Section 2 VASCULAR PLANTS, PLANT COMMUNITIES AND ECOSYSTEMS

2.1 Vegetation Survey - Rationale and Methodology

A review of the literature was done to determine what baseline data was missing for the Englishman River Estuary and what studies could be initiated or repeated to produce the most useful data from a management perspective. Various methodologies of inventory were reviewed and compared including Resources Inventory Committee (Howes et al. 1999), Sensitive Ecosystems Inventory (Ward et al. 1998), Site Inventory and Conservation Evaluation (Kirkby 2003, unpubl.; Buechert 2004, unpubl.), inventories of federal lands under the Species At Risk Act (Dawe et al. 2004), Photopoint Monitoring (Lucey and Barraclough 2001), releves at regular intervals along transects (Dawe and McIntosh, 1993) and Community Based Mapping (Harrington ed. 1996). Assessment of the appropriate inventory methodology was done in light of the project's goal of involving a broad diversity of people in the inventory process.

On this basis, it was decided to initiate the following:

- catalogue and map invasive species on the estuary for use in designing an invasive species management plan
- research what has been done to manage invasive species and begin experimenting with control measures
- map vascular plant communities on the estuary for comparison with plant communities in 1976 based on the map of Kennedy (1982)
- develop easy to use methods such as sample points and transects that help to map the plant communities now and, at the same time, allow return visits to the same polygons over many years, allowing comparisons far into the future
- add to the list of species and plant communities known to be present on the estuary and note those that are designated rare or threatened.
- map special places and features on the estuary that are likely to be important for consideration in management planning

Why quantify, map and photograph native plant communities, special places and invasive species? Why not just get out there and cut broom or rescue fry? The rationale for each one is different and can be understood from the description under each section below. However, an overview of the assumptions is useful here.

1) Each plant community is a marker for a larger community of plants and animals including some that are less apparent but significant or critical to the ecological functioning of that community. A record of the proportions of ground covered by each plant species *within a plant community* and also the areas covered by each plant community *within the estuary* as a whole, gives an indication of what other species are likely to be present at a particular time and place.

2) Each plant community is an indication of the presence of the abiotic conditions required for survival of each of the plant and animal species present.

3) The record of plant communities can be compared with earlier records (such as the Kennedy map from 1976) in order to monitor changes that have occurred. For example, one carefully documented photograph of a tidal channel on the Little Qualicum River estuary has provided startling evidence of the changes that have occurred to the vegetation patterns on that estuary

over a 30 year period.

4) By monitoring changes in vegetation patterns over time, we can detect changes that may be affecting human values such as fisheries resources, endangered species, ecosystem services, and special places within the estuary. Anthropogenic trends may be revealed and altered, but only if we have the knowledge in time. For example, plant communities provide an easy way to monitor the period and salinity of inundation which in turn may indicate changes in watershed hydrology, channel characteristics, licensed or unlicensed water removals, erosion and deposition patterns, sea level rise and climate change.

5) The new plant community map is more comprehensive and more detailed than Kennedy's work, primarily because of the use of GPS technology and higher resolution digital orthophotos. The western dyke isolated the lands behind it from 1969 to 1979, the period in which Kennedy did her vegetation work. This project begins the process of creating a new community map that covers the entire estuary, including the western marsh and the forest. Thus, the new map allows for comparisons now and it provides improved baseline data for comparison and identification of trends far into the future.

6) Invasive species data can be used to show to neighbouring landowners, planners and the public at large the size and immediacy of the threat to the estuary. Maps assist in planning the spatial component of any campaign for control or removal. Future maps can be compared with our invasive species baseline to show trends. This helps to plan allocation of scarce resources to the most needed campaigns. It also helps to highlight successes, which is a necessary part of motivating people whether they are volunteering or being paid.

7) Maps are generally more accessible and memorable to the general public and to planners than words in a report that sits on a shelf. Information and involvement moves everyone towards buying into the plan. Maps of special places can capture the imagination, motivate inquiry, help to plan an outing, trigger involvement, and create a feeling of ownership.

2.2 Vegetation Survey - Plant Community Mapping and Point Sampling Methods

The project had initially identified 32 spatial study units for which vegetation data would be collected for the purpose of mapping the ecosystems at that scale. In addition, three permanent new transects had been established and two more were being planned to repeat earlier studies on the West Marsh of the estuary (Dawe and McIntosh, 1993). Data on percent plant cover by species would be collected from 1- metre square quadrats at 5-metre intervals along the transects. It was thought that the percent vegetation cover data might be more comparable and consistent if it was performed by a single person, an ecologist, while volunteers would take a standardized series of photographs (adapted from photopoint monitoring methods) and handle documentation of the transect. The volunteers would then have the experience necessary to continue doing photographic records of the transect quadrats every few years.

Moving to finalizing the plant community mapping methodology involved experimentation with equipment and volunteers, and consultation with experts. At a meeting on 6 May 2008, Nature Trust representative Tom Reid announced that transect data would not be useful to them because they unexpectedly had a specialized crew collecting similar data in an area that included the Englishman River Estuary. Furthermore, MVIHES was having difficulty locating the transects in the West Marsh/Lagoon area that we intended to repeat from Dawe and McIntosh (1993) because the landmarks described were either no longer present, or no longer visible. Finally, by this time we already had one field season on the estuary, and it was becoming apparent that major changes had occurred to the vegetation on the eastern and central parts of the marsh since Kennedy mapped the plant communities there in 1976. At this point, it was decided to expand the ecosystem mapping component to greatly increase that level of detail (from 32 spatial study units to over 400), while reducing the number and complexity of the transect data. Because the large changes we had already observed, we decided at that time to give priority to mapping the eastern and central marshes of the estuary, including San Pareil Lagoon, Big Island Marsh and Centre Marsh, in order to make a detailed comparison with the plant communities that Kennedy mapped in 1976. The task of creating a baseline of Biogeoclimatic Ecosystem Classification (BEC) based primarily on Mackenzie and Moran (2004) and on the British Columbia Conservation Data Centre (2008; BCCDC) for the remainder of the estuary would be initiated in those areas that had not been mapped by Kennedy and then expanded later to include the entire estuary.

The final methodology chosen for plant communities involved 5 basic procedures: delineation, sampling, data management, classification and mapping. The steps taken are given below.

2.2.1 DELINEATION OF GEOGRAPHIC STUDY UNITS

- obtained recent high quality digital colour orthophotos of the study area.
- using GPS on the study area, recorded the locations of what appeared to be an occurrence of a consistent plant community (a point) or a vegetation transition (a line) that could be plotted on a computer as a layer over the orthophoto.
- used these lines and points to help interpret the meaning of the patterns visible on the orthophoto.
- delineated geographic study units (GSUs), as many as needed, with the idea of making each polygon represent a uniform vegetation pattern such as a single plant community or a uniform mosaic of plant communities. On the Englishman River estuary, over 400 GSUs were delineated.
- visited different kinds of polygons in different areas and defined the transitions in terms of plant species visible (ideally, plants easily visible to volunteers).

An ecologist accompanied volunteers in exploring the estuary with GPS, camera and high quality air/ortho photos. They identified and recorded the locations of some of the plant communities and some transitions between plant communities. They familiarized themselves with how the transitions varied. For example, in a brackish area, the species and transitions at a particular elevation (tidal level) were different from a more saline area. In an area disturbed by erosion or grazing, the species and transitions differed from areas that were not disturbed.

