EVALUATION OF SYSTEMS TO CLASSIFY AND MAP COASTAL PROCESS ZONES, AND TO ASSESS AERIAL PHOTOGRAPHY.

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Table of Contents Page

List of Figures and Tables

CHAPTER I. The Coastal Zone

I. 1. Introduction

The coastal zone is one of British Columbia's most valuable attributes. In recent years, land and water use have become concentrated in this zone. As a result, there have been conflicts between the man-made and the natural environment. With increasing pressure on the coastal zone to provide more resources and support more uses there is a definite need for coastal zone planning and management.

In the past there has been little effort towards management or planning of the coastal zone of British Columbia. This was due, in part, to: 1. The attitude that existing conflicts were not too serious and that the coastal zone was so extensive that its resources were "inexhaustible", 2. The compartmentalization of the coastal zone's component parts (land, water, and air) by government jurisdiction and by scientific disciplines, 3. The complexity of the coastal zone, and 4. The wide variety of use options it provides and thus the diversity of demands placed on it.

CHAPTER II. The Coastal Zone Defined

II. 1. Defining the Coastal Zone

It is important that the coastal zone be regarded as a system because as Clark (1974) noted, the "basic unit of coastal management is a single and complete ecosystem including the coastal water basin and the related adjacent shorelines."[1] Coker (1962) substantiates this when he emphasizes that "it is important for us to keep in mind that the oceans, the land areas, and the atmosphere are not to be regarded separately, but are really parts of one great system."[2]

The United States Army Coastal Engineering Research Center(1975) defines the coastal area diagrammatically[3] as that area of land and sea including the "zone of variable width...seaward from the low tide shoreline covered by water over which the beach sands and gravels oscillate with changing wave condition (inshore),"[4] and the foreshore, the backshore and the coast, that "strip of land

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[1] J. Clark, Coastal Ecosystems (Washington, 1974), 178 pp., Quoted in Dana D. Silk, A Basis for Coastal Classification in Atlantic Canada (Halifax, Nova Scotia, 1975), P. 31.

[2] R.E. Coker, This Great and Wide Sea (New York, 1962), 325 pp., Quoted in Dana D. Silk, p. 31.

[3] U.S. Army Coastal Engineering Research Center, Shore Protection Manual, Volume I (Fort Belvoir, Virginia, 1975), p. 1-3.

[4] U.S. Army Coastal Engineering Research Center, Volume III, p. A-33

of indefinite width (may be several miles) that extends from the shoreline inland to the first major change in terrain features."[5]

This definition of the coastal zone has not been widely accepted as a management or planning definition but it does outline the two major problems in defining the coastal zone: delineating the seaward and the landward boundaries.

The Seaward Boundary

With the enactment of the Federal Coastal Zone Management Act of 1972, the coastal states of the United States have attempted to define the boundaries of the coastal zone. While it is generally accepted that the area extending from the shoreline to "the depth at which waves first interact with the land...,"[6] is part of the coastal zone, the drawing of "a geographic boundary line is an arbitrary act. However, a line must be drawn."[7]

The United States Coastal Zone Management Act ((CZMA) 1972) defines coastal waters as: "...those waters adjacent to the shorelines, which contain a measurable

[5] U.S. Army Coastal Engineering Research Center, Volume III, p. A-6.

[6] Dana D. Silk, A Basis for Coastal Classification in Atlantic Canada, (Fredericton, New Brunswick, April 1975), p. 32.

[7] A Staff Working Paper, Alternative Boundaries for New Jersey's Coastal Zone, (Trenton, New Jersey, 1976), p. 4

quantity or percent of seawater, including but not limited to sounds, bays lagoons, bayous, ponds, and estuaries."[8] The problem with this approach to defining the seaward limit of the coastal zone is that "a salinity threshold is arbitrary and not ecologically significant. Salinities are highly variable in all dimensions and are not appropriate for virtually fixed boundaries."[9]

Many coastal classification systems, for example Bauer (1976),[10] include the nearshore zone as part of the coastal zone. According to the Office of Coastal Zone Management the coastal states of the United States should arbitrarily delineate the seaward limit of the coastal zone as the state's offshore jurisdictional boundary. Owens (1974) has the most all-inclusive definition of the extent of the coastal zone which he claims should extend to the outer edge of the continental shelf.

Silk (1975) reports that while the seaward extent of the coastal zone should be defined by the nearshore zone, "offshore areas must also be considered, but like inland areas that are only indirectly connected with coastal processes, they do not warrant the attention that

[8] A Staff Working Paper, Alternative Boundaries for New Jersey's Coastal Zone (Trenton, New Jersey, 1976), p. 11.

[9] Alternative Boundaries for New Jersey's Coastal Zone, p. 11.

[10] Wolf Bauer, Western Community Shore-Resource Analysis, 1976. passim.

must be given to the very heart of the coastal zone."[11]

The Inland Boundary

In Canada there is no accepted definition of the coastal zone and no guidelines adopted for its delineation. In the United States, however, thirty-four coastal states are developing management programs under the CZMA of 1972[12] and must define coastal zone boundaries. The definition of the inland boundary for the coastal zone is directed by CZMA guidelines which determine the criteria to be used in formulating these boundaries. According to those guidelines, the coastal zone "extends inland from the shoreline only to the extent necessary to control shorelands, the uses of which have a <u>direct</u> and <u>significant</u> impact on the coastal waters (emphasis added)."[13] "Whatever inland boundary is chosen should be a relatively permanent feature (ie. existing political boundary, railroad, canal, interstate highway, (break in slope)). It should also enable the public to easily recognize what areas are included within the Coastal Zone, and what areas

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[11] Silk, p. 32.

[12] U.S. Department of Commerce, National Oceanic and Atmospheric Administration, Office of Coastal Zone Management, <u>State of Washington Coastal Zone Management Program</u> (Washington, 1976), Appendix I.

[13] New Jersey Department of Environmental Protection, Office of Coastal Zone Management, <u>Alternative Boundaries for New Jersey's Coastal Zone</u> (Trenton, New Jersey, 1976), p. 7.

are excluded."[14]

In order to attain the definition of the inland boundary of the coastal zone for management and planning purposes many alternatives have been investigated. Some of these include:

1. Biophysical Parameters

i. Geology: The only coastal state of the United States to define the inland boundary of its entire coastal zone on the basis of a geologic feature has been Virginia. Virginia's coastal zone extends inland to the fall line which is a major geologic feature of the state.

The state of Louisiana has a line of geologic contact between a Pleistocene terrace and marsh, swamp and floodplain deposits along its coast. Through studies it was determined that this line of contact was "the major factor delineating coastal from non-coastal features and wetland from non-wetland features."[15] The line of contact is also associated with a topographic break in slope.

One of the inland boundary alternatives for the state of Georgia is called the Talbot geologic formation, an ancient coastal shoreline. The 50-foot contour line corresponds to this formation. This alternative boundary includes: 1) headwaters of small creeks and rivers of

[14] William G. McIntire, Marc J. Hershman, Rodney D. Adams, Kai D. Midboe, Barney B. Barrett, A Rationale for Determining Louisiana's Coastal Zone (Baton Rouge, Louisiana, 1975), p. 9.

[15] McIntire et al., p. 9.

coastal watersheds which flow directly into salt water, 2) all tidally influenced rivers and wetlands, 3) many fresh water swamps which provide many functions related to rivers and swamps.

Another geologic formation which forms an inland boundary alternative for Georgia's coastal zone is the Wicomo geologic formation, another ancient coastal shoreline. This formation is approximated by the 100-foot contour and forms the escarpment of the lower Coastal Plain. Therefore, it "defines a natural landward boundary of 'Geologic Coastal Georgia'."[16]

The Department of Environmental Protection of the state of New Jersey has an alternative inland boundary concept called the "Coastal Plain." In this concept the geological area known as the Coastal Plain would be included in the coastal zone. "This coastal plain is highly uniform with respect to numerous factors critical to resource management (ie, geology and hydrology)."[17] This geologic area, however, could not form the inland boundary of the coastal zone for the entire state because it does not reach the full length of the coastline.

ii. Elevation: McIntire et al. (1975) examined the use of the 5 and 25-foot contour lines as alternative

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[16] Georgia Department of Natural Resources, Alternative Inland Boundaries of the Coastal Zone (Atlanta, Georgia, 1976), p. 12.

[17] New Jersey Department of Environmental Protection, Office of Coastal Zone Management, p. 33.

inland boundaries for Louisiana's coastal zone. The contour lines were very irregular, following local relief and extending well up river valleys. The 5-foot contour was found to approximate the Pleistocene/Recent contact (see geology section) and delineated on 1:24,000 maps; the most detailed maps available which provide across-state control. The 25-foot contour line was considered because it was the lowest elevation on 1:250,000 maps produced by the U.S. Geological Survey.[18]

The Nassau-Suffolk Regional Planning Board of the State of New York defined thir 'primary' coastal zone as 1000 feet from mean high water or to the 10-foot contour line, whichever was greater. The State of Alaska has also defined its initial coastal planning area on the basis of the 200-foot contour line. In addition, areas which are deemed to be directly or indirectly related to coastal waters (coastal wetlands, streams and lakes with anadromous fish runs, migratory waterfowl nesting areas, etc.) were mapped and the coastal boundary defined to include these physical/biological areas.

iii. <u>Arbitrary Inland Distance</u>: The states of New York and Claifornia have adopted the arbitrary distances of 1000 feet and 1000 yards respectively, inland

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[16] Georgia Department of Natural Resources, Alternative Inland Boundaries of the Coastal Zone (Atlanta, Georgia, 1976), p. 12.

[17] New Jersey Department of Environmental Protection, Office of Coastal Zone Management, p. 33.

from the mean high tide level to delineate the inland boundary of their coastal zone. New York uses the 1000-foot distance where it includes an area of land greater than the 10-foot contour line. California uses the 1000-yard distance except in areas of special concern and urban or built up areas.

iv. Coastal Wetlands: This alternative has been addressed by McIntire et al., (1975) through references to the many parameters by which coastal wetlands may be defined.[19] The Georgia Department of Natural Resources also considered coastal wetlands for an alternative inland boundary of the coastal zone but defined it according to the 50-foot contour line (or Talbot geologic formation) rather than the 5-foot contour line (or Pleistocene/Recent geological contact)[20] as McIntire et al. do for Louisiana. For Georgia this alternative includes rivers, marshes and swamps below the 50-foot contour (refer to Georgia Department of Natural Resources (1976) for the reasons that wetland areas have direct and significant affects on coastal waters).[21]

v. Vegetation: Scientists in Louisiana have studied the distribution of wetland vegetation and plotted

[18] McIntire et al., p. 34.

[19] McIntire et al., passim.

[20] Georgia Department of Natural Resources, p. 14.

[21] Georgia Department of Natural Resources, p. 16.

The boundary between wetland and non-wetland vegetation. It is this wetland/non-wetland boundary that is defined by the vegetation and is being considered as an alternative inland boundary. The importance of wetland vegetation in combination with nutrient interdependent river basins was emphasized and supported the rationale that portions of the river basins of Louisiana should be included in the coastal zone.

Loucks (1968) reports that "the presence or absence of indicator species that are particularly susceptible to marine air masses"[22] can form a tool for delineating the landward extent of the coastal zone. As Silk (1975) notes, however, "the affect of salt spray is diminished in areas with sufficient precipitation to wash off the salt before it does much damage."[23]

vi. Tidal Wetlands: An alternative inland boundary for Georgia's coastal zone is the inland limit of tidal wetlands. "This alternative includes rivers and adjacent wetlands influenced by the force of the tide."[24] Tidal influence affects "vegetation, wildlife patterns, and other resources (refer to p. 18 of Alternative Inland

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[22] O.L. Loucks, A Forest Classification for the Maritime Provinces, (Ottawa, Ontario, 1968), 167 pp. Quoted in Dana D. Silk, p. 28.

[23] Dana D. Silk, p. 28.

[24] Georgia Department of Natural Resources, p. 18.

Boundaries of the Coastal Zone)."[25]

"The inland reach of that influence (tidal) is theoretically the limit that sea water would reach in the absence of freshwater flow of the rivers"[26] "The precise extent of tidal influence varies with the season, volume of freshwater flow from inland areas and other factors (e.g. the Correolis effect)."[27] The tidal influence is different from the inland extent of salinity because tidal influence on many rivers extends beyond salt water to include fresh water areas."[28] "It is always important to use as many different sources of information as are available to indicate inland limits of tidal influence (since) exact limits cannot be defined."[29]

vii. <u>Salinity--Inland Intrusion</u>: Salinity is a key factor in determining the inland intrusion of marine influences.[30] As such, salinity distributions form an alternative inland boundary for the coastal zone. It is one of the primary characteristics of seawater and "is also the parameter which most strongly influences species dis-

[25] Georgia Department of Natural Resources, p. 18.

[26] Georgia Department of Natural Resources, Appendix, p. 7.

[27] Georgia Department of Natural Resources, p. 18.

[28] Georgia Department of Natural Resources, p. 18.

[29] Georgia Department of Natural Resources, Appendix, p. 8.

[30] McIntire et al., p. 10.

tribution."[31]

The Georgia Department of Natural Resources (1976) reports that vegetative species indicate the presence or absence of saline conditions by their relative tolerance to salt water. They also report that additional information about the presence of salt water is provided by soils data, [32] but that "it is always important to use as many different sources of information as are available to indicate inland limits of salinity...(because)...exact limits cannot be defined."[33]

viii. Tidal Marshes (Fresh and Salt): Tidal marshes are "intricately and inseparately connected with coastal waters"[34] and the Georgia Department of Natural Resources (1976) which is considering the inland extent of coastal marshes as an alternative inland boundary reports that:

> tidal marsh serves a number of purposes related to coastal waters, in addition to nutrient production. The banks of tidal marshes are used by oysters and crabs, as well as birds, insects and mammals which depend upon the marsh for protection or food sources. The marsh buffers inland areas from the force of storms, and buffers coastal waters from some pollutant impacts.[35]

[31] McIntire et al., p. 49.

