

# State of the Sound Methodology Manual

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State of the Sound GIS Project

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## **1.0 Introduction**

The State of the Sound Program establishes a comprehensive and standardized process to monitor and report on the ongoing state of Baynes Sound environmental health and water quality. This is accomplished through the creation of a geographic information system (GIS) for managing and reporting Baynes Sound remediation project data and information. It is also accomplished through the development of clearly defined and standardized processes and procedures to gather, record, maintain and retrieve data in both database and mapping formats. The State of the Sound reporting process is used to increase public awareness and help support individual communities as they move toward local waste management program planning and implementation.

The State of the Sound GIS Project is delivered by the Comox Valley Project Watershed Society (Project Watershed) in three linked phases that lay the foundation for the State of the Sound Program (a long term, ongoing planning and reporting process). Phase 1 of the State of the Sound GIS Project took place between July and December of 2000. The acquisition of data, its development, and the creation of a GIS system to house the data were the products of this phase.

This manual describes how the Baynes Sound GIS system was developed, and defines the procedures used in its creation. The establishment of the GIS, acquisition of the data, data development techniques, data creation, resources used, and the management of the database are all described in full.

## **2.0 Resources**

### **2.1 Software**

Deciding what type of software to use was a key consideration in the initial stages of the project. While many software products exist on the market that promise users the ability to perform many different tasks, the bottom line in GIS development is that no ONE software product alone will give users all of the functionality they need. The three main areas of GIS data management software used in the development of the Baynes Sound GIS were:

1. Data Viewing and Analysis Tools
2. Database Editing Tools
3. Graphical Data Tools

#### **2.1.1 Data Viewing and Analysis Tools**

The Baynes Sound GIS uses ArcView 3.1 for GIS data viewing and analysis. This is the platform in current use by Project Watershed. ArcView 3.1 allows economical, reasonably non-problematic integration of diverse data from variable sources.

ArcView can be customized for additional functions and tasks using the Avenue programming language. In later phases, the creation of interfaces for specific tasks will allow for the development of user-friendly access to the program.

#### **2.1.2 Database Editing Tools**

For editing databases, engine tools such as Microsoft Excel and Access were used, rather than employing the less robust database tools in ArcView 3.1. Both Excel and Access are able to view, edit and create dbf4 databases, the database file format used to hold attribute data in ArcView. The Access mdb format or Excel xls format allow multiple data sheets to be exported in a single document.

#### **2.1.3 Graphical Data Tools**

While the ArcView program can perform simple functions in terms of graphical data editing, it has limitations. To perform more advanced graphical functions, the AutoCad 14 drafting program was used to

provide functionality for creating, editing and manipulating graphical data. AutoCad 14 was used to draw multi-line or multi-polygon entities, and for receiving graphical data.

## **2.2 Hardware**

The computer system used to develop the Baynes Sound GIS was a standard PC running Windows 98 with a Pentium processor and 128 Mb of RAM. There were two hard drives used in the project: the C drive, with 10 GB of disk space, and the D drive, with 2GB of disk space. The SOS folder on the C drive houses all the data that is considered ready to be used in analysis, while the D drive houses all the data that is being developed and not yet ready for analysis.

Geographical information systems are computer intensive programs that require a higher-end computer to function properly. In the development of the Baynes Sound GIS, it was necessary to evaluate the existing hardware situation for upgrade requirements. The main hardware factors considered in this evaluation were:

- 1.Computer Speed
- 2.Hard Disk Space.

### 2.2.1 Computer Speed

The nature of spatial data and its high graphical content requires the computer to compute large amounts of data to display its content. The computer used to develop the State of the Sound GIS Project was upgraded from a 333 MHz Celeron central processing chip with 8 Mb of video memory to a 600 MHz Pentium III processor with 32 Mb of video memory.

### 2.2.2 Hard Drive Space

Hard drive space was evaluated for efficiency due to the sheer size of the data that was incorporated into the Baynes Sound GIS project. Large files average 10 MB in size or more. Each of the 12 orthophotos used as basemaps exceeded 180Mb in size. To house all the data, it was necessary to place the finished data on one drive (drive C) and the data that was being developed on another drive (drive D).

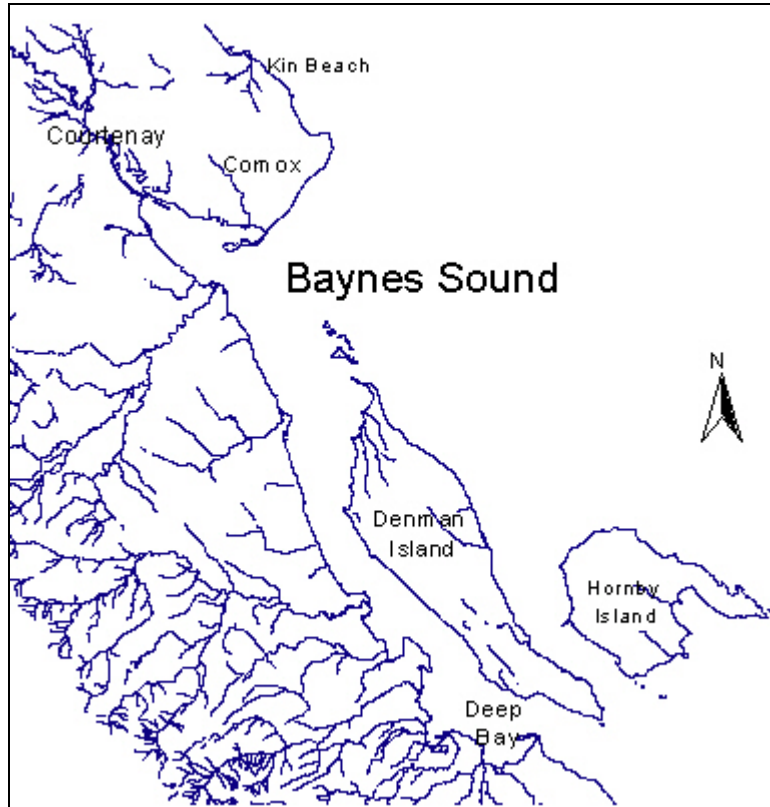
During the State of the Sound GIS Project Phase 1 – Information Collection and Data Management, the computers in the offices of Project Watershed were linked up via a network. It was subsequently possible to store data on additional drives, and the speed of downloading files from the Internet increased.

