CHAPTER 3

SPATIAL DATA ARCHITECTURE

There are two sources of digital hydrographic spatial data in New Brunswick. Hydrographic features exist within the New Brunswick Department of Natural Resources and Energy's provincial forest cover and the Service New Brunswick's topographic base. The latter was selected as the source of digital data as it was felt their digitizing procedures were more accurate. In addition, the Service New Brunswick (SNB) digitized stream centre lines which are essential for stream networks and displaying stream information (see **Design Considerations** below).

SNB's hydrographic features were digitized from early spring and late fall aerial photographs. Streams and lakes are represented by line segments or arcs with each segment coded with the type of hydrographic feature (Figure 3). Streams less than 10 m wide are represented by single lines while wider streams have parallel lines representing left and right stream banks. Sections of double line streams which represent areas of tidal influence are coded as coastline. In addition, in-stream features, such as rapids, beaver dams, and falls are represented by arcs perpendicular to the stream. Table 1 contains a list of hydrographic feature codes and the standard plotting colours.

SNB's hydrographic data, however, lacks any association to individual lakes and streams. That is, GIS software recognizes that a line segment is a single line stream or lake for instance, but one could not ask the software to display a specific body of water, such as the Southwest Miramichi River or Grand Lake. The software only recognizes the segments as being water features, but not belonging to a particular stream or lake.

How then does one attach resource attribute data, such as habitat units, water flows, water quality or fish population data to a lake, stream, or stream section?

One alternative is to digitize a graphical representation of the data; that is each data set you wish to present on a hydrographic map must first be digitized. For instance, individual habitat units could be identified by digitizing line segments for each unit. This approach works for stream sections, but the GIS software still does not recognize the various segments which make up a particular lake or stream. Therefore, attributes associated with a complete water body, such as angler catch and effort or lake characteristics cannot be attached. As well, digitizing attribute data is time consuming and costly as specialized digitizing hardware is required.

An alternative method is to create lake and stream route systems and use a GIS technique called "dynamic segmentation" to display the attributes. ArcInfo and Caris are the predominant GIS packages used in New Brunswick. At this point only ArcInfo and its desktop version, ArcView, contain dynamic segmentation functionality.

The first step in using dynamic segmentation is the creation of route systems for each lake and stream. Routes define the arcs or segments which belong to a water body. This is accomplished by selecting all segments (arcs) which belong to a particular lake or stream and then indicate those segments represent a given stream ("makeroute" command). The name of the water body and its unique water

Figure 3. Sample feature codes used within the Service New Brunswick's hydrographic data.

