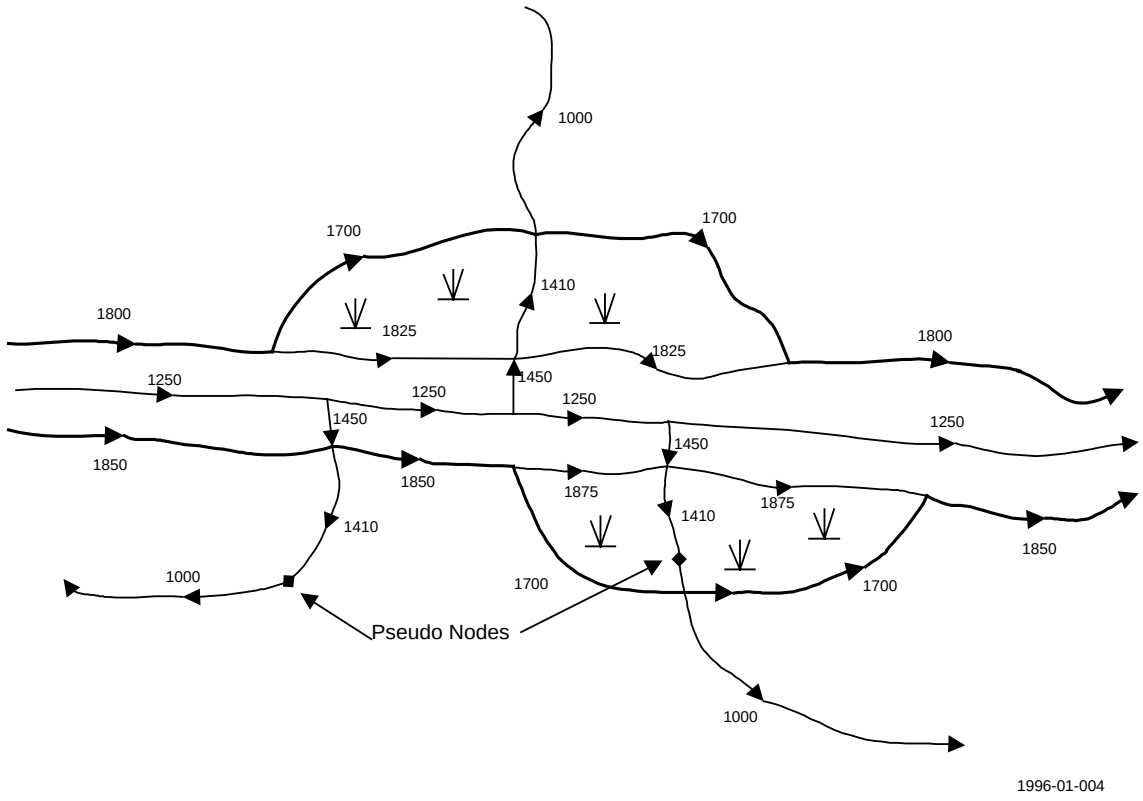
Detailed Description: Operator chooses the most dominant wetland (largest or longest) and builds construction line through the lake and the chosen wetland. All arcs are digitized in an upstream direction towards the "head" of the wetland. The lake must be closed.

Example 12 - Wetland Associated With A River - No Conspicuous Channel



Detailed Description: Construction line (code = 1200) would run through the wetland polygon in an upstream direction. All arcs are digitized in an upstream direction.

Example 13 - Double-Line River, Wetland Areas On Both Banks, Tributaries



Detailed Description: A double-line river has wetland areas associated with both banks. Three tributary creeks approach but do not connect directly to the double-line river.

Neither wetland requires a constructions line because the river banks (code = 1825 and code = 1875) act as construction lines in this case.

Tributary A (furthest to the left in the diagram) appears on the NTS map with an arrow-head pointing towards the double-line river. It is connected to the bank of the river with an arc (code = 1410) and then to the main flow of the double-line river with another arc (code = 1450).

Tributary B (centre tributary in the diagram) flows to the edge of the wetland but from there it has no discernible or conspicuous channel. It should be connected through the wetland polygon with an arc (code = 1410) and then to the main flow with another arc (code = 1450).

Tributary C (furthest to the right in the diagram) flows into the wetland but again fails to have any discernible channel which would extend it to the bank of the river. That portion of the creek within the wetland should be coded as 1000 and connected through the wetland polygon to the bank of the river with an arc (code = 1410) and then to the main flow with another arc (code = 1450).

All arcs are digitized in an upstream direction.

7. TECHNOLOGY ENVIRONMENT, SUPPORT ROUTINES AND UTILITIES

The key characteristics of the technology environment that is used to build each Watershed Group dataset are as follows:

- The main processing platform is the personal computer;
- The GIS package used for processing is ESRI's ARC/INFO; PC ARC was used for data capture and validation, Workstation ARC is utilized for final processing, storage and distribution;
- The main routines used to support the develop the Atlas are SML's. SML is a macro language that allows an analyst to develop batch and interactive routines;
- An important constraint on the use of these routines is the fact that SML's will not run in UNIX-ARC/INFO environments.

Two detailed source documents are included in the Appendices:

- Appendix B contains notes and documentation, written by a data conversion contractor, which explains how the source mylars were scanned and processed to produce the linework;
- Appendix C contains a guide, written by a GIS consultant, to explain how many of the key processing steps work, and how the spatial dataset is created from the source linework.

Appendix A - Reference Tables

Naming Conventions for Thematic Layers

The table below show the naming convention for the thematic map layers.

Table 12 - Naming Convention for Thematic Map Layers

Name of Layer	Name (UTM Version)	Name (ALBERS Version)
Parent	***"wsg"***	LWSA***"wsg***
Coastline	***"wsg"***_CST	LCST***"wsg"***
Linear Boundaries	***"wsg"***_LB	LWLB***"wsg"***
Zero Order Remnant Polygons	***"wsg"***_O0	LWB0***"wsg"***
1st Order Remnant Polygons	***"wsg"***_O1	LWB1***"wsg"***
2nd Order Remnant Polygons	***"wsg"***_O2	LWB2***"wsg"***
3rd Order Watersheds	***"wsg"***_O3	LWB3***"wsg"***
4th Order Watersheds	***"wsg"***_O4	LWB4***"wsg"***
5th Order Watersheds	***"wsg"***_O5	LWB5***"wsg"***
n-1th Order Watersheds	***"wsg"***_On-1	LWBn-1***"wsg"***
nth Order Watersheds	***"wsg"***_On	LWBn***"wsg"***
Rivers, Lakes, Wetlands, Canals and Reservoirs	***"wsg"***_RLW	LWSL***"wsg"***
Stream Network	***"wsg"***_SS	LWSS***"wsg"***
Text	***"wsg"***_TXT	LWSX***"wsg"***
Watershed	***"wsg"***WSD	LWSD***"wsg"***
Watershed Group Polygon(s)	***"wsg"***_CC	LWSG***"wsg"***
Special-Purpose Layers:		
Obstructions/Barriers	***"wsg"***PNT	LWSO***"wsg"***

Mapping of MOEP Standard Numeric Code to Arc Feature Codes

Table 13 - MOEP Standard Codes versus Atlas Arc Feature Codes

ARC Feature Code	MOEP Code	Description
100	WA21100000	Coastline
150	WA21100111	Construction line, coastline
200	----------	Icefield or glacier *** (rarely used)
1000	WA24100110	Single-line blueline, mainflow
1050	WA24100120	Single-line blueline, mainflow through wetland
1100	WA24100130	Single-line blueline, secondary flow
1150	WA24100140	Single-line blueline, secondary flow through wetland
1200	WA24111110	Construction line, mainflow
1250	WA24111120	Construction line, double-line river, main flow
1300	WA24111130	Construction line, secondary flow
1325	WA24111140	Construction line, segment delimiter *** (not used)
1350	WA24111150	Construction line, double-line river, secondary flow
1375	WA24111160	Construction line, river delimiter
1400	WA24111170	Construction line, isolated water body axis
1410	?	Construction line, network connector
1425	WA24111180	Construction line, subsurface flow
1450	WA24111190	Construction line, connection
1475	WA24111111	Construction line, lake arm
1500	WA23100110	Lake shoreline
1525	WA23100120	Lake shoreline shared with wetland
1550	WA23111110	Construction line, lake shore
1600	WA23100130	Island shoreline
1625	WA23100140	Island shoreline shared with wetland
1700	WA23100150	Wetland shoreline
1800	WA24200110	Double-line blueline, right bank
1825	WA24200120	Double-line blueline, right bank shared with wetland
1850	WA24200130	Double-line blueline, left bank
1875	WA24200140	Double-line blueline, left bank shared with wetland
1900	WA24220110	Island in river, right bank
1925	WA24220120	Island in river, right bank shared with wetland
1950	WA24220130	Island in river, left bank
1975	WA24220140	Island in river, left bank shared with wetland
2000	WA22200110	Single-line, canal
2100	WA22200120	Double-line, canal or reservoir
2300	?	Single-line, man-made waterbody, secondary flow

ARC Feature Code	MOEP Code	Description
4000	WA17100000	Frequent floodplain limit
5000	WA25100110	Major watershed boundary
5100	WA25100120	Minor watershed boundary
5200	WA25100130	Lesser watershed boundary
6000	----------	International Boundaries
9000	EN1100000	Map neat-lines
9999	----------	Undefined
1455	--------	Construction line, secondary flow connector (downstream)
1456	--------	Construction line, secondary flow connector (upstream)

Digital Mapping Specifications for B.C. Watershed Atlas Features

Mapping Specifications for Arc Features

BC Watershed Atlas linear (arc) and areal (polygon) features are represented cartographically as lines of varying colors, thicknesses and patterns that have been defined in the BC Ministry of Environment's Standard ARC/INFO lineset - **BCENV.lin.**

Table 14 - Digital Mapping Specifications for Arc Features

Arc Feature Code	Name	Color	Line Thickness (mm)	Lineset Number[4]
100	Coastline	brown	0.25	226
1000	Single line blueline, mainflow	blue	0.25	552
1050	Single line blueline, mainflow through wetland	blue	0.25	552
1100	Single line blueline, secondary flow	blue	0.25	552
1150	Single line blueline, secondary flow through wetland	blue	0.25	552
1500	Lake Shoreline	blue	0.25	552
1525	Lake Shoreline shared with wetland	blue	0.25	552
1600	Island Shoreline	blue	0.25	552
1625	Island Shoreline shared with wetland	blue	0.25	552
1800	Double line blueline, right bank	blue	1.00	52
1825	Double line blueline, right bank shared with wetland	blue	1.00	52
1850	Double line blueline, left bank	blue	1.00	52
1875	Double line blueline, left bank shared with wetland	blue	1.00	52
1900	Island in river, right bank	blue	0.25	552
1925	Island in river, right bank shared with wetland	blue	0.25	552
1950	Island in river, left bank	blue	0.25	552
1975	Island in river, left bank shared with wetland	blue	0.25	552
2000	Single line, canal waterbody	light blue	0.25	553
2100	Double line, canal or reservoir waterbody	light blue	1.00	53
2300	Single line, man-made waterbody, secondary flow	light blue	0.25	553
5000	Major Watershed Boundary	red	1.00	50
5100	Minor Watershed Boundary	red	0.50	204
5200	Lesser Watershed Boundary	red	0.25	2
Note:	All Construction lines	dashed grey	0.25	277

[4] Note: These linesets are accurate as of January 1996, but may be updated periodically. Please browse the BC Environment GIS Forum World-Wide Web site (http://www.env.gov.bc.ca/gis/) to verify the current shadeset values before you use them.