[32] Georgia Department of Natural Resources, Appendix, p. 3.

[33] Georgia Department of Natural Resources, p. 8.

[34] Georgia Department of Natural Resources, p. 20.

[35] Georgia Department of Natural Resources, p. 20.

For these reasons, tidal marshes should be part of the coastal zone.

ix. Faunal Distributions: McIntire et al. (1975) report studies which concentrate on: the occurrence of a brackish water clam (Rangia cuneata), inland records of crabs and marine fish, mammal and reptile ranges, and the landing patterns of large scale trans-Gulf (of Mexico) flights consisting of several species of birds. These are discussed in terms of their relevance to the inland boundary delineation problem for Louisiana. It was found that the occurrence of the brackish water clam and inland records of crabs and marine fish correlate with salinity intrusions in river basins. Distributions of mammals and reptiles which restrict their ranges to non-wetland habitats but are found in close proximity with the coast were found, in some cases, to give a good indication of the non-wetland/wetland boundary. The use of these indicator species, however, hinges on the adoption of the wetland/non-wetland boundary as an important factor when determining the inland boundary. Studies of the ability of birds in trans-Gulf migrations to select appropriate habitat while aloft gives "an indication of the coastal/inland boundaries as reflected by forest vegetation."[36] Further analysis of the landing patterns of migratory birds and the coastal vegetation are being

[36] McIntire et al., p. 11.

carried out in an attempt to find other resource considerations on which to base the inland boundary of the coastal zone for Louisiana State.

x. Shore-Functional Inland Boundaries: Oertel (1975) found that a buffer zone was necessary to protect the various components of the dune-beach-bar system of Georgia's coastal zone. "In general, the buffer zone should be located on the landward margin of the beach and on the seaward side of the offshore shoals and bars."[37] This boundary indicates a fundamental functional relationship between the ocean and the land and as such it forms an alternative inland boundary for the coastal zone.

This functional emphasis is also promoted by Wolf Bauer (1976)[38] who suggests the instigation of a zoning effort in British Columbia to identify the terrestrial boundary of the Shore-Process Corridor: "that earth-water diffusion zone which straddles the extreme limits of riverine, lacustrine, estuarine, and marine waters, including those terrestrial and aquatic fringes that can directly affect, or that are affected by, the prevailing

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[37] George F. Oertel, "The Value and Vulnerability of Coastal Beaches, Sand Dunes, and Offshore Sand Bars," in The Value and Vulnerability of Coastal Resources, ed. by Resource Planning Section, Office of Planning and Research, Georgia Department of Natural resources (Atlanta, 1975), p.29.

[38] Wolf Bauer, Western Community Shore-Resource Analysis, (Victoria, 1976).

geohydraulic and geopneumatic systems,"[39] in terms of hazardous as well as shore functional considerations and classification.

It would form a "boundary that can be assigned to any arbitrary shore-process time interval of the future. Such a 'hazard' or 'function' line may relate to setbacks from stream floodways, storm-tide flooding in shore-adjacent reponds, marshes, Class I beach berms, or the rim of receding sea bluff.s"[40] Oertel (1975) suggests that in historically retreating or unstable areas the width of the buffer zone should be based upon the hundred year rate of shoreline retreat.

While these inland boundaries are based on resource considerations they also take into account legal and governmental considerations (e.g. how far into the future should we plan a bluff setback or hazard line?).

x. Watersheds: The State of Georgia proposes an alternative inland boundary for its coastal zone which it terms the "Coastal Watershed". This would include the major river basins flowing into Georgia's coastal waters as well as watersheds draining directly into the tidal rivers of the coast. This type of approach was considered because "river basins and watersheds have long been recog-

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[39] Wolf Bauer, Shore Resource Overview, (critique on the Corps of Engineers' Washington State Environmental Reconnaissance Inventory), Undated copy, p. 15.

[40] Bauer, (1976), p. 23.

nized as basic resource planning units. Although not every land area in the coastal watershed directly contributes materials to coastal waters...their potential for doing so is greater than lands outside of these watersheds (refer to p. 9 of Alternative Inland Boundaries of the Coastal Zone).[41]

New Jersey's Department of Environmental Protection has an alternative inland boundary concept which it calls "Selected watersheds with clearly identifiable relationships to the coastal waters could be incorporated in the coastal zone...watersheds to be included...would be selected on the basis of the unique or special natural resource characteristics of the watersheds themselves, as well as the relationship of existing and potential activities within each watershed to coastal waters...this alternative concept would enable the state to manage those uses the potential impacts of which on hydrologic systems draining to coastal waters are cause for concern."[42]

The Oregon State coastal zone extends inland to the crest of the coastal mountain range except for three major river basins which penetrate the coastal mountains There, three artificial boundaries mark the inland limit of the coastal zone.

Alaska's inland boundary, although mainly defined by

[41] Georgia Department of Natural Resources, p. 9.

[42] A staff Working Paper, (Trenton, New Jersey, 1976), p. 31.

the 200-foot elevational contour also takes into account streams and lakes for which direct or indirect physical or biological links to coastal waters have been established.

Several other states, notably California and Louisiana have indirectly included river basins as a consideration while attempting to define the inland boundary of their coastal zones. The State of California has actually made bulges in its adopted inland boundary to include the coastal watersheds of significant coastal, estuarine, habitat, and recreation resources.

2. Legal Governmental Parameters

In addition to resource considerations there is a multitude of legal and governmental or socio-economic factors which must be taken into account when determining the inland boundary of the coastal zone. Some examples of these which are based, in part, on resource considerations are:

i) Navigable Waters: These are "all waters that are in fact navigable, regardless of whether they are influenced by the tide, are landlocked or open, or are saline or fresh. Waters are navigable when they are, in their ordinary condition, used or susceptible of use as highways for commerce..."[43] This definition does not "extend shoreward far enough to meet the requirements of the Coastal Zone Management Act (1972)...that the Coastal Zone

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[43] McIntire et al., p. 7.

shall extend inland from the shoreline to the extent necessary to control shorelands, the uses of which have a direct and significant impact on coastal waters."[44]

ii) <u>100-Year Flood Elevation Line</u>: Many coastal states of the United States have established a 100-year flood elevation line for insurance purposes as required by the "National Flood Insurance Act of 1968, as amended by the Flood Disaster Protection Act of 1973." The area seaward of this boundary has stringent building and land use restrictions and as such could form a legal and governmental boundary of the coastal zone.

iii) <u>The Storm Surge Reference Line</u> (SRL): McIntire et al. (1975) have suggested the SRL as one of Louisiana's alternative inland boundaries. The SRL is the landward projection of the maximum surge height of storm water as it surges landward. For Louisiana, however, "the SRL follows the coastline closely and does not include a vast area of the state's wetlands and estuaries which should rightfully be included within the Coastal Zone."[45]

iv) <u>Mean High Tide Line</u>: Using the narrowest definition of 'direct and significant impact on coastal waters' the New Jersey Department of Enviromnental Protection has derived an inland boundary concept called the "Water's Edge." To be within the coastal zone defined by

[44] McIntire et al., p. 7.

[45] McIntire et al., p. 8.

this boundary, activities must be "in, on or adjacent to coastal waters. In practice, the existing upper wetlands boundary and the mean high tide line would approximate the landward extent of the coastal zone under this alternative concept."[46]

v) Ownership and Legal Boundaries: New Jersey has three legally defined boundaries within its coastal zone. "First, the mean high tide line delimits the extent of the State-owned tidelands...Second, at the direction of the Legislature in the Wetlands Act of 1970...the Department (The New Jersey Department of Environmental Protection) established the landward limit of coastal wetlands..."[47] Third, the Coastal Area Facility Review Act established a boundary for the Coastal Area using New Jersey'a seaward limit, bayward and river boundaries, road system, railroad rights-of-way, and county boundaries.

While taking into account environmental factors (by extending the boundary inland in areas of significant resources), the inland coastal zone boundary of California is defined by governmental and legal parameters (E.G. Property lines, roads etc.) over much of its length. The inland boundary of the State's coastal zone can be adjusted to make allowance for property lines in areas of contention.

[46] A Staff Working Paper, (Trenton, New Jersey, 1976), p. 21.

[47] Alternative Boundaries for New Jersey's Coastal Zone, p. 80.

In addition to these considerations, there are a multitude of other legal and governmental considerations (e.g. existing laws, rights and policies) which must be taken into account when defining the inland boundary of the coastal zone. Their priority will vary from place to place.

Types of Boundaries

1. Tiered Boundaries: The Georgia Department of Natural Resources emphasizes that although the alternative boundaries it suggests are discrete, "it is possible that the eventual boundary recommended...will include a combination of boundaries, with varying permitted uses and regulations applying to different areas."[48] This is termed the "multiple boundaries or tiered" approach.

> The strongest and most direct control would normally be exercised in the zone or tier adjacent to the water's edge. Generally, but not always, the degree of control would decrease in each succeeding zone landward. In any case, the controls in a particular zone should be appropriate for existing planned or potential uses of the land and water within that zone.[49]

The State of New Jersey has an alternative inland boundary concept called "Water's Edge Buffer." This is essentially a tiered boundary concept. The first tier of the coastal zone is a narrow strip of shoreland accommodating activities which directly affect coastal waters by being in, on, or adjacent to coastal waters. The directness

[48] Georgia Department of Natural Resources, p. 7.

[49] Georgia Department of Natural Resources, p. 7.

and significance of impacts to be regulated (in this tier) is unquestioned."[50] The second tier is essentially a buffer strip. "The width of the buffer is the inland extent of the coastal zone and depends upon the significance of impacting activities. As a matter of convenience, the boundary should follow readily identifiable cultural features, such as roads and rights of way."[51]

Washington State has a two-tiered concept of coastal zone boundaries. "The first or primary tier... is all of the states marine waters (this extends three miles seaward from shore) and their associated wetlands including at a minimum all upland area 200 feet landward from the ordinary high water mark."[52] The inland boundary is limited to the saltwater intrusion limit in river basins. This primary inland boundary is based on the coastal resource. The second tier, bounded by 'planning and administrative boundaries' is composed of the area within the fifteen coastal counties which front on saltwater. "The use of the two tiers provides the state a basis to differentiate in terms of both the need for control and the intensity

[50] A Staff Working Paper, (Trenton, New Jersey, 1976). p. 23.

[51] A Staff Working Paper, (Trenton, New Jersey, 1976), p. 23.

[52] Office of Coastal Zone Management, NOAA, State of Washington Coastal Zone Management Program, Final Environmental Impact Statement, (Washington, D.C., 1976), p. 33.

of control The most immediate and direct control is exercised in the tier adjacent to the waters edge."[53] If land use proposals in the second tier have the potential to have direct and significant impacts on coastal waters or directly affect the coastal zone, these can be regulated by a second set of laws.

2. Variable or "Bulging" Boundaries: The State of California defines Coastal Zone as:

> that land and water area...extending seaward to the states' outer limit of jurisdiction including all offshore islands, and extending inland generally 1,000 yards from the mean high tide line of the sea. In significant coastal estuarine, habitat, and recreational areas it extends inland to the first major ridgeline paralleling the sea or five miles from the mean high tide line of the sea, whichever is less, and in developed urban areas the zone generally extends inland less than 1,000 yards.[54]

Thus, the inland boundary remains at about 1,000 yards in many areas and "bulges" to protect significant resources. This "bulge" concept has also been adopted by the State of Alaska to include areas with a direct or indirect link with coastal waters.

3. Single Fixed Boundaries: Although few, inland boundaries of the coastal zone which are well defined by recognizable features and based on resource and legal/

[53] State of Washington Coastal Zone Management Program, p. 35.

[54] Office of Coastal Zone Management, National Oceanic and Atmospheric Administration, (Washington, D.C.) and California Coastal Commission, State of California Coastal Management Program and Revised Draft Environmental Impact Statement (San Fransisco, California, 1976), p. 27.

governmental considerations do exist. A prime example is the State of Virginia where a resource boundary based on a State-wide, easily recognizable geologic feature (refer to geology section of this report) also forms a convenient legal/governmental boundary.

Discussion

Alternative inland boundaries of the coastal zone vary from those including the entire land area to those including none.

Examples:

a) Entire Land Area: The entire state of Hawaii has been declared part of the coastal zone for management purposes. This seems logical because Hawaii is made up of several islands all of which are obviously affected by, or affect coastal waters directly.

The State of New Jersey's Department of Environmental Protection have also proposed an alternative definition of its inland boundary which would include the entire state. The logic for this alternative concept was that "some activities, such as agriculture or specified industrialized processes, could produce a measurable change in coastal waters if the activity occurred anywhere in the state."[55]

b) No Land Area: "The proposed Texas coastal zone does not include any land area. Rather it includes

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[55] A Staff Working Paper, (Trenton, New Jersey, 1976), p. 33.

bay and estuarine areas, tidal areas, salt marshes, and grasslands."[56] This definition is too narrow for most areas of the coast because it does not "extend inland to the extent necessary to control activities on shorelands which have a direct and significant impact on coastal waters."[57]

1. Direct and Significant Impact: When determining the criteria used to formulate coastal zone boundaries, one must define the terms "direct and significant impact on coastal waters." It is the definition of these terms which determines how much land area is included in the coastal zone. Individual states have chosen widely varying interpretations of these terms.

The New Jersey Department of Environmental Protection (1976) report that most alternative definitions of direct impact fall within the meaning of two alternatives:

> a) A direct impact is a change in the built or natural environment that is the immediate result of an impacting activity without any intermediate processes between the impacting activity or the change that it causes.

This definition implies a very narrow coastal zone and yet is broad enough to be applicable to any type of impact (ie. social, economic or resource oriented).

> b) A direct impact is a change in the built or natural environment that is either the immediate result of an

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[56] A Staff Working Paper, (Trenton, New Jersey, 1976), p. 55.