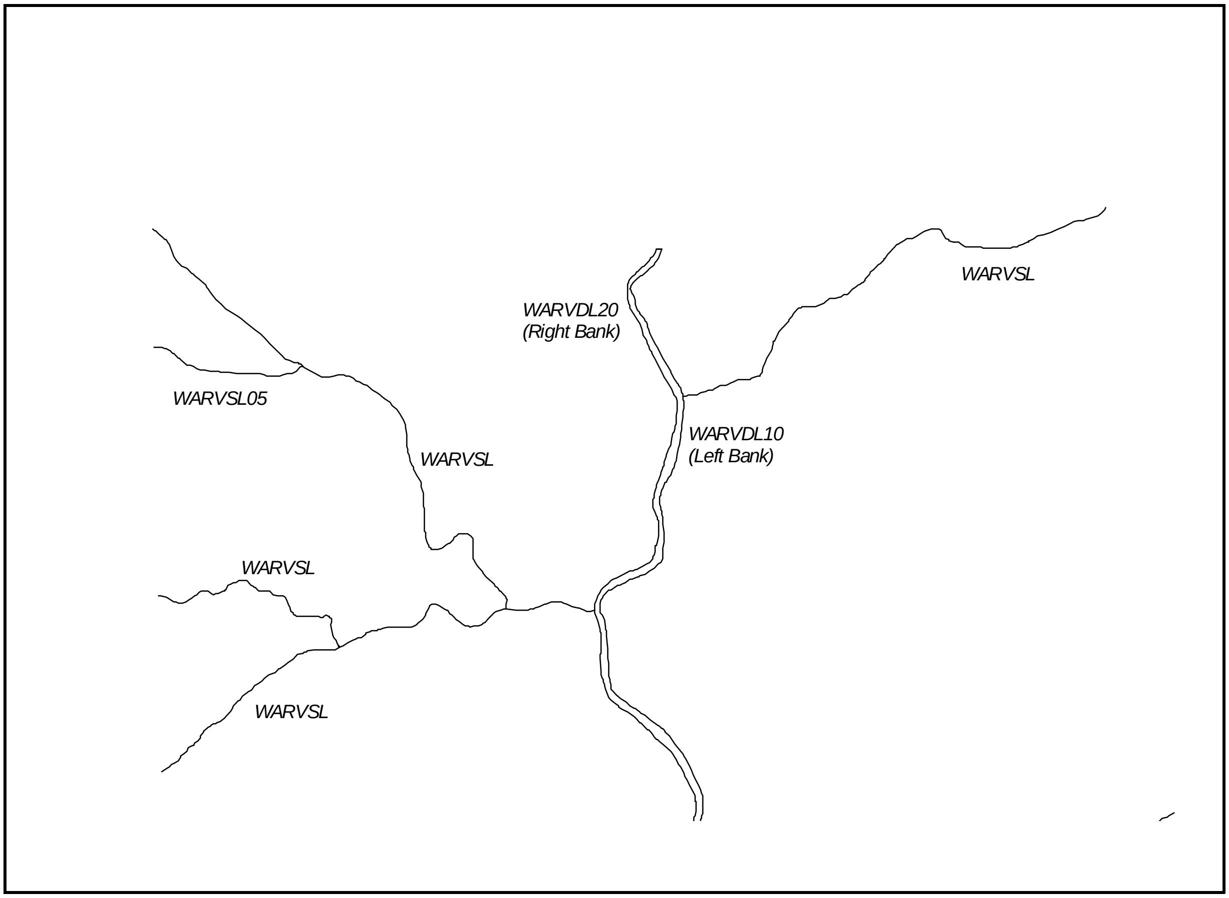


Table 1 Water feature codes used in the Service New Brunswick's hydrographic spatial data.

WATER FEATURE CODE	DESCRIPTION	STANDARD PLOTTING COLOUR
WACA	Canal	Pink
WACA04	Canal Abandoned	Pink
WADI	Ditch	Yellow
WADI05	Ditch Indefinite	Yellow
WACO10	Coastline (left)	Green
WACO20	Coastline (right)	Green
WACOIS	Coastal Island	Green
WALK10	Lake (left)	Brown
WALK20	Lake (right)	Brown
WALKIS	Lake Island	Black
WARS10	Reservoir (left)	Light Blue
WARS20	Reservoir (right)	Light Blue
WARVDL	River Double Line	Blue
WARVDL10	River Double Line (left)	Blue
WARVDL20	River Double Line (right)	Blue
WARVDL15	River Double Line Indefinite (left)	Blue
WARVDL25	River Double Line Indefinite (right)	Blue
WARVIS10	River Island (left)	Black
WARVIS20	River Island (right)	Black
WARVIS15	River Island Indefinite (left)	Black
WARVIS25	River Island Indefinite (right)	Black
WARVLK10	River Lake (left)	Blue
WARVLK20	River Lake (right)	Blue
WARVIS	River Island	Black
WASL	River Single Line	Blue
WASL05	River Single Line Indefinite	Red
WARVSP	River Split	Light Blue
WARVSP05	River Split Indefinite	Light Blue

body ID's are attached to the stream route. The water body ID now becomes the critical link between the tabular data and the spatial representation of the water body. All aquatic information associated with this particular lake or stream must contain the appropriate water body ID.

The "makeroute" command also measures the total distance (metres) of the stream and the mouth is assigned the starting point with a measurement of 0.0 metres. Figure 4 illustrates the route system concept.