Mapping Specifications for Polygon Features

BC Watershed Atlas areal (polygon) features are enhanced cartographically by shading with a variety of colors and patterns that have been defined in the BC Ministry of Environment's Standard ARC/INFO shadeset - **BCENV.shd.**

Table 15 - Digital Mapping Specifications for Polygon Features

Polygon Feature Code	Name	Color	Shadeset Number[5]
L	Lake	Light Blue	796
M	Land	Sandy/Beige	21
R	River	Blue	55
W	Wetland	Light Purple	782
X	Man-made	Cyan	805

[5] Note: These shadesets are accurate as of January 1996, but may be updated periodically. Please browse the BC Environment GIS Forum World-Wide Web site (http://www.env.gov.bc.ca/gis/) to verify the current shadeset values before you use them.

Appendix B - Data Conversion Technical Notes

This list of instructions assumes that the operator is using PC ARC/INFO and has set the function keys as follows;

<F5> Draw
<F6> Select
<F7> Zoom Out
<F8> Pan (towards cursor)
<F9> Zoom in (to extent of box defined by cursor)
<F10> Zoom out to full map extent

First Inspection of Line-work

1. Import coverage(s) using ArcView's **IMPORT.EXE** utility. ArcView's import utility has been found to be more versatile than PC ARC/INFO and more closely copies the coverage(s) to the work-station version of ARCINFO.
   NOTE: Remember to specify the name of the output coverage as "**Q#**". This name MUST NOT be more than 5 characters in length.

   C:> cd ArcView
   C:\ArcView> import exportfile Q#

2. Now copy the coverage(s) from ArcView to the chosen working directory.

   C:\ArcView> arc
   (C:\ARCVIEW)[ARC] copycov Q# C:\DIR_NAME\Q#

3. Change to the working directory and from ArcInfo, make an original "safe-copy" of the coverage(s) "as-supplied".

   (C:\ARCVIEW)[ARC] cd..
   (C:\)[ARC] cd dir_name
   (C:\dir_name)[ARC] copycov q# oq#

4. Run the **"Inspect.sml"** if you are running/processing a single quad coverage.
   IF you wish to run a "number" of quads, use the **"Dan.sml"** after modifying the file to "list" the desired quads to be "inspected" (best run over-night or over long weekends).

   Both of these SML's do the same thing. First, they utilize ArcInfo's build and describe utilities to ensure that the coverages are topologically correct and can be "built" (i.e. no intersections). Results are copied to a **Q#.dsc** file which can be viewed/printed as needed. Secondly, the SML goes through a "PSEUDO NODE" removal process which eliminates those pseudo nodes which can be removed and prints "to-screen" those which can not. As such, particularly for week-end or over-night runs, a printer should be connected and toggled on with the <CTRL-P> command. Thirdly, a **Q#.txt** file is created, listing by the "Q#_id" field in the data base, those arcs that ARE NOT code 1000 (single-line stream lines) which are "dangles". Finally, these SML's create a **Q#.cnt** file which lists "by code" the number of arcs which are less than 10 m in length.

   a) **(C:\dir_name)[ARC] @inspect q# <CTRL-P>**
   OR

   b) **(C:\dir_name)[ARC] @dan <CTRL-P>**

   *after modifying dan.sml to list quads to be run

5. Confirm that the coverage(s) have;
   a) built successfully for polygons (also check printer output)

   (C:\dir_name)[ARC] type Q#.dsc

   b) has an acceptable number of "warnings" from the printer output of the pseudo node removal program. Pay particular attention to the "codes" which are involved. Some codes flagged just simply SHOULD NOT or CANNOT be located together. IF found, this can (sometimes) be an early indication of further problems to be encountered.

c) has an acceptable number of errors from the dangle program. Large numbers of dangles (ie + 20) indicates that a polygon is not closed.

(C:\dir_name)[ARC] type Q#.txt

d) has an acceptable number of "warnings" from the short arcs program. "High numbers" in the code 1450 are generally expected IF the coverage has a fair number of "double-line" rivers. Counts of greater than 10 should be subjected to the **CLEAN10.SML.** If a count of under 10 occurrences is encountered, these can generally be looked at in arcedit while doing "general edits" by using the select command **: sel length < = 10**.

(C:\dir_name)[ARC] type Q#.cnt

AT THIS POINT, A CONSCIOUS DECISION MUST BE MADE.

BASED ON THE PREVIOUS PHYSICAL INSPECTION OF THE CHECK PLOTS, AND THE COMPUTER INSPECTION OF THE DIGITAL FILES, AND THE MELP'S CRITERION OF NO GREATER THAN 3 HRS OF EDITING EFFORT TO BE REQUIRED (EDITING TIME - NOT TO INCLUDE ERRORS UPON MOELP'S PART) ARE TO BE THE BASIS OF ACCEPTANCE.

IF ACCEPTED, THE MELP IS 90 - 95% COMMITTED TO ACCEPTING THE SCANNING AND SCAN CONVERSION AS BEING ACCEPTABLE. ONLY GROSS MIS-CODING (not visible as color-coded differences on the check plots or evident in the first computer-inspections) SHOULD RESULT IN A RETURN OF A QUAD COVERAGE PAST THIS POINT.

6. After viewing the reports **Q#.dsc, Q#.txt** and **Q#.cnt** and the decision "to accept" has been tentatively made, the second stage or "General Edit" stage can be entered into.

General Edits of Linework

1. The first stage of this process is to proceed on the basis of the previous reports. The first step(s) should center on the "worst" of the reports, i.e. if the node dangle report is overly large, then the linework should be inspected to locate the suspected offending "open polygon(s)" and make a fix. On the other hand, if the arcs of less than 10 m are viewed as being suspect then the "**CLEAN10.SML**" should be used. Either way, it doesn't hurt to run the "clean10" routine to start the process.

   (C:\dir_name)[ARC] @clean10 q#

   a) the "clean10" SML automatically creates a temporary file with X,Y co-ordinates of all arcs of less than 10 m, invokes ARCEDIT, loads the desired edit coverage, and by calling the temporary X,Y co-ordinate file "steps" through a manual inspection of ALL arcs of less than 10 m. The first inspection is automatically zoomed into.

   b) "Step" through the inspection and editing process by typing **"&return"** command at the **":"** prompt; use the **"F9"** and the mouse buttons to zoom into the "less than 10 m arc area" and deciding "whether, when, and how" to facilitate the change. As an example, the following, could be seen as a likely scenario:

   EXAMPLE

   Initial screen (usually) too far removed to determine problem:

   : <F9> zoom in
   : use mouse button to define area
   screen zooms to area of concern (repeat if not close enough)

   : examine area, (in this example, site is determined to be an "OK" code 1450.
   : &return

   screen zooms to area of concern (again too far removed)

   : <F9>
   : use mouse button to define area

   screen now shows that a watershed boundary has not been properly "snapped" to the node at the mouth of the creek.

   One of two choices can be used; either "box" the offending arc with the "sel box" command and delete it, then use the "EF NODE" command and "MOVE" the remaining nodes together OR you can gamble and go directly to the "EF NODE" and "MOVE" commands to automatically delete the "offending arc".

   OPTION 1

   : sel box
   : use mouse button to define area
   : setd 3 sets color select (green)
   : draws colors desired arc(s)
   : delete deletes highlighted arc

: ef node changes edit feature to nodes
: move
: use mouse to select node to move; use 1 to select, 2 to change selection, and 3 Who to ensure proper node is to be moved. The general rule is that we DO NOT move "scanned" lines (for data integrity purposes). Move only digitized and/or construction lines.

: ef arc returns to arc edit mode
: &return moves onto next "situation". May have to be typed several times depending upon the number of arcs "attached" to the "offending" arc.

OPTION 2 - Gamblers method assumes that offending arc is small enough and without vertex's so as to be automatically deleted by ArcInfo (this is successful on about 99% of the arcs identified by the "clean10" SML - if it isn't successful it can require more involved steps).

: ef node changes edit feature to nodes
: move
: use mouse to select node to move; use 1 to select, 2 to change selection, and 3 Who to ensure proper node is to be moved. The general rule is that we DO NOT move "scanned" lines (for data integrity purposes). Move only digitized and/or construction lines.
: ef arc returns to arc edit mode
: &return moves onto next "situation". May have to be typed several times depending upon the number of arcs "attached" to the "offending" arc.

Continue with ALL edits until completion.

The most common "errors" encountered, have (to-date) been found to be; watershed boundaries not being snapped to mouths of creeks, construction lines through lakes or wetlands snapping to shorelines rather than creek outlets/inlets, and to a minor extent watershed boundaries coming too close or cutting through wetlands.

These problems have been identified as being attributed to misunderstandings and/or operator errors.

Upon completion the "CLEAN10.SML" will give a message of "ALL DONE". Proceed as follows:

: save
: q quit, can also be typed as "quit"

(C:\dir_name)[ARC] build q# or build q# poly

At this point "intersections" might be indicated as failures in the build program. If they are, carefully RECORD the values given on the screen AND refer to the Fisheries Branch detailed PC ARC/INFO commands appendix.

To provide security and have a "fall-back" we STRONGLY RECOMMEND that a copy of the current "coverage" be made.

(C:\dir_name)[ARC] copycov q# q#cop

NOTE: at this point, particularly if space is of concern on your hard-drive the "**oq#**" coverage can be saved onto tape back-up and killed from the hard-drive (ie there is generally no longer a need to "carry" three copies of the same coverage).

2. Proceed with examining and editing of the coverage by examining for node dangles and pseudo nodes. As no "dangle plots" are produced, a fast examination of both node dangles and pseudo nodes (based upon the initial "inspect" SML routines) has proven necessary.

(C:\dir_name)[ARC] arcedit
: display 4 or simply : disp 4
: editc q#
: ef arc
: drawe arc node dangle
: draw or **<F5>**
: <F9> zoom in
: use mouse to select an easily examinable "size" section of the quad. Look for "out-of-place" dangles. "Fix" as necessary.

Also handy, is the polygon search which identifies the areas on either side of the arc as being the same, thus indicating a break in the line or an "open" polygon. For our purposes we "ignore" the code 1000 (stream lines) because they by nature should dangle at their headwaters.

: sel lpoly_ = rpoly_ and code <> 1000
: draws

The Q#.txt file generated in the "inspect.sml" procedure should also be examined at this time. By using the print-out, selections of the identified arcs should be made, as follows:

Example text from a Q#.txt print-out

Q11_ID	CODE
595	1200
703	1050
1963	1050

In ARCEDIT of the Q11 coverage

: sel q11_id = 595
: draws
: <F9> use mouse to zoom into area

Examine the problem identified and correct as necessary.

After all "node dangles" are examined and fixed, proceed to examine "pseudo nodes" in the same manner.

: drawe node pseudo
: draw or **<F5>**

Etc.

3. Once these first three basic computer edits have been completed, the task turns to performing edits and examinations identified in the "check-plot" edits. The most common of these errors include the following:

a) arcs coded incorrectly,

b) missing arcs (generally construction lines, i.e. codes 1450 1400 or 1410, and possibly 1425)
c) misplaced arcs (ie watershed boundaries not connected to the mouths of creeks and rivers)
d) watershed boundaries drawn through wetlands

For detailed instruction in fixing the above, see APPENDIX B.

It is helpful right at the beginning to select all arcs coded 9000 (neat-lines), colour them bright green and draw the selected elements to see if any interior arcs have been incorrectly coded 9000. If such arcs appear, they must be checked on the NTS map and recoded properly.

```
: sel code = 9000
: setd 3
: draws
```

One trick we have learned is to turn specific codes on with different colors to assist in inspecting the arc coding that may have been missed at the "check-plot" edit stage. To do this for example you could set up the following:

```
: sel code <= 100                  coastline
: ca $symbol = 3                   color bright green
: sel code = 1000                  single-line stream lines
: ca $symbol = 4                   color dark blue
: sel code = 1500 or code = 1525   lakes & lake
                                           wetland interface
: ca $symbol = 6                   color light blue
: sel code = 1700                  wetland boundaries
: ca $symbol = 5                   color bright yellow
: sel code = 1200 or code = 1250   construction
                                           lines-mainflow lake/river
: ca $symbol = 2          color red
: draw  or      <F5>
```

Continue edits until you are satisfied that you have checked all items identified on the check plots and/or happened upon while doing these edits. Mark on the check plots at the examination sites, corrections done or not done "OK".