[57] A Staff Working Paper, (Trenton, New Jersey, 1976), p. 7.

> impacting activity or is linked to the impacting activity through an identified chain of cause and effect without further human intervention.

This definition implies a very wide coastal zone as long as there is a linkage, "irrespective of the physical distance", between the activity and coastal waters.

The New Jersey Department of Environmental Protection (1976) found that although numerous definitions exist for the term "significant impact", most definitions fall between two broad alternatives:

> a) A significant impact is a measurable change in the built or natural environment.

This alternative depends on the ability of people to measure changes in the environment and does not involve value judgements.

> b) A significant impact is a measurable change in the built or natural environment that is cause for concern.

This definition leaves a large margin for value judgements to be made once a measurable change in the environment has been detected.

It is interesting to note that the range of alternattives for inland coastal zone boundaries which the New Jersey Department of Environmental Protection (1976) presents for public debate covers the entire spectrum of definitions for "direct and significant impacts."

The Georgia Department of Natural Resources distinguishes between the term "direct" and the term "significant": The term "direct" is related to the cause of the impact in question. The term "significant" on the other hand, deals with the judgement or determination of whether the impact is of special consideration for planning and management.[58]

2. Types of Boundaries: The types of inland boundaries chosen vary according to the natural and built features of the land and the legal and governmental constraints encountered. Any boundary is arbitrary but some are based on more relevant factors than others. In rare cases, a resource boundary will coincide with legal and governmental boundaries to form a convenient and recognizable boundary (e.g. Virginia's inland boundary). In such a case, a single fixed boundary appears ideal. In cases where no state-wide or province-wide natural boundary exists, attempts ranging from arbitrary fixed boundaries to multiple tiered boundaries have been adopted.

The most widely accepted type of boundary has been the tiered boundary. This type of boundary whether based on resource and/or legal/governmental considerations, satisfies the dilemma of control over coastal lands; generally the further inland a given type of activity occurs, the more dampened will be its impact on coastal waters.

3. Inland Boundary Alternatives: British Columbia

[58] Georgia Department of Natural Resources, p. 4.

has over 17,000 miles of coastline. It is heterogeneous in all respects. Therefore it is important to remember that any parameters considered for inland boundary determination must apply over the entire coastline.

Some of the alternatives considered in this paper could not apply to the delineation of an inland boundary of the coastal zone of British Columbia, while others have inherent limitations to their use:

i. Geologic: While an elevational (e.g. five- or 50-foot contour) inland boundary could be approximated, there is no corresponding geologic contact or formation like that of Louisiana or Georgia which extends the full length or even a significant portion of British Columbia's coastline. If there was a geologic boundary such as this in British Columbia, it would not necessarily coincide with the area which should be included to "control activities which have a direct and significant impact of coastal waters."

ii. Salinity and Tidal Influence: Although salinity and tidal influence are key factors in determining the inland intrusion of marine influences, they are highly variable in all respects and are therefore difficult to measure accurately (refer to Georgia Department of Natural Resources (1976), and McIntire et al. (1975)). Any inland boundary based on landward salinity or tidal intrusion would not necessarily include shorelands which have a "direct and significant impact of coastal waters." Rather, the areas these parameters affect must be part of a larger coastal zone.

iii. Coastal Wetlands, Fresh and Salt Marshes, Mean High Tide Line: The areas included in the coastal zone as defined by using these parameters have a direct and significant impact on the coastal zone (refer to Georgia Department of Natural Resources (1976)). The validity of using these parameters to define the inland boundary is subject to debate since it has not been determined that non-wetland, non-marsh, and land areas above mean high tide, should be excluded from the coastal zone. While fresh and salt marshes and coastal wetlands should be included in the coastal zone due to "direct biological and nutrient links with coastal waters,"[59] other land areas may also have, "direct and significant impact(s) on coastal waters."

iv. Elevation and Arbitrary Inland Distances: Although elevational boundaries and other arbitrary inland distances are convenient to adopt, they do not often correlate well with resource boundaries. In British Columbia there is no geologic or other resource parameter which coincides, for the full length of the coast, with any given elevation or arbitrary inland distance. Therefore, it bears no relation to potential or actual "direct or significant" impacts on coastal waters. If such a boundary were chosen it would be difficult for the public to locate because there are few recognizable features, especially in undeveloped areas, with which to associate such a boundary. As Silk (1975) reports, "a definition (of an inland boundary for the coastal zone) composed of arbitrary cartographical boundaries is unacceptable."[60] This has been realized by most of the states considering elevational or arbitrary inland distances as inland boundaries and so they have usually promoted these in combination with other approaches to attain a more 'natural' boundary.

[59] McIntire et al., p. 11.

[60] Silk, p. 30.

v. Vegetation, Faunal Distributions, and Soils: Vegetative, faunal and soils data have been used in attempts to define some boundary or parameter of the coastal zone (i.e. wetlands verses non-wetlands, the extent of landward salinity intrusion, or the inland influence of tides). These factors are useful when considering the relationships between natural resources in the coastal zone. However, the actual boundary which these define must be kept in mind. Loucks (1968) suggested using only vegetation to define the inland boundary. However, confusion resulted from the overriding influence of climate.

vi. Functional Shore Boundaries: Inland boundaries of the coastal zone based on shore processes and their effects on the land (e.g. those proposed by Bauer (1976) and Oertel (1975)) are important from both biophysical and legal/governmental points of view. In this zone much of the conflict between the man-made environment and the natural environment exists. This type of inland boundary does not coincide with any recognizable features of the landscape either cultural or natural, nor does it include all areas of shoreland which have a potential impact on coastal waters.

vii. Navigable Waters, 100 Year Flood Elevation Line, SRL, Ownership Boundaries, and Other Legal/Governmental Boundaries: When resource and legal/governmental considerations do not coincide, the boundaries are difficult to recognize. This is usually the case for these parameters. The boundaries could be approximated by cultural features such as roads and right-of-ways, but most of British Columbia's coastline is undeveloped. It is much better to choose a resource boundary which coincides with legal/governmental boundaries or convenient management units, so planners and managers may work with, rather than against, natural systems.

viii. Coastal Watersheds: The coastal watershed alternative has been seriously considered in one form or another by almost every state and province which has attempted to delineate an inland boundary to the coastal zone. It seems logical that based on resource considerations, watersheds should form the basis of a boundary which delineates the landward extent of the coastal zone. Clark (1974) notes that the "basic unit of coastal management is a single and complete ecosystem including the coastal water basin...."[61]

Runoff from lands of coastal watersheds contributes materials (water, nutrients, and sediments as well as pollutants) to coastal waters, and therefore affects them. Whether this effect on coastal waters is direct or significant is not yet determined in many cases. What is important is that there is a potential for the effect on coastal waters to be direct or significant. Silk (1975) concurs when he reports that:

> the landward extent (of the coastal zone, for management purposes) should be defined by delineating drainage basins according to their contiguity with coastal waters, which may be determined for each region by stream order (see glossary). The zone must include those basins, usually lacking streams, that front directly upon coastal waters, as well as those with at least first order streams that discharge into such waters.[62]

Silk also notes that one of the best processes to use for subdividing the landward part of the coastal zone is "the hydrologic cycle....The delineation of surficial drainage systems provides a geographical basis for managing land uses that can affect coastal resources."[63]

Recently, Dennis Briére has presented a land classification system based on watersheds. The system defines hydrology units within watersheds on the basis of: 1) the stream order (which also defines the drainage basin order), 2) the aspect (determined by the orientation of a line drawn from the watershed outlet, dividing the watershed in half), and 3) the

[61] J. Clark, Coastal Ecosystems, (Washington, 1974), 178 pp. quoted in Dana D. Silk, p. 40.

[62] Silk, p. 31.

[63] Silk, p. 40.

water regime which indicates any areas having a water storage capacity before the water gets to the first lake or the ocean. This basis for land classification is in contrast to most other Canadian land classifications because it is based on erosional rather than depositional landforms.

Many basic relationships exist among streams of the same order within watersheds, and within a physiographic region between watersheds containing streams of similar order. The use of watersheds as basic planning and management units in British Columbia's coastal zone would allow one to take advantage of these relationships. Watersheds are natural planning units and although the legal/political boundaries existing in British Columbia do not often follow watershed boundaries, much can be done to alleviate this problem, especially in the large areas along British Columbia's coast which are unsurveyed. Planners throughout British Columbia are realizing the many advantages of planning with nature and therefore the importance of using watersheds as management units. An example of a plan for a coastal area in British Columbia based on the watershed ("shire") approach is that for Malaspina Peninsula Planning Area by Pence, Fogarty and Ladret (1978). The objective of this plan was to "blend the man-made with the natural."

In his landscape unit approach to land classification of the Seymour Watershed (1976) Briére demonstrates some of the relationships which exist between stream order and: a) hygrotope/position on slope, b) aspect and exposure, c)land features as observed on air photos (e.g. soil, landform, and erosion), and d) vegetation. Thus, planning and managing the landward portion of the coastal zone based on watersheds is truly "design with nature."

Briére and Jones (1976) report that Brieré's landscape approach to land classification can be applied through the "delineation of watershed boundaries (drainage basins) at whatever scale required (as dictated by the objectives of management); these boundaries may be considered permanent and have obvious advantages in their interpretation with respect to water quantity and quality."[64] It is this water quantity and quality link with the coastal waters which makes the watershed approach to coastal zone management necessary. Watershed boundaries also form naturally recognizable and mappable coastal zone boundaries.

According to Silk (1975), the use of a watershed approach "enables an increasing area of land to be included, recognizing that the potential effect on coastal waters of any given land use decreases as stream order increases."[65] Hence, using watersheds allows for the "tiered" or "multiple boundaries" approach to inland boundary delineation. This is favoured by many of the Coastal States of the United States.

Obviously the entire drainage basin of large rivers cannot be included in the coastal zone because the entire land area of North America would be a part of the coastal zone. As the New Jersey Department of Environmental Protection (1976) cautions, "coastal zone management is not a panacea. The delineation of a coastal zone must be done with an eye to the management of the coastal zone--the special area where the land meets the sea....A boundary is a means to an end, and that end must be generally defined before a boundary can be selected."[66] Silk (1975) also states that "an all inclusive definition of the coastal zone may be ideal for research purposes but is not acceptable for management needs due to its breadth and ambiguity."[67] At the very least the primary tier of the British Columbia coastal zone must include zero and first order drainage basins emptying directly into coastal waters. The entire coastal zone, however should extend to the height of the coastal range and include all the land area of offshore islands. River basins which penetrate the coastal mountains could

[64] D. Briere and K. Jones

[65] Silk, p. 32.

[66] A Staff Working Paper, (Trenton, New Jersey, 1976), p. 4-5.

[67] Silk, p. 30.

be monitored as a lower priority tier.

Summary

In order to manage the 'coastal zone' we must first designate coastal zone boundaries. Defining the boundaries of the coastal zone is not as easy as Gieth (1972) claims when he states that "there is an accepted reliable system for practical (coastal zone) boundary mapping, which the National Ocean Survey has been utilizing for years. Very simply it consists of mapping the mean low water and mean high water lines."[68] Rather, resource considerations must be examined and the effect of inland land uses on coastal waters must be studied (refer to The State of California Coastal Management Program (1976) for a list of land and water uses subject to management in the coastal zone of that state and to Inland Land Use Activities and Georgia's Coastal Waters, for examples of the effects of land uses on coastal waters).

The seaward boundary of the coastal zone must include the nearshore zone where waves begin to affect the land by creating nearshore circulation patterns and other wave-bottom effects. The actual seaward limit of the coastal zone, however, is not agreed upon and will probably be determined not by environmental but by legal/governmental factors. The seaward limit of the coastal zone should not exceed the edge of the continental shelf or the term "coastal zone" will not have any specific meaning.

As long as the coastal zone boundary, landward of the coastal waters, does not include the entire land area of a continent, it must be noted that some activities occurring outside the defined coastal zone may still affect coastal waters.[69] For this reason, the use of these areas must

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[68] Jack E. Gieth, The National Ocean Survey Coastal Boundary Mapping, in Tools for Coastal Zone Management, Proceedings of the Conference, (Washington, DC), p. 68.

[69] Resource Planning Section, Office of Planning and Research, Georgia Department of Natural Resources, Inland Land Use Activities And Georgia's Coastal Waters, (Atlanta, Georgia, 1976), p. iii.

still come under some form of performance standards to protect coastal waters.

It must also be recognized that selection of a boundary for the coastal zone today may not be the best selection for a future time. Changes in needs, pressures, or knowledge may require revisions at a future time.

Since "activities and land uses throughout the coastal watershed can potentially affect the shore," we should be using a watershed basis for defining the inland boundary of the coastal zone. In British Columbia the coastal zone should be defined by the height of the coastal mountains and include the entire area of offshore islands. A primary tier for planning and management purposes could consist of those drainage basins containing zero and first order streams which drain directly into the ocean. River valleys which penetrate the coastal mountains should be treated as a lower priority tier in their upper reaches.

The adoption of a landscape classification such as Brière's (1976) for the landward portion of the coastal zone, based on surficial hydrology would provide a natural basis for boundary delineation. By realizing that as the stream order increases the effect of any given land use on coastal waters decrease it is clear that a tiered or single boundary approach to inland boundary definition is possible when based on sound resource considerations. It would also standardize the units of the coastal zone with those recently adopted by the British Columbia Forest Service for forest management and encourage "a more precise and rational definition (to) provide a manageable working tool,...(and) a philosophical basis for coastal zone management."[70]

[70] Silk, p. 30.

II.2 A Working Definition For the Coastal Zone

Due to the complexity and difficulty of defining the coastal zone in a generally acceptable form, the following working definition has been arbitrarily adopted for use in this study:

> The coastal zone extends landward from the mean lower low water line to 300 metres inland from the mean higher high tide line.