Aquatic information can be displayed along the route by knowing the location it occurs along the route, that is "*x*" metres from the starting point. For instance, a sampling site occurs 5000 m (5 km) upstream from the mouth. Data can be displayed as points or lines. Linear features, such as habitat units, have start and end measurements along the stream route. These measurements along the route are called "route measurements". Route measurements, whether points or linear, are stored in the tabular data file. To display the data, ArcInfo (or ArcView) simply reads the data file and displays the points or linear features based on the recorded water body ID and route measurement(s). No digitizing is required and should the site location change, the data file is simply updated to reflect the changed route measurement.

Route measurements can be determined manually or as a batch process. Using ArcInfo or ArcView, one can select a point along the route where, for instance, an electrofishing site occurs. The software will return the stream route measurement - *x* metres from the starting point. Continuing with this scenario, the route ID and route measurement are then recorded in the data file which maintains a list of permanent electrofishing sites.

Habitat units can be similarly spatially referenced. Most surveys begin at a convenient access point and each consecutive habitat unit is measured in metres. Instead of digitizing the start and end of each unit, one simply determines the route measurement of the survey starting point. This represents the starting route measurement of the first habitat unit. The unit's end measurement is calculated by adding the habitat unit length to the start measurement. The end measurement of habitat unit #1 becomes the start measurement of habitat unit # 2, add the length of habitat unit # 2 to get its end measurement and so on. By knowing the starting point, a simple program can be written to populate the route measurement data within the habitat unit data file.

ArcInfo also provides a facility to calculate route measurements from a point coverage which may have been created from GPS recordings. The point coverage is overlayed with the route systems and where the two intersect, route measurements are calculated. An intersection tolerance can be provided to accommodate points which do not intersect the route systems.

Where data applies to an entire body or water, such as angler harvest information or lake surveys, the tabular data files simply contain the stream or lake route ID. In this manner, a particular lake or stream can be selected graphically, which in turn selects the appropriate subset of tabular data for easy viewing.