The creation of new geographic study unit (GSU polygon) boundaries was done by an ecologist using ArcView on digital 2007 colour orthophotos (.gif format) with an effective pixel size of 20cm X 20cm (i.e. 25 pixels per square metre). With this resolution, photo interpretation could be done at scales as large as 1:300 (and even greater in some cases). To assist in orthophoto interpretation, the ecologist plotted UTM coordinates of some vegetation transitions that had been recorded on the ground using a GPS (Garmin GPSMAP 76CSx). To do this, the points were downloaded onto the computer, plotted as a theme on the orthophoto, and in most cases, the dots were joined to create free floating lines using ArcView 3.1. The lines observed and plotted on the ground could then be compared directly with patterns visible on the orthophoto.

In some cases, the entire line of waypoints thus created appeared out of alignment due to a consistent error by the GPS unit on that day. When it was clear the error was consistent, it was corrected by moving the entire line to match features on the orthophoto.

The points recorded in the field were based on selected vegetation transitions between various plant communities. Which transitions were chosen for mapping was not deemed to be critical to the success of the method because their only purpose was to help in the photo-interpreted delineation of GSUs, with each GSU intended to represent a consistent vegetation pattern within its boundaries. However, to be useful, each line or group of GPS points had to have a clear definition of what was being observed and recorded and that definition had to be adhered to consistently until a new line with a new definition was started. Because this was often done by volunteers, it was helpful if the GPS points represented a feature that was easily observable on the ground. For example, the volunteers might be asked to use a GPS to record the UTMs of a line marked by yellow flowers if there was only one species of yellow flower open at that time.

It was helpful, but not essential, if the feature or the vegetation transition being mapped turned out to be something that was also discernible on the orthophoto. Lines of GPS points with a consistent meaning were expected to enhance interpretation of the patterns visible on the ortho photos and ultimately make it easier for an ecologist to delineate the GSUs in a way that would make it simpler to describe and map the plant communities on the ground.

Vegetation transitions were defined by an ecologist to meet these criteria. Some examples of how the transitions were defined include: the edge of a species range that had conspicuous flower heads, or the edge of the area where a single species comprised more than 95% of the vegetative ground cover in a square metre, or a line formed by mapping where two species could be found separated by one metre or less. The definitions of vegetation transitions could be different from one area to another to accommodate differences in vegetation patterns (due to variations in salinity, inundation, wave action, sedimentation, erosion, grazing pressures etc) providing that the mapping of each line of points represented a consistent definition and a set of clear observations on the ground. Teams of two volunteers or paid summer students working closely with an ecologist in the field used a GPS unit to record the locations of these transitions.

When mapped, this combination of photo interpretation and data collected in the field was at a level of detail that allowed the remaining natural estuary to be divided into more than 400 GSU polygons to assist in the long term study of plant communities.

2.2.2 SAMPLING OF VEGETATION COVER BY SPECIES AND LAYER

- in each GSU polygon, chose one or more sample sites (using non-random SEI methodology) to represent the plant community or communities of that GSU polygon.
- set the GPS unit to average the readings at the centre of the chosen sample site, and left it there to record the position to within 5 meters (+ or -). Sometimes an antenna was used to improve GPS accuracy.
- estimated and recorded the vegetation by percent cover for each species in each structural (vertical) layer for a plot that can range in size and shape depending on the shape of the plant community. The ideal plot was 10m by 10m for forb areas and 20m by 20m for forested areas.
- created a photo record of the sample site by systematically facing each of 4 (or 8) compass directions and taking a photo that included the horizon and/or the edge of the plant community being documented.
- photographed the vegetation looking downward being careful to include some size reference such as a 20 cm ruler (or the photographer's foot or the GPS unit).
- oblique angles were sometimes photographed to include special features that would otherwise not be recorded but it was found that this was rarely necessary.
- photographed the face of the GPS unit showing the waypoint number, date, UTM coordinates, and elevation (elevation was optional).

Initially, potential sample sites were identified on the orthophoto within each study unit as possibly typical of that unit and then the UTM coordinates of that potential sample site were recorded. A number of the GSUs, especially those that were difficult to find on the ground, were visited by using the GPS to get to the UTM coordinates that had been pre-chosen remotely on the computer. However, it was found that the pre-chosen coordinates were sometimes unsuitable for sampling because they appeared to be not typical of the surrounding vegetation. Furthermore, it was learned that finding a location using pre-chosen coordinates could be time consuming. A laptop computer was brought into the field during good weather to assist with this.

In the end, as much as possible, the sample sites were visited by sampling any place where a different plant community could be discerned on the ground. Printed copies of the GSU polygon maps cased in plastic were carried in the field to minimize duplications. When incoming data was plotted indicating a GSU or plant community was being overlooked, then the sample crew would revert back to the method of targeting a specific UTM coordinate as a sample location to fill in the oversight.

Sampling of vegetation was done using non-random methods similar to those developed for the Sensitive Ecosystems Inventory (Ward et al. 1997). On 118 of the GSU polygons, the vegetation was sampled in a formal plot of a size and shape appropriate to the polygon. Ideally the plots were 10m X 10m on forb and shrub dominated sites and 20m X 20m on fully forested sites. Each sample plot location was chosen by an ecologist from the GSU polygon to be representative of the polygon as a whole and to avoid transition areas where the vegetation would be less uniform. The objective is for the sample site to be typical of the GSU polygon. The percent cover by species was visually estimated for the sample plot. Digital photographs (equivalent to a 35mm camera with a 55mm lens) were taken in four compass directions (usually E, N, W, S) using the camera angle to record as much of the polygon as possible and also the edge of the polygon or the horizon for reference. One or more photographs were also taken pointing downwards from a height of approximately one metre with some object on the ground included for scale, such as a compass or a GPS unit or part of the photographer's foot. In addition, oblique angle photographs were used to record features like vegetation, logs or reference points that might otherwise not be recorded.

The sample plot data consisted mainly of a GPS file (date, time, waypoint number, and UTM-NAD83 coordinates, and sometimes elevation in metric), handwritten field notes (date, waypoint number, UTM coordinates, field surveyors and percentage cover by plant species) and photographic data (photos facing E, N, W, S, DOWN, and a photo of the face of the GPS showing date, waypoint number, and UTM coordinates, and sometimes elevation. The sample plot data also included the camera-assigned number for each photo, which was not available until photos were downloaded onto a computer. Photographing the GPS was an innovation that started part way through the project to help demarcate the end of the photos for one sample site and to provide an independent cross-referenced link for the photographic data that was recorded on the camera's chip and later downloaded in a file separate from the GPS data.

The sampling that was done east of the Shelly Road Dyke was aimed at creating a map for comparison with the Kennedy (1982) map from 1976. The sampling that was done west of the Shelly Road Dyke (the West Marsh) began the process of baseline mapping the vegetation of the estuary using the biogeoclimatic classification (Mackenzie and Moran,2004; BCCDC, 2009). For this purpose, a soil pit was dug from 20cm to 60cm deep to sample the substrate, primarily to look at soil textures down to the first impervious or slow draining layer. The full field data script that was used for vegetation plot samples in the West Marsh is shown in Appendix 2.1**.** Plant species identifications were done using *Plants of Coastal British Columbia* (Pojar and MacKinnon 1994) but with reference to the *Illustrated Flora of British Columbia* (Douglas et al. 1989).