If a number of new arcs have been added during the course of editing, it is highly recommended that a recalculation of the q#_id's be performed. The easiest way to do this is to make the q#_id's equal to the record number, as follows:

```
: sel all
: ca $id = $recno
: save
: q
```

(C:\dir_name)[ARC] build q#

4. Restart Arcedit and delete any neatlines (code 9000) which occur in open ocean.

```
: sel code = 9000
: resel many          - sel neatlines in open ocean
: delete
```

Save the changes and quit arcedit. Then build and backup the work completed in arc.

: save
: q

(C:\dir_name)[ARC] build q#
(C:\dir_name)[ARC] kill q#cop all -deletes prev. backup
(C:\dir_name)[ARC] copycov q# q#cop - makes new backup

Prepare Stream Atlas IGDS Labels

1. Make a list of the Stream Atlas (IGDS files) which make up the map composition of each of the quads (i.e. use the "report card" form, designed for the SCAN project).

   From this list, create a file to be used in the **"CONVLAB.SML"**, listing the path and the "alias" name of the map sheet, as follows (Q11 used as example):

   C:\dir_name> edit q11.lst invokes DOS editor

   C:\dir_name\ws920\a92F11
   C:\dir_name\ws920\a92F12
   C:\dir_name\ws920\a92F13
   C:\dir_name\ws920\a92F14
   C:\dir_name\ws925\a92F11
   C:\dir_name\ws925\a92f14
   C:\dir_name\ws930\a92F12
   C:\dir_name\ws930\a92F13

   Y
   Y

   At this point, save the above file, ensuring that there are no "empty lines" after the final **"Y"**. Back at the DOS prompt, copy this file to a second file called "q11.234" as follows:

   C:\dir_name> copy q11.lst q11.234
   C:\dir_name> edit q11.234 invoke DOS editor

   At this point edit the "q#.234" file to eliminate the "a" located in front of the map sheet number, as well as the "Y"'s at the bottom of the file. The resultant file should appear as follows (again q11 is used for demonstration):

   C:\dir_name\ws920\92F11
   C:\dir_name\ws920\92F12
   C:\dir_name\ws920\92F13
   C:\dir_name\ws920\92F14
   C:\dir_name\ws925\92F11
   C:\dir_name\ws925\92f14
   C:\dir_name\ws930\92F12

C:\dir_name\ws930\92F13

Again, save the above file, ensuring that there are no "empty lines" after the final entry.

2. Copy both the "Q11.234" and the "Q11.lst" to the "CONVLAB" sub-directory under the work directory

C:\dir_name> copy q11.234 c:\dir_name\convlab
C:\dir_name> copy q11.lst c:\dir_name\convlab

3. From ARC/INFO run the "convlab.sml" to convert the IGDS data files to label covers. Use the "E" extension if the loaded IGDS files are in their original format or the "A" extension if the files have beeen converted to ASCII format.

C:\dir_name> cd convlab
C:\dir_name\CONVLAB> arc
(C:\dir_name\CONVLAB)[arc] @convlab q# E - orig. IGDS
or

(C:\dir_name\CONVLAB)[arc] @convlab q# A -ASCII convrt.

4. Following the running of "convlab.sml", a check should be made for the presence of "NTSmap.WAR" files (ie 92F11.WAR) within the watershed (WSD) sub-directories. If these warning files are present, there are duplicate files in the "NTSmap.234" file(s). These should be examined and edited (if necessary) in FoxPro:

(C:\dir_name\WSD_dir)[arc] dir *.war check for presence
(C:\dir_name\WSD_dir)[arc] fox invoke FoxPro if true

From the FoxPro command "box" enter the following:

use c:\dir_name\WSD_dir\NTSmap.234 list path to *.234
index on str(x_uor,11)+str(y_uor,11) to junk
browse

Look at each of the duplicates (DUPLICATE = .T.) and if appropriate, delete one or more of the duplicates, then **PACK** the file.

Duplicate "id_type" TB's with ws_codes that differ by 1 are not a concern. Nor are "id_type" IS and IE (island start and island end (present in all WSD **5 directories) - these are ignored in the present "computer-automated input programs". Detailed notes of the watershed codes, in these cases, should be made as these codes will have to be manually entered during the "TE" process to facilitate input during the "TB" process.

Other types of duplicates are generally a problem and a check of both the IGDS "check plots" and/or the dictionary are often necessary. A helpful hint is that the originating "NTSmap.D0#" files indicates the date of the last editing of each label. This may be helpful in sorting out which entry to keep.

5. Using FoxPro, create a TB234.DBF file as follows;

(We are still using Q11 as an example)

C:\dir_name> cd ws920
C:\dir_name\ws920> fox

In fox select all files

[x] all files

Select first NTSMAP#.234 in the sequence and "OPEN" it, the result will be displayed in the Fox command window as follows;

use 92f11.234

From the command window, enter the following;

copy to TB.234
use TB.234
append from C:\dir_name\ws920\92f12.234
append from C:\dir_name\ws920\92f13.234
append from C:\dir_name\ws920\92f14.234
append from C:\dir_name\ws925\92f11.234
append from C:\dir_name\ws925\92f14.234
append from C:\dir_name\ws930\92f12.234
append from C:\dir_name\ws930\92f13.234
set filter to id_type = 'TB'
copy to TB234.DBF
quit

The TB.234 and TB234.DBF will be inside the first watershed directory used to create them. Copy both into the convlab directory after renaming the TB.234 and TB234.DBF from the previous quad (Q#) to Q#TB.234 and Q#TB234.DBF

6. From ARC/INFO run the "batch.sml" to create the required TE, TB, etc. label coverages.

(C:\dir_name\CONVLAB)[arc] @batch q#

Copy the resulting Q#PNT, Q#TE, Q#TB, Q#CE and Q#LO coverages into the working directory.

7. From ARC/INFO, run arcedit and edit the Q#.CE coverage. Delete the CE and CS labels that fall along the internal neatlines. Also examine and delete any CS nodes which are connected by a single arc to a CE or a TE (This is the result of a programming oversight that eliminates/overwrites ws_codes given to CE's where arc direction - fnode/tnode was or is a consideration). Then assign the appropriate ws_code to all of the CE labels on the outer neatlines.

(C:\dir_name)[arc] arcedit

: display 4	or disp 4
: editc Q#CE	
: ef label	or ef lab (fewer keystrokes)
: drawe label	or drawe lab
: backc Q# 2	gives a red backcover of arcs

: backe arc
: setd 5 selected items show in yellow
: draw
: sel box select CE & CS labels on inner neatlines
: delete
: sel id_type = 'CE'
: draws highlighted CE's appear yellow
: <F9> zoom to appropriate-size box
: use mouse to define box
: draws highlighted CE's as above

At this point there are two options, one is to utilize ARC/INFO's **"FORMS"** utility, selecting, updating and entering the appropriate ws_code to the appropriate CE node. The advantages are that the form has an automatic "stop" after all 37 digits of the ws_code are entered, you can "read" all of the data base fields and abort if a wrong node is selected, and you can select a large area of the coverage and (depending upon the CE density) move from one CE to the next. The other option is to select the individual CE's and utilize the "movei" command to insert ws_codes to the CE coverage. There are few advantages to this method.

Option 1

: forms
: use mouse or "1" to select
: use "3" to confirm selection
: use "4" to update

enter appropriate ws_code, then <enter> and update record and continue as above until all CE's have been updated in the selected screen.

Option 2

: sel or sel box, use mouse to define
: movei '##########################, etc' ws_code

the difficulty here is in knowing when the 37 digits of the ws_code are complete.

After all CE's are believed to have been "filled" with the appropriate ws_code, zoom out to the full coverage, select for id_type = 'CE' and ws_code = ' ', as follows: if it is done, then save, quit and build the Q#CE coverage

: <F10> zoom out to full coverage
: sel id_type = 'CE' and ws_code = ' '
: draws hopefully, "no items selected"
: save
: q or quit
(C:\dir_name)[arc] build q#CE point

8. Add TS labels where mainflow tributaries drain to secondary flows. This program automatically places a TS id_type at the confluence of a stream line - code 1000 (single line creek) meets a secondary flow - code 1100 (single line secondary flow) or a code 1350 (double line construction line for secondary flow). The program is incomplete in that it only resolves those situations that occurred in the IGDS files that were the

result of TJ to JS, trib starts that resulted in a TE being created at the headwaters. Other situations where a marker TB was created in IGDS to accommodate streams flowing into a side channel, must for now, be dealt with manually later in the "TBPROCS" procedures:

(C:\dir_name)[arc] @add_ts Q#

9. Append the TE, TS, and CE label covers together to create the Q#END coverage:

(C:\dir_name)[arc] @apd2 q#

Begin the TE Process

1. Build and examine the main flow lines created by combining the scanned coverages with the original IGDS files:

(C:\dir_name)[arc] reselect Q# mflow line mainflo.sml
(C:\dir_name)[arc] arcedit

: display 4	or disp 4
: editc mflow	
: ef arc	
: drawe arc node dangle	
: draw	
: <F9>	zoom to manageable size
:	use mouse, toggle to area

Systematically examine portions of the coverage for continuity of the linework, improper coding and "inappropriate" dangles. It can help to have the backc "Q#" turned on in color 2 (red) to see if dangles are caused by wrong codes or missing linework. Correct all obvious errors in the Q# coverage by switching back and forth to the Q# coverage and the Mflow coverage, i.e. continuing from above, an error is spotted, lets say, in coding:

: editc q#	
: ef arc	
: drawe arc	
: sel many	use mouse to select item
: lis code	display the suspect code
: ca code = ####	calculate the proper code
: editc mflow	return to mflow coverage
: ef arc	
: <F7>	zoom out to desired size
: <F8>	pan - direction via mouse

Continue until all edits have been completed, then save, quit and build the Q# cover.

: save

The ArcEdit session always ends by saving the "current" edit coverage. If you have made changes, you should be in the Q# coverage when saving - if not, then you must answer "YES" to the "save changes" prompt upon quitting.

: q or quit
(C:\dir_name)[arc] build q#

2. From ArcInfo, run "TEPROCS.SML".

(C:\dir_name)[arc] @teprocs q#

This process first kills the previous mainflow (MFLOW) cover used above, creates a new MFLOW cover and then checks that all the IGDS labels used to create the Q#END cover are near the end of only one tributary. If this is not the case a list of label problems is created, a message is displayed, ArcEdit is started and the operator is prompted to resolve each label problem by adjusting or deleting the label. The original IGDS plots and NTSmaps should be consulted frequently. Most label moves can be accomplished with a use of common sense.

The typical response following the initial display (label high-lighted in yellow - MFLOW coverage in background) would be as follows:

: lis ws_code

Consult IGDS check plot for comparison of listed ws_code. Make decision.

: move

Click mouse first on label to be moved, then on desired new position of the label. Close is generally "good-enough".

: &return "cycles" through to next screen

After the ArcEdit session ends the user is informed "All Done" and the program starts into the next phase where the user is asked:

a) whether the original quad needs to be rebuilt?
b) whether the user wants to make changes in FoxPro?
c) whether MFLOW needs to be regenerated?

Notes:
If you have made **any** changes to the original Q# coverage, then it needs to be rebuilt.

If you only need to change codes rather than changing linework, then it is more efficient to make a list and record the q#_id's and the required changes and then make these changes to the AAT of the original Q# using FoxPro. This avoids lengthy save and build routines. Remember, the ArcEdit session always ends by saving the "current" edit coverage. If you have made changes to another coverage then you must answer "YES" to the "save changes" prompt upon quitting.

After the coverages have been updated by building and/or regenerating MFLOW the labels are again checked against the tributary ends and this process repeated until there are no more label problems. Then the program is automatically executed assigning the ws_codes to the arcs in the MFLOW coverage.