## **3.0 Establishing the GIS**

### **3.1 Area Boundaries**

For the Baynes Sound GIS, the area from Kin Beach Park in the north extending to Deep Bay in the south was chosen for inclusion in the Project. (figure 3.1) Also included in the project area were the western watersheds draining into Baynes Sound from Vancouver Island, and both Denman and Hornby Islands, which for the purposes of the project are considered integral areas within Baynes Sound.

Figure 1 Area Boundary



### 3.2 File Formats

ArcView's Shapefile format is the primary file format used in the Baynes Sound GIS project. Each shapefile is a collection of three different files used to represent a set of geographic features, such as streets or lakes, or cartographic areas, such as towns or regional districts. A shapefile represents a set of point features (e.g. hospital locations), a set of line features (e.g. streets), or a set of area or polygon features (e.g. lakes). All the features in a single shapefile are of the same type (point, line, or polygon). A shapefile is comprised of a main file with a ".shp" extension, an index file with a ".shx" extension, and a dBASE file with a ".dbf" extension. All three of these files have the same prefix for a single shapefile. The main file describes the shape and location of each feature with a list of the feature's defining coordinates. The index file maintains an index of the features in the main file to permit access to those records. The dBASE file contains the attributes (i.e. street name, street type, and address information for a street shapefile) for each feature in the main file.

### 3.3 Basemaps

Basemaps are the maps that all subsequent data will be placed upon to give viewers an understanding of where everything is located spatially. The basemaps used for Phase 1 of the SOS GIS project were 1 meter resolution orthophotos of Baynes Sound. The orthophotos are photo images of the study area captured in 1999. In terms of developing maps, users are able to recognize where entities were spatially located when orthophotos are used as basemaps. In addition to orthophotographs, TRIM mapsheets are required for use as basemaps in the Baynes Sound GIS project, but were not available to the project when this manual was prepared.

## **4.0 Data Acquisition**

A primary development task was to identify which data would be most useful and usable for inclusion in the Baynes Sound GIS and the ensuing State of the Sound Program. Water quality data and remediation project results were identified as key data for inclusion to meet the original project objectives identified when the idea of the State of the Sound Program was first considered. During the development of the workplan for Phase 1, project objectives were expanded to include land use and habitat data, in order to ensure that relevant information would be in place for comprehensive relational analyses on the overall health of Baynes Sound.

A list of potential datasets and maps ranked by the Baynes Sound Stewardship Action Group (BSSAG) formed the basis of the first data dictionary. This list was further evaluated according to the following criteria:

- the value of the data for relational analysis of the health of Baynes Sound
- the format of the data (ie. electronic vs. paper copy, compatible software program)
- whether the data was geo-referenced spatially

Possible datasets were researched to determine availability, and the process of gaining access to the different data was followed. This included discussions and negotiations about data provider concerns, definition of limitations for use and display, and eventual agreement (please refer to 4.2 Data Agreements for more information).

In Phase 1 - Information Collection and Data Management, water quality, land-use, and habitat data was received from many different sources (Table 2 Data Received to Date) and organized in an ArcView GIS project known as the Baynes Sound GIS Project.

### **4.1 Availability**

Data was not always immediately available for inclusion in the Baynes Sound GIS project. Various factors delayed the receipt of data, including the busy nature of people's schedules, data transfer problems, and data not available in a usable format within the project timelines.

Some agency data managers are responsible for meeting the diverse demands of several ongoing projects. Although these individuals were very supportive of the Baynes Sound GIS project and its objectives, it was often a challenge for them to find time within their busy work schedules to retrieve and send data to Project Watershed (Environment Canada, Regional District of Comox-Strathcona, BC Ministry of Fisheries, others).

Data transfer problems occurred with Environment Canada data protected by electronic security systems (a "firewall" to prevent certain data from entering and leaving their database). To resolve this situation, the data was converted to a different format. This conversion may have affected data structure and content, and the data will require careful examination before it is analysed.

Some data was not available in a format usable to the project during the project timeline, or was in the process of being compiled or upgraded. This was the case with much of the cadastral data from the Town of Comox, the City of Courtenay and the Regional District of Comox-Strathcona (RDCS), including zoning, OCP, and property parcel data that was updated at different times during the project.

### **4.2 Data Agreements**

Each potential data provider was contacted initially by telephone and email with an introduction to the project and an invitation to participate. In order to create clearly defined parameters for data use and presentation and to ensure proper data management and accountability, data providers were encouraged to provide written authorization articulating any concerns, limitations, and requirements for use and display of the data.

At the end of Phase 1, data use was authorized through formal data use agreements with five agencies; with letters of authorization from two partners; and with two approvals received via email. Five other partners are in the process of providing written authorization for the use of their data, and other arrangements have been deferred until data becomes available in 2001.

Please refer to Appendix 1 for details about data use authorization.

### 4.3 Data Transfer

Depending on the file size of the data and the resources available, data was sent through many different mediums.