2.2.3 DATA MANAGEMENT

First we downloaded the data from the GPS as a txt file and manipulated it to form the basis of a spreadsheet file (open document spreadsheet) into which data from the field notes and photography were entered by keyboard. This spreadsheet was saved as a dbf file for input into the GIS program ArcView. The dbf file was never edited or altered in any way. All edits were done to the ods spreadsheet, saved over as an ods file and then saved again as a dbf file which is then immediately closed to avoid confusion.

Downloading the data was done daily in order to keep the three components of the data together. Organizing that data was done within a week. It involved putting the data into a database for the following categories: form of data such as waypoint number (wp#) or a photograph number (J~), yyyy/mm/dd, time, UTM-NAD83 zone, x and y spatial coordinates (easting and northing respectively), elevation, species codes (7-capital letters for plants, 4-capital letters for birds, italicized scientific names or English names in some cases) and notes which is intended to include the initials of the people doing the sampling.

The GPS data was downloaded as a txt file, manipulated to remove some idiosyncrasies that the computer would read incorrectly, and then it was saved as an ods file (open document spreadsheet). Open Office (copyright 2000 to 2006 by Sun Microsystems Inc.) software allowed the option of working in a Microsoft Excel-compatible environment that could be saved as a dbf file at the end of each session. The dbf format is readable by the GIS program ArcView 3.1. Unfortunately, the dbf file would often truncate column entries that were too long. Data remained accessible in the ods format where it was first imported or entered because all modifications to the data file were done and saved first in the ods format and then it was saved again in dbf format. However, each time the data was moved from ods to dbf and then into ArcView, some of the data under species and notes was sometimes truncated.

A better system was needed. Ideally, we needed to get an extension to ArcView that allowed it to accept other formats such xls (or ods which seems highly compatible with xls). In this way, the ease of entering data in the spreadsheet format would allow more columns with more specific data requirements such as a place for each of the ten most abundant species, a place for the percentage cover for each of those ten species, a place for the initials of those persons sampling and a place for field notes, etc. Alternatively, the data could be entered directly into ArcView, but for most people this seems to be a less user-friendly environment.

Consulting a GIS or data management expert would have been very useful and cost effective in this process but the timing is important. Because the consultants may not address these issues, the consultation needs to occur after decisions have been made in answer to the following questions:

- what kinds of data does the project need - what figures and maps will be produced?
- what kinds of data can volunteers collect and process?
- what is needed from a database - size? compatibility? should it handle all of the data?
- who will do the data entry check the data, and manipulate it in preparation for GIS?
- who will do the mapping?

Ideally, the database structure needs to be finalized before much data is collected or entered into a database. Part of the purview of this study was to explore and develop those data collection methodologies and decide what data is possible to collect with volunteers and what is useful to have accessible in a database for presentation in figures, maps and text. As a result, the development of the final database structure had to wait for answers to these questions which came late in the project.

2.2.4 CLASSIFICATION OF OBSERVED PLANT COMMUNITIES

We decided what plant community classification system to apply to the data that had been collected and would continue to be collected. On the Englishman River estuary east of the Shelly Road Viewing Tower, it was decided to facilitate comparisons by using the 19 plant communities that Kennedy defined and mapped in 1976. We added 7 plant communities to represent those observations in 2008 within the same area that Kennedy mapped but which did not seem to fit within Kennedy's plant community descriptions. It was then decided to begin the process of classifying and mapping the estuary using the BEC system on the Englishman River estuary west of the Shelly Road Viewing Tower. We used sample plot data consisting of GPS file (date, waypoint number, and UTM coordinates), field notes (date, waypoint number, UTM coordinates and percentage cover by plant species); and photographic data (photos facing E, N, W, S and DOWN and the camera-assigned numbers of the photos) to decide what layer (theme) best represented the plant community observed at that location.

On the east and central sections of the Englishman River estuary, it was decided to use the same classification system that Kennedy (1982) used, based on 19 plant communities that Kennedy had mapped in 1976, plus an additional 7 plant community descriptions that we added to represent plant groupings that were observed in 2008 in the same areas that Kennedy mapped, but that did not seem to fit the descriptions Kennedy had developed 32 years earlier. Descriptions are given below of the 7 plant hypothetical communities that were added to Kennedy's list.

As in Kennedy's work, the community descriptions in this report are intended to help an ecologist understand the vegetation patterns on the estuary and in particular, the changes that have occurred. They are not intended as a formal classification scheme based on a statistical analysis of large numbers of vegetation plot data.

Sea Milkwort (*Glaux maritima*) - early seral
This is a community near the low marsh - mid marsh boundary dominated by Sea Milkwort (.01% to 50% cover), usually on a firm inorganic substrate. In association with the Sea Milkwort, we found small amounts of Canadian Sand-spurry (*Spergularia canadensis*) and American Saltwort (*Salicornia virginica*). Some of the sites that we mapped in 2008 as "Sea Milkwort - early seral" were in 1976 supporting one of the communities dominated by Lyngbye's Sedge. The sedge was gone from the "Sea Milkwort - early seral" sites we mapped, but also absent was the organic layer and root mass of the marsh platform usually associated with Lyngbye's Sedge.

American Saltwort (*Salicornia virginica*) - 95 to 100
In this mid-marsh community, the American Saltwort is typically at least 10 cm tall and it accounts for 95% to 100% of vegetative cover. There is little or no bare ground - if American Saltwort was less than 100% of the vegetative cover, the remainder of the area was usually covered by Orache (*Atriplex patula*). The substrates have not been sampled yet, but it is likely that the "American Saltwort - 95 to 100 Community" is a form of the CDFmm Em02 *Salicornia virginica-Glaux maritima* Ecosystem which is RED-listed by the Province of BC (BCCDC, 2009).

Dunegrass (*Leymus mollis*)
Based on Kennedy's species description of the Dunegrass community, it likely included areas that were dominated by Dunegrass as well as sandy beach and spit areas where Dunegrass was sparse or absent. We decided to map areas dominated by dunegrass separately from other sandy beach and spit communities.

Seacoast Bulrush (*Bolboschoenus maritimus*)

MacKenzie and Moran (2004) describe additional estuarine site associations for which no BEC code had been assigned. One of these is a monospecific stand of Seacoast Bulrush in saline depressions in the high marsh. These occur on the Englishman estuary so we decided to map them separately, even though they do not appear in Kennedy's classification table, probably because of their small areal extent. For convenience in mapping, we also included in this classification that part of the Jamieson Marsh which was nearly monospecific Seacoast Bulrush, even though its features are different and its origins include recent human intervention.

Tule (*Scirpus lacustris*)
Patches of a community of near monospecific Tule occur in the Jamieson Marsh. We mapped these separately even though their origins are recent and not entirely the result of natural processes.