3. Check if ws_codes are assigned correctly in the MFLOW coverage. Use ArcEdit to edit MFLOW and select any arcs with blank ws_codes. If any exist determine the cause and make appropriate fixes.

   Next, select prominent arc "groupings" such as a coastline. Select a coastline arc. List the ws_code, then select and draw all arcs with the same ws_code. Only the selected arc "grouping" should draw. If not, determine the problem and make fixes. Repeat this procedure for one or two other arc "groupings" i.e. major stream systems, etc. In all cases, if the ws-codes aren't assigned correctly, look for problems (such as loops or dangles, missed in step 1), fix them in the Q# coverage, build and repeat from step 2. An example of the steps as follows:

   : editc mflow
   : ef arc
   : drawe arc
   : sel many use mouse to select arc "group"
   : lis ws_code write down ws_code
   : sel ws_code = '##################################'
   : setd 3 select prominent display color
   : draws

   repeat as necessary, until you are satisfied.

   : save
   : q or quit

   Once all appears OK in the MFLOW as related to the TE process, the next stage, TB process can begin.

   Do not build Q# between the TEPROCS and the TBPROCS.

Begin TB Process

1. Make sure that the TB234.DBF is copied from the Convlab directory to the current working directory. From ArcInfo run "TBPROCS.SML".

   (C:\dir_name)[arc] @tbprocs q#

   This process attempts to match TB labels against "new" mainflow tributaries. If the TB labels generated by the IGDS files cannot be matched against the node positions of the scanned line-work (50 m search radius) then ArcEdit will be started and the operator prompted to edit (move/delete) the TB labels as appropriate. The program will loop ("outs" have now been provided) until all TB labels have been matched. This program is very similar to the previous "TEPROCS.SML". Note, as mentioned previously, the program currently has a problem dealing with TBs provided for tributaries flowing into side channels, and these will have to be dealt with manually. It is important to note that TBs which appear to NOT be near any new trib may actually be indicating an isolated waterbody that should be connected to the parent with an arc coded 1410.

   An error_msg "field" is indicated for each identified TB point. These indicate the type of TB problem encountered:

   'MS' - means the label is near more than one new trib. 'NS' - indicates the label is NOT near any new trib. 'DM' - means the trib is supposed to be a duplicate but in fact is only near to one new trib.

After the process in ArcEdit, the program will automatically run the "CK_FORK.SML". This portion of the program will zoom-in on each new tributary with forks and locations of where two tributaries enter the mainstem at the same node. The "forks" portion of the program requires the user to decide which "arm" of the stream is the parent and which is the child. The duplicate node problem requires the original IGDS check plots and that the operator decide the tributary sequence, as IGDS simply numbered the sharing tributaries consecutively.

Check the mflow coverage for anomalies such as ws_code = '0', ws_code = '99999999999999999999999999999999999999' and ws_code = ' '. Make appropriate corrections using the IGDS plots and the NTS maps for reference. There should not be any blank or '0' ws_codes in the mflow coverage, and the only acceptable instances of ws_code = '99999999999999999999999999999999999999' are when new tributaries exist that have not yet had their watershed codes created.

Save, quit and then build the MFLOW coverage as follows:

```
: save
: q                                    or quit
(C:\dir_name)[arc] build mflow line
```

Copy the mflow attributes back into the original quad:

```
(C:\dir_name)[arc] fox flo2all Q# mflow
```

There are six (6) 'house-keeping' duties to perform before going on to the next main step.

1. Any arcs that may still be in the wrong direction need to be flipped.

```
(C:\dir_name)[arc] arcedit
        : editc Q#
        : ef arc
        : sel flip_mark = 'Y'
        : sd 0.01
        : flip
        : movei ' ' flip_mark
```

2. Before saving and building the current coverage, all the bl_keys and ws_keys should be set to zero.

```
        : sel all
        : ca ws_key = 0
        : ca bl_key = 0
        : save
        : q                            or quit

        (C:\dir_name[arc] build Q#
```

3. If the coverage contains any arcs coded 4000, they must be removed and placed in a separate coverage named Q#Z.

```
(C:\dir_name)[arc] copycov Q# Q#Z
(C:\dir_name)[arc] arcedit
        : editc Q#Z
        : ef arc
```

: sel all
: unsel code = 4000
: delete
: save
: editc Q#
: ef arc
: sel code = 4000
: delete
: save
: q or quit

(C:\dir_name)[arc] build Q#Z line
(C:\dir_name)[arc] build Q#

4. Repeat the procedures in step 3 above if the coverage contains any arcs coded as "ice" code 200. These must also be removed from the coverage and placed into a separate coverage called Q###ICE.

   In FoxPro check the Q#_id for both coverages (the Q##_id SHOULD be the same as the record number) and rebuild as necessary after calculating $id = $recno. Kill the resultant pseudo-nodes in the Q# coverage using the kilps2.sml.

   (C:\dir_name)[arc] @kilps2 Q##
   (C:\dir_name)[arc] build Q##

5. Save the Q##LO coverage to a separate directory for later processing for watershed groups.

6. Run the program "ck_labs" to ensure that all possible.IGDS watershed codes have been transferred to the "new" PC ARC/INFO watershed atlas files. Check the resultant ck_labs.doc file against the IGDS check plots and resolve any outstanding problems.

ASSIGN KEYS to MAIN FLOW ARCS

1. Since there have been changes made to the current coverage, and it has been re-built, reselect mflow using the mainflo.sml as was done before running the TE Process. Then, in FoxPro, run the MKNEWK.PRG. This assigns WS_KEY and BL_KEY to the main flow arcs.

   WS_KEY - is a unique identifier for a watershed (an integer value which is not duplicated for any other digital file); never blank. An example would be the Fraser River mainstem, including all side channels and the distributaries (North Arm, South Arm, etc. at the mouth).

   BL_KEY - is a unique identifier for a blueline segment within a watershed (an integer value which is not duplicated for any other blueline in any other digital file); never blank. An example would be a segment of a watershed such as the mainstem of the Fraser River, a portion of the Fraser River such as the North Arm, the South Arm or any single side channel of the Fraser River.

   (C:\dir_name)[arc] fox mknewk

2. Check the text file "MKNEWK.ERR" for error messages. In ArcEdit, edit the coverage MFLOW to correct any errors noted. Ideally, there will be no error messages, other than, as an example, the following:

   Date Time
   Max Bl_Key now = ####
   Max Ws_Key now = ####

Record = #### has blank ws_code

the Record #### should be one more than the total number of arcs in the mflow coverage, while the Max Bl_Key and the Ws_Key should be identical.

3. Record the data from 2. above

4. Use FoxPro to confirm that the values are correct.

```
(C:\dir_name)[arc] fox
        use c:\dir_name\mflow\aat.dbf
        index on bl_key to junk
        brow
```

Go to the bottom of the record for bl_key and compare the data recorded in step 3. above. Repeat the procedure for ws_key. If the numbers differ at this point make a note. It will be necessary to identify why there is a difference (i.e. a possible "bug" in the program. If the two numbers are the same proceed to the next step.

5. Using FoxPro, run the FLO2ALL.PRG. This program essentially copies the MFLOW coverage's ws_key and bl_key (s) back into the original coverage. The MFLOW coverage can now be killed if you are pressed for space on your hard-drive.

```
(C:\dir_name)[arc] fox flo2all q# mflow
(C:\dir_name)[arc] kill mflow all
```

Assign Keys to Secondary Flow Arcs

1. In ARCINFO run the MKSFLO.SML to create a coverage of secondary flow arcs. The coverage will appear in your directory as SECFLO.

```
(C:\dir_name)[arc] @mksflo q#
```

2. In FoxPro run the AS_SIDE.PRG. This assigns bl_key (s) to secondary flow arcs.

```
(C:\dir_name)[arc] fox as_side q#
```

3. Check the text file "AS_SIDE.DOC" for message. The following message should appear;

```
11/02/93  11:41:06 q##
Current max bl_key is  :        ####
Current max ws_key is  :        ####
```

**Note this current max bl_key is (or should be) the first bl_key that will be used when manually assigning bl_keys from this point onwards.

4. Record the data from 3. above.

5. Use FoxPro to confirm that the values are correct.

```
(C:\dir_name)[arc] fox
        use C:\dir_name\secflo\aat.dbf
        index on bl_key to junk
        brow
```

Go to the bottom of the record for bl_key and compare the data recorded in step 4 above. If the numbers differ at this point make a note. It will be necessary to identify why there is a difference (i.e. a bug in the program)

6. In ARCEDIT edit the coverage SECFLO. Examine the secondary flow arcs for parent/child relationships. Much intuition upon the operator is required at this point. Utilize NTS maps or any other available data to make decisions. Three steps are generally needed to proceed past this stage (dependent upon the number of secondary flows encountered). The first step should be to examine those secondary flows which are missing both a bl_key AND a ws_key, secondly to identify those arcs that are missing a ws_key and finally to those arc which require only a bl_key.

(C:\dir_name)[arc] arcedit
: disp 4
: editc secflo
: ef arc
: drawe arc
: sel bl_key > #### enter the MAX bl_key from 3.

IF there are any values greater than the MAX bl_key then a "bug" IS present. Narrow down the actual MAX bl_key by repeating the above. Once it is found, make a record of it. ANY new bl_keys needed to be manually input from this point onward will be this MAX bl_key plus 1. Once this record has been established, proceed to the next step.

Step 1. Examine secondary flow arcs that have neither a bl_key nor a ws_key.

: sel bl_key = 0 and ws_key = 0
: setd 3
: draws
: <F9> use mouse to define area

decide reason for "0" code, resolve and correct as necessary. This will involve decisions on parent/child relationships and may involve toggling back and forth between the original quad coverage Q# and the secondary flow coverage SECFLO. Copy appropriate WS_KEY and WS_CODE to the secondary flow arcs as needed;

: sel many select all related sec. flows
: ca ws_key = ####
: movei '############### etc' ws_code

Now from the pre-determined maximum BL_KEY ### add one and reselect apparent continuous sections of secondary flow (including code 1100, 1150 and 1450 connectors, if present). Calculate these continuous sections to the new BL_KEY.

: resel many
: ca bl_key = #### - this number is +1 from last

Continue selecting/reselecting until ALL secondary flow arcs have a WS_KEY and a BL_KEY that are not equal to "0".

Step 2. Repeat the process to eliminate those secondary flows which have a WS_KEY = 0.

: sel ws_key = 0
: setd 3
: draws

Copy the appropriate WS_KEY and WS_CODE to the secondary flows as required.

Step 3. Repeat the process to eliminate those secondary flows which have a WS_KEY but no BL_KEY;

: sel bl_key = 0
: setd 3
: draws

Again from the pre-determined maximum BL_KEY ### add one and reselect apparent continuous sections of secondary flow (including code 1100, 1150 and 1450 connectors, if present). Calculate these continuous sections to the new BL_KEY.

: resel many
: ca bl_key = #### - this number is +1 from last

Continue selecting/reselecting until ALL secondary flow arcs have a WS_KEY and a BL_KEY that are not equal to "0". After all secondary flows have both a BL_KEY, WS_KEY and a WS_CODE, save and build

: save
: q

(C:\dir_name)[arc] build secflo line

In FoxPro copy the secondary flow keys back to the original coverage;

(C:\dir_name)[arc] fox flo2all q## secflo

Assign WS_CODES to Isolated Waterbodies

1. In FoxPro run the "SMALAKE.PRG". This identifies isolated waterbodies (lakes and wetlands) larger than a threshold area value (currently set at 10,000 sq. m.) and also sets a "flag" for the presence of isolated bodies which require the operator to identify a "parent" blueline.

   C:\dir_name> arc
   (C:\dir_name)[arc] fox smalake Q#

2. In ARC/INFO run "PULLISO.SML". This checks for the flag set by "SMALAKE.PRG" and when found, prepares a list of coordinates of the isolated waterbodies.