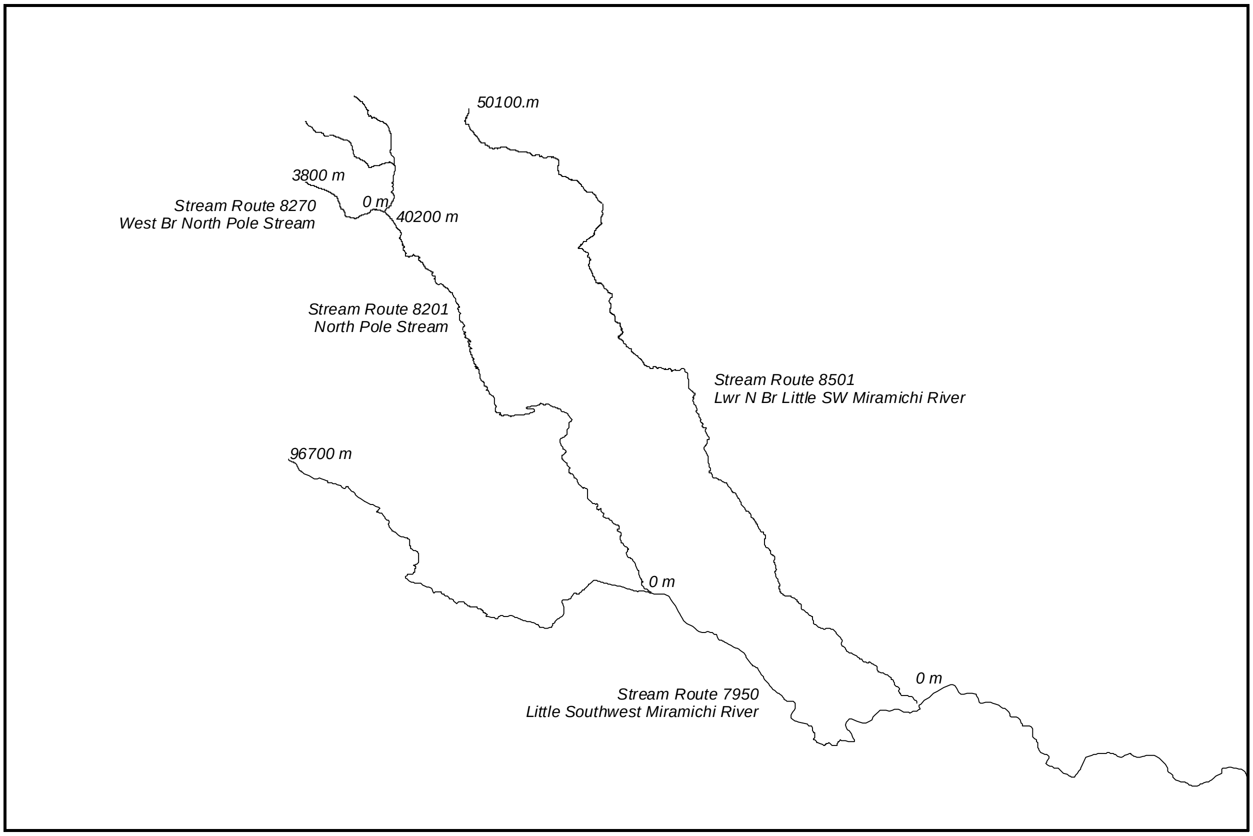
DESIGN CONSIDERATIONS

Stream Centre Lines

The Service New Brunswick released an "enhanced" digital topographic base in 1997. In addition to updating and streamlining road information, it added centre line arcs for all double line streams (streams greater than 10 metres wide).

Route systems are generally created by selecting the arcs along a single line path. For smaller streams represented by single line features this does not present a problem. However, for larger streams with a left and right bank (double line features) either the right or left bank would have to used to create the stream's route system. Many of New

Figure 4 Illustration of ArcInfo's route systems applied to hydrographic data.



Brunswick's streams have "bogans" or backwater side channels. If one follows the bank, these features are incorporated into the route system, thereby inaccurately reflecting the stream's linear path and length. Stream centre lines overcome this problem, eliminating the need to digitize additional arcs to bypass bogans and make the route system straighter.

Size of Route Systems

SNB's topographic data spans 1893 1:10,000 map sheets or files. This means lakes and streams may span one or more map sheets. However, route systems cannot cross map boundaries, requiring map sheets to be combined into one file. It would be inefficient (or impossible) to combine all map sheets for the entire province. Instead map sheets will be combined on a drainage unit basis prior to the construction of the route systems. Initially, only bodies of water which have been surveyed or have some other attribute information associated with them will be assigned route systems. Approximately 3000 lakes and streams are estimated.

Data Transfer to Other GIS Packages

It is anticipated there is a need to exchange aquatic information to organizations with different GIS packages. ArcInfo has the ability to convert dynamic segmentation points and segments into point and line coverages for transferring data to other GIS packages, such as Caris and MapInfo.

Point Data

Point data from coordinate grid systems or GPS can be converted to route system measurements by overlaying the point files with a route system and intersecting the two (the intersection tolerance can be set). Alternatively, ArcView can display point data (*x*,*y* coordinates) stored in tabular data files or the points may be digitized.

Stream Orders

A stream may be considered a single order stream or it may consist of two or more sections with different orders. For instance, the starting point or origin of a stream is considered 1st order. If another 1st order stream joins it, then the section below the confluence becomes 2nd order. If further down stream another 2nd order stream joins, the next section of the original stream is elevated to 3rd order. And so on.

Stream orders can be represented as continuous events. Stream order positions are always the end of a stream (end of the route) or along a stream at the confluence of an equal or higher ordered stream. Where streams have only one order, there will be one event with a route measure equal to the end point of the route (stream). Larger streams with multiple orders will have two or more events with the route measure being the point of confluence of a stream of equal or higher order.

There are two methods to determine the route measure where order changes. One can interactively ask for the route measure by clicking on the stream route at the point of change. Alternatively, the points could be digitized into a separate coverage (using the hydrographic cover as a backdrop) and overlayed with the route system to capture the order route measures.

Route Calibration

ArcInfo provides a method to re-calibrate the length of a route in the event the digitized length does not equal the field measured length. For instance, stream surveys generally measure a significant portion of a stream's length. This measured field length may not equal the GIS length. If the field length is determined to be more accurate, the digitized length can be re-calibrated to reflect the field length.