Low Clubrush (*Isolepis cernua*) - Wigeongrass (*Ruppia maritima*)
This community consists of low marsh areas, usually with Low Clubrush, Canadian Sand-spurry and/or Wigeongrass growing on mud substrate. In mapping this community, we included areas where these species occurred at very low densities. Other species of vascular plants are generally absent. These intertidal areas are low elevation so they are flooded most of the time and, where the tidal water cannot drain, they are flooded all of the time. This community is not the same as the American Saltwort - Sea Arrow-grass Community (K1) that Kennedy described, even though K1 is the only community in which Kennedy listed Wigeongrass. However, this community is likely a form of the CDFmm Em01 *Ruppia maritima* Site Association; both grow on muddy substrates. The only difference appears to be that Canadian Sand-spurry was present in this community on the Englishman estuary but it is not listed for the CDFmm Em01 Site Association, as described by MacKenzie and Moran (2004)

Unvegetated or Nearly Unvegetated Sands and Gravels
Some areas that had supported middle marsh and possible high marsh communities in 1976, now appeared to be lower in elevation and almost barren of vegetation. In order to represent this major change in vegetation on the maps, it would be inappropriate to leave them unclassified, so we created this mapping category.

The classification system of Kennedy required a few other minor modifications in order to be usable. Cattail (*Typha latifolia*) and Pacific Water-parsley (*Oenanthe sarmentosa*) were not found on the saline and brackish marshes of the Englishman estuary in 2008, which is to be expected because they are not salt tolerant. Therefore, any references to these two species in the plant communities defined by Kennedy were not considered when classifying the estuarine plant communities that were observed in 2008, during this study.

A few species required nomenclature transcriptions. *Agrostis alba* in Kennedy (1982) is referred to as Creeping Bentgrass (*Agrostis stolonifera*) in this report. *Agropyron repens* in Kennedy is referred to as Quackgrass (*Elymus repens*) in this report.We assume that *Hordeum murinum* in Kennedy is the same species we refer to as Foxtail Barley (*Hordeum jubatum*) in this report, since Kennedy also refers to *Hordeum brachyantherum* in her report. We assume that *Juncus balticus* in Kennedy is the same species that we refer to as Arctic Rush (*Juncus arcticus*) in this report. *Elymus mollis* in Kennedy is Dunegrass (*Leymus mollis*) in this report. *Potentilla pacifica* in Kennedy is Silverweed (*Potentilla egedii*) in this report. *Pyrus fusca* in Kennedy is Pacific Crabapple (*Malus fusca*) in this report.

On the area west of the Shelly Road Viewing Tower (the West Marsh), the process was started to classify and map the entire estuary using the BEC system (MacKenzie and Moran, 2004; BCCDC, 2009).

2.2.5 MAPPING OF PLANT DATA BY COMMUNITY

Plant community mapping copied the GSU as a feature from the GSU map and pasted it into the layer (theme) appropriate for that community. We used ortho/air photo interpretation (Quads 07, 08, 11, 12 and 13; 2007) and ground photos to map GSUs that did not have sample plots
We started mapping at the area west of the Shelly Road Viewing Tower (the West Marsh) which had not been mapped by Kennedy. We used the Biogeoclimatic Ecosystem Classification (BEC) system.

On the eastern marshes, the purpose was to make a comparison of old and new maps. To aid comparisons at a similar scale, the Kennedy map from 1976 was scanned into a digital file, the geographic data made to fit (i.e. rubber sheeted) the projection of the 2007 ortho/air photos (Quads 07, 08, 11, 12 and 13; 2007) and then digitized by a GIS technologist directly from the hardcopy of the 1976 polygons.

The decision about what plant community was represented by (or typical of) each GSU polygon was made primarily on the basis of air/ortho photo interpretation on the computer. This was greatly aided by the vegetation sample plot data and the ground photos both at the plot locations and at any other location where a photo was taken and the location was recorded with a GPS.

The result is two comparable maps of the same estuarine areas (San Pareil Lagoon, San Pareil High Marsh Finger, East River Channel, Big Island, the current (2007) Main River Channel, and the Centre Marsh) separated by a period of 32 years. One map is the plant communities on the estuary in 1976 and the other is of the vegetation in 2008 using our interpretation and modification of the plant communities as Kennedy described them (Kennedy, 1982).

2.3 Vegetation Survey - Transect Sampling Methods

The transect component of this project was reduced to one permanent photographic transect 55m long designed to cross an area that appeared to be be heavily grazed. The transect was surveyed using a GPS (Garmin GPSMAP 76CSx) and its end points were marked with 70cm U-shaped re-bar pounded like a staple into and below the surface of the marsh. Orange flagging tape was attached to the re-bar staple during the work and then removed later. During the process, a reeled tape measure was stretched and tied from the start of the transect to its finish, along the south side of the transect. The tape was removed later.

Moving from west to east, and walking on the right (south) side of the transect, a photo was taken every five metres, being careful to include the tape (and a boot) in the picture but not to step across the tape measure into the sample area. The camera was consistently held at lower chest level, approximately 110 centimetres off the ground surface, but this is not particularly important as long as a one-metre square of untrampled vegetation and the tape measure are both clearly visible in each photograph. It was assumed that this method would require modification for areas where the vegetation was too high to photograph easily for a person on the ground so a sturdy wooden box was brought for standing on. (A step ladder, stool or chair would sink into the substrate.) However, as it turned out, the box was not needed on this particular transect.

2.4 Vegetation Surveys - Results and Discussion

The changes in vegetation on the Englishman River estuary over the 32 years from 1976 to 2008 are described here from east to west, based on the map from 1976 (Kennedy 1982) and the plant community map that is based on the 2007 and 2008 data collected in this project. Each of the two plant community maps is superimposed on the same ortho photo from 2007 to aid in comparison, but it is important not to attempt interpreting the 1976 map from this report as if the features on the 2007 ortho basemap were present in 1976. The plant community definitions used were those developed by Kennedy but with the modifications described under the Methods - Mapping section above.

2.4.1 Behind the Mine Road Dyke

The south end of the Mine Road Dyke starts where a vehicle on Plummer Road entering San Pareil - Shorewood subdivision would first encounter houses as the road turns suddenly northeast. Behind the Mine Road (San Pareil) dyke, alienated from most of the influences of the river and the ocean, the terrestrial plant communities have shown an increase in the total area covered by shrubs and trees. Kennedy recorded two plant communities: K6 in which 5 species of shrubs occur but none are dominant or subdominant, and K7, which does not include any shrubs at all. Much of the area that had a few shrubs in 1976 (K6), is now dominated by shrubs (K16 and K17), although approximately half of the K6 remains today as a mosaic of shrub patches and grass/forb patches. The area that was formerly occupied by K7 (no shrubs) is now almost completely covered by shrubs and small trees (K16, K17, K19).

The terrestrial communities behind the dyke appear to be moving through a process of natural succession towards a forest cover. Unless there are changes in land use, such as livestock grazing, increased pedestrian or bicycle traffic, or a breach in the dyke, it is likely that the area will become a forest within another 20 to 50 years. If this occurs, most of the meadow grasses and forb species will be shaded out and disappear because they are early seral and depend on an abundance of light; this includes most of the invasive species present at that location including Quack Grass (*Agropyron repens*), Common Velvet Grass (*Holcus lanatus*), Orchard Grass (*Dactylis glomerata*), Reed Canary Grass (*Phalaris arundinacea*), Creeping Thistle (*Cirsium arvense*), and Bull Thistle (*Cirsium vulgare*). The invasive shrubs Scotch Broom (*Cytisus scoparius*) and Armenian Blackberry (*Rubus armeniacus*) will also likely disappear, except at the edges of the forest. Continued succession towards a forest would also result in eventual reduction of some native species as well, such as Nootka Rose (*Rosa nutkana*) and Western Terrestrial Garter Snake (*Thamnophis elegans*).