   C:\dir_name> arc
   (C:\dir_name)[arc] @pulliso q##

In arcedit check for arcs that have been marked 'big', ie: mark_big = 'Y', and use the arcedit command ADD to add straight arcs coded 1410 where needed. These large isolated waterbodies are most likely going to be ws_code = '9999999999...etc'. Use the NTS mapsheets to follow contour lines and determine where the 1410 arcs should attach to the parent streams.

Assign WS_CODES and keys to shorelines

1. Run the "FIXSHOR.PRG" from FoxPro. This uses the WS_CODE, the WS_KEY, and the BL_KEY given to the "flow" arcs to assign the same to the shoreline arcs.

   C:\dir_name> arc
   (C:\dir_name)[arc] fox fixshor q##

2. Check the text file "FIXSHOR.ERR" for warnings and error messages. Should any be found, start Arcedit and check each warning/error message and make edits as appropriate. Exit by saving and build the coverage.

Create and code polygon labels

1. In ARC/INFO create labels, check for label errors and resolve any label errors.

   (C:\dir_name)[arc] createlabels q##
   (C:\dir_name)[arc] build q##
   (C:\dir_name)[arc] labelerrors q##

   Polygon # 1 should have no label, all others should have one and only one label. If more than one label is found to be present in a polygon, edit the coverage in ArcEdit, then save, BUILD, and test again for labelerrors (as above)

   (C:\dir_name)[arc] build q##
   (C:\dir_name)[arc] labelerrors q##

2. In FoxPro run "MKTYPE.PRG". This crudely assigns the "TYPE" attribute to each polygon based on the shoreline and construction coding.
   C:\dir_name> arc
   (C:\dir_name)[arc] fox mktype q##

3. Check the text file "MKTYPE.ERR". In ArcEdit check any indicated errors. In addition, the program has been found to be far less efficient than expected and further editing is common.

   (C:\dir_name)[arc] arcedit
   : disp 4
   : editc q##
   : ef arc
   : drawe arc label
   : sel code = 1500 or code = 1525
   : ca $symbol = 6
   : sel code = 1700
   : ca $symbol = 5

```
: sel code = 1800 or code = 1825 or code = 1850 or code = 1875
: ca $symbol = 4
: sel code = 2100
: ca $symbol = 2
: ef label
: sel type = 'L'
: ca $symbol = 6
: sel type = 'W'
: ca $symbol = 5
: sel type = 'R'
: ca $symbol = 4
: sel type = 'M'
: ca $symbol = 3
: sel type = 'X'
: ca $symbol = 2
: sel type = ' '
: draw                                  or <F5>
: draws
```

Check first for blank feature type, then edit for wrong feature type(s). The colourization of the arcs with the same colour as the label type assists in locating wrong "typing". Correct all apparent errors, then save and build the cover.

```
: save
: q
```

(C:\dir_name)[arc] build q##

4. In FoxPro run "MKPATKY.PRG" to assign WS_CODEs, WS_KEYs and BL_KEYs to the polygon labels

C:\dir_name> arc
(C:\dir_name)[arc] fox mkpatky q##

5. Check the text file "MKPATKY.ERR" for error messages. In ArcEdit check each message and make corrections as appropriate. **Note:** it may be necessary to edit the type attributed if errors are found on shoreline or construction line coding. Exit by saving and then BUILD. If a significant number of corrections are necessary you should repeat from step 2 onward

Validation

Validation involves working through a serirs of programs each of which tests various aspects of coding and topology. Each program will display warnings and error messages on the monitor as it executes. These messages will also be output to a text file: programname.err.

In ArcEdit examine each warning/error message and make corrections as appropriate. Where a program produces a warning message that should be ignored, you should record this in a text file: "EXCQ##.DOC" which will be stored in the coverage subdirectory. Normally you should use an editor (such as DOS EDIT command) to cut-and-paste the appropriate warning message into the EXCQ##.DOC and then add a brief commentary as to why the exception is acceptable.

Note: Certain kinds of coding and topology errors may cause earlier validation programs to overlook errors. Therefore you must repeat the validation process until no corrections are required at any step in the validation sequence.

The following is the order in which validation is to be performed;

1. **(C:\dir_name)[arc] labelerrors q##**
   All polygons should have one and only one label and polygon #1 should have no label.

2. **C:\dir_name> fox ck_aat q##**
   Generates no detailed error report (only a summary is generated in the ck_aat.err report) but the aat error_msg field can be given either a "C,D,G,K,L,Z,0(zero)" error codes. In ArcEdit, edit the coverage to identify and correct each of these errors.

3. **C:\dir_name> fox ck_key q##**
   Generates a detailed report (see report types). AAT error_msg field can be given "H,J,W" error codes.

4. **C:\dir_name> fox ck_bank q##**
   Generates a detailed report. AAT error_msg field can be given "K,$L,$R,$O" error codes.

5. **C:\dir_name> fox ck_cont q##**
   Generates a detailed report. AAT error_msg field can be given "E,M,S,Z" error codes.

6. **C:\dir_name> fox ck_cont2 q##**
   Generates a detailed report. AAT error_msg field can be given "N" error code.

7. **C:\dir_name> fox ck_1450 q##**
   Generates a detailed report. AAT error_msg field can be given "T" error code.

8. **C:\dir_name> fox ck_1375 q##**
   Generates a detailed report. AAT error_msg field can be given "U" error code.

9. **C:\dir_name> fox ck_pat q##**
   Generates a detailed report. PAT error_msg field can be given "C,D,Z" error codes.

10. **C:\dir_name> fox ck_poly q##**
    Does not generate a detailed report. AAT error_msg field can be given "F,X,Z" error codes. PAT error_msg field can be given "B,T,Z" error codes.

11. **C:\dir_name> fox ck_poly2 q##**

Generates a detailed report. AAT error_msg field can be given "G" error code. PAT error_msg field can be given "A,I,$L,$M,$R,$W,$X" error codes.

12. **C:\dir_name> fox ck_islnd q##**
Generates a detailed report. AAT error_msg field can be given "Q,R" error codes.

13. **C:\dir_name> fox ck_bank q##**
Generates a detailed report. AAT error_msg field can be given "K,$L,$R,$O" error codes.

14. **C:\dir_name> fox ck_cont3 q##**
Generates a detailed report. AAT error_msg field can be given "K" error code.

15. **C:|dir_name> fox mk_seg q##** (note this is a new program)

16. **C:\dir_name> fox ck_poly3 q##**
Generates a detailed report. PAT error_msg field can be given "N" error code.

17. **C:\dir_name> fox ck_isol q##**
Generates a detailed report. AAT error_msg field can be given "P" error code.

18. **C:\dir_name> fox ck_wscod q##**
Generates a detailed report. AAT error_msg field can be given "1" error code.

Error Message Codes

AAT

C = arc with code = 0 or illegal code
D = arc with _ID = 0
E = end of chain (not really an error)
F = construction line BL_KEY different than shoreline
G = dangle but should be closed
H = BL_KEY has both main flow & secondary flow codes
J = WS_KEY = 0
K = wrong direction
L = loop (fnode_ = tnode_) and not coded as island or coast
M = multiple arc junction
N = secondary flow not connected to main flow with same WS_KEY
P = code 1400 in waterbody polygon but not isolated flow
Q = land on both sides of 1600 (island) code shoreline
R = island shoreline, not connected
S = start of chain (not really an error)
T = error on arc with code 1450 (check listing for error type)
U = error on arc with code 1375 (check listing for error type)
V = problem with polygons bordering shared wetland arc
W = 2 WS_KEYs for this BL_KEY
X = can't find matching construction line
Z = arc with BL_KEY = 0
0 = zero length arc
1 = WS_CODE is less than WS_CODE for next trib. downstream
$L = should be left bank
$R = should be right bank
$O = other error (type not river or wrong BL_KEY or not a bank)

PAT

A = incompatible shoreline codes
B = PAT BL_KEY dos not match the AAT BL_KEY
C = label with an empty or illegal TYPE
D = label with _ID = 0
E = ??????????????????????
I = illegal code detected on an arc within the polygon
N = not enough polygons in waterbody
T = PAT TYPE doesn't match AAT CODE for significant const. line
V = ??????????????????????
W = WS_KEY = 0
X = can't find construction line
Z = BL_KEY = 0
$L = TYPE should be "L" based on shoreline
$W = TYPE should be "W" based on shoreline
$X = TYPE should be "X" based on shoreline
$R = TYPE should be "R" based on shoreline
$M = TYPE should be "M" (no construction line or 1400 dangle)

Appendix C - Watershed Processing Guide

DWA Watershed Processing Guide

Jan 1996

Created for the British Columbia Ministry of Environment Lands and Parks by Pacific Spatial Systems Limited, June 1995.

General Notes

This documentation is meant to be used in conjunction with the on-line help files which can be accessed by typing @HELP [subject name]

All copies made of the coverage that are marked *backup only* can be removed when you do the next backup, but it is better to keep at least two revisions on your machine or more if you can afford the space.

Each night copy the current version of the coverage into a backup directory, on another drive if possible.

Foxpro version 2.0 uses expanded memory. WS_PROP requires 5 - 7 meg expanded free RAM to work. Foxpro 2.6 nees 5 - 7 meg XMS to run WS_PROP.

Pre-processing Stage

1. Receive maps from MoELP.
2. Record maps in log book.
3. Find most recent copy of the quads and quad LOs that are in our possession and load onto your machine.
4. Receive remaining quads and quad LO coverages from MoELP and load onto your machine.
5. Get a control sheet and fill in the general information.

Quad Processing Stage

Projection

1. Go to the source map and locate the UTM zone for each quad.
2. Set up the projection parameters in [zone_5,000,000_shift].sml

ARC command Project

These are notes on projecting between UTM Zones.

I. How to project from zone 10 to zone 9

Conveniently name an sml (e.g. Z10_2z9.sml) and place in it the following text:

```
input
projection UTM
units meters
zone10
parameters
output
projection UTM
units meters
zone9
parameters
end
```

II. How to subtract 5,000,000 from the Northing in same zone (e.g. 9)

Conveniently name an sml (e.g. z9_sb_5m.sml

```
input
projection UTM
units METERS
ZONE 9
parameters
output
projection UTM
zone 9
yshift -5000000
units meters
parameters
end
```

III. How to add 5,000,000 to the Northing in same zone (e.g. 9)

Conveniently name an sml (e.g. z9_ad_5m.sml

```
input
projection UTM
units METERS
ZONE 9
parameters
output
projection UTM
zone 9
yshift 5000000
units meters
parameters
end
```

IV. How to move between yshifted UTM zones that must remain yshifted.

Conveniently name an sml (e.g. z9y2z10y.sml

```
input
projection UTM
units METERS
ZONE 10
YSHIFT 5000000          (add 5000000 so project is done correctly)
parameters
output
projection UTM
zone 9                  (switch zones)
yshift -5000000         (subtract 5,000,000m again)
units meters
parameters
end
```

Always create a project.map or prj.adf file in the directory with a text editor so you don't forget the current projection.

3. PROJECT [quadname] [temp_quadname] [smlname]
4. PROJECT [quadname]LO [temp_quadname]LO [smlname]
5. BUILD [temp_quadname] POLY
6. BUILD [temp_quadname]LO POINT
7. RENAMCOV [quadname] O[quadname] *Backup Only*

8. RENAMCOV [quadname]LO O[quadname]LO *Backup Only*
9. RENAMCOV [temp_quadname] [quadname]
10. RENAMCOV [temp_quadname]LO [quadname]LO

Prepare quad for watershed processing

- At this point you need to fix ws_codes and bl_keys, then define a CLIP coverage for each of the quads defining major watershed boundaries. You will be using the key map given by MoELP Fisheries Branch to code the watershed boundaries that are marked on the map.

Help for WS_PROP.SML

Ws_prop is used to propagate ws_code to all arcs AND labels having the same ws_key, either on a quad or on a watershed coverage.

Ws_prop assumes a correct ws_key code. The ws_code will not be propagated to the set of ws_key arcs if the arcs are NOT connected, or if 75% of the arcs do not have the same ws_code, unless the remaining ws_codes are 9999999.