II.3 Coastal Zone Components

3.1 The Foreshore Defined

There is a clear and widely accepted definition of the foreshore which is adopted for use in this study. Basically, it is the area of beach exposed at low tide and submerged at high tide but more specifically it is:

> The part of the shore lying between the crest of the seaward berm (or upper limit of wave wash at high tide) and the ordinary low water mark, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall.[1]

3.2 The Distinction Between Backshores and Lowlands

Wolf Bauer defines a backshore as:

> The storm-tide wetted, but normally dry, erosion or accretion zone located between the coastline and the high tideline. The backshore may be a more or less narrow storm berm (ridge of wave heaped gravel) under a seabluff, or it may constitute a broader complex of berms, marshes, meadows, or dunes landward of the high tideline. It is past of the littoral drift process along its seaward boundary.[2]

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[1] U.S. Army Coastal Engineering Research Center, Dept. of the Army, Corps. of Engineers, Shore Protection Manual Vol. III, (Washington, 1975), p. A-13.

[2] Wolf Bauer, Accretion Beach Inventory, Western Community Shore-Resource Analysis (Victoria, 1976), p. 43.

The definitions of a backshore by Keser (1976), [3] Gary, et al. (1972)[4], and The Canada Land Inventory (1969)[5] agree with the definition by the Environment and Land Use Secretariat (E.L.U.C.) (undated) which, like Bauer, defines the backshore as the "zone above the limit of the swash of normal high spring tide extending from the berm back to the farthest point reached by waves. It may be a narrow storm berm, or it may constitute a broader complex of berms, marshes, meadows or dunes landward of the high tideline."[6]

3.3 Lowland Defined

Gary, et al. (1972) define a lowland as: "low lying land or an extensive region of low land, especially near the coast and including the extended plains or country lying not far above tide level."[7] The E.L.U.C. (undated) definition of lowland agrees with Gary, et al. but distinguishes it from backshores: a lowland "is that zone above the erosional attack of marine waters but below the first major break in slope."[8]

Discussion

From the above definitions it can be seen that functionally, lowlands and backshores are different. This functional difference is important. While backshores are subject to infrequent inundation by storm waves coincident with high tides, lowlands remain free of inunation by marine waters.

[3] Nuretin Keser, Interpretation of Landforms from Aerial Photographs, (Victoria, 1976), p. 144

[4] Margaret Gary, et al. Glossary of Geology (Washington, 1972), p. 52.

[5] Department of Regional and Economic Expansion, The Canada Land Inventory for Recreation, Report Number 6, p. 111

[6] E.L.U.C. Shorezone Classification, (Victoria, undated), p. 2

[7] Gary, et al., p. 419

[8] E.L.U.C., p. 2

Thus the land use and land cover should be influenced by the distinction between backshores and lowlands. Unfortunately, development on backshores does not always take into account this functional difference. Costly protection of, or damage to, development occurs during the infrequent inundations.

Inventorying backshores and lowlands, however, is difficult. The height to which waves can reach depends not only on the height of the storm-surge and the storm waves, but also on the wave energy zone (also called the beach energy level).[9] Bauer (1976)[10] approximates the wave energy zone of a beach based on beach orientation, nearshore depth in terms of maximum storm wave impacts at high tide, and presence or absence of wave-refracting or attenuating headlands or islands. He also suggests refinement of these approximations using wind-rose data for each location.

Conclusion

Bauer (1976) reports that: "housing placed on accretion shoreforms within medium to high wave-energy zones may be inundated by combined wave and storm-surge water levels of eight feet or more above MHHW along open...Strait (of Georgia) shorelands,"[11] where all three of the classification systems being studied were used and developed. For inventory purposes the 8-foot contour should form the dividing line between backshores and lowlands in areas of medium to high wave-energy zones until refinement according to, local wind-rose data, and actual inundation events.

[9] E.L.U.C., Shorezone Classification, p. 2

[10] Bauer, p. 7

[11] Bauer, p. 41.

3.4 Upland and Lowland Defined

1. Gary et al (1972) : An upland is "An area of land above flood level, or not reached by storm tides..."[1]

2. The California Coastal Zone Conservation Commission (1975) (CCZCC) : An upland is "the area landward from the oceanfront area, generally to the coastal zone boundary." (The oceanfront was defined as "The area from the shoreline landward, including the beach and/or rocks above the high tide line to the top of adjacent bluffs and cliffs."[2]

3. The Environment and Land Use Committee Secretariat (Undated) (ELUC) : An upland is "that zone above the first major break in slope. This zone extends from the lowland (or backshore if there is no major break in slope) to the height of land."[3]

4. The Department of Regional Economic Expansion (1969) (DREE) : An upland is "all land other than shoreland" while shoreland "extends from the 5-foot depth contour at normal low water, inland from the shoreline to a natural boundary, or to a boundary which encompasses the direct zone of influence of the water body."[4]

Discussion:

The definition of an upland used by Gary et al. includes lowlands, but not backshores as part of uplands. The definitions used by the CCZCC and the ELUC exclude both lowlands and bluffs as part of the uplands but do not provide a means of separating lowlands from uplands. The DREE definition distinguishes the upland from the backshore but, like Gary et al. includes the lowland as part of the upland.

Conclusion:

The definition of an upland varies from publication to publication. The upland does not include the backshore in any definition of an upland. In some instances the lowlands have been separated from uplands but no

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[1] Margaret Gary, Robert McAfee Jr., and Carol L. Wolf, Glossary of Geology (Washington, 1972), p. 805.

[2] CCZCC, California Coastal Plan (San Francisco, 1975), p. 423.

[3] ELUC, Shorezone Classification (Victoria, Undated), p. 3.

[4] DREE, The Canada Land Inventory Land Capability Classification for Outdoor Recreation, Report no. 6. (Ottawa, 1969), p. 111

definition has given specific criterion on which to separate lowlands from uplands.

The lowland, however, must be separated from the upland because of:

1. The difference in materials between the upland and the lowland.
2. The difference in flooding hazard between lowland and upland areas in the study areas, and,
3. The physical separation of upland from lowland.

Thus, the lowland has been arbitrarily separated from the upland as: That area of low lying land in the coastal zone between the backshore and the scarp.

In turn, the upland has been arbitrarily defined as: That area of the coastal zone lying beyond the lowland and the scarp.

CHAPTER III: The State-of-the-Art and the Application of Coastal Zone Classification Systems in British Columbia.

III.1 Introduction to Study

Silk (1975) reports "the relatively recent interest in coastal classification for management purposes...has not yet been reflected in the literature."[1] Since this statement, a small amount of literature has appeared (e.g. Burns and Falls (1977) and Bauer (1976))and some classifications for management and planning purposes have been used here in British Columbia. As Burns and Falls note,many of the approaches to coastal zone classification were not very successful because of the complexity and extent of the coastal zone where boundaries were not clear.[2] Other classifications apply at a scale too small to be applicable to the specific problems of planning and management in the coastal zone of British Columbia. In a search for classification systems for planning and management purposes which could be applied at a detailed inventory or preliminary site investigation[3] level it became apparent that only three such classifications had been used in British Columbia. One of these, Bauer (1976) emphasized geohydraulic processes while the others, Walmsley (undated) and ELUC (1976), were inventory classifications of land use, beach materials, and geomorphic physical features of the landscape in a static sense. All three of these systems were comparible because they concentrated on approximately the same area of the coastal zone (from mean lower low tide level to the inland limit of the coastal process zone) and were designed to break the coastal zone into units on the basis of the natural environment.

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[1] Dana D. Silk, A Basis for Coastal Classification in Atlantic Canada, (Fredericton, New Brunswick, 1975), p. 2.

[2] Ted Burns and Rob Falls, A Review of Coastal Zone Boundary Definition, Land Classification and Management Approaches Relative to the British Columbia Situation, With Suggestions for Future Direction, (1977), p. 19.

[3] Environment and Land Use Committee, Recreation Capability Inventory, (Victoria, 1976), p. 36.

Walmsley and ELUC's systems are criticized by Wolf Bauer[4] for inventorying only static parameters and not reflecting or inventorying processes Therefore, it was felt that an evaluation of all three systems, in an attempt to evolve a more useful system of classifying the coastal zone, would be a valuable undertaking.

Silk (1975) concluded that for Atlantic Canada a highly structured coastal classification system was undesirable for management purposes at this time because of "an extreme variation in data bases, the infancy of coastal zone management...and thus the undefined state of user needs. As the literature shows again and again, de facto coastal classification systems are generally applicable only to specific users from narrow disciplines—it is of course, possible to combine such classification systems into a comprehensive one."[5]

"Recreation areas are becoming one of the most important land uses, particularly around metropolitan areas. The demand (for recreational areas) is growing much faster than the population because per capita demand is also increasing."[6] The British Columbia coastal zone provides recreation for millions of people each year. Providing recreation areas and cottaging sites constitutes a valuable part of British Columbia's economy. Planners and managers have also expressed a need for information regarding potential recreation sites. For these reasons, and because baseline recreational site data was reflected in all three of the classification (inventory) systems chosen for this study, evaluation of these systems was limited to the specific planning and management necessities required for organized

[4] Comments made in field examination of previous study areas, Courtenay, B.C. (1976).

[5] Dana D. Silk, Coastal Classification and Planning Needs, Land/Water Integration, Proceedings of the first meeting, February 17-18, 1977, p. 44.

[6] David W. Fischer, John E. Lewis, and George B. Priddle, Land and Leisure, Concepts and Methods in Outdoor Recreation, (1974), pl. 226.

camping, picnicking and cottaging. It was also realized that the data required for these purposes would form valuable background information for other planning and management purposes.

Factors affecting capability and suitability for these recreational uses were chosen because, as Twiss (1972) reports: "basic data or resource suitability, environmental capability, and land use considerations can be combined to describe, articulate and evaluate most of the critical policy and planning issues confronting coastal planners."[7]

[7] Robert H. Twiss, Methods for Environmental Planning of the California Coastline, in Tools for Coastal Zone Management, Proceedings of the Conference, February 14-14, 1972, Washington, p. 78.

III.2 Brief Overview of Classification Systems

The type of classification system limits the information provided by that system. According to Dana Silk (1975) inventories are of limited value for coastal classification purposes because most are either "issue oriented, dealing with only one coastal feature, e.g., beaches, or salt marshes, or site specific, dealing only with a single area that may not be representative of the coastal zone."[1]

The systems developed by Bauer, Walmsley and ELUC qualify as classifications according to the following definitions: "A classification is an orderly arrangement of objects or ideas placed into categories according to their relationships to each other",[2] and "Classification is essentially the organization of information into manageable units that are easily understood".[3]

We classify because:[4]

1. without classification there are too many individuals to remember
2. natural populations are too heterogeneous to be able to recognize patterns
3. classification is required as a basis of communication for relating experience and research
4. for comparison purposes.

The three classification systems studied here are inventory classifications because they are based on an inventory of some of the features of the areas they classify. Although they all involve some form of classification they cannot be truly called coastal zone classifications.

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[1] Dana D. Silk, A Basis for Coastal Classification in Atlantic Canada, (October, 1975), p. 28.

[2] W. A. Ehrlich, in The System of Soil Classification for Canada, (Canada Department of Agriculture), (Ottawa, 1970), p. 9.

[3] Dana D. Silk, Coastal Classification Systems A Review and Documentation, (April, 1975), p. 2.

[4] Les Lavkulich, University of British Columbia, Forestry 422 Lecture notes, 1975.

This is because the coastal zone, although its boundaries are not defined as yet, (refer to the literature review on coastal zone boundaries) is a system and "should be regarded as the result of the continuing interaction of the land, sea and air."[5] Coker (1962) emphasized that "the oceans, the land areas, and the atmosphere are not to be regarded separately, but are really parts of one great system."[6] "There seems little doubt that an approach which unifies environments by treating them as interacting parts of a whole is preferrable."[7] A classification system should give equal emphasis to each part of the system.[8] All three of the inventory classifications being evaluated fall short of attaining this goal, although Bauer's classification is the only one which gives the air and water components of the system any recognition at all. He only concentrates on the more dynamic parts of the coastal zone and almost ignores rocky shorelines. His approximation of the seaward coastal zone boundary is a plus factor which helps his system gain credibility but the lack of consistently detailed information is the nearshore zone is a problem. The lack of water-based information is not unique to these systems but is the rule rather than the exception in coastal zone classifications to date.

Silk (October, 1975) reports that inventories of beaches are quite common and provide valuable information but are no substitute for an inventory of the entire coastal zone. In fact, Bauer's inventory does concentrate on the beach resource, but does not stop there.

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[5] Dana D. Silk, <u>A Basis for Coastal Classification in Atlantic Canada</u>, (October, 1975), p. 45.

[6] R. E. Coker, <u>This Great and Wide Sea</u>, (New York, 1962), in Silk, (October, 1975), p. 31.

[7] Silk, (October, 1975), p. 31.

[8] Les Lavkulich, (1975).

He reports some other features of the coastal zone as well, e.g. coastal processes, genesis of features in the coastal zone and relationships between the two. Silk states that "the existence of so many inventories simply indicates the need for a basic coastal zone inventory capable of being used for many different purposes."[9] This is a need which Bauer's classification begins to approach although it falls short of encompassing all the factors related to a basic coastal zone inventory capable of being used for many different purposes (refer to Dana D. Silk (1975) for a further discussion of coastal zone classification systems).

[9] Dana D. Silk, (October, 1975), p. 28.

III.3 A Description of Three Selected Systems

Introduction

Each of the three systems evaluated in this study falls short of providing the informational requirements chosen for this evaluative study because each classification was developed for its own purpose. "Purpose is implicit in all classifications and different purposes lead to different classifications."[1]

The rational utilization of land resources (and water resources) must be preceded by knowledge of their nature and their extent."[2]

Classification systems are based on measured observations, emperical inferences, or value judgements. The type of classification systems used by Bauer, Walmsley, and the Environment and Land Use Committee (ELUC) serve as bridges between technical information and practical applications.