Table 1 Data Transfer

Medium	File Size	Comments	Data
Paper	No file size	Non-digital data	Septic Repairs, upgrades and alterations, summer beach results
1.44 Floppy Disks	Files less than 1.4 Mb in size	Cheap, easy to transfer	CVCARE Hotspots, Union Bay Septic Data.
E-mail	Files up to 5 Mb in size	Easy to transfer depending on internet speed and ISP provider	<ul style="list-style-type: none"> <li>• Bird aggregate populations, numbers</li> <li>• Points of Diversion</li> <li>• Environment Canada water quality data.</li> <li>• Shellfish legal tenure boundaries</li> <li>• Shellfish harvest quantity</li> <li>• foreshore substrate data</li> <li>• Waterway growing conditions – estuaries/beaches/combined</li> <li>• Town of Comox: Stormdrain, Zoning / OCP / Property parcel</li> </ul>
File Transfer Protocol (FTP)	Usually Files up to 20 Mb in size	Easy to transfer depending on internet speed and ISP provider	<ul style="list-style-type: none"> <li>• Sensitive Ecosystem Inventory</li> <li>• Fisheries and Oceans Stat sub-areas.</li> </ul>
Zip Disk	Files up to 100 Mb in size	Expensive, not cost effective	<ul style="list-style-type: none"> <li>• Courtenay Stormdrain system, Zoning, OCP</li> </ul>
CD-ROMS	Files up to 450 Mb in size	Cheap, but takes time to create	<ul style="list-style-type: none"> <li>• Legal Description, Assessment Roll #, address, PID#, property class, area</li> <li>• Land Reserves, Farm Locations, Soil Types</li> <li>• Regional District A Cadastral – zoning / OCP, Political Boundaries / Jurisdictions</li> </ul>

The most efficient transfer method in terms of time was online, via e-mail and / or File Transfer Protocol (FTP). Once the Internet connection at Project Watershed was upgraded from a dial up modem system to a high speed cable connection, the data transfer was much faster and more reliable. The dial-up speed, while more affordable, was prone to lost connections and subsequently lost or incomplete data.

#### **4.4 Metadata**

Many files were received lacking “metadata” during the collection of the project data. Metadata is data that describes the information and structure of a database or map file.

Without metadata, data is limited in its usefulness. Lack of information (such as the term definitions or legend keys) will limit the user’s ability to truly understand the data. A certain number of databases had to be tracked back to their previous owners and the metadata requested. Others databases that could not be tracked back to their original creators required interpretation and manual creation of metadata files.

The Baynes Sound GIS project metadata files include the following information:

- File Name
- File Format
- Projection
- Datum
- Extent
- Date Created
- Data Received from
- Agreement
- Terms and Conditions
- Expiry Date
- Comments

Please refer to Appendix 2 to review the Baynes Sound GIS metadata files.

#### **4.5 Scale Differences**

The difference in scale between how map data was originally created and how it might be presented in the project influence how accurate the data will appear to be when viewed at certain scales. A level of error is introduced when coverages created at a scale different from the scale of the base map used for presentation are layered over the base map. The data may appear accurate in the coverage at the scale it was created, but closer views may show inaccuracies.

### **5.0 Data Development**

#### **5.1 Delineating Area of Interest**

To ensure faster loading for end-users the themes were edited so that only the area of interest (Baynes Sound region) is shown. This allows the user to bring a theme on screen without the need to pan and zoom to the area of interest from a wider area. Clipping and merging functions were used to edit theme areas to improve data manageability.

##### **5.1.1 Clipping a theme:**

The Clipping method was used to reduce the size of a basemap for faster loading and easier navigation. This procedure was performed on Environment Canada’s water quality monitoring data, Fisheries and Oceans Statistical Sub-area data, BC Ministry of Environment Points of Diversion data, and the in-house Sensitive Habitat Atlas data that was used as a reference during the development of the Baynes Sound GIS.

Method: Open the theme to be clipped in ArcView. Use the selection box button to draw out the general area of inclusion. To add in additional outlying areas or areas that do not quite fit into the rectangular



polygon, hold down the shift key and draw additional polygons to include those additional areas. Once finished, all the areas intended to be inside the area of interest are yellow. Under the *edit* menu choose the command "*Convert to Shapefile*" to produce a shapefile limited to the desired area.

### 5.1.2 Merging Themes

Merging themes help to reduce initial loading time when the area of interest has been initially separated into several different extents. This was necessary for the Agricultural CLI data, received as separate themes of the same area of interest.

The X-Tools ArcView extension merges themes using ArcView 3.1 or higher. This extension may be obtained for free from the ESRI website at <http://www.esri.com>.

Method: Download the X-Tools extension and place it in the ArcView ext32 folder. Open ArcView, create a new view and open the file menu. Click on "extensions" to view the extension popup menu. Click the X-Tools checkbox to select it, and choose "OK". Once the X-Tools extension is loaded there will be a new menu option called *x-tools*. Click on the X-Tools menu and go to "*merge themes*". The extension will now ask which themes to merge. Choose the themes to be combined from the list. The extension will then ask for a name for the new theme. Enter a new name and place the file in the folder of choice.

*NOTE: If the attributes of the themes are different then only one theme's attributes will be preserved in the output file.*

## **5.2 Data Conversion**

Differing data formats presented a challenge when incorporating data into the Baynes Sound GIS. Formats that were frequently encountered in the development of this GIS were ArcInfo e00 files and CAD files.

### 5.2. ArcInfo e00 files:

Among the data received in e00 format were Fisheries and Oceans Statistical Sub-area data and BC Ministry of Environment Points of Diversion data. ArcInfo e00 files required conversion to Shapefile format using the ESRI Import71 program.

Method: Place the ESRI Import71 program in the ESRI file, or create a shortcut on the desktop. Select the Export Filename by browsing to the file of interest (must be in Arc/Info Interchange format (.e00)). Double-click the file to place it in the Export Filename slot. Copy the file name and path (without the .e00 extension) to the Output Data Source slot, and press OK. This creates a folder to house all of that coverage's data, imports the data to ArcView, and places in the new folder. The original file with the .e00 extension still exists. To see this coverage in ArcView, click the "*Add Themes Button*", navigate to the theme (.shp file) and click "OK" Check the box next to the theme to activate it.