This area suffers a serious threat from new invasive species being introduced adjacent to San Malo Drive, in the vicinity of the bicycle park. It appears that several introductions to the area have already come from dumped yard waste, prunings, flower pots and planters. Our observations of yard waste dumped in this area in 2008 indicate that the potential for disastrous introductions is ongoing.

2.4.2 Jamieson Wetland

Within the dyked area, there is also a wetland at the northern end. In 1976 the wetland supported a community with Lyngbye's Sedge (Carex lyngbyei) in association with 15 or more other vascular plant species (K8 plant community). In 2008, much of the area has become nearly monospecific stands of Tule (*Scirpus lacustrus*) or Seacoast Bulrush (*Bolboschoenus maritimus*). The remainder is still a Lyngbye's Sedge community but most of that area has moved from K8 to K4 as shown by an increase in the proportion of Seashore Saltgrass (*Distichlis spicata*) and a decrease in overall plant diversity.

It is uncertain to the authors, what perturbations and introductions occurred during and after residential construction near the wetland since 1976, but whatever their influences, the wetland now seems stable and likely to remain a wetland into the foreseeable future. If the dyke is breached at some time in the future (Summers and McKenzie, 1990), this wetland will likely become brackish again and the Lyngbye's Sedge can be expected to expand in area.

2.4.3 San Pareil Spit

The northeastern corner of the estuary just south of the sandspit area is referred to as San Pareil Lagoon in this report. There are three plant communities/natural habitat types centered around the San Pareil Lagoon.

The locations of the sandy beach and spit areas at the northeastern corner of the estuary have moved and changed over time, based on the air photo records. Beach and spit plant communities (K11), often typified by Dunegrass (*Leymus mollis*) and Silver Burweed (*Ambrosia chamissonis*) depend on this natural instability; if the sandy areas become stable for a sufficient length of time, other plant communities begin to take over from K11. It is likely that the edges of the K11 community have been destroyed and re-established many times as the beach and spit areas moved and changed. Although changes are occurring, the equivalent of ecological stability can be present if the total area of beach and spit habitat remains relatively constant over time.

If we make an estimate of the historic area of K11 community on the east side of the Englishman River and we base the estimate on the size and appearance of the spit in a 1954 air photo (BC 1667 No.49), the beach and spit community would likely have occupied approximately 7 hectares at that time. Unfortunately, these plant communities were not mapped in 1976 so the changes since then are difficult to assess. If we base the estimate on the size of the spit in the 2007 air/ortho photo, as if the residential development of the spit had never occurred, we get an estimate of 3.5 to 5 hectares of potential beach and spit community. The actual size of the remaining intact beach and spit community on the east side of the Englishman River, near its mouth, is approximately 0.75 hectares.

The beach and spit areas in the vicinity of San Pareil support some invasive species such as Scotch Broom and a small amount of pedestrian traffic, but otherwise they are in a relatively natural state.

Today beach and especially spit communities are some of the rarest on the east coast of Vancouver Island (Ward et al. 1998, McPhee et al. 2000). The Regional District of Nanaimo area was found to have an approximate total of 8 hectares of intact beach and spit community in around 1997. Therefore, 10% (0.75 hectares) of the remaining intact beach and spit community in the entire regional district is located in that little patch of intact sandy beach vegetation on the east side of the mouth of the Englishman River.

Thin soils make them vulnerable, even to pedestrian traffic. They could also be altered by erosion patterns as the river's main channel appears to be continuing its move eastward.

2.4.4 Mudflats - Low to Middle Marsh of San Pareil Lagoon

The intertidal lagoon consisted of a sparsely vegetated mud flat ringed by some saltwater and brackish marsh communities in 1976 and it is still that today. The mudflats are often coated with a thin layer of algae and many areas are sparsely occupied by Low Clubrush (*Isolepis cernua*) often coated with algae. Approximately 10 plants of Widgeongrass (*Ruppia maritima*) were encountered during an inspection of the mudflats in 2008. This is probably similar to what was present in 1976, however, there have been some changes which are described below.

The band of American Saltwort (*Salicornia virginica*) on the east side of the lagoon where the boardwalk is today has become narrower and it occupies a fraction of the area that it did in 1976, assuming similar mapping definitions then and now. A slight difference in the density of plants that is required to qualify for inclusion could make large difference in the geographic area that gets mapped as this particular community. In the field, there appeared to be an obvious and natural edge to the community, but Kennedy may have defined it otherwise so we can only draw tentative conclusions. This location is an exception, in most places on the estuary, these kinds of definitional differences are unlikely to make any significant difference to the outcome of mapping.

Based on Kennedy's plant community definition for K1, we would have expected to see Sea Arrowgrass (*Triglochin maritimum*) as the codominant with American Saltwort, but in 2008 we found Sea Arrowgrass almost absent. Instead Sea Milkwort (*Glaux maritima*) was present and often codominant in 2008 and at the lower elevations, the Sea Milkwort was often the most abundant species, below the edge of the American Saltwort and as an early seral plant community on vegetated *island* remnants surrounded by a *sea* of more sparsely vegetated mud. Note that the early seral Sea Milkwort community was not mapped by Kennedy but in this study it was mapped as a separate layer.

On the north side of the lagoon, the plant community typified by Seashore Saltgrass and American Saltwort (K2) appears to have been heavily grazed right up to the beach. Part of it appears to have been replaced by an early seral community of Sea Milkwort. Waterfowl faeces and goose footprints were observed and abundant in the area in 2007.

On the south side of the lagoon, the large area of Seashore Saltgrass (K3) that was present in 1976 is mostly gone, replaced by 'islands' of the early seral Sea Milkwort plant community surrounded by mud.

2.4.5 San Pareil High-Marsh Finger

The peninsula of high marsh that borders the south side of San Pareil Lagoon was classified in 1976 and again in 2008, as K4 at the eastern base and K5 at the northwestern tip. Assuming similar definitions then and now, the area has for more than 32 years supported plant communities that are more densely vegetated (higher biomass) and biologically diverse (more plant species) than the other plant communities at lower elevations in and around the San Pareil Lagoon. This is partly because the East River Channel has been relatively stable over that period of time, based on historic airphotos.

However, one major change appears to be underway in the last few years. All the stages of waterfowl grazing, from changing species composition through disintegrating marsh platform and finally to bare mud slumped into the low marsh, appear to be present in the area closest to the San Pareil viewing tower at the northeast corner of the high marsh finger. (See photo #   ; for more detail about the stages of waterfowl grazing on the Englishman River estuary, see the *Invasive Species* section of this report under *Canada Goose*) This suggests that parts of the high marsh finger were being grazed intensively. The goose grazing probably depends on easy and safe access to the high marsh from San Pareil Lagoon.