3.1 Bauer

The purpose of Bauer's Western Community Shore Resource Analysis (1976) was to provide a preliminary inventory and evaluation, shore status and analysis of the marine shore resources in the study areas as well as to provide general recommendations for shore-use planning and management. It was a preliminary study which "concerned itself primarily with an inventory and evaluation of the beach resources in view of the fact that these represent not only the more changeable and least stable component of the coast, but are also of high recreational and esthetic resource value."[3]

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[1] J. S. Rowe, Soil, Site and Land Classification, Forestry Chronicle, 38:4 (1962), pp. 420-432.

[2] D.S. Lacate, Wildland Inventory and Mapping, Forestry Chronicle, 42:2 (1966), pp. 184-194.

[3] Wolf Bauer, Western Community Shore Resource Analysis, (1976), p.2.

"If the categories of an inventory system of shoreforms reflect genetic and integral process relationships, then it is possible to meet one of the prime objectives of the Environmental Reconnaisance Inventory, namely to provide an environmental "Early Warning System". It is to this objective, as well as that of providing public information on present shore-use problems that these guidelines and analysis have been presented."[4]

Bauer describes all beaches of 100 feet in length or more in general terms. The following inventory data is included for each beach described:

a) beach code number
b) description of geographic location in terms of nearest reference point
c) beach classification (Class I, II, or III)
d) beach length
e) backup shoreland
f) beach orientation
g) approximate wave energy zone
h) unique features
i) land jurisdiction

(For further information about data provided by Bauer, refer to the evaluation section of this report).

The base maps show: The near-shore water prism, beach code numbers, fresh and salt marshes, Mean Higher High Water tide line, feeder bluffs, rocky shores, areas of erodable gravel, sand and clay, direction of net drift and roads.

In giving some general recommendations, Bauer notes that his inventory and evaluation may be viewed as a catalyst for further investigations and analysis of coastal areas and specific management areas. In his general recommendations he also suggests further investigation into several potential Class I beach park sites, a shore-access program, and feeder bluff studies.

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[4] Wolf Bauer, Shore Resource Overview, Critique on the Coros of Engineers, Washington State Environmental Reconnaissance Inventory, (Undated), p. 15.

3.2 Walmsley

Walmsley's system was developed in the Vancouver area;

> an area popular for human habitation....Since Vancouver first became the nation's key western port, the rapidly expanding pressures of urban and industrial development have created a legacy of mismanagement of the coastline and coastal region resulting in part from a lack of knowledge of the physical nature of the area. To assist the planner in his endeavours (sic), a thorough store of background environmental data is required as part of the overall information package which may eventually lead to effective legislation which will protect the coastal zone."[5]

The objectives of Walmsley's study were to :

1. identify and cartographically display the different types of surficial materials which composes the waterfront or beach sections along the coastline....
2. evaluate waterfront land in terms of various general land use categories.
3. identify areas of man-made features such as land fill, dykes, wharves, and retaining walls.

Walmsley does not claim that his inventory system provides all the baseline environmental data which form tools for land use planning in the coastal zone, because it was a pilot project using a limited budget. He hopes it will provide some of the background physical environmental information concerning the coastal zone of the metropolitan Vancouver area. The information was provided when its need was indicated by a preliminary literature review and discussion amongst potential users of such information.

Walmsley's inventory data included the beach material, bluff material, height, and slope, some general land use categories, and some man-made features. (Refer to the Evaluation section and Appendix II of this report for details of the information provided by Walmsley's inventory system). The beach material data was intended to 'form the backbone' of the classification.

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[5] Mark Walmsley Shoreline Characteristics of the Greater Vancouver Area, Draft Report, (Undated), p. 1.

This information was considered important "from ecological as well as social points of view."[6] Bluff information was inventoried because "it is often the material which comprises these bluffs that significantly contributes to the material comprising the beach...."[7] The slope categories for bluffs were used "because of erosion and recreational use consequences."[8] The slope classes indicate areas better suited to particular uses than others. Some of the man-made features were inventoried because they influence the kind of beach or use (particularly recreational use) of the beach. The six general land use categories were chosen because "land use along the waterfront has implications as to the changes to the land which will occur in proximity of that use."[9] The land use categories were "intended for use as background information only, to shed more light on the reasons for particular beach materials occurring on a particular unit as well as to indicate the large amount of land alienated along the waterfront to uses which may or may not actually require waterfront land for them to function."[10]

In giving some examples of intended uses for his inventory data, Walmsley emphasizes that the information displayed is not intended to be used by itself, but should be used with "backup information concerning such things as land and water based recreation requirements and geophysical data,"[11] in order to identify areas suited to particular uses.

[6] Walmsley, p. 5.

[7] Walmsley, p. 6.

[8] Walmsley, p. 6.

[9] Walmsley, p. 11.

[10] Walmsley, P. 11.

[11] Walmsley, p. 12.

Walmsley indicates that the information his system supplies can be used to identify: 1. bluff areas susceptible to failure and land uses occuring near the bluff which may contribute to instability, and 2. the combination of beach materials and adjacent land use which are amenable to beach recreation use. He also notes that "in summary it is hoped that the reconnaissance nature of this excercise is understood and that future work will be conducted to refine the map and enlarge on its usefulness."[12]

3.3 Environment and Land Use Committee (ELUC): The purpose of ELUC's inventory classification system was to undertake a limited pilot project on coastal zone mapping. For this purpose the E.L.U.C. (1976) Terrain Classification System (T.C.S.) was used in combination with Walmsley's inventory classification at a more detailed inventory (at a scale of 1:15,840 rather than 1:63,360) to see how applicable the T.C.S. was. In doing this ELUC described: 1. the beach materials using the textural symbols (and connectors) of the ELUC Terrain Classification System (1976),[13] 2. the scarp, lowland (and backshore) materials accordingto the ELUC Terrain Classification System, and 3. the man-made features and general land uses according to Walmsley's inventory classification system.

[12] Walmsley, p. 16.

[13] ELUC, Terrain Classification System, (1976), passim.

CHAPTER IV THE OBJECTIVES AND SCOPE OF THE STUDY

IV.1 Objectives

The main objective of this coastal zone study is to evaluate three systems of classifying and mapping the coastal zone: 1. Bauer (1977), 2. Environment and Land Use Committee Secretariat (1976), and 3. Mark Walmsley for the Lands Directorate (undated). The three systems will be evaluated for the information which they provide to land use planners and managers concerning some biophysical and cultural factors affecting the capability and suitability of sites for organized camping, picnicking and cottage development. The result of this evaluation will be a proposed composite system of mapping and inventorying in the coastal zone for the above purposes.

1:15,840 black and white aerial photography of the study area will be interpreted to assess which information concerning the above criterion can be derived from them. 1:3,600 color and color infrared aerial photography will also be interpreted to determine what additional information they provide.

IV.2 Scope

This study is limited to the coastal zone as arbitrarily defined in Chapter II. It concentrates on those biophysical and cultural factors affecting capability and suitability for organized camping, picnicking and cottaging which can be interpreted from the scale and type of aerial photography used and collected during rapid field observations.

There are a broad range of features associated with activities related to camping, picnicking and cottaging in the coastal zone (e.g. water quality and temperature, beaches, etc.). These have been limited to include only the following:

1. beaches - because they are used for so many intensive (e.g. sunbathing, game playing) and extensive (e.g. beachcombing,sightseeing) activities related to camping, picnicking and cottaging.

2. factors affecting sewage filter field placement - as camping, picnicking and cottaging sites are almost always associated with these.

3. unique and attractive features - were included because the recreational activities being studied do not always occur wherever limitations are few but are also associated with other attractive and/or unique features.

4. other natural and cultural features of the coastal zone which affect a site's capability and suitability for organized camping, picnicking and cottaging.

Data Limitations: The users of the maps (Appendix II) and descriptions (Appendix III) of the Nanoose and Saltspring Island study areas according to the classification systems by Walmsley (197), ELUC (1976) and Bauer (1976) should be aware that:

- the author of this study has had previous experience with mapping according to the E.L.U.C. and Walmsley classifications and with mapping surficial geology.
- the author has had little previous experience (apart from studying books and papers) with mapping shore processes as used in Bauer's classification.
- more detailed field inspection may result in more homogeneous units.

CHAPTER V: Methodology

V.1 The Study Areas

The three systems to be evaluated were used to classify and map two study areas. Thus, by becoming familiar with each of the classifications and the coastal zone, a more thorough evaluation was made possible. The same study areas were used for the evaluation of aerial photography. The intent of this study was to chose two areas in which to apply the three systems and test the applicability of air photo interpretation. Areas of both unconsolidated and rocky, as well as developed and undeveloped shorelines were selected. A literature review of aerial photographic information revealed that color and color infrared photography would provide the most valuable source of remote sensor information.

While approaching survey companies to have the required photography flown it was discovered that the photography for two suitable study areas was already in existence. It was decided that the areas for which suitable photography existed would be used (see General Description of Study Areas).

1.1 General Description of Study Areas

As part of the Strait of Georgia, the study areas can be considered one of Canada's most important outdoor recreation areas. It has diverse environmental and aesthetic resources and a dry, mild climate which combined makes appreciation of the regions unique flora, fauna, and marine resources second to none.

(i) Geographic Location:

a) The Saltspring Island Study Area: 35.41 Kilometres (22.01 miles) of high-tide shoreline (caliper "walked" at 100-foot intervals).

(From 1:500,000 Scale Map, N.T.S. No. 92 S.E., from the Canada Department of Energy, Mines and Resources, Surveys and Mapping Branch.)

b) The Nanoose Study Area: 41.97 Kilometres (26.08 miles) of high-tide shoreline (caliper "walked" at 100-foot intervals).

(From: 1:500,000 Scale map, N.T.S. No. 92 S.W., from the Canada Department of Energy, Mines and Resources, Surveys and Mapping Branch.)

The following section briefly describes the climate, geology, geomorphology, soils, biology and built environment of the two study areas.

(ii) Climate:[1]

a) Temperature: According to Koppen's World Climatic Classification (the most widely accepted system of climatic classification in Canada) the climate of both study areas is described as Csb (dry summer subtropical or Mediterranean) a warm moist climate with a cool dry summer period.

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[1] Nature Conservancy of Canada--Islands Trust, Natural Areas Inventory, Prepared by D. R. Ben, (December, 1975), passim.

(S = dry season in summer; i.e. rainiest month of the winter receives at least three times as much rain as the dryest month of the summer. B = cool summer; with the mean temperature of the warmest month under 71.6°F. but with at least four months over 50°F. [2]) "The maritime influence tends to overshadow the effects of elevation and aspect,[3] with resulting cool summer temperatures and mild winter temperatures. Summer mean maximum temperatures are mainly between 21°C. and 24°C., while mean temperatures of 15 to 18°C. are common.[4]

b) Precipitation: In comparison to other areas of coastal British Columbia, the study areas receive low precipitation. The rainshadow effect of the Vancouver Island Ranges is responsible for this phenomenon but the effect decreases from south to north resulting in higher precipitation in the Nanoose study area than further south near Victoria. A pronounced precipitation increase also occurs near the high mountains of Vancouver Island. The mountains on Saltspring Island result in an orographic increase in rainfall as compared to lower-lying Gulf Islands nearby. Total precipitation at Ganges in the heart of the Saltspring Island study area is 40.41 inches. At Nanaimo's Departure Bay at the southern extremity of the Nanoose study area, total precipitation is 36.60 inches and at Parksville, four miles north of Nanoose study area it is 37.49 inches. The expected twenty-four hour extreme precipitation amounts vary from 3.0 to 4.0 inches. "Heavy falls such as this may cause problems of flooding in low lying areas of the region."[5] Due to mild winter temperatures only 3% to 8% of precipitation falls as snow.

[2] Department of Mines and Technical Surveys, Atlas of Canada, Geographic Branch, (Ottawa, Ontario, 1957) p. 30.

[3] Nature Conservancy of Canada--Islands Trust (1975), p.A-20

[4] Nature Conservancy of Canada--Islands Trust, p.2.

[5] Nature Conservancy of Canada--Islands Trust, p. A-21

"About 75% of all precipitation falls in the winter months. Moisture deficits occur from April to October resulting in severe fire hazard and drought conditions throughout the summer. The drought and exposure to wind also results in attractive forms of vegetation especially on south and southwest facing aspects."[6]

c) Wind: During times which frontal systems are affecting the climate in the Straits of Georgia (at all seasons except summer as a rule), strong winds may buffet all except very protected bays or coves. The effects of winds vary according to the effects of exposure, aspect, topography, fetch, and the marine environment.

The effects of wind are particularly critical during the April to September growing season when rainfall is low and areas of shallow soils experience severe droughtiness. The Nature Conservancy of Canada--Islands Trust (1975) reports that in reality, the wind is not the direct cause of plant growth problems but that "it is more likely the salt introduced to the site by the wind."[7] The effect of increased evapotranspiration, however, cannot be ignored.

d) Sunshine: The amount of sunshine received on a site varies with aspect and exposure. Southerly slopes receive much more sun and this results in different vegetation in areas of shallow soils where summer droughtiness is accentuated. "Westerly and easterly aspects receive approximately the same amounts of sun, although the west slopes have much warmer temperatures that the east aspect."[8] There is probably 1,800 to 1,900 hours of sunshine in the study areas each year.

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[6] Nature Conservancy of Canada--Islands Trust, p. 3.

[7] Nature Conservancy of Canada--Islands Trust, p. A-26.

[8] Nature Conservancy of Canada--Islands Trust, p. A-24.

Climatic Summary

"For planning purposes, analysis of recreation carrying capacity and recreation features provides only some of the relevant information about the physical environment. For example, an area with a diversity of features and a high carrying capacity may be of low recreational value if it is typically too cold, too wet, or too windy."[9]

According to Bennett's (1977) classification,[10] both the Nanoose and the Saltspring Island study areas fall into the same classification of climatic suitability for recreation; that is, the climate is relatively dry and mild and highly conducive to recreation particularly in the summer months.