### 5.2.2 AutoCad dxf/dwg files:

The most common and problematic format encountered when incorporating data into the Baynes Sound ArcView GIS was the .dwg/.dxf format utilized by AutoCad. The datasets that were received in CAD file formats were:

- Comox OCP / Zoning / Stormdrain
- Courtenay OCP, Zoning, Stormdrain
- RDCS Cadastral files

The problem: In ArcView, all spatial data is stored in three basic files: the shp, shx and dbf file. The .shp file stores the feature geometry (lines, points, poly, etc). The .shx is a file that stores the index of the feature geometry. The .dbf file is the dBASE file that stores the attribute information of features. Each geographic feature seen in a shapefile is linked to information found in the database. All the data identifying what that feature represents is kept in the database. The core functionality of a GIS is that every feature has data linked to it that may be analyzed. AutoCad possesses many of the same features as a shapefile visually, but has no

ability to hold data. Data may be viewed in an AutoCad drawing, but because there are no data attributed to the spatial features, no true spatial analyses can be conducted using dxf/dwg files. Nor can these files be combined with existing ArcView Shapefiles. To solve this problem for polygon coverages, each of the dwg/dxf files required conversion into a shapefile. This conversion was accomplished using ArcView's CAD conversion and X-Tools extensions.

Method: Load the CAD reader and X-tools extensions into ArcView to the extensions folder. (Both extensions can be found on the ESRI website as freeware). Open ArcView, and select "*Extensions*" under the "*File*" menu. A popup menu lists all available extensions. Select both the Cad reader extension and X-Tools extension. Add the CAD files using the "*Add theme*" button. Once it is visible on the screen under the "*edit*" menu, select the "*convert to shapefile*" command. This converts the single dwg/dxf file into the three ArcView shapefiles.

Through this process, the AutoCad files were converted into shapefile coverages, but with no information in the database. The data was then entered manually after linking each important graphic feature with a unique identity key to allow it to be uniquely identified in the database. All other information was entered into the database using database management software such as MS Excel. Once completed the new shapefile was available for spatial analyses and data integration within the Baynes Sound GIS database.

### **5.3 Projection**

Map projections allow areas on the surface of the Earth (a spheroid) to be represented on a map (a flat surface). In this way the precise position of features on the Earth's surface can be obtained from the map. A map's projection will differ between agencies depending on that user's specific needs. Each different projection has certain advantages and disadvantages when representing three dimensional data (real world) on a flat two dimensional surface (map).

The problem of combining different map projections was encountered when geographical data from many sources was assembled in the Baynes Sound GIS. The datasets that needed to have their projections altered were:

- BC Ministry of Fisheries Waterways growing conditions – estuaries / beaches, foreshore substrate data
- BC Ministry of Environment points of diversion data

All of the datasets were altered using the MELP-Kid method, with the exception of the foreshore substrate data, which was altered using the projection utility in ArcView 3.2. Most data agencies in BC use the UTM format to house their data. In later stages of Phase 1, it was found that data was not always available in this projection, and methods were developed to change these files into usable format.

Image files such as the CASI remain problematic due to the lack of a resource that can change the projection of an "Image file". Currently there are no programs that have been found to alleviate this problem.

#### 5.3.1 Using MELP-KID (ArcView 3.1 or lower and in BC)

BC MELP KID is an extension for ArcView 3.0a (or ArcView 3.1) developed under contract for the BC Ministry of Environment, Lands, and Parks.

Method: To install this extension, download it from <http://www.env.gov.bc.ca/gis/melpkid/>. Place it within the ArcView extensions folder "ext32". (use the *Find* option in Window to locate the folder). Once placed within the ext 32 folder, a new view is created in ArcView. Add the theme to be altered into the view, and select it as the active theme. The MELP-Kid extension can be activated from a menu option entitled "MELP-Kid". Click on this menu and select "*change projection*". A popup menu appears asking for an input projection and an output projection. Select the appropriate projection for both and then "OK". Give the theme a new name and place it in an appropriate folder.

### 5.3.2 Using The Projection Utility (ArcView 3.2 or higher)

With the “Projection Utility” a theme’s projection can be permanently changed by creating a new shapefile with the desired projection properties. This was especially useful for aligning themes in a view. To align properly, it is not enough for the themes in the database to occupy the same coordinate space; they must also have common coordinate system properties (projection, datum, units, and spheroid).

Method: To use this extension, load the Projection Utility option from the Extensions list, then with the view active, select the Projection Utility from the File menu. Once the extension is loaded, the Projector icon appears as part of the View menu in ArcView (its icon looks like a small north arrow in a box toward the right side of the View menu). Click on the icon and the projection wizard will start.

#### **Step 1**

Press ‘Browse’ and navigate to the data directory that contains the input shapefile. The browse window will close and the shapefile appears in the wizard. Press the “*Next*” button on the Step wizard.

#### **Step 2**

If the shapefile selected contains projection information, the wizard will read this information and display it in this dialog. If the shapefile does not have any projection information stored with it, the utility needs to be told which projection parameters are used for this shapefile. Changing coordinate systems included transforming between datums. To check datums, select check “*Show Advanced Options*” and click on the Datum tab to control this transformation. If only one Geographic Transformation method is available, this field will be grayed out and that method will be used. If more than one method is available, it is set here. For most cases, use the default method. Answering the prompt to save the projection parameters with the shapefile with “Yes” permanently stores the new parameters in a projection file (.prj) which is stored with the input shapefile. The ArcView Projection Utility reads the stored parameter information from this file the next time the shapefile is opened.

#### **Step 3**

Enter parameters for the output shapefile. To unproject shapefiles to decimal degrees, choose “*Geographic*”, then choose the appropriate values from the Name and Units fields. To project or reproject shapefiles, choose *Projected*, then choose the appropriate values from the Name and Units fields. Created along with the new shapefiles are projection files (.prj). These files store the information about the coordinate system the shapefiles were created with.