In 1976, the presence of one Canada Goose on the Englishman River estuary would have been an unusual sight. If numbers of the Canada Goose have been grazing the area intensely for 5 or more years, this might explain the loss or transformation of some of the other plant communities around San Pareil Lagoon. Geese using the lagoon might have grazed the Seashore Saltgrass, the Sea Arrowgrass and the American Saltwort, thus creating the conditions suitable for the early seral Sea Milkwort community to become dominant on the higher ground that was, through grazing, stressed or denuded of vegetation.

2.4.6 Mid and High Marsh Between Mine Road Dyke and East River Channel

In this area, north of the Plummer Road Forest, the plant community seems to have diversified over the last 32 years. It has transformed from a community where Arctic Rush (Juncus arcticus) and Seashore Saltgrass were abundant 32 years ago and Lyngbye's Sedge was absent (K18), to a community where Lyngbye's Sedge is now present on approximately half the area, usually on the lower elevations and often that sedge comprises more than 20% of the vegetative cover. This area is one of only 3 places in the study area (the others are the south end of the Centre Marsh area and the southwest corner of the estuary, near Golden Dawn Trailer Park) where Lyngbye's sedge appears likely to have expanded its distribution. Furthermore; these 3 areas support the only remaining pockets of tall Lyngbye's Sedge channel edge community which appears to match the description of the CDFmm Em05 *Carex lyngbyei* Herbaceous Vegetation Site Association. In that case, it is likely an occurrence of the BLUE-listed ecosystem of the same name (BCCDC, 2008). Sampling of the substrate would be necessary to confirm these 3 occurrences.

Although the Canada Goose was observed nearby on the water of the East River Channel, and there were two nests for two consecutive years just across the channel, geese were not seen using the area between the Mine Road dyke and the channel. This may be because of the frequent presence of dogs, usually with pedestrians or bicyclists during daylight hours.

2.4.7 Big Island Marsh

From 1976 to 2008, the main channel of the river has been moving east while the East River Channel appears to have changed little during that period. This report refers to the area between these two river channels as the Big Island of the Englishman River estuary. In 1976, the Big Island Marsh was a mosaic of many plant communities and it remains that today. The changes over time can be seen when comparing Kennedy's map of the plant communities in 1976 (Map, Figure 2.1) with the mapping that was done 32 years later as part of this project. (Map, Figure 2.2). The two plant community maps are superimposed on the same ortho photo from 2007 to aid in comparison but it is important not to attempt interpreting the 1976 map as if the features on the 2007 ortho basemap were present in 1976.

Natural succession has occurred at the edge of the marsh as shrubs colonize the graminoid areas and trees colonize the shrub areas.

Erosion from 1976 to 2007 appears to have removed approximately 65 to 75 metres all along the western edge of Big Island Marsh as the main channel of the river continued to move east. Of the Lyngbye's Sedge community (K8) that was once there, only a few tiny pockets remain; they can still be identified by the species present (Lyngbye's Sedge, Tufted Hairgrass *Deschampsia cespitosa,* and Sea Plantain *Plantago maritima*). They are growing on steep sided islands among the large woody debris deposited by the river but now their location is on the opposite side of the river channel from where they were 32 years ago because the main channel has moved.

In contrast to the Centre Marsh, most of the marsh on Big Island appears to have been protected from active river erosion. During the study period two flood events were observed in which the river water levels were exceptionally high; the depth of the water in parts of the Big Island forest was sufficient to plaster sticks and leaves 5 to 100 cm up the tree trunks, depending on the elevation of the tree and its location in relation to old channels in the forest. However, the force of the water seems to have been insufficient to tear at the ground surface or topple trees in the forest. In fact, the opposite was observed; new depositions of fine alluvium were present in some broad areas after the flood. Deposition suggests that the water was moving relatively slowly with low turbulent energy, in spite of the flood. It seems likely that the trunks of the trees dissipated the energy of the river's flood water.

Except for erosion near the main river channel, active erosion on Big Island from 1976 to 2008 appears to have been confined to sediment at the edge of a steep-sided bowl, over one metre deep, which has formed at the southern tip of the main tidal channel. This bowl probably looks like a small waterfall when floodwater moving northward exits the forest during 1-year to 5-year flood events.

2.4.8 Main Tidal Channel on Big Island

In spite of what appears to be protection from erosion, the plant communities centered around the main tidal channel on Big Island seem to have undergone major changes since Kennedy mapped the area as being dominated by Lyngbye's Sedge in K8 and K4 plant communities. In 1976, the K8 community occupied the length of the main tidal channel (Big Island) across a width ranging from 10 to 20 metres and it had a large contiguous appendage running from the main tidal channel onto higher ground to the northwest; the total area of this polygon of K8 community in 1976 was approximately 0.6 hectares. Surrounding this K8 polygon, Kennedy's map shows four K4 polygons.

One of these is the K4 polygon fronting on the East River Channel. The K4 areas that are situated north of the K8 polygon and fronting onto the East River Channel are excluded from this analysis because their existence is hypothetical. In 1976, the K4 plant community that Kennedy mapped there would have required marsh-like conditions with frequent, almost daily flooding by brackish water. Today that area appears to be a mound of material rising more than a metre above the marsh and the river. The mound appears to be a continuation of the levee that lies southeast of it, but that levee was already in existence in 1976. Why would the levee have expanded over the last 32 years? Where would the gravel and sand have come from?

Air photo interpretation (B.C. 7760 No. 175; date=1975) at a scale of approximately 1:10000 suggests perhaps a natural process may have created the levee and that same process is continuing to act periodically or seasonally on the East River Channel and Big Island, burying the sedge marshes there and extending the levee northwards.

Sometime between 1976 and 2007, the river bed of the East River Channel may have been dredged, perhaps to enhance log booming or to channel floodwater, and then the dredged material was filled on top of the K4 marsh community, creating a mound of gravel where, in 1976, there used to be a marsh dominated by Lyngbye's Sedge.

Perhaps, a simple transcription error was made by Kennedy. On the 1975 air photo, the areas on both sides of the entrance to the main tidal channel of Big Island appear to have some upland vegetation that Kennedy did not seem to record on her map. Perhaps the areas in question never were K4 brackish marsh communities and Kennedy knew that; her intent was to label the plant community on the levee as K17 or K16 but for some reason it was labeled K4 by mistake.

No single hypothesis seems to explain the observations. More time would be needed to research the history of dredging in that location before that area could be included in an analysis of the vegetation changes, natural or anthropogenic, that have occurred there in the last 32 years.

- areal extent of the changes
Excluding those areas that are now a mound of gravel, the three other K4 polygons surrounding the main tidal channel on Big Island in 1976 had a total area of approximately 0.6 hectares (.02ha + 0.1ha + .55ha - .07). Thus, the total area occupied by plant communities with Lyngbye's Sedge as a dominant or codominant species (one K8 polygon and three K4 polygons) in and around the main tidal channel on Big Island in 1976 was approximately 1.2 hectares. In 2008, only .24 hectares (20%) of sedge communities remained in that area, and all of it was K4. In 2008, the K8 community was gone completely including the tall Lyngbye's Sedge channel-edge community that was likely present there as part of the K8 polygon that was mapped in 1976.