(iii) Geology, Geomorphology, and Soils:

Moderately to shallow dipping sedimentary rocks of sandstone, conglomerate, and shale make up the mainly bedrock coastline of the Saltspring Island study area. The coastline of the Nanoose study area consists of a large amount of unconsolidated deposits as well as volcanic and metamorphic bedrock with some areas of sandstone and conglomerate bedrock.

Both study areas are part of the Georgia Lowland "a major physiographic part of the Coastal Trough. The Lowland is mainly structual in origin and much of it is submerged beneath the Strait of Georgia. However, intense glaciation during the Pleistocene, has greatly modified the region resulting in relatively subdued topography and relief."[11] This glaciation has resulted, in the more exposed areas of the study areas consisting largely of soils which are shallow to bedrock. This is the case over much of the

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[9] R.C. Bennett, Climatic Suitability for Recreation in British Columbia, (British Columbia, Resource Analysis Branch, Victoria 1977), p. 3.

[10] R.C. Bennett, passim.

[11] Nature Conservancy of Canada--Islands Trust, p. 3.

Saltspring Island study area and the Wallis Point and the Departure Bay to Sunrise Beach areas of the Nanoose study area. In valleys and along the coast of the Nanoose study area, deep glacio, glacio-fluvial and marine deposits are common. They extend almost uninterrupted along the shoreline from Sunrise Beach to Nanoose Bay. These types of deposits are not as widespread in the Saltspring Island study area, although a major glacio and glacio-fluvial deposit does occur along the coastline near Ganges. The valleys and depressions of the Saltspring area often consist of deep marine deposits of fine textured or sandy materials, while both study areas have major glacial till deposits.

Generally, soils on steeply sloping hills and mountain slopes are shallow, gravelly or sandy, well drained, and include a significant proportion of bare rock.[12] In more gently sloping terrain, soils are often sandy or gravelly in texture and of varying depth. Depressional or level areas may consist of deep organic soils subject to frequent ponding or high water tables. These areas are often underlain by clays at lower elevations. Gently sloping lowland positions usually have medium to fine textured soils with marine parent materials. These areas are subject to ponding and the water table remains near the surface for much of the year. In areas of glacio-marine and glacio-fluvial terraces, soils consisting of stratified sand and gravel of varying depth may be found. These soils have rapid permeability and occur on gently to moderately sloping topography. Gravel and sand pits are frequently built in these deposits.

[12] Environment and Land Use Committee Secretariat, Undated copy of Soil Association Descriptions for Saltspring Island and Southeastern Vancouver Island.

(iv) Vegetation:

The study areas are part of the Dry Coastal Douglas-fir zone (Krajina, 1965). Douglas-fir is the most frequently occurring tree species but characteristically, areas of Garry oak and arbutus may be found as climax vegetation. "The Garry oak is invariably found in pure groves with a ground cover of grasses and forbes. Almost all such areas have been disturbed expecially by sheep grazing, however most still feature an array of wild flowers such as dogtooth, violet, rice root, shooting star, camus and sea blush."[13] Arbutus, on the other hand, is scattered throughout the study areas and is usually found in combination with other species. One pure grove of arbutus forms an attractive setting in the Nanoose study area north of Fleet Point along the Vancouver Island Highway. Where logging on moist slope and bottomlands has not been followed by a vigorous planting program, red alder stands flourish. Also scattered throughout the study areas are distinctive tracts of park-like vegetation-trees over grass. These areas form aesthetically appealing attractions which are desirable for hiking, photography, viewing and other recreational persuits. On the more exposed sites open grasslands persist.

The shores of the study areas vary from being steep and rocky to shallow and sandy. The ocean currents and circulation patterns, water temperatures, and freshwater inputs are all highly variable. Therefore it is hard to characterize the aquatic vegetation in a simple manner. Haegele and Hamey (1976) have produced Shoreline Vegetation Maps of Nanoose and Ganges Herring Management Units, which identify five major vegetation types:

1. Sea grasses, mainly *Zostera marina*.
2. Rockweed, mainly *Fucus* sp.
3. Red Algae, (33 species were encountered).
4. Brown algae (mainly kelp such as Laminarians and *Agarum* sp. and the japweed *Sargassum muticum*).[14]
5. Green algae, mostly *Enteromorpha* sp. and *Ulva* sp.

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[13] Nature Conservancy of Canada--Islands Trust, p. 3.

[14] Carl W. Haegele and Marry Jo Hamey, (Nanaimo, 1976), p. 2.

(v) Wildlife:

The wildlife of both study areas is diverse. On Saltspring Island there is an abundance of blacktail deer, raccoons, pheasants, grouse, and quail. Wildlife viewing and photography is a pastime of many visitors to the area. While terrestrial wildlife is not as abundant in the Nanoose study area, the diversity of species is even greater. The park-like areas which occur are highly attractive to and frequented by wildlife.

The most noticeable wildlife in the study areas are the birds. "Close to 200 species of birds occur of which over half nest in the area. Sea birds, raptor, shore birds, waterfowl, and passerine birds are all found in highly significant numbers."[15] Several parcels of land and intertidal areas have been set aside as bird sanctuaries. Most notable of these include Sunset Spit near Ganges and a parcel of land in the Nanoose estuary. These areas are vital as a stopover along the Pacific Flyway--a major migration route.

In addition to the more attractive or spectacular forms of wildlife, beavers, otter, mice, mink, newts, frogs, toads, garter snakes, and lizards may be encountered in the study areas. Apart from bees, ants, and the occasional bear (in the Nanaimo study area only), there are no forms of wildlife which form a hazard for recreationists.

Marine life includes many forms of fishes (both commercial and non-commercial), several types of seals and whales, sea-lions and porpoises. The intertidal areas offer excellent opportunities to view, collect and photograph marine plants and animals. The intertidal fauna includes starfish, sea urchins, sand dollars, oysters, shrimp, clams, crabs, drills, chitons, jellyfish, sea cucumbers, sea anamones, periwinkle, and limpets.

[15] Nature Conservancy of Canada--Islands Trust, p. 5.

(vi) The Built Environment

a) Jurisdiction and Ownership:

The land area of the study areas falls under a wide range of jurisdictional bodies. Most of the Saltspring study area is privately owned with possible points of public access being few, widely spaced, and often situated on steep, rocky shores. The entire area falls under the regional control of the Islands Trust. The land area of the Nanoose study area, while being almost totally privately owned, or in long-term leases (alienated from the crown through the Esquimalt and Nanaimo Land Grants), falls under a variety of controlling bodies. From Departure Bay to the boundary of Lantzville, the land is part of the Municipality of Nanaimo. From Lantzville to the northern boundary of the study area most of the land falls under jurisdiction of the Nanaimo Regional District. An exception to this is the Indian Reserve at Fleet Point, the Provincial roadside rest along Nanoose Bay, the Second Century Fund bird sanctuary in Nanoose estuary, and the Department of National Defence (DND) lands between Ranch Point and Wallis Point along Nanoose Harbour. Foreshore access points have been established by the Municipality of Nanaimo and the Nanaimo Regional District, but as in the Saltspring Island study area, these are often inadequate with large stretches of inaccessible foreshore.

b) Development:

Apart from the Athol Peninsula in the Saltspring Island area and the DND lands along Nanoose Harbour, most of the coastline (and backshore areas) have been developed for residential and recreational (cottaging and tourism) use. The Saltspring Island study area centres around Ganges, the major population centre of Saltspring Island. Within the area there are several mooring sites and marinas, one public boat launch and a ferry terminal linking Saltspring Island with Vancouver.

Log dumps and booming grounds and a commercial wharf also centre around the Ganges area. The main industry of the area is tourism. Retirement, logging, fishing, and agriculture are lesser industries of the Island. In the summer months, the population of the area more than triples due to the tourist trade.

The Nanoose study area boasts Nanaimo, the major population centre of Vancouver Island north of Victoria. The city of Nanaimo sprawls in patches for several miles north along the coastline to touch Lantzville, a smaller settlement which diminishes north to an area of lower density cottages and residences. At the head of Nanoose Bay is a small settlement aptly named Nanoose, based on tourism, logging, and the nearby DND base. Settlement of the rest of the study area consists of widely spaced cottages and residences with a large housing development near Dolphin Bay. Industries in the area include logging, tourism, fishing, the DND, the railway, and agriculture. Some of the people taking up residence along the shoreline are retired, but many work in the pulp mill, sawmills, commercial centres, and British Columbia Ferries in Nanaimo. The ferry terminal in Departure Bay links North Vancouver Island with Vancouver.

V.2 Methodology

2.1 Preparation

Prior to the field work for this report, preparation involved the collection and study of literature pertaining to: 1) coastal geomorphology, 2) the use of aerial photography and other remote sensor data in the coastal zone, 3) coastal zone classification, 4) coastal zone boundary definition, and 5) recreation planning and management. An attempt at gathering existing information about the study areas was made at this time but it soon became clear that it would take longer to find the existing information for the study areas than it would to collect it anew. This was due to: 1) the large number of agencies and individuals who have done work which is related to the coastal zone, 2) the lack of any central listing of information collected about the coastal zone, 3) the division in jurisdiction between federal, provincial, regional and municipal governments over the lands and waters of the coastal zone, and 4) the variation in level of detail, scale, and type of information gathered from place to place.

2.2 Scale

The three mapping and classification systems evaluated in this report were originally used at different scales. Walmsley's was developed and used at a scale of 1:50,000, Bauer's at a scale of approximately 1:12,000 and ELUC's at a scale of 1:20,000. In this study, however, all three systems were mapped at a scale of 1:15,840. This was done after a review of the literature revealed that "as an aid to planning...detailed inventory and preliminary site investigation are aided by the use of "air photo scales of 1:15,000 (1:10,000 to 1:60,000) and mapping scales of 1:25,000 (1:10,000 to 1:50,000)."[1]

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[1] Environment and Land Use Committee, Recreation Capability Inventory (Victoria, 1976), p. 36.

This is in contrast to the recommended air photo scales of 1:60,000 (1:30,000 to 1:120,000) for reconnaissance inventory and broad planning and 1:100 to 1:1,000 for site planning.

2.3 Mapping and Classifying

The mapping and classifying commenced in September with a brief review of areas which had already been classified and mapped by the authors of the three systems being evaluated. This was an introduction to the actual field mapping and classifying. Bauer's study area was the Western Community coastline near Victoria extending from Becher Bay to Fort Rodd Hill inclusively. Walmsley's study area was the Greater Vancouver Area coastline from just north of Horseshoe Bay ferry terminal to just south of Tsawwassen (Boundary Bluff) inclusive of Bowen Island, and the islands at the mouth of the Fraser River.

Aerial photographs* at a scale of 1:15,840 were employed to pre-type the units for each classification system according to the mapping legends and the definition of units according to each. Color coded overlays were used (refer to Appendix VI) to record the following photo-interpreted information:

1. present land and water use
2. scarp slopes (general)
3. surficial materials
4. surface water
5. shore width
6. areas of accretion and erosion
7. beach materials
8. beach types
9. areas of attractive vegetation
10. areas of attractive vegetation

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* Aerial photographs used: flown in 1975 at a scale of 1:15,840.
Nanoose area: BC7754:067-084, 198-204; BC7751:146-150, 158-167
Saltspring Island: BC7754: 160-164, 237-244, 264-268.
As a matter of record the photographs were flown at an altitude of 17,500 feet during periods of lowtide in July of 1975. A 12 inch lens was used. Flight line BC7751 was flown on the 18th and flight lines BC7754 and 7751 were flown on the 22nd day of July.

Scarp slope information was augmented using contour maps. For the Saltspring Island study area 1:15,840 topographic maps were available, while for the Nanoose area 1:50,000 contour maps were used.

Information about erosion and accretion was to be augmented with earlier (1930's) Federal aerial photographs but these are not yet available. Instead, hydrographic field charts were acquired for the parts of the study areas where they were available. While it was evident from these charts that certain areas had eroded and others had accreted since the field charts were made, no definite conclusions could be reached because the field charts were stamped: "CAUTION, Unverified Information."

The pre-typed aerial photographs were used as references when the entire coastline of both study areas was field checked to ensure the accuracy of the pre-typing. The field work also lead to the subdivision of the pre-typed units into more homogeneous units. Units of less than 100 feet in length (along the shoreline) were not isolated due to scale constraints. Many areas of the coastline were inaccessible by land approach and were visited via small outboard boat. More accessible areas were reached by road and on foot. The use of the boat was found to be very expedient during times of good weather and decreased the field inspection time even in many areas of existing land access. This was due to the time involved in getting permission to cross private lands, Indian Reserves, and Department of National Defense lands. This process was especially frustrating when trying to cover as much area as possible at times of low tide.

Notes were taken during the field work to record information about the units and problems and advantages of using the classification systems in the field (see Evaluation section). Color slides were taken to photodocument some of the more salient features of the units. These slides are mounted in book form and are organized on the basis of the mapped units. E.g. the slide entitled B7WE10 corresponds to Unit #7 of the map after Bauer and Unit #10 of the maps after Walmsley and ELUC. The field notes and slides were used during the final examination of the aerial photographs in the office. This examination led to the final delineation of the units as they appear on the base maps. The data presented by each of the three systems can be seen in Appendices II and III.

The base maps used to display the information for the Nanoose study area was drawn from Interim Base Maps produced by the Air Survey Division, Survey and Mapping Branch, Department of Lands, Forests and Water Resources (1969). The base map for the Saltspring study area was drawn from a topographic map of Saltspring Island produced by the Department of Lands, Forests and Water Resources, Surveys and Mapping Branch, Topographic Division (1969). The scale of all base maps coincided with the scale of aerial photography used for field work (i.e. 1:15,840). In some areas, the shoreline detail of the interim base maps was insufficient and had to be redrafted according to the more recent aerial photographs used for field and office work. Hydrographic charts were also used because they contain a "much greater amount of information concerning the land-water interface zone."[2] Examples of the information provided by hydrographic charts that does not generally occur on topographic maps includes piles, dolphins, tide levels, and nearshore water depths. The hydrographic charts were especially valuable in delineating the nearshore water prism for the mapped classification after Bauer (1976).