#### **Step 4**

By default, the new shapefile is written to the current working directory with the name “Newshape.shp”. Change the location or the file name, by pressing the Browse button. The Save As dialog asks for a new file name, and the folder to store the new shapefile.

**The Summary** panel lists the input and output information for the shapefile. Review and press Finish.

### **5.4 Rotation and Geocorrection**

Resolving data with inappropriate coordinates proved to be a time-consuming problem. Engineering departments of both Comox and Courtenay provided data without coordinate data. The original data was created by the Regional District of Comox Strathcona and given to the municipal engineering departments. Coordinate data was stripped from the layer by municipal staff, with the result that layers no longer faced true north, and were displaced from true geographic location by several thousand kilometers.

Two methods were used to realign the data to its original location, as follows:

- 1.) Convert the data into dwg/dxf form, and use Autocad to manually move it by eye into its correct geographic location and rotation.
- 2.) Use a combination of ArcView extensions and scripts to move the data layer into its correct place and rotation by mathematical calculation.

#### 5.4.1 To realign a shapefile using Autocad

Add and use the "CAD Fusion" extension, found on the ESRI website under Avenue Extensions.

Method: Activate the “CAD Fusion” extension in ArcView by clicking "File" → Extensions → CAD Fusion. This adds the intended shapefile into the view. Click on the "CAD Fusion" menu → "save as drawing" menu item. A dialog box will appear for each theme asking for layer and label information. Choose a layer name (the default is the theme name), or place entities on a layer derived from attribute data. If the theme is labeled, then the user has the option of adding these as text on a layer they specify. The name, path of the drawing file, and format (dxf or dwg) should all be specified. Once it is fully converted into a dxf/dwg file, Autocad R14 is opened with a file that roughly covers the same area but is geographically correct with alignment points for the new Autocad file. In the command line enter "ddinsert" to bring up a popup menu for locating files. Find the new file and set all the options to "on-screen. The image will now appear on screen and may be lined up with the existing drawing. Click on the basepoint where they should overlay. To work with the rotation, simply click on the angle that works best and the new drawing will now be realigned accordingly.

If the drawing is off by a slight distance or needs to be rotated slightly, type the "move" command in the command line. The computer will ask for what objects to move, a basepoint, and an area to move to. The "rotate" command is much the same.

#### 5.4.2 To realign a Shapefile using ArcView

When realigning a shapefile using ArcView, use a reference file that represents the same geographic location with correct spatial coordinates, and an ArcView extension, “First Tools”, available from the ESRI website. The extension file was downloaded and placed it within the ext32 folder.

Method:

##### **Step 1**

Add both the reference file and the file to be realigned to the view. Pick a reference point visible on both themes (such as the corner of a street cul-de-sac or zoning polygon). To read the coordinates, move the mouse over a precise point on both themes, and record the x,y coordinates that appear on the top right hand corner of the ArcView Screen, just above the view.

##### **Step 2**

Once the coordinates have been recorded from the same reference point on both themes, calculate the distances needed to shift the incorrect theme. This formula was used to determine the distances of the shift:

$$\text{Correct X} - \text{Incorrect X} = \text{Distance of Shift in X direction}$$

$$\text{Correct Y} - \text{Incorrect Y} = \text{Distance of Shift in Y direction}$$

##### **Step 3**

Load the “First Tools” extension to ArcView by right clicking anywhere within the view and selecting “First Tools” from the list of options that appear on screen. The First Tools popup menu that appears on screen will have offer several selection. Select the “x-y shift” button. Enter the distances to be shifted in the x and the y directions. After giving it a name and placing it in the correct folder location, open the new theme in the view to confirm that it appears in its correct location.

## **6.0 Data Creation**

In addition to acquiring and developing data, new themes were created from data for inclusion in the Baynes Sound GIS. Some data were kept in databases with spatial data references, (Event Themes) which had to be converted before they could be used. Coverages of Project Watershed’s past monitoring projects needed to be recreated, or created from scratch for the project.

### **6.1 Event Themes**

At times, databases were received including coordinate data (ie x,y or UTM coordinates), but with no accompanying map. An **event theme** was created to make a coverage from these coordinates. An event theme is an ArcView table containing X and Y coordinate fields that allow display of the records as point features in a view. The coordinates can be lat-long decimal degrees, or coordinates in any projection. If the

coordinates are projected, the View should have that projection, as specified in “View—Properties”. Unlike point shapefiles, event theme tables can be created, edited or updated outside the ArcView platform, using any database or spreadsheet program that handles dBase-format data. This procedure was required when creating coverages of the Environment Canada Monitoring data, Project Watershed Monitoring data, Boater Pumpout data, Environmental Health beach monitoring data, Comox Harbour monitoring data and the Ships Point monitoring data.

Method:

To create an Event Theme, select “Table → New” to name and create an empty table, which is open for editing. Select “Edit → Add Field” to create the appropriate fields, and then add records with Ctrl-A (“Edit → Add Record”). The data is entered manually with the Table Edit tool. It's quicker to enter data by field rather than by record, since the Enter key jumps to the next record. Once finished, click “Table → Stop Editing” to save the edits.

Because of the large file size, Environment Canada provided their data as an event theme with x-y coordinates. To add an event theme to a view, add the table with X-Y coordinates to the project, and choose “View → Add → Event Theme”. In the dialog box, specify the table name and the fields in the table that contain the x and y coordinates. Once this is complete, the entities are visible in the view. To create a real point shapefile from an Event Theme, select “Theme → Convert to Shapefile” and specify the path and name for the new file. Once this is done, a new point theme displays all its associated attribute data.