- the changing shape of tidal channels
However, two-dimensional mapping does not tell the whole story; the 32-year transformation of this 1.2 hectare area has more than two dimensions. What was likely a narrow, steep-sided channel with permanent water in it, even at low tide, is now a broad flattened channel that is low relief (like the cross section of a saucer). In 1976, the tall Lyngbye's Sedge channel-edge community would likely have overhung the steep channel edges providing shade and cover for aquatic animals in the channel and the roots would have provided stability for the steep sides. Today, the centre of the saucer lacks standing water at low tide, so it is no longer suitable for fish.

- what replaced the sedge communities?
Approximately 80% of the sedge community (K8 and K4 combined) at this location had been replaced by 2008. The highest elevation parts of the sedge communities were replaced by a community that we described in 2008 as 'Simplified K4&K8-b.' It is typified by some native species like American Saltwort and Silverweed cinquefoil (Potentilla egedii) that are likely remnants of the community that has been modified by grazing but it also includes invasive species like European Annual Saltwort, Brass Buttons and Creeping Bentgrass (Agrostis stolonifera) which seem to be more tolerant of, or less targeted by, the grazing. The total vegetative cover for many parts of this Modified K4&K8 area is less than 50%, and the plants that are present appear to be cropped short and often depauperized. Compare this with the greater height and density of the plant cover on the area beyond the grazing edge (mostly community K14).

At lower elevations, the sedge communities were replaced by the early-seral Sea Milkwort community and at the lowest elevations near the channel, the sedge communities were replaced by a community comprised of mud, mud-surface algae and sparse Low Clubrush (*Isolepis cernua*). Widgeongrass (*Ruppia maritima*) was probably present in the centre of the channel for the length of the main tidal channel on Big Island in 1976, but in 2008 its occurrences were few and sporadic in the lower half of the main tidal channel on Big Island. For understanding the changes over time, it is unfortunate that Kennedy did not map the K1 (or similar) community in the narrow channel as separate from the K8 community that would have likely overshadowed it in 1976.

- the grazing front
The active grazing front follows the edges of the this same area where Lyngbye's Sedge was once dominant or codominant and most of the area that lies below (i.e. lower in elevation from) this active grazing line no longer supports Lyngbye's sedge.

2.4.9 Centre Marsh

The river and tidal channel immediately east of the Shelly Road Viewing Tower was the main channel of the Englishman River in 1976. The area between it and the new (2008) main channel is referred to in this report as Centre Marsh. It is a mosaic of different plant communities, many of which appear to be in various stages of succession after the disturbance associated with flooding by fast flowing river water as the river destabilized and moved its location a number of times in that 32 year period. Changes in the plant communities can be seen by comparing the map from 1976 (Kennedy 1982) with the plant community map from 2008 that is based on data collected in this project. The two plant community maps are superimposed on the same ortho photo from 2007 to aid in comparison but, again, it is important not to attempt interpreting the 1976 map as if the features on the 2007 ortho basemap were present in 1976.

Changes to the vegetation have occurred in nearly every polygon of Centre Marsh since 1976. However, the largest changes have occurred in the communities where Lyngbye's Sedge was one of the dominant species (K10, K8 and K4).

- areal extent of transformation
In contact with the northwestern edge of the marsh, there were three polygons of Lyngbye's Sedge, one polygon of K10 plant community and two polygons of K8 plant community in 1976. These three sedge-dominated polygons with a combined total of approximately 2.2 hectares (1.5 + 0.6 + 0.2) are now completely gone, replaced by an archipelago of Early Seral Sea Milkwort Community with unvegetated or sparsely vegetated sand and pebbles in between the islands of Milkwort.

- changes in biomass, productivity, biodiversity and marsh platform
There appears to have been a major decrease in the biomass, productivity and diversity of that part of the estuary because Sea Milkwort does not grow as tall or a dense as the communities that were there in 1976. It is likely that this was accompanied by erosion of the rich alluvial silt and organic matter, sometimes more than a metre thick, that would normally be associated with the Lyngbye's Sedge plant communities, and held there by the roots of the sedges and other brackish marsh plants. As on Big Island, a few remnants of this marsh platform remain surrounded by the simpler early seral marsh typical of disturbed lower elevations.

A number of possible explanations can be hypothesized to explain the changes in the Centre Marsh:

1. Increased salinity -

Since Lyngbye's sedge seems dependent on brackish water, if an increase in salinity occurred, it might eliminate the sedge and the resultant loss of the rootmass might destabilize the whole marsh platform. An increase in salinity could be caused by changes in the location of the main river channel. Between 1976 and 2008 there have been changes to how the freshwater mixes with the salt. The rising sea level from global warming makes estuaries particularly vulnerable because an increase of only a few millimeters might affect a large geographic area if it is low elevation and flat (low relief). The possible change in relative sea level from plate tectonics as Vancouver Island continues to rotate on its long axis, could complicate prediction of the sea levels resulting from global climate change. For more details and references, see section on *Topography, Surficial Geology and Hydrology of the River System* in the *Introduction* to this report.

The river may be carrying less water because of the increase in licensed removals that have been granted, and possibly an increase in unregulated uses (through new uses of riparian rights and groundwater, or possibly through illegal withdrawals).

Changes in other climatic or hydrological factors that affect the seasonal flow regime might create an increase in salinity that occurs in summer only. For example, the deforestation of the watershed that has occurred over the last 150 years might have increased flows in winter and during floods. At the same time it decreased freshwater availability during summer and other periods of low flow because of an increased tendency for the river to discharge its water more quickly than in the past (For more details and references, see the *Introduction* to this report).

2. Erosion by the river -

As the main river channel moved east, large amounts of fast moving water might have been crossed these polygons at times during the period from 1976 to 2008, disturbing and scouring the surface of the marsh.

3. Erosion by storms and large woody debris -

Note that all three areas where the sedge plant communities vanished are facing the open Strait of Georgia. Around some of the large woody debris scouring of the vegetation appears to have occurred in an arc around the tree, with the root ball apparently acting like an anchor.

4. Grazing by waterfowl -

During the period from 1976 to 2008, Canada Goose numbers increased from between one and 10 seasonal visitors to hundreds of birds that appear to be resident (see *Canada Goose* in the section on *Invasive Species* below.

At the south end of the Centre Marsh in 1976 Kennedy delineated an area as Red Alder Plant Community (K19). This community's description does not include Lyngbye's Sedge. In 2008, approximately 25% of that area was unrecognizable because it lies within the new main channel of the river. To understand this, compare the same area in the maps in Figure 2.1 and Figure 2.2. Other areas appear to have developed a plant community on top of part of the log jam that occurred there years ago. Patches of the land that remained terrestrial since 1976 were occupied by Lyngbye's Sedge in 2008; in the 2008 map (Figure 2.2) this area is shown as unclassified polygons. The conditions suitable for Lyngbye's Sedge were probably created by an increase in the salinity of the water and substrate brought about by greater tidal inflows up the Western River Channel as the main flow of the river moved away from the Western River Channel. Comparing the records suggests that the south end of Centre Marsh is one of 3 areas where Lyngbye's Sedge has expanded its distribution on the Englishman River estuary during the last 32 years; in each case there appear to be pocket occurrences of the CDFmm Em05 *Carex lyngbyei* Site Association. These might represent occurrences of the BLUE-listed ecosystem of the same name (BCCDC, 2008). Substrate sampling would need to be done to confirm this presence.