Ws_prop can be run at any time during processing, any number of times, however it is best to make sure that the bl_keys (and ws_keys) are correct before running it, because it is easier to check these than fix accidentally overwritten WS_CODEs.

It is recommended ws_prop be run before quads are split, then again
after merge_bl, if inspection passes.

Usage:

@WS_PROP [wsdname]

arguments

[wsdname] DWA coverage

notes

Ws_prop is run from the \arcexe\dwa\new_trib directory.

In the examples below, assume each blueline has the same ws_key

WS_CODE will be copied:

```
ws_code=      1   1   1   2
           *---*---*---*---*
```

```
ws_code=      1  999.. 999..
             *---*------*----*

ws_code=      1   1  999..  1   1   2
             *---*---*-----*---*---*---*
```

WS_CODE will NOT be copied:

```
ws_code=      1   1   2
             *---*---*---*

ws_code=      1   2   3   999.. 999.. 999..
             *---*---*---*-----*-----*-----*
```

If any ws_codes could not be propagated completely to a ws_key, the following message will be displayed:

"WS_prop.sml complete."
"Some ws_codes connections could not be diagnosed."
"Use @FS WS_prop to resolve."

See help within @FS for hints on correcting errors.

Procedure for WS_PROP and for creating the CLIP coverages.

1. @DO NEW_14 [quadname] This tags secondary flow connectors as such, reducing exceptions in the following programs.
2. @DO CK_ORDER [quadname] Fix errors (CK_ORDER.DOC and ERROR_MSG) in ARCEDIT and re-run until clean, BUILDing as necessary. There will be some exceptions in most quads because of streams flowing off and on maps.
3. @DO CK_WS37 [quadname] Fix errors (CK_WS37.DOC and ERROR_MSG) in ARCEDIT and re-run until clean, BUILDing as necessary.
4. @DO MK_1450 [quadname]
5. @WS_PROP [quadname] If any errors fix with @FS

Creating a CLIP Coverage

Most arcs in the watershed CLIP coverage will come from existing 5100s. Any offshore islands that are to be included within a watershed coverage must be added to the CLIP coverage. Be sure not to move any 5000 while adding these additional lines.

6. ARCEDIT
   - EDIT [quadname]
   - EF ARC
   - SEL CODE IN {5000,5100}
   - CA $SYMBOL = 3
   - RESEL MANY

Select the arcs that make up the watershed boundaries as specified by MoELP on the key map.

- CA CODE = 5000
- CA $SYMBOL = 4

Inspect for missing segments and add missing watershed boundaries (1375s, 5000s) as necessary.

- @CALCID (calculate all dash-ids to a unique value)

SAVE;Q

7. RENODE [quadname]
8. BUILD [quadname] POLY
9. LABELERR [quadname] Fix label errors and re-build if necessary.

10. @MK_CLIP [quadname]

Reselects for code = 9000, 5100, 1375, 5200, 100, 150, 6000.
creates Q###TMP includes the 9000s, 1375s, 5000s
creates Q###C which hopefully only includes 5000s and required 1375s.

Changes indicated on the key map provided by the Branch should be revised. Other edgematching problems should be estimated and updated.

11. ARCEDIT
    - EDIT [quadname]C
    - DRAWE ALL OFF ARC NODE DANGLE
    - BACKC [quadname]TMP 4
    - BACKE ALL OFF ARC
    - Add 5200s to encircle any off shore islands. Connect these to existing 5100s.
    - DRAW

Make sure that there are no dangles and that all watershed boundaries that should have come across did. If there are errors, fix the problem in [quadname] and build and @mk_clip until it is clean..

- QUIT

11. @SET_QUAD [quadname]
    Do this for all the quads. SET_QUAD is a critical process to the later MERGE_BL process. It creates an attribute called QUAD_NUM in the AAT and PAT, and fills it with the coverage name for each arc and label. The quad coverage names should remain under five letters if possible.

12. @SAMEF_37 [quadname]
    Changes the pat and aat table structures for later append.

Creating and Editing the Watershed Coverages Stage

Creating and edgematching the CLIP coverage.

We must define a coverage that has closed polygons for all of the major watershed boundaries.

1. Append the watershed boundary clip coverages into a single coverage.
2. Create a new directory.
3. In that directory, using a text editor, create a list file [listfile] giving the full path names of all the [quadname]C coverages created in the MK_CLIP step in the following format:
   C:\W\Q##1C
   C:\W\Q##2C
   etc...
4. @MK_SPLT2 [clipname] [listfile]
   Where [clipname] is the name you want to call your CLIP coverage, and [listfile] is the file created in step 2
5. RENODE [clipname]
6. BUILD [clipname] LINE
7. ARCEDIT
   - EDIT [clipname]
   - DRAWE ARC NODE DANGLE
   - Edgematch the [clipname] coverage, being careful not to move any of the existing lines. Close polygons by adding lines between nodes rather than moving nodes. (This would move existing lines)
   - @CALCID
   - SAVE;Q
8. RENODE [clipname]
9. BUILD [clipname] POLY
10. CREATELABELS [clipname]
11. BUILD [clipname] POLY
12. LABELERR [clipname]
13. ADDITEM [clipname].PAT [clipname].PAT WSD_NAME 6 6 C
14. ARCEDIT
    - EDIT [clipname]

- EF LAB
- for each polygon, MOVEI '[wsdname]' WSD_NAME
- SAVE;Q

15. BUILD [clipname] POLY
16. COPYCOV [clipname] [clipname]BAK *backup only*

Clipping out the watershed coverages.

This step takes the [clipname] coverage and uses it as a "cookie cutter" to pull all features from the quads and place them into watersheds. This must be done for both [quadname] and [quadname]LO coverages. Use the text below to help you create list files to split out the [wsdname] and [wsdname]LO coverages from the quads. In general, these list files contain the location of the watershed coverages, the name that you gave them in Step 13 above, and a list of the quads included in the watershed. To simplify matters, call these files WSD.LST and WSDLO.LST

Help for QSPLIT

usage

@QSPLIT [clipname] [split_item] [instruction file] [cover type]
(eg. @QSPLIT CLIP WSD_NAME WSD.LST NET
@QSPLIT CLIP WSD_NAME WSDLO.LST POINT)

arguments

[clipname]	the coverage consisting of watershed boundaries to be extracted from the quads and assembled into a polygon coverage.
[split item]	The item or attribute name in the pat that contains the unique identifier. For this project, WSD_NAME is suggested.
[instruction file]	This is a file created using an editor that describes each watershed, and what quads are within that watershed. See description below. Any file name can be used, but for simplicity, WSD.LST and WSDLO.LST are suggested.
[cover type]	If point coverages are being split and appended (ie. lake outlet or stream points) then use the keyword POINT, else use the keyword NET for polygon DWA coverages.

instruction file format

Figure out all the quads that make up the new watershed. This should be known since the split coverage is a superset of the same quads in question. For each new watershed, list the polygon to be used as the clip polygon in the split coverage, and the quads needing to be split and appended as per the format below.

Note: any reference to a coverage can have a path included if the coverage is not in the current directory.

The example below will create a coverage called c:\w\brk using a polygon in the split coverage with the value BRK and will split and append quads Q1 and Q04. The same will also be done for NIM.

EXAMPLE	GENERAL	DESCRIPTION
C:\W\BRK	[coverage name]	New target watershed coverage name.
BRK	[name in split item]	The value in the split coverage.
C:\W\Q1	[quad name]	Quad coverage name.
C:\W\Q4	[quad name]	Quad coverage name.
END	END	KEYWORD END
C:\W\NIM	[coverage name]	New target watershed coverage name.
NIM	[name in split item]	The value in the split coverage.
C:\W\Q4	[quad name]	
C:\W\Q2	[quad name]	
C:\W\Q10	[quad name]	
END	END	

notes

Qsplit will create a series of small smls used in splitting and later appending. These are prefixed with:

- a$ (append smls)
- d$ (tracking lists)
- e$ (split smls)

These can be deleted by you if a crash occurs, then rerun from start.
No files should exist after the append is complete.

hints

Do a few at a time. Processing takes a long time, and if something fails, you don't have to start from scratch with so many covers.

Problems to watch out for:

1) Empty coverages. If you choose a quad that is not within the clip polygon, it will be empty. Appending an empty polygon coverage screws up the resulting append coverage by mixing up the labels. A feature count is done before the append, and is aborted if no polygon or point features are present in any one particular coverage

2) Didn't get all the quads. This one cannot be checked for. Make sure all of the watershed is accounted for when complete, by going into arcedit and drawing up the watershed.

3) Long coverage names. The intermediate coverages have names based on combinations of the watershed name the quad name. Keep them both to 3 or 4 letters.

4) Not in same UTM zone. Quads need to be adjacent to be clipped properly.

5) Watershed boundaries get clipped. If during editing the watershed boundary moves, even a bit, this will cause the boundary not to be copied into the new watershed. Make sure the boundary in the quad is IDENTICAL to the boundary in the split coverage.

6) Append didn't work., The pat and/or aat may be different among quads. Run @same_fat37 on each to ensure fats are IDENTICAL. Do not run @Same_fat37 on point coverages.

Procedure for QSPLIT

1. @QSPLIT [clipname] WSD_NAME WSD.LST NET
2. @QSPLIT [clipname] WSD_NAME WSDLO.LST POINT
3. Copy each of the [wsdname] coverages into a separate directory along with its [wsdname]LO coverage to prevent confusion later.
4. Note: If you have troubles with the APPEND at the end of the QSPLIT you can do each manually, this way you will locate the problem quickly.

   - APPEND [wsdname] NET ALL
     Enter the component parts of the watershed:
     C:\W\BRKQ1
     C:\W\BRKQ4
     END

Edgematching the watersheds.

This step takes a watershed coverage that still has all the attribute values for the individual quads (i.e. BL-KEY, WS_KEY, etc...) and gets it ready for conversion to a new set of watershed values.

Make a backup copy of the coverage.

1. ARCEDIT
   - EDIT [wsdname]
   - EF ARC
   - DRAWE ALL OFF ARC ARROW NODE DANGLE
   - Confirm the QUAD_NUM flag is set and all of the watersheds are present.
   - - Do a check for problems that may have occurred from having an empty Quad append in or that @set_quad was over looked etc.
   - EF ARC
   - SEL CODE = 0
     - if an entire quad comes up or many of them, this is a problem.
   - SEL QUAD_NUM nc 'Q'
     - if an entire quad comes up or many arcs , this is a problem
   - If there were only a few problems with CODES and/or QUAD_NUM do the fixes:
   - EF LAB
   - SEL TYPE = ' '
     - if a lot come up this is a problem
   - SEL TYPE = 'M'
   - CA $SYMBOL = 5
   - Scan the watershed for correct shape and label integrity. If there is a problems with the labels getting mixed up it will be obvious.
   - If you find many problems you should kill this coverage, locate the problem in the earlier steps and fix it, then re run @QSPLIT for this watershed.
   - Edgematch the watershed where the quads touch. This involves deleting the 9000 code arcs and any extra labels created from these deletions. As well, the linework will not match exactly. In most cases, you can reshape by moving the endmost nodes to half the distance between the two arcs. However, for the 5000 code arcs, you must add lines without moving the existing nodes. For this step it is useful to have the arcs colour-coded by CODE (F8) or by the colours shown below, and the land labels colour coded as well. When edgematching, 9000s should be deleted as you work rather than all at once so that you can keep track your progress.
   - All of the notes below are for various components of the edgematching process.
   - **Set the arcedit edit session to the following optional colour scheme:**
   - EDITC [wsdname]
   - DRAWE ARC ARROWS NODE LAB

- SETD 5
- EF ARC
- SEL CODE = 9000
- CA $SYMBOL = 2
- SEL CODE = 5100 OR CODE 5000
- CA $SYMBOL = 4
- EF LAB
- SEL TYPE = 'M'
- CA $SYMBOL = 5

- **Delete the neatlines (a bit at a time)**
- Zoom to where two quads met.
- SEL BOX
- RESEL CODE = 9000
- DELETE

- **Snapping linework**
- Zoom in tight to arc nodes across boundary
- SNAPDIST (Set as needed)
- use F6 or
    - EF NODE
    - MOVE
    - EF ARC
- Flip any blueline arcs that meet at the quad boundary head/head or tail/tail. These will be flagged later if you do not do them now. See Figure 2.
- If any bluelines meet in a 3 or 4 way intersection at a quad boundary, you should fix the topology now to save time later. See @HELP merge_bl (io_degree) for an explanation. See figure 1A, 1B.