[2] Mark E. Walmsley for Environment Canada, Shoreline Characteristics of The Greater Vancouver Area, (Vancouver, undated), p. 4.

After drafting and printing the base maps, the units were transferred from the aerial photographs. Due to the configuration of the coastline, the unit symbols used by Walmsley and ELUC could not be put directly on the maps. Rather, reference numbers replaced the mapped symbols and lists of the symbols were appended to the maps. Bauer's system also uses this method. The legends were put on the base maps and an example of typical symbols was provided to familiarize the user with the mapping technique.

2.4 Report Writing

Upon completion of the mapping and classification a comprehensive literature review of the "Biophysical and Cultural Factors Affecting Capability and Suitability for Organized Camping, Picnicking, and Cottage Development and Use" was prepared. Information about beaches and factors affecting sewage filter field location were included in this literature review because recreational sites in the coastal zone are usually associated with both. Of those factors discussed in the literature review, those which could be readily inventoried in the field or by using conventional aerial photography (vertical black and white) were selected. These were used as the basis for an evaluation of the information which the three systems studied provide concerning suitability and capability for organized camping, picnicking, and cottage development and use in the coastal zone. These were chosen because the information collected in each of the three classification systems studied was only that which could be readily collected in the field or from aerial photographs, hydrographic charts, and topographic maps.

For purposes of the evaluation and the resultant composite classification system the boundaries of the coastal zone were arbitrarily defined as extending landward from the mean lower low water line to 300 metres inland from the mean higher high tide line. From the literature review "Defining the Coastal Zone Based on Resource Considerations" it can be seen that in fact, the coastal zone should extend both landward and seaward of the boundaries set for this study. However, the landward boundary had to be set, and short of inventorying the entire coastal watershed, which is not the purpose of this report, any arbitrary boundary was equally justified. The inland boundary chosen included all the inland area inventoried according to Walmsley's and ELUC's systems and almost always included that area inventoried by Bauer's system. The seaward boundary for this study was set at the low water mark as this was the limit set by all three of the systems being evaluated (apart from the 6-fathom line delineated by Bauer to estimate the seaward limit of the "Nearshore Water Prism.") This seaward boundary also reflects a lack of expertise in inventorying or mapping parameters of the aquatic environment.

Evaluation of the three classification systems involved a review of the amount and type of information which each system provided concerning capability and suitability for organized camping, picnicking and cottaging in the coastal area defined. It also involved an assessment of the objectives and type of each classification system and their limitations for use in the field. On the basis of field data, literature reviews, and resulting maps, matrix evaluation tables were constructed. Using these tables and the other data, a proposed composite system was developed. This system was based on the best aspects of the three classification systems involved and attempts to satisfy the shortcomings as discussed in the Evaluation Section of this report. This composite system is also based on information which can be gathered through interpretation of conventional aerial photography and rapid field observation at a detailed inventory level.

2.5 Air Photo Study

A preliminary literature review on the state of the art of "The Use of Remote Sensing in the Coastal Process Zone" (refer to Appendix V) revealed that the possibilities for using remote sensing in the coastal zone were almost limitless. Research into the use of even the most common imagery (panchromatic aerial photographs) was found to be needed to obtain the most information about a given locality because of the dynamic nature of the resources and the many resources in the coastal zone.

The coastal zone in British Columbia is immense no matter how the boundaries are defined. Much of this zone is inaccessible and part of it is only exposed for short periods during the tidal cycle. Therefore, remote sensing has a valuable role to play in coastal resource management. For this reason, and because of the literature review it was felt that investigation into the use of conventional (panchromatic) aerial photography at a scale of 1:15,840 in the study areas would be in order. Photographs rather than transparencies were used because of their wide availability throughout British Columbia and their utility for field use and mapping. In addition, color and color infrared aerial photography (transparencies) at a scale of 1:3,600 were selected for investigation because positive transparencies reveal the most information of any photo format* and because the literature revealed that color and color infrared were useful for purposes of this study.

* The 23-cm. X 23-cm. format transparencies were developed from Kodak Aerochrome Infrared #2443 film with a medium yellow (Wrotten #9) filter and Kodak Ektachrome M.S. Aerographic #2448 film. Aerial photographs of the Saltspring Island study area and the Nanoose study areas were obtained on July 9th and 10th respectively. "There was 60% forward overlap between adjacent frames and 20% overlap between parallel flight lines. Altitudes were 1097 metres and the photo scale was 1:3,600."[3] Photography took place near times of low tides of 0.2 metres for the Saltspring study area and 0.4 metres for the Nanoose study area.

[3] Carl W. Haegele and Marry Jo Hamey, Shoreline Vegetation Maps of Nanoose and Ganges Herring Management Units, (Nanaimo, 1976), p. 1.

The 1:15,840 black and white aerial photographic prints and the 1:3,600 color and color infrared positive transparencies were evaluated for the information which they could provide concerning capability and suitability for recreational camping, picnicking and cottaging. Advantages and limitations to their use with the suggested composite system were recorded and suggestions made.

The black and white aerial photographs were examined using the Abrams model CB-1 two or four power stereoscope while the color and color infrared positive transparencies were examined on a light table using the Zeus-3 power stereoscope. A parallax bar was used when making height measurements. Mylar overlay was used for recording information.

CHAPTER VI: Information Requirements for Organized Camping, Picnicking and Cottage Development.

VI.1 Review of Interpretation Needs and Environmental Parameters

1.1 Capability and Suitability

Introduction - The realization that a rational utilization of the coastal zones resources is necessary has led to the need for capability and suitability information concerning the coastal zone. Basically, this involves collecting information in the form of a classification scheme which reflects the ability of the environment to support various land and water uses and their related activities.

Webster's dictionary defines capability as: "the quality or state of being capable physically...:a feature or faculty capable of development or likely to improve, :a latent valuable characteristic (and): the quality or state of being susceptible to action or treatment as indicated."[1] Suitability is defined by Webster as: "the quality or state of being suitable (adapted to use or purpose):as a:compatibility, b:fitness, qualification, c:appropriateness."[2]

1.2 Examples of Capability and Suitability as Used in the Literature

Twiss (1972) reports that resource suitability reflects attributes which attract certain uses and that environmental capability reflects attributes which will limit the resources potential to accept and continue to support development and use.[3] The Canada Land Inventory (CLI) combines these two ideas into its land capability for recreation inventory when it provides "capability" units for recreation in terms of attractive features

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[1] Webster's Third New International Dictionary, Unabridged (Springfield Massachusetts, 1967), p. 330.

[2] Webster's, p. 2286.

[3] Robert H. Twiss, "Methods for Environmental Planning of the California Coastline," Tools for Coastal Zone Management, Conference, (1972), p. 71.

and the "quantity of recreation which may be generated and sustained per unit area of land per year."[4] In context, it is clear that the "capability" ratings according to the CLI are based on both capability and suitability for recreation. This is further emphasized when it is stated that the "capability for angling on streams and small rivers is determined by normal sport fish populations...(and) by suitability of shore conditions for angling from shore...."[5] The carrying capacity classes for each unit are based on the amount and severity of physical limitations to a wide range of recreational uses. Annotations are used to further describe a limitation and in some cases interpretations of the limitations for a particular use are given (e.g. septic tank suitability). Here capability refers to recreation in a general way while suitability refers to the appropriateness of specific factors for a given use. Dooling (1977), however, notes that "the Canada Land Inventory Land Capability Classification for Outdoor Recreation (1969) method by design, is use-capability oriented as land capability is considered mainly in terms of unit ability to sustain use. Thus, land units within a given capability class are not necessarily the same in terms of topography and landscape, but just in terms of the degree of limitation to recreational use."[6]

The British Columbia Land Inventory Recreation Capability Inventory (BCLIRCI 1976) attempts to minimize the confusion between quality and quantity as used in the CLI by separating the inventory into two parts: 1) a recreation features inventory identifying the type and location of recreation features and attractions, and 2) a physical carrying capacity inventory (in terms of biophysical limitations) which looks at the use of landform,

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[4] Department of Regional Economic Expansion, The Canada Land Inventory, Land Capability Classification for Outdoor Recreation (Ottawa, 1969) p. 7.

[5] Department of Regional Economic Expansion, p. 5.

[6] Peter J. Dooling, Perspectives on Alternative Approaches to and Evaluation Criteria of Recreation--Resource Inventory and Assessment Systems for Provincial, Regional and Site Plans, (Banff, Alberta 1977), p. 5.

soils, vegetation, climatic, and water data to estimate the quanity of recreational use that land units are able to sustain.[7] Then the features inventory and the carrying capacity inventory are combined into capability ratings.

The BCLI defines the physical carrying capacity of land for outdoor recreation as "the inherent ability of the landscape to sustain recreational use,"[8] and interprets limitations for a particular use as suitability. The BCLI and CLI carrying capacity classes are based only on biological and physical parameters of the environment and do not reflect social or economic factors. Nor do they reflect present land use, ownership or access. These factors are seen "as important not to a capability but to a suitability analysis."[9]

The U.S.D.A. (1972) <u>Guide for Interpreting Engineering Uses of Soil</u> reports limitation ratings for some uses of soil and suitability ratings for other uses. All the ratings are based on estimated engineering properties and are intended as a guide. Soil suitability was rated by the terms <u>good</u>, <u>fair</u>, and <u>poor</u> which have meanings approximately parallel to the terms <u>light</u>, <u>moderate</u>, and <u>severe</u> used in rating limitations for specific uses of those soils (e.g. for septic tank absorption fields).

Many of the soil parameters which the BCLI has included as part of the Recreation Capability Inventory (1976), the U.S.D.A. (1967) and Allan et al. (1963)[10] have referred to as suitability parameters in their studies of soils for specific uses. In rating soils for their suitability for management for several important wildlife habitat elements (vegetation types, Allan (1963) reports that "from evaluation of various combinations of these habitat

[7] Environment and Land Use Secretariat, <u>Recreation Capability Inventory</u>, p. 2.

[8] Environment and Land Use Secretariat, (1976), p. 39.

[9] Dooling, p. 25.

[10] Phillip F. Allan, Lloyd E. Garland, and Franklin R. Dugan, "Rating Soils for Wildlife Habitat", <u>North American Wildlife and Natural Resources Conference</u>, 28 (1963), pp. 247-261.

elements we can get an approximate idea of the suitability of soil units."[11] The ratings of suitability of soils for wildlife were made on the basis of values assigned to a selection of habitat elements "appropriate" (suitable) to the type of wildlife studied. Thus, Allan also defined soil suitability for certain uses in terms of limitations of soil factors (e.g. texture, flooding, drainage, stoniness slope, etc.) to specific uses.

The Nassau -Suffolk Regional Planning Board (1977) has prepared a land capability classification system which defined land capability as "a land classification scheme which reflects the ability of the environmental resource to support various land uses and the related activities."[12] The classification divides land into capability units which are assigned on the basis of the land's physical and locational characteristics. According to this system, areas of high capability can support almost any land use "without adverse environmental effects if controls are provided to meet groundwater and freshwater standards and the aquifer is sufficient to meet the demand."[13] Other capability ratings identify a range of permissible uses that can occur with minimal environmental impact. Existing environmental laws are also taken into account in assessing the capability ratings.

Jubenville (1976) refers to resource suitability in terms of site selection while developing a point evaluation system of resource variables.[14] The resource variables selected include natural site features such as slope, aspect, size of area, vegetation density, etc., in order to determine the suitability of the resource which he calls the "resource potential".

[11] Allan, et al., p. 247.

[12] Nassau-Suffolk Regional Planning Board, Coastal Zone Management Program, Land Capability Classification System, (New York), p. 2.

[13] Nassau-Suffolk Regional Planning Board, p. 1.

[14] Alan Jubenville, Outdoor Recreation Planning, (Toronto, Ontario), passim.

1.3 Summary

Clawson and Knetsch (1972) report that suitability is appropriateness and is "a cultural thing which is extremely difficult to define,"[15] but that the problem of defining suitability for certain uses can be eased by carrying on the required land research.

McHarg (1969) distinguishes between suitability and capability when he summarizes with an example: "Accessibility will determine those areas suitable for wilderness as opposed to those areas capable of short-term intensive recreation."[16] Lavkulich (1975) explains the distinction with another example: "People may change drainage...won't change capability but raises suitability for certain things...more for present use."[17]

Dean (1975) defines capability as the synonym of carrying capacity--"The ability of an ecosystem or resource feature to support a particular use or activity based upon the natural characteristics of the resource."[18] Therefore, a capability analysis (an analysis of the "natural" suitability) is an assessment of the amount and type of certain activities which can be supported without changing the ecosystem. Any information about environmental impacts, therefore, contributes to a capability analysis. Dean also defines suitability as: "The appropriateness of a proposed actitivty for a particular resource or location based upon a variety of factors. (Usually these factors include social, political, and economic considerations, as well as natural resource considerations.)"[19]

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[15] Marion Clawson and Jack L. Knetsch, Economics of Outdoor Recreation, (Baltimore, Maryland), p. 1137.

[16] Ian L. McHarg, Land Use Capability in Natural Processes, Design With Nature, (New York), p. 142.

[17] Les Lavkulich, Course notes for Forestry 422 at U.B.C., (January 1975).

[18] Lillian F. Dean, "A Resource Planning Process for Georgia's Coast," The Value and Vulnerability of Coastal Resources, (Atlanta, Georgia), p. 3.

[19] Dean, p. 3.