West Marsh

In this report, the area referred to as the West Marsh is that part of the estuary lacking trees and shrubs that is situated west of the Shelly Road tower and the dyke which is a continuation of the drivable trail that runs north from Shelly Road. The dyke effectively closed the West Marsh to the influences of tide and saltwater from 1969 to 1979, with the possible exception of periods when the flapgate in the culvert under the dyke was in disrepair. Dawe and McIntosh (1993) comment that the culvert was almost blocked by Blue Mussels, so the influences of tide and salt may have been effectively excluded even when the flapgate was jammed open. In 1979, that dyke was breached and the gap was spanned by a bridge. This reopened the entire western part of the estuary to the influences of tide and salt water. The bridge has since been removed and the breach was widened to improve the connection between the West Marsh and the rest of the estuary, the Englishman River and with the Strait of Georgia.

Kennedy's mapping of the estuarine plant communities in 1976 did not include the Western Marsh, likely because at that time it was alienated and not functioning as part of the estuary. However, numerical baseline data were collected on 9 transects starting in 1979, within 12 weeks after the breaching of the dyke, and it continued each year near the end of June until 1983, and then again in 1986. Vegetation cover data was collected using the Braun-Blanquet scale for each species within a one-metre square releve placed at five-metre intervals along the transects. From this, percent cover and frequency of occurrence data was calculated. The methods and the details of vegetation changes during that period are described by Dawe and McIntosh (1993).

They grouped the species present according to the changes in frequency of occurrence in their 200 releve sample plots within their period of observation:

upland species that disappeared from the study area during the period from 1978 to 1986,

colonizing species that arrived after the dyke was breached in 1979,

ephemeral species that appeared and disappeared with irregularity, and

residual species that were present in the study area before and after the breaching of the dyke:

species that increased in frequency of occurrence,

species that stayed the same and

species that declined in frequency of occurrence during the period of study.

The results indicated a sudden die-off of salt intolerant species followed by an invasion of the newly bare soil by salt-tolerant colonizing species that included some annuals and some non-native species. "By 1986 (the end of the study), the marsh was dominated by the *Distichlis - Salicornia virginica* community which included over 52% of all the releves; halophytic vegetation was now dominant," (Dawe and McIntosh 1993). Seashore Saltgrass (*Distichlis spicata*) and American Saltwort (*Salicornia virginica*) are perennial native species.

Dawe and McIntosh noted that a decline in both the frequency and percent cover of Lyngbye's Sedge on the study site had occurred just before and after the end of their study period. Some areas with 100% cover of Lyngbye's Sedge in 1983, were "devoid of vegetation or held only Spergularia canadensis (Canadian Sand-spurry) in 1986." They attributed this, at least in part, due to the increases in soil salinity that they measured along the transect. As a brackish marsh species, Lyngbye's Sedge is dependent on inputs of both fresh and saltwater and the soil salinity appeared to have moved above the level that the species could tolerate.

The major changes to the West Marsh since 1986 seem to be a continuation of the trends observed during their 1979 to 1986 study period. In 2008, communities dominated by Seashore Saltgrass and/or American Saltwort continued to cover the majority of the ground in the middle marsh area. Most of the area appeared to be CDFmm/Em03 *Distichlis spicata* Site Association which is likely an occurrence of the RED-listed ecosystem of the same name. Substrate sampling was done at 8 locations and the findings of fine-textured poorly drained sediments support the designation of these polygons as CDFmm/Em03. However, to classify other polygons where Seashore Saltgrass was observed or interpreted to be most abundant, it would be necessary to do substrate sampling at a typical location within each of those polygons.

In 2 of the polygons sampled, the CDFmm/Em03 Site Association appeared to be complexed with the CDFmm/Em02 *Salicornia virginica-Glaux maritima* Site Association. CDFmm/Em02 occurred at sites closer to the main tidal channel and, at the two locations sampled, the substrate of the CDFmm Em02 sites appeared to present less of a barrier to drainage than did the substrate at the CDFmm/Em03 sites. Closest to the main tidal channel in the West Marsh, we found a vegetation cover that best matched the CDFmm/Em02 *Salicornia virginica-Glaux maritima* Site Association, but no substrate sampling has been done there yet to confirm this occurrence.

In the West Marsh, the main tidal channel itself appears to be an occurrence of the CDFmm/Em01 *Ruppia maritima* Herbaceous Vegetation Site Association with Widgeongrass and Low Clubrush present on mostly muddy substrates. Canadian Sand-spurry was also present in some areas of the channel - a species which is not listed as part of that Site Association in the description by MacKenzie and Moran (2004). This presence of CDFmm/Em01 *Ruppia maritima* Herbaceous Vegetation Site Association is likely an occurrence of the RED-listed ecosystem of essentially the same name (BCCDC, 2008)

Dawe and McIntosh provide baseline data on the distribution of Lyngbye's Sedge within their transects on the West Marsh during the period from 1979 to 1986. Unfortunately, baseline data on the distribution of that species on the remainder of the West Marsh is not available. By 2008, Lyngbye's Sedge appeared to be absent from the northern and central parts of the West Marsh. This matches the trend that Dawe and McIntosh noted on their transects by 1986, the end of their study period.

Lyngbye's Sedge was present in 2008 from near the Mills Road storm drain outfall, just downslope (west) of the area where Cattails (*Typha latifolia*) grow in freshwater, west to the southwestern corner of the study area, near the Golden Dawn Trailer Park. Within that area it is present on both sides of the main tidal channel of the West Marsh, but occurrences are patchy and not all contiguous. In some areas near the main tidal channel and in the southwest corner of the estuary near Golden Dawn Trailer Park, Lyngbye's Sedge is present as the most abundant species, 50 to 70 centimetres tall, in a channel edge plant community (see photos #) that is typical of brackish areas on other nearby estuaries such as the Little Qualicum River estuary. This appears to be one of 3 remaining occurrences on the Englishman estuary of the CDFmm Em05 *Carex lyngbyei* Herbaceous Vegetation Site Association described in MacKenzie and Moran (2004) and it likely represents an occurrence of the BLUE-listed ecosystem (BCCDC, 2008) of essentially the same name. However, confirmation of this classification would require sampling of the substrate which has not yet been done.

It is likely that Lyngbye's Sedge tall channel edge community did not occur this far upstream (upslope) on the West Marsh prior to the breaching of the Shelly Road dyke in 1979, however it may have been present as a stressed remnant from the time before the dyke was completed. The stormdrain outfalls at Mills Road and Bagshaw Road and the small creek that enters the southwest corner of the estuary near the Golden Dawn Trailer Park, would likely have been providing freshwater to the area 35 years ago, as they do today. However, Lyngbye's Sedge also requires the tidal input of saltwater to create the brackish conditions that it needs. This salt input would not have been available prior to breaching the dyke, so the southwestern corner of the estuary was more likely to support Cattails than support a thriving Lyngbye's Sedge community. Dawe and MacIntosh recorded the disappearance of Cattails from their study area.

Section 2 Plant Communities - 1976 by Kennedy 1982

Legend Section 2 Plant Communities - 1976   by Kennedy 1982

Section 2 Plant Communities – 2008 ,

Legend Section 2 Plant Communities – 2008 ,