## 6.2 Creating and Editing Point Shapefiles

New point coverages of water monitoring data and other data with no coordinate data were manually created and digitized. Shapefiles were created on basemaps of orthophotos and in-house TRIM maps, used for visual referencing of the new features. The coverages that were created using this method include: Bird Studies Canada data; sealions and seals; Aquamatrix water quality data; Baynes Sound Remediations maps; Boater Pumpout project data; Comox Harbour Monitoring Project data; Environment Canada data; Environmental Health summer beach survey data; Project Watershed water quality monitoring data; and the Ships Point and Stormdrain water quality monitoring datasets.

Method:

To create a new point shapefile, activate the view using select “View → New Theme”, select "Point" as the feature type, and specify a path and name for the new shapefile. The empty shapefile will be added to the View as a new Theme. Alternately, to open an existing shapefile for editing, select “View → Theme”, and use “Theme → Start Editing” to open the shapefile for edits. The Theme's check box in the View's legend has a dashed border, indicating that the shapefile Theme and its attribute Table are open for editing. Add point features to the shapefile, using the “Draw Point” tool. This will be the only available tool in the Drawing tool pulldown menu since this is a point Theme; the other tools will be greyed out. Each left mouse click in the View will create a new point feature and an empty attribute record for it in the Theme's attribute Table. Any erroneous points can be deleted with the Delete key. Points can be repositioned as necessary by selecting them with the pointer and dragging them in the View. Any erroneous delete or move can be undone with Ctrl-Z (“Edit → Undo Feature Edit”). To define and add attribute data for the new points, use “Table → Add Field”. Activate the View and use the Pointer tool to select each point in the View. When the associated attribute Table record is highlighted, use the Table Edit tool to select successive fields and type in the data.

## 7.0 Data Management

Data and maps received from project data partners was organized in the Baynes Sound GIS in the following five sections:

- Cadastral
- Biological
- Physical
- Monitoring
- Shellfish

## 7.1 Cadastral Data

Integration of the cadastral data received from the Town of Comox, the City of Courtenay and the Regional District of Comox Strathcona to the Baynes Sound GIS required a large amount of work. This cadastral data included: Official Community Plans (OCP), Zoning, Property parcel information, municipal stormdrain systems, and basic cadastral coverages. Of these, the OCP, Zoning, and Stormdrain coverages required modification for integration to the Baynes Sound GIS.

The cadastral data produced by the Town of Comox and City of Courtenay was provided to Project Watershed in dxf or dwg format (CAD files), stripped of all spatial information (ie coordinates) and rotated slightly, so it was no longer be in alignment with True North.

The files were integrated into our databases in one of two methods:

1. Autocad was used to make most of the graphical adjustments because most of the data had originated in Autocad format. Autocad was used to realign the map data with a similar coverage that covered the same extent but in the correct geographic location. The Autocad program was used to rotate the file to face true north. After all the geographic corrections had been made, the dxf/dwg file was opened up in ArcView and converted into a shapefile using the CAD Reader/Fusion extension. The resulting shapefile had all the spatial information required, however the attribute data necessary for performing analysis still needed to be created. A unique identifier was added to each part of the spatial data to link it to data that would be added later. Microsoft Excel or Access was used to create the database with all the necessary attribute information. After the database was completed, the spatial data and the newly created database were joined using the “JOIN” operation in ArcView.
2. In the early stages of the State of the Sound GIS Project development, the Autocad program was not always available for spatial data editing, so the ArcView program was used to perform all of the required functions. The dwg/dxf file was first converted as ArcView has no way of editing anything other than shapefiles. The “X-Tools” extension was utilized to move the file into the right geographic extent, along with mathematical calculations used to determine the shifts in the x and y direction. Once the data was moved into place and rotated in the correct way, a unique identifier ID was included to link the spatial information to data that would be added later. Microsoft Excel or Access would then be used to create the database with all the necessary attribute information. After the database is completed, the spatial data and the newly created database would be joined using the “JOIN” operation in ArcView.

In addition to challenges presented by the absence of spatial information, the data provided by the City of Courtenay used ‘cross-hatching’ rather than enclosed polygons to represent boundaries. Cross-hatching is an inefficient way to represent polygons because it limits different analyses, including those that are dependent on the area of a boundary and its adjoining boundaries.

The data produced by the Regional District of Comox Strathcona (RDCS) tended to be of higher quality due to the fact they have fully functioning GIS departments. The data was easily implemented and of high quality. However obtaining data from the RDCS was not always easy due to their busy schedules.

## 7.2 Biological Data

While integrating the cadastral data was the most time consuming, the biological data was by far the most difficult to work with. This data included the Compact Airborne Spectral Imagery (CASI Images), and the Bird Studies Canada data.

The main problem with the CASI Images was the projection they were in. The images were projected in Albers rather than the UTM format used by Project Watershed. Although methods for changing projections of shapefiles have been found, techniques for changing the projection of image data have not been found to date.

The Bird Studies Canada data remains problematic due to the nature of the shapefile format and the additional databases we were hoping to utilize. The shapefile was built as a polygon coverage that delineated the areas of study. Each individual polygon would have a unique ID and have data attached to it using this primary key. The additional database that held data to be appended to the coverage was a problem however. The database was designed in such a way that each of the individual polygon areas would be linked to multiple attributes. Due to the nature of ArcView's database structure (dbf), it cannot handle one-to-many relationships between the graphical data and its attributes. One polygon cannot represent attributes that represent multiple types of phenomena over multiple periods of time. While more sophisticated GIS database engines can handle this problem (such as ArcInfo), these programs are very expensive and are not used by the State of the Sound GIS Project. The best way to approach the problem also tends to be the most time consuming, in that the entire database structure of the attribute table needs to be redesigned. However other attempts are being made to order to avoid this labour intensive method to resolving this problem.

### **7.3 Physical Data**

The Physical data included: agricultural data, foreshore substrate data, growing condition data, the Points of Diversion coverage, Sensitive Ecosystem Inventory data, and the Environment Canada Statistical Sub-areas data.