- **Deleting extra labels**
- Zoom out to the full extent of surrounding polygons.
- EF LAB

- SEL MANY (Sel any extra labels, leaving only one behind)
- DRAWS
- DELETE

- **Start over at the next quad junction.**

- **Once complete, ensure you have not missed any areas**
- EF ARC
- SEL CODE = 9000
- CLEAR
- MAPEXT DEF
- DRAWS
- Zoom to any highlighted areas and check for completion

- **Before saving from Arc/Edit, and if you added or split any lines, or added labels, you must calc $ID = $RECNO**
- EF ARC
- SEL ALL
- CA $ID = $RECNO
- EF LAB
- SEL ALL
- CA $ID = $RECNO
- SAVE;Q

2. RENODE [wsdname]
3. BUILD [wsdname] POLY

4. LABELERRORS [wsdname]
   This is to check if any duplicate or missing labels exist, except for the universe polygon which is reported as follows:

   Polygon 1 has 0 label points.

   This is required. If this message does not come up, you must find and delete the label in the universe polygon. The universe polygon should generate an error in the centre of the coverage. This is OK.
5. COPYCOV [wsdname] [wsdname]EDG *backup only*

Merging the BL_KEYs.

- In this step, we help MERGE_BL.SML create new BL_KEYs for all the arcs (necessary because of duplicates between quads) and propagate those BL_KEYs across the former quad boundaries.

Help for MERGE_BL

usage:

@MERGE_BL [wsdname]

arguments

[wsdname] is the DWA coverage, after @set_quad and @samef_37 have been run, and put into watersheds.

notes

Used to resolve ws_keys and bl_keys across quad boundaries, after quads have been appended into watersheds.

Merge_bl.sml executes from the \arcexe\dwa\append directory running iodegree.prg and merge_bl.prg

fixing problems

IO_DEGREE.PRG:
This program checks correct topology across quad boundaries. Only one path is permitted across quads. If some paths are not a single line, then processing stops, and you are required to correct any head to head, tail to tail or intersecting arcs at quad boundaries. These can be located by using @FS, and selecting Merge_er (Merge Error).

Example 1

Figure 1A. Not one path. (Average 10 per coverage)

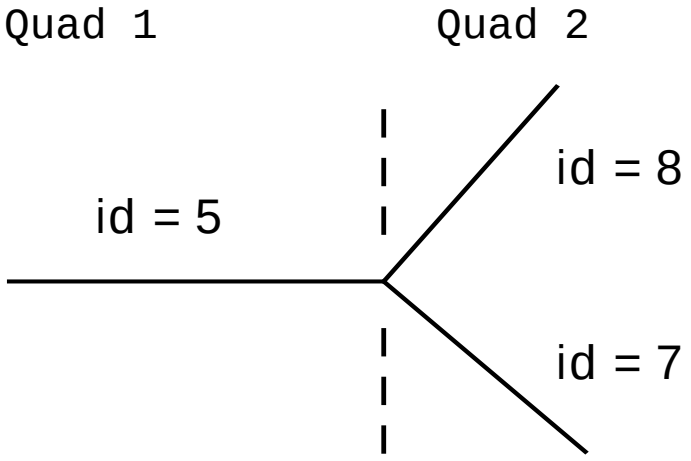
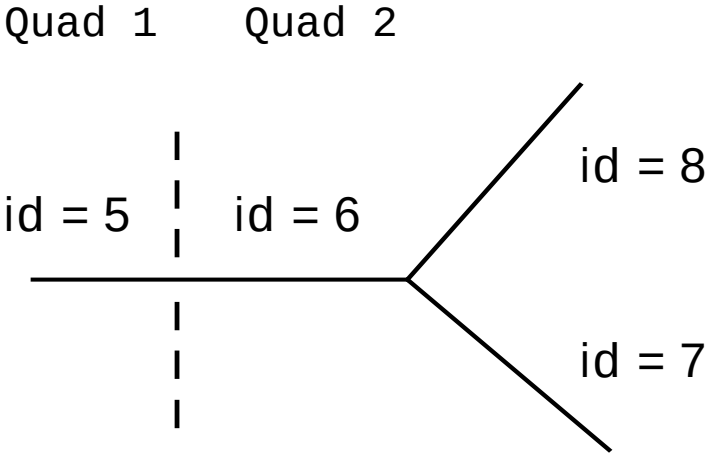


Figure 1.B Change to:

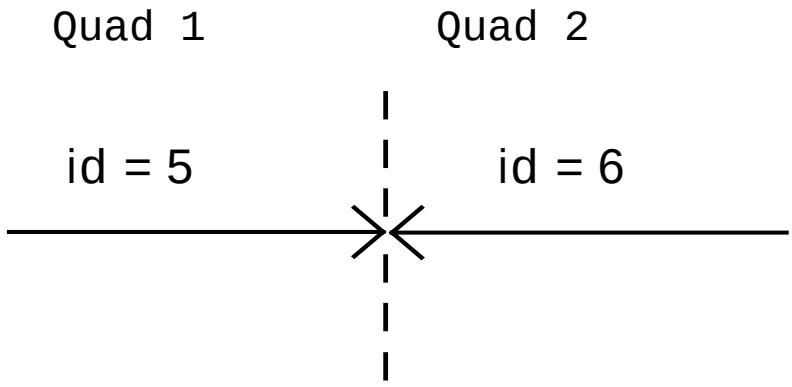


Action:

Fix by changing the quad_num item in Quad1 _id 6 from 'QUAD1' to 'QUAD2'. The path will then cross the quad boundary at the node in Quad1, a single path, rather than at the node with one arc in, and two arcs out, at the boundary. Note the quad boundary is defined as where arcs have different quad_num values rather than the real spatial boundary. All arcs within a watershed will have their parent quad_num.

Example 2

Figure 2. Head to Head / Tail to Tail (Average 20 per watershed)



Action:

Choose the blueline to flip, either _id 5 or _id 6

If IO_DEGREE finds any incorrect topology, the following message is displayed, and execution halted.:

"Merge_bl.sml NOT complete."
"Some arc at quad boundaries require topological correction."
"Use @FS Merge_err to resolve."

MERGE_BL.PRG:

This program propagates any ws_key and bl_keys at quad boundaries within a watershed to all appropriate features. All ws_keys and bl_keys are renumbered, starting from 1. It is critical that Set_Quad has been run successfully on the quads before merge_bl is run. Both arcs and labels must have the quad_num set.

No errors are generated by merge_bl, but ws_code warnings are generated if the ws_codes are different across quad boundaries. @WS_PROP will choose the significant ws_code (75% of all arcs within a blueline must have the same ws_code) and change the less significant remainder. This may not be correct. It is recommended you confirm correct ws_code and change it manually if required in Arc/Edit.

If ws_code warnings exist, the following message will be displayed at program termination:

"Merge_bl.sml complete."
"Some ws_codes at quad boundaries are not the same."
"Use @FS Merge WS codes to resolve."

Procedure for MERGE_BL

1. @MERGE_BL [wsd coverage]
2. @FS — Starts an Arcedit session with function menus. Also runs your version of arcedit.sml. Note your F9 and Alt-F9 keystrokes will be replaced)
   - EDIT [WSDNAME]
   - EF ARC
   - Colour code all arcs by QUAD_NUM
     (e.g. SEL QUAD_NUM CN 'Q127'
     CA $SYMBOL = 3
     etc.)
   - Repeat the step for labels.
   - EF ARC.
   - ALT-F9. — Begin Menu System
   - Select MERGE_ERR from the list.
   - Select TTY.
   - Fix the error. To see what is an error refer to the above help text or @HELP MERGE_BL. Basically, in order for the program to work there must only be head to tail pseudo nodes at quad boundaries. If there are three arcs joining, MERGE_BL will not know where to propagate the BL_KEY to.
   - To get back to the menu press F9, or type '&RETURN'
   - Select Next Feature.
   - Repeat from selecting TTY until the last error is fixed.
   - Select Quit Menu
   - @CALCID
   - SAVE;Q
1. Delete MERGE_ER.FTS and XYAAT.DBF from the [wsdname] directory. The XYAAT,dbf is used in the roaming functions, and only needs to be deleted if changes to the coverage have been changed. MERGE_ER.FTS contains the error messages displayed in the arc session. This file is updated each time @merge_bl is run. You can delete the xyaat.dbf each time you process, but this will increase processing time.
2. Repeat from step 1 until no more MERGE_ER problems appear.
3. RENODE [wsdname]
4. BUILD [wsdname] poly

5. If there are MERGE_BL errors (different than MERGE_ER errors) use the same process with @FS to fix them. They are usually cases where there is a '999999...' WS_CODE in one quad with a real WS_CODE in the other. Sometimes you get real topology errors that need to be figured out and fixed.
6. RENODE [wsdname]
7. BUILD [wsdname] POLY
8. COPYCOV [wsdname] [wsdname]MRG *backup only*

12. @DO NEW_14 [wsdname] — This tags secondary flow connectors as such, reducing exceptions in the following programs. No errors are generated.
13. @DO CK_ORDER [wsdname] — Fix errors (CK_ORDER.DOC and ERROR_MSG) in ARCEDIT and re-run until clean, BUILDing as necessary. ERROR_MSG will contain a 'NS' or an 'E'
14. @DO CK_WS37 [wsdname] — Fix errors (CK_WS37.DOC and ERROR_MSG) in ARCEDIT and re-run until clean, BUILDing as necessary. Exceptions include 6000 running off and on the map and 1410s connected to 1100s.
15. @DO MK_1450 [wsdname]
16. @ WS_PROP [wsdname] — An @FS session request will appear if any problems were encountered.

Your watershed should have continuous attributes across quad boundaries. Note meta data at map level will be clobbered.

Linking up any waterbodies larger than 5 ha.

In this step, we run FIND_5HA to flag large waterbodies with the MARK_BIG attribute and then go into ARCEDIT connect them. These programs reside in the dwa\layer directory. Either copy them into your local directory, into the dwa\bin directory, or set the SMLDIR to dwa\layer.

@DO FIND_5HA [wsdname] — Marks all 5ha isolated lakes and wetlands with a '+' in attribute Mark_Big

1. ARCEDIT
   - EDIT [wsdname]

- At this point it is useful to use the programs FIND_BIG.SML and ZERO_BIG.SML (I assign them to CTRL-F1 and CTRL-F2) to pan around the coverage fixing the MARK_BIG errors.
- @FIND_BIG (CTRL-F1) Zoom to box on one or more labels needing correction.
- Select the labels you want to fix. (Keep zoomed to this set until ZERO_BIG is complete)
- Connect the waterbodies with 1410s, being sure to propagate the BL_KEY, WS_KEY, and WS_CODE from one of the waterbodies as necessary.
- @ZERO_BIG (CTRL-F2) will report any problems within the current zoom (sel screen). It will also un-flag these as problems if correct.
- Select the labels of the waterbodies you fixed.
- Fix any blank CODE or BL_KEY noted by ZERO_BIG.
- Repeat from FIND_BIG until all waterbodies of over 5 ha are connected to flows.
- @CALCID
- SAVE;Q

2. RENODE [wsdname]
3. BUILD [wsdname] POLY
4. Rerun @DO FIND_5HA to check for completeness
5. COPYCOV [wsdname] [wsdname]5HA *backup only*

The watershed should contain all 1410 connections with correct attributes.

Validating the [wsdname] coverage.

In this step, re-validate the coverage to make sure that no new errors have emerged in the watershed creation process. It is possible here to refer to the quads' error documents, but unless all the work was yours, it is more sensible to re-check all of the errors personally.

1. @DO NEW_14 [wsdname]	This tags secondary flow connectors as such, reducing exceptions in the following programs. (1450s become 1455s and 1456s, inflow and outflow connectors)
2. @DO CK_ORDER [wsdname]	Check_order will confirm each bl-key has only one start and stop, and for each bl-key coming into a node has one arc of the same bl-key leaving the node, and any other arcs leaving the node have a different bl-key. (A single path between start and stop nodes.) Fix errors (CK_ORDER.DOC and ERROR_MSG) in ARCEDIT and re-run until clean, BUILDing as necessary.

3. @DO CK_WS37 [wsdname]	The intrinsic order within the ws-code defines the parent child relationships among the ws-keys. Check WS-CODE 37 ensures parent/child topology is reflected in the ws-code. Fix errors (CK_WS37.DOC and ERROR_MSG) in ARCEDIT and re-run until clean, BUILDing as necessary. The only exception is 1410's at secondary flows.
4. @DO MK_1450 (wsdname)	Replace 1455 and 1456 with 1450s.
5. @DO CC_BL [wsdname]	Colours up arcs by bl-key. In ARCEDIT, colour arcs by CC and check for aberrant BL_KEYs that do not follow a logical path (eg. Flows into a new watershed, etc...) Pan through the entire coverage fixing as necessary. In ArcEdit: EF ARC SEL ALL CA $SYMBOL = CC DRAW
6. RENODE [wsdname]	
7. BUILD [wsdname] POLY	
8. @WS_PROP [wsdname]	Fix any errors. (WS_PROP.DOC and OLD_WS_COD help) See page 6 for details.
9. @INSPECT [wsdname]	This checks for dangles, and removes pseudo nodes. Fix any dangles in ARCEDIT and BUILD as necessary.
10. @REVAL [wsdname]	Fix any errors, writing down exceptions for future reference.
11. @REVAL [wsdname]	Make sure that you haven't made any new errors fixing the old ones.
12. Create an Error.doc file	
13. COPYCOV [wsdname] [wsdname]REV	*backup only*

Running the Lake Sequence process.

Help for Lake Sequencing

- The new DWA needs links back to the original fisheries data. This is done through re-establishing the lake sequence number with a water body, whether it is a lake, wetland, double line river or double line man-made feature.

Usage:

@LAKE_SEQ [wsdname] [wsdnameLO] [wsdnameLO#]
(eg: @lake_seq umus umuslo umuslo1)

arguments

[source cover]	DWA coverage
[lake outlet cover]	The lake outlet coverage
[new lake outlet cover]	A new lake outlet coverage, one without duplicate labels.

notes

Lake_seq.sml runs as 2 foxpro programs:

- The first program is used to remove duplicate IGDS labels near the same lake. This data problem was encountered in some coverages. A new subset coverage is created, and used in subsequent processing. Use this coverage as the original outlet coverage if lake_seq is to be re-run.

- The second program checks the integrity of the nearness fit to waterbodies.

A listing of all those IGDS label with a different ws-code than the existing water body is found in lake_seq.doc. Use these to update the fisheries data base with the new ws-codes.

The first time this is run, use [wsdname]LO and [wsdname]LO1, and increment one with each successive running.

eg:

the first time:	@lake_seq umus umuslo1 umuslo2
the next time:	@lake_seq umus umuslo2 umuslo3

Lake sequencing relies on a correct wb_key (generated from @MK_SEG).

Procedure for Lake Sequencing

1. @LAKE_SEQ [source cover] [lake outlet cover] [new lake outlet cover]
2. @FS — Starts a Arcedit session with function menus.
   - EDIT [wsdname] — (MUST issue for search to work.)
   - BACKC [wsdname] 4
   - EF ARC — (MUST issue for search to work)

- DRAWE ARC LAB
- BACKE ALL OFF ARC
- ALT-F9
- Choose Lake Sequencing
- Choose TTY
- EDIT [wsdname]LO[#] {1 the first time, increment each time}
- DRAW
- Move the label, check to make sure that the arc's WS_CODE isn't wrong, or ignore the error, depending on what is required. We are not allowed to change the LO's WS_CODE to match the arc. Instead, update the arcs in the parent coverage to be the LO watershed code if the topology and attributes support the watershed code.
- **If no change can be made, and the ws_code of the LO is different than the ws_code in the parent coverage, move the LO watershed code into the parent XREF_WS_CO field, for both the lines and polygons. This is so a lookup can be done between the historic Lake Outlet database and the DWA map base.**
- @CALCID
- SAVE;Q

3. BUILD [wsdname]LO[#] POINT {The most recent one)
4. Repeat the above steps until you're satisfied, then delete any intermediate LO coverages, leaving the first and last.
5. COPYCOV [last lo point voerage] [XXXXLOE] where XXXX is the wathershed group, and the E suffix denotes End.

NAD Shift your coverage(s) from dataum NAD27 to NAD83. Be sure to shift the Los, the parent coverage and the Barriers point coverage.

Preparing the Watershed for Delivery Stage

Updating the watershed's database structure.

This process deletes unwanted database fields and converts the old 37 digit watershed code to the new 45 digit version.

1. Copy the following files into the dwa/bin directory:
   STRUCTUR.PRG
   UPD_WSC.PRG
2. @DO STRUCTUR [wsdname] In FOX or a dB viewer check to make sure that the WS_CODE is now a 45 digit field. May 31, 1994 format is: 3-6-5-5-4-4-3-3....
3. @DO UPD_WSC [wsdname] In FOX or a dB viewer check a few arcs to make sure that the WS_CODE and OLD_WS_COD are equivalent.
4. COPYCOV [wsdname] [wsdname]UPD *backup only*

Giving values to connected arcs with a '999999....' WS_CODE.

This process uses a proportional technique to assign WS_CODEs to arcs that are connected to main flows and have a '999999...' WS_CODE.

1. Delete [wsdname]\XYAAT.DBF if it exists in the parent coverage.
2. @NEW_TRIB [wsdname]
3. @FS (will appear only if errors have been detected. Check coverage for '9999999' ws-codes
   - EDIT [wsdname]
   - EF ARC
   - Fix any errors, approximating a WS_CODE where the NEW_TRIB has incorrectly assigned a ws-code, or none has been assigned. Generally in the case of several error messages where a WS_CODE already exists, the WS_CODE that was assigned is not correct. NEW_TRIB version 1.91 has problems with secondary flow 1410s and some tributaries that come off secondary flows. Bug fix to come. These revisions take about an hour.
   - @CALCID
   - SAVE;Q
1. RENODE [wsdname]

2. BUILD [wsdname] POLY
3. @DO CK_WS45 [wsdname] Checks integrity of 45 digit watershed code
4. @WS_PROP [wsdname]
5. COPYCOV [wsdname] [wsdname]NTR *backup only*

Creating a CLIP coverage for minor (3rd order) watersheds.

Creates a polygon coverage containg all 3rd order watershed boundaries, named xxxxWSD.

1. The file MK1_WSD.SML should be in your UTOOL directory.

   - Delete the oldaat.dbf and oldpat.dbf.

2. @MK1_WSD [wsdname] This will extract the 5000s, 5100s and 5200s, and other codes to create a continuous network of watershed boundaries. MK1_WSD will begin a arcedit session intended to facilitate network closure. In most cases, use existing linework to close the boundaries, except in deltas, where a new boundary will connect adjacent streams. Add this to the WSD coverage only. This new boundary does not have to be added to the parent coverage.

   - Fix any dangles that show up by editing [wsdname].
   - EDIT [wsdname]
   - @CALCID
   - EDIT [wsdname]WSD
   - @CALCID
   - If changes to [wsdname]
     SAVE ALL
   - Else
     SAVE
   - QUIT
   - Keep all edit changes? NO

4. If changes to [wsdname]:
   RENODE [wsdname]
   BUILD [wsdname] POLY

5. COPYCOV XXX_CLIP (Backup Only)

PARENT coverage separation and WSD processing

This step confirms the coverage adheres to DWA specifications and breaks the watershed down into component parts.

LA_II (layering part II) runs the following set of foxpro programs and smls.

- Mk_wsd2.sml - processes the WSD coverage to polygon topology and allocates minor watershed attributes.

  - overlays WSD with Parent coverage and propagate WSD attributes to parent coverage.

- Cr_order.prg - stream ordered and magnitude of each tributary are calculated.

  If you are working with a watershed coverage that has inflows from upstream watershed coverage(s) (i.e. The Muskwa watershed has been broken into Upper Muskwa and Lower Muskwa coverages) the stream and magnitudes calculated for the downstream watershed coverage will not be correct. You must run LA_II (cr_order) on the upstream watershed coverages and copy the resulting stream order and magnitude into the downstream coverage manually in ARCEDIT.

  Do this by finding the 2 linking arcs between the lower and upper watershed coverages. Copy the L_order and L_magnitude from the upper coverage arc to the attributes of the lower coverage arc. Make the L_order and L_magnitude attribute in the lower watershed coverage **negative** to set the override flag in the cr_order program. This will force cr_order to use these values as the inflow order and magnitude.

LA_III (Layering part III) runs the following foxpro programs and smls:

- Codewsd.prg - Determines watershed ws_code from mainstem and downstream watershed.
- Sumwsd.prg - Creates summary table sum_wsd.dbf.
- Structur.prg - Removes unwanted attributes.
- Genlayer.sml - Seperates the parent cover into components and dissolves ordered watersheds.

Begin Processing

1. @LA_II [wsdname]

2. @REVAL45 [wsdname]	Fix any errors that have emerged since the last revalidation and re-run.
3. @LA_II [wsdname]	
COPYCOV XXXX_LAII	Backup Only
4. @MK_1450 [wsdname]	
5. @LA_III [wsdname] [Y/N]	**Note the new addition of the Y/N parameter. This is an override for the duplicate watershed condition that halts processing. There are some exceptions, for example, a river system that flows into tye US and back into BC. Clearly, more than one watershed will be allocated the same ws_code. To continue processing and ignore the duplicate watershed condition, use the 'Y' parameters. 'N' should be specified otherwise.** Check the [wsdname].COD file for errors, and fix any that are not exceptions. Check for: a) Each minor watershed should have a unique ws-code as derived from the mainstem. b) Edit the xxxx_O2, xxxx_O3, ... xxxx_On in sequence looking for downstream watershed problems. Lesser order watersheds should not be present in greater order watersheds. If changes to WSD boundaries are required, be sure to make the same EXACT changes in the parent cover, (if required), build poly and begin processing at LA_II
6. @DO ck_layer. (xxxx_RLW)	Check the layers for the following: a) SS layer has correct l_order by colouring up on l_order b) RWL layer has dissolved properly: (no excess construction lines)

7. Delete any backups in your directory. Keep the following for bulk storage:

   [wsdname_REV]

   [wsdname_NTR]

8. Remove any .sml, .idx, .prg, .fxp, etc... files from your working directory. **except** XXXX_wsd.dbf and lake_seq.fts.

9. The following Coverages should be delivered to Fisheries Branch:

- [wsdname]	Parent Coverage, including the lake_seq.fts file and the error.doc
- [wsdname]_SS	Stream Segments
- [wsdname]_CST	Coast line
- [wsdname]_LB	Linear Boundaries
- [wsdname]_O0 - On	Watershed Orders
- [wsdname]_RLW	Rivers, Lakes and Wetlands
- [wsdname]_TXT	Annotation
- [wsdname]_LO, LOE	The orignal and final LO coverages
- [wsdname]_PNT	Barrier points
- [wsdname]_WSD.dbf	summary table
- [wsdname]_CC	This is the outer boundary of the watershed group.

10. PKZIP -ex -rP -m [wsdname]_DUN *.*
11. Back up your coverage to your FINAL directory and to tape.

- END of Document -