The data obtained from the Ministry of Agriculture, Food and Fisheries was well detailed and already in ArcView Shapefile format, which made it one of the easier datasets to work with. The only real problem with the data was its lack of metadata. The soil data coverage used a coding system to identify each of the areas, however without the coding key; these values are not accessible to users. Currently there are volunteers decoding the necessary information needed to make use of the data.

The foreshore substrate data and growing condition data were obtained from Fisheries and Oceans Canada in ArcView format. The main problem with the data was the projection in which they were sent in. The coverages were all in Albers projection instead of UTM, but after much research, the "MELP-Kid" extension for ArcView was added and used to change the coverages to the right projection for our needs.

The Points of Diversion and the Fisheries and Oceans Statistical Sub-Area coverages both arrived in ArcInfo's e00 file format. The coverages were converted into shapefiles using ArcView's "Import71" tool. The Points of Diversion coverage had very little attribute information included, except for a code number that is used to obtain additional information from their website. Once the Points of Diversion coverage was converted into a shapefile, the additional attribute information was requested from the data's originator, who retrieved the data within the delineated area of interest. Once the data had been received, a 'Join' was used in ArcView to produce a shapefile with all of the information.

The Sensitive Ecosystem Inventory information was already in the format required for the project, and was quite easy to implement.

### **7.4 Monitoring Data**

The monitoring data include: stormdrain monitoring sites and data, Ships Point monitoring sites and data, Project Watershed water monitoring sites and data, Business Survey databases and coverages, 1995-1999 Remediations coverage, Aquamatrix water quality sites and data, Comox Harbour monitoring sites and data, Environmental Health monitoring sites and data, and Environment Canada monitoring sites and data. All are point coverages (i.e. each monitoring site or time is delineated by a point on the map).

With the exception of the Environment Canada data, the shapefiles were created by developing a new coverage in ArcView, and placing the monitoring points by eye on basemaps of orthophoto images or TRIM mapsheets. Usually this involved obtaining hard copy maps with the points marked for reference, then creating a digital version of the map in ArcView.

Once the point coverage was created, it was linked to attribute data using the “JOIN” operation. Some of the attribute data was in mdb or xls format, so either Access or Excel was used to export the data in dbf4 format so it could be easily joined to the new coverage. If the data was only available in hard copy format (ie. the Environmental Health beach monitoring data, it was manually entered into a database in Excel, then saved as a dbf4 file.

The Environment Canada data was very difficult to integrate. The data originally arrived in Access mdb format because it was easy to e-mail or FTP. However, the electronic security systems that protect Environment Canada data would not allow it to be transferred or opened. After a long arduous procedure the data was finally received in a usable format, exported to Project Watershed in xls format, but with some of its linked databases missing.

The Environment Canada information was received with the coordinates to each of points already included. The data was then added into the coverage using the “new event theme” function in ArcView. The coordinate data had to be converted into UTM projection from Geographic using the MELP-Kid extension in ArcView. Once converted, the attribute data that existed within another database could be converted into a dbf file, then joined to the coverage using the ‘Join’ function.

The monitoring data often had multiple monitoring dates for each site. This resulted in problems due to the limits of ArcView’s database structure. After much experimentation, this situation was resolved by creating a ‘legal’ many-to-one join, rather than a one-to-many join, which is illegal in ArcView.

Method:

Use the ‘X-tools’ extension to add a coordinate field to the existing spatial data, then perform a ‘REVERSE JOIN’. Usually a ‘JOIN’ would be performed by adding the attribute data to the spatial data, however in this case the opposite function was performed. The new coordinate fields would be added onto the numerous attribute fields.

This is possible with point coverages only, with the result that a low number of coordinates is added on a large number of attributes and multiple records pop up when the user clicks on a point in the theme.

## **7.5 Shellfish Data**

The shellfish tenure sites arrived in proper shapefile format, although the coverage was in an Albers projection rather than the UTM projection used in the Baynes Sound GIS. Using the MELP-Kid ArcView extension, the files were converted from Albers to UTM projection.

## **8.0 Ongoing Challenges**

Many problems were encountered during the development of the GIS, most of which can best be described as the norm, rather than the exception in exercises of this kind. Although most problems have been satisfactorily addressed, the key issues that remain include:

- ArcView’s lack of functionality with “one-to-many” relationships. One of ArcView’s biggest flaws is its inability to link several attributes to a single entity such as a point, line or polygon. This is mainly due to the nature of its database file structure. Efforts to correct this problem continue.
- Access to basemap data. Clearly defined and long term access to base map resources must be arranged as soon as possible. At the end of Phase 1, only one agreement is in place for the use of base map data, an interim agreement with the BC Ministry of the Environment, Lands and Parks for the use of orthophoto images ending on March 31, 2001. To date, Project Watershed does not have formal authorization for the use of TRIM data or the Comox-Strathcona Regional District Sensitive Habitat Atlas data, or an extended agreement for the use of orthophoto images.



- Metadata files must be completed for all datasets and maps that have been and will be received for use in the Project.
- Development of a comprehensive quality assurance plan. The State of the Sound data management program must be built upon a solid foundation of accuracy and quality assurance. A quality assurance plan must be developed in Phase 2 - *Data Analysis and Interpretation* to ensure that data is carefully gathered, is used as intended, and is displayed accurately in terms of its production scale

## **9 Data Dictionary**

### **9.1 Data Already Received**

Table 2 Data Received-to-Date (December 31, 2000)

<b>Classification</b>	<b>Data</b>	<b>Source</b>
<u>Water quality</u>	Marine sample stations and results 1984-2000	Environment Canada
	Freshwater sample stations and results 1984-2000	Environment Canada
	Points of Diversion locations (water use licences)	BC Ministry of Environment
	Marine sample stations and results – Aquametrix Study /95	BC Shellfish Growers Assoc
	Freshwater sample stations and results – Aquametrix Study 1995	BC Shellfish Growers Association
	Summer beach surveys 1997-2000	Community Health Services
	Septic repairs, upgrades and alterations – 1996 - 1999	Community Health Services
	Hotspots Septic Project results – 1996	Comox Valley CARE
	Union Bay septic data – 1996/98	Comox Valley CARE
	Stormdrain monitoring sites and results	Project Watershed
	Comox Harbour marine monitoring sites and results	Project Watershed
	Boater Education Project marine sampling sites and results	Project Watershed
	Ships Point sampling sites and results	Project Watershed
<u>Land Use</u>	Assessment roll number, legal description	BC Assessment
	PID #, property class, actual use	BC Assessment
	Zoning	City of Courtenay
	Official Community Plan	City of Courtenay
	Stormdrain system	City of Courtenay
	Zoning	Town of Comox
	Official Community Plan	Town of Comox
	Stormdrain system	Town of Comox
	Property parcel information	Town of Comox
	Zoning – Area A	Regional District C-S
	Official Community Plan – Area A	Regional District C-S
	Cadastral – Area A	Regional District C-S
	Property parcel information	Regional District C-S
	Fisheries statistical sub-area coverage	Fisheries and Oceans Can.
	Shellfish legal tenure boundaries	BC Ministry of Fisheries
	Shellfish harvest quantity (value/area)	BC Ministry of Fisheries
	Waterway growing conditions – estuaries and beaches	BC Ministry of Fisheries
	Waterway growing conditions - combined	BC Ministry of Fisheries
	Agricultural Land Reserves	BC Ministry of Agriculture
<u>Habitat</u>	Bird aggregate by season	BC Coastal Waterbird Survey
	Bird populations by species and survey area	BC Coastal Waterbird Survey
	Sensitive Ecosystem Inventory	Canadian Wildlife Service
	Soil types	BC Ministry of Agriculture
	Foreshore substrate data	BC Ministry of Fisheries

## 9.2 Future Data Acquisition

Although every effort was made to acquire all the data that would form the Baynes Sound GIS during the duration of Phase 1 - *Information Collection and Data Management*, in some cases it was not possible to achieve this target. The following table lists data that has been identified as valuable for future inclusion in the Baynes Sound GIS.

**Table 3 Data – Receipt Pending:**

Source	Data	Note	Type
City of Courtenay	Property parcels	Jan 2001	land use
Cumberland (via RDC-S)	Zoning/OCP/property parcel	late 2001	land use
CVCARE	“Down the Drain” septic project data	undeveloped dbase	water quality
Ducks Unlimited	Conservation areas	no action yet	habitat
Fisheries and Oceans	Courtenay River Estuary Mgt Plan	received Dec 2000	land use
Fisheries and Oceans	Baynes Sound Habitat Atlas	winter 2001	habitat
Fisheries and Oceans	herring spawn areas	winter 2001	habitat
Fisheries and Oceans	purse seine samples – 1998/2000	winter 2001	habitat
Georgia Strait Alliance	Shoreline Quadrat Study data	spring 2001	habitat
Islands Trust/Denman Is.	OCP - DPAs, cadastral, Schedule D, landuse codes	available winter 2001	land use
Ministry of Environment	Wildlife Mgt Areas/Nature Trust Lands	winter 2001	habitat
Ministry of Environment	Crown Reserves	winter 2001	habitat
Ministry of Environment	Orthophotos - interim	renew March 2001	base map
Ministry of Environment	Discharge permits	unknown	water quality
Ministry of Environment	Water quality data	unknown	water quality
Ministry of Environment	TRIM	unknown	base map
Ministry of Fisheries	Recreational shellfish harvest sites	unknown	land use
BC Mines	mines and showings	no action yet	land use
RD Comox-Strathcona	Area B/C cadastral, zoning, OCP, property parcel	winter 2001	land use
RD Comox-Strathcona	regional aquifer data	no action yet	water quality
RD Comox-Strathcona	shoreline classification – hard copy	winter 2001	habitat
UICC Cmty Health Soc.	Septic repairs, upgrades 1999-2000	winter 2001	water quality

## **10.0 Conclusion**

The Bayne Sound GIS Project included stages of research, planning and development:

The research and planning stages of the project required the establishment of standards and practices. Criteria such as software, hardware, file formats, and metadata had to be formalized to ensure success not only within the lifetime of the immediate project, but for future projects as well.

The majority of this project was devoted to the integration and development of the data that is the heart of the Baynes Sound GIS. For the purposes of this project, data has been classified as water quality, land use, or habitat data. The majority of data that has been received to date has been fully integrated into the ArcView Baynes Sound GIS, and is ready to be used in the development of user interface and presentation configurations. The exceptions are: files that are missing data such as spatial or attribute data; files whose structure has internal flaws (ie relationships between polygons and attribute data); and files that need to be manually entered and created.

The next phases of the project's development, include: advanced analysis of the data, and development of user interface methodologies for information dissemination. Depending on the limitations that have been defined regarding its presentation, and the analyses that will be performed from it, the presentation criteria for each dataset will be defined in Phase 2 - *Data Analysis and Interpretation* and Phase 3 - *Report and Recommendations*. In many cases, this will involve the display of information through tables, charts, and modified databases, rather than large, unwieldy databases.

The key result of State of the Sound GIS Project Phase 1 - *Information Collection and Data Management* is that a solid foundation has been established for the next stages of the State of the Sound initiative. Project Watershed will continue to develop this critical tool for protecting the health of Baynes Sound in partnership with the member agencies of the Baynes Sound Stewardship Action Group and other community stakeholders.

Please credit the Comox Valley Project Watershed Society when using excerpts from this document.

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# Appendix 1

## Data Use Authorization

# Appendix 2

## Metadata