Suitability for the purpose of this study, therefore, refers to the compatibility of intrinsic features of a site for a specific use. i.e. the capability of certain development as it relates to wildlife values or the disruption of shore processes. Capability refers to the hazards and limitations to use of that site in terms of its being capable of use or development--refers to energy that must be expended. That is, capability refers to inherent features such as soil parameters which are conducive or limiting to recreation. For example, climate is an intrinsic feature of the environment which cannot be managed. Therefore we speak of climatic suitability, and not climatic capability, for a particular use.

VI.2 Biophysical and Cultural Factors Affecting Capability and Suitability for Organized Camping, Picnicking, and Cottage Development & Use A Rationale Behind Selection of those Factors Which Could be Interpretated from Aerial Photographs or Collected in the Field Without Detailed Study

There are a broad range of factors which influence site selection and development for recreational use of the coastal zone. Some of these are biophysical factors. Others are factors resulting from man's activity. These factors may not be compatible with particular recreational uses of the coastal zone (e.g. urbanized areas are not usually compatible with organized camping). This study has been limited to the biophysical and cultural factors affecting the capability and suitability of sites for organized camping, picnicking and cottaging. Beaches, one of the main recreational attractions of the coastal zone have also been included in this study. Since organized campsites, picnic sites, and cottages in the study areas invariably rely on sewage filter fields, factors which affect their location have also been examined.

2.1 Upland, Lowland, Scarp, and Backshore Areas

1. Climatic Factors:[1] "Outdoor recreation involves a very complex interaction between people and the physical environment."[2] As such, weather plays an important role in determining if an area is desirable for recreation. Even if an area has a high carrying capacity and many

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[1] University of British Columbia, "Forestry 422 Course Notes," (1975); Robert W. Douglass, Forest Recreation, (New York, 1975), p. 1.; U.S.D.A., Soil Conservation Service, "Interpretation of Soils for Engineering, Guide for Interpreting Engineering Uses of Soils", (1972), p. 142; R.C. Bennet, Climatic Suitability for Recreation in British Columbia, (1977), p. 3.

[2] R.C. Bennet, p. 3.

attractive features, it may have low recreational value if the weather is not suitable. Thus, weather influences the recreational area selected and the type of recreational use to which that area may be put. Weather, however, is not easily observable on aerial photography, or from quick field checking and therefore belongs to the general description of a study area rather than to a detailed report of its biophysical components. Microclimate is also important to an area being considered for a camping, picnicking, or cottage site. "The microclimate on any given site is influenced by the factors of temperature, aspect, air drainage, exposure, wind, rainfall, and position on slope."[3] Except for aspect these climatic factors are overriding considerations and are therefore part of an introduction to study area rather than a part of an inventory classification.

i) Temperature: A wide spread between the mean daily high temperature and the mean daily low temperature is undesirable for camping or picnicking areas. Sites with uniform temperatures provide more comfort. Temperature is affected by exposure, wind, rainfall, position on slope, and aspect.[4]

ii) Aspect:[5] "The compass direction in which a slope faces dictates its aspect."[6] East slopes receive more morning sunshine and afternoon shade and thus are preferrable to other aspects. The morning sun can warm up and dry out campers and the afternoon shade can keep picnickers and campers cool in the heat of day. "West or southerly aspects are best for swimming beaches"[7] because people usually swim in the afternoon and therefore prefer

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[3] Douglass, p. 82.

[4] Douglass, p. 82.

[5] University of British Columbia, Forestry 422 Course Notes, "Sampling and Analysis for Specific Objectives", (1975), p. 1.; Douglass, p. 3.; Department of Regional Economic Expansion, The Canada Land Inventory (CLI), "Land Capability Classification for Outdoor Recreation," (Ottawa, Ontario), p. 20.

[6] Douglass, p. 83.

[7] Douglass, p. 83.

sun to shade.

iii) Air Drainage: Air drainage "affects temperature, humidity and fog."[8] Poor air drainage can be a problem in camping and picnicking areas as it may result in accumulation of smog. Air drainage can be increased by opening the canopy of campsites and picnic sites to allow ventilation and by locating these sites away from low or flat lying areas where cold air lies.

iv) Exposure refers to the ability of sunlight to fall on an area. Position on slope and aspect affect exposure. Areas with high exposure tend to become hot and are not desirable except as swimming areas or for spring and fall camping and picnicking.[9]

v) Wind: "The prevailing wind should be considered when positioning cabins, tents and camping units...."[10] In areas of long wave fetch, high winds and large waves can be created.

vi) Rainfall: "When combined with other site influencing factors, rainfall becomes very important in influencing the quality of a recreation site."[11] If rainfall occurs during intensive use of a site, deterioration through soil puddling and compaction and resultant damage to vegetation may occur. In dry recreation areas vegetative growth may be limited and dust becomes a problem.

vii) Position on slope affects air drainage patterns temperature extremes, and exposure of the recreation site to sunshine. Douglass (1969) reports that middle slopes offer the best microclimatic conditions for

[8] Douglass, p. 83.

[9] Douglass, p. 84.

[10] Douglass, p. 84.

[11] Douglass, p. 85.

recreation area developments because morning updrafts and evening downdrafts produce good ventilation and provide a moderating effect on the temperature even though they may lack gently sloping terrain.[12]

2. Soil Factors:

i) Soil shear strength[13] refers to a soil's ability to resist sliding when supporting a load. The highest resistance to sliding occurs in soils that are composed of clean gravels. Soil shear strength decreases as fines (see glossary) increase. This information must be obtained through special field and laboratory studies.

ii) Soil shrink-swell potential:[14] "that quality of soil that determines its volume change with change in moisture content. Building foundations, roads, and other structures may be severely damaged by the shrinking and swelling of soil."[15] The shrink-swell potential is influenced by the moisture change and the amount of clay. Therefore, it is related to soil texture. The U.S.D.A. (1972)[16] reports five classes of soil shrink-swell potential. The least limiting class includes loamy sands and sand and the most limiting class includes clay, silty clay and sandy clay soils composed of montmorillinite or other high shrink-swell minerals. The quantitative measurement of shrink-swell minerals requires laboratory analysis and equipment.

iii) Soil bulk density[17] is "the mass of dry soil per unit volume including the air space."[18] It affects building sites through its effect

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[12] Douglass, p. 86.

[13] ELUC, Recreation Capability Inventory,(Victoria, 1976), p. 79; University of British Columbia, "Sampling and Analysis for Specific Objectives," p. 1.

[14] ELUC, p. 79; University of British Columbia, "Sampling and Analysis for Specific Objectives," p. 1; U.S.D.A., Soil Conservation Service, p. 31.

[15] U.S.D.A., Soil Conservation Service, p. 14.

[16] U.S.D.A., Soil Conservation Service, p. 15.

[17] ELUC, p. 79; Univerisity of British Columbia, "Sampling and Analysis for Specific Objectives," p.1.

[18] U.S.D.A. Soil Conservation Service, p. 29.

on bearing strength and settlement of the natural soil under load.[19] "The ability of a soil to support a load is important in many kinds of recreational activities."[19] Bulk density is related to soil texture. For example: "since the particles of sandy soils generally tend to lie in close contact, such soils have high bulk densities. The low organic matter content of sandy soils further encourages this. The particles of silt loams, clay loams, and clays, on the other hand, ordinarily do not rest so close together. Granulation (see glossary) encourages a fluffy, porous condition which results in low bulk-density values."[20] Quantitative measurements of soil bulk density must be obtained through laboratory analysis or special field studies.

iv) Soil texture[21] is "the relative proportion of the various soil separates (individual-size groups of mineral soil particles--sand, silt, or clay) in a soil.[22] Texture indicates the availability of construction aggregate and "is directly related to such characteristics as drainage, permeability, erodibility, trafficability (compaction), and vegetative productivity (nutrient availability)."[23] As such, it affects the amount and type of recreational use that may occur. Fine textured soils high in clay and silt content are subject to puddling and compaction[24] when wet, and become sticky and slippery.[25] These problems are especially

[19] David W. Fischer, John E. Lewis, and George B. Priddle, Land and Leisure, Concepts and Methods in Outdoor Recreation, (1974), p. 246.

[20] Harry O. Buckman, and Nyle C. Brady, The Nature and Properties of Soils, (Toronto, Ontario, 1969), p. 53.

[21] Harry O. Buckman, and Nyle C. Brady, p. 60; ELUC, p. 79; Fischer, et al., p. 246; U.S.D.A., Soil Conservation Service, p. 19.

[22] Buckman and Brady, pp. 625-627.

[23] ELUC, p. 49.

[24] Univeristy of British Columbia, "Sampling and Analysis for specific objectives", p. 1.

[25] Fischer, et al., p. 246.

noticeable in flat areas where drainage is minimal. Septic tank absorption fields are severly limited to wet areas with fine textured soils due to the poor drainage. Septic tank suitability is also severely affected by coarse textured soils that are rapidly drained.

Coarse textured soils, while able to sustain large amounts of use without severe compaction, may be unstable and dusty when dry. "Sandy loam and loam textured surface soils that also have other favourable characteristics are the most desirable for recreational uses involving heavy use by people."[26] Coarse textured soil directly affects soil permeability, and affects the bearing strength and settlement of the natural soil.[27] Although soils with rapid permeability have slight soil limitations (for septic tank absorption fields) it should be noted that a contamination hazard may exist if water supplies, streams, ponds, lakes, or water courses are nearby and receive seepage from the absorption field.[28]

v) Soil drainage[29] "refers to the rapidity and extent of water removal from the soil by both internal water movement to subsurface soil horizons and by surface runoff."[30] "In humid areas soil drainage classes provide clues to soil limitations for septic tank absorption fields."[31] Poorly drained, very poorly drained, and rapidly drained soils limit septic tank absorption fields due to the risk of surface and groundwater

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[26] Fischer, et al., p. 247

[27] U.S.D.A., Soil Conservation Service, p. 29.

[28] U.S.D.A., Soil Conservation Service, p. 24.

[29] ELUC, p. 79; U.S.D.A., Soil Conservation Service, pp. 31 & 60; U.S.D.A., Main Agricultural Experiment Station, Soil Suitability Guide for Land Use Planning in Main, (1967), p. 19.

[30] ELUC, p. 51.

[31] U.S.D.A., Soil Conservation Service, p. 35.

contamination.[32] Imperfectly drained soils that are wet for parts of the year present severe limitations to intensive recreational use. Poorly and very poorly drained soils[33] present severe limitations for any type of facility development due to the cost of subsurface drainage installations. They are also unsuitable for dispersal fields, heavy traffic, or buildings.[34] In rapidly drained soil, vegetation is difficult to establish.[35] Drainage influences the amount and ease of excavation.[36]

vi) Soil depth: Shallow soils are defined as soils less than one metre deep.[37] Soils shallow to bedrock or impervious horizons present many limitations to development for camping and picnicking especially when associated with steep slopes.[38] The kind of bedrock also influences some engineering uses of soils.[39] Areas shallow to bedrock cannot be easily levelled. On steep slopes, shallow soils are easily eroded and thus vegetation is difficult to establish and maintain. "It is difficult to establish vegetation on soils shallow to impervious soil layers or rock thus making them poor locations for intensive use areas."[40] Shallow soils either to bedrock or an impervious horizon would prohibit septic tank facilities and hinder the construction of roads or buildings."[41] The U.S.D.A. (1972) reports that a slight limitation for septic tank absorption fields occurs

[32] Douglass, p. 87.

[33] Canada Department of Agriculture, The System of Soil Classification for Canada, (Ottawa, Ontario, 1970), p. 215.

[34] Douglass, p. 87; ELUC, pl. 52.

[35] ELUC, Secretariat, Recreation Capability Inventory, p. 49.

[36] U.S.D.A., Soil Conservation Service, p. 29.

[37] U.S.D.A., Soil Conservation Service, p. 23,24 & 29; UBC, "Sampling and Analysis for specific objectives," p. 1; ELUC, p. 80; Fischer, et al., p. 246; U.S.D.A., Main Agricultural Experiment Station, p. 50

[38] ELUC, Recreation Capability Inventory, p. 51.

[39] UBC, p. 1.

[40] Fischer, et al., p. 236.

[41] ELUC, p. 80.

if the depth to bedrock is more than 72 inches, a moderate limitation occurs if the depth is 48 to 72 inches, and a severe limitation occurs if the depth is less than 48 inches. For cottage construction the limiting depths are given as: 60 inches, 40-60 inches and less than 40 inches respectively.[42] Deep organic soils also severely limit intensive recreational uses such as camping and picnicking due to their low bulk density and high compactibility.

vii) Rockiness:[43] refers to the amount of ground surface covered by bedrock outcrops. Bedrock outcrops limit the amount and ease of excavation for buildings and septic tank absorption fields especially when associated with steep slopes.[44] The type of bedrock is also important because "crevasseed or fractured rock without adequate soil cover permits unfiltered sewage to travel long distances"[45] If bedrock is soft enough to be dug with light power equipment it presents less of a limitation to construction.[46]

viii) Presence of coarse materials:[47] ELUC (1972) defines coarse materials as "particles greater than 76 mm. (3 inches) in diameter (cobbles, stones, and boulders)"[48] and states that soil containing 50 to 75 percent of coarse materials seriously limits intensive site development due to levelling

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[42] U.S.D.A., Soil Conservation Service, pp. 23 & 31.

[43] ELUC, P. 79; U.S.D.A., Soil Conservation Service, pp. 25 & 31; U.S.D.A., Main Agricultural Experiment Station, p. 50.

[44] U.S.D.A., Soil Conservation Sercie, p. 23.

[45] U.S.D.A., Soil Conservation Service, p. 25.

[46] U.S.D.A., Soil Conservation Service, p. 31.

[47] ELUC, p. 71; U.S.D.A., p. 9; Department of Regional Economic Expansion, (1969), p. 19; Fischer, et al., p. 247.

[48] ELUC, p. 50.

costs. The presence of coarse fragments also influences the amount and ease of excavation for structures and increases construction costs for septic tank absorption fields.[49] This information is valuable for scarp slopes as well as upland and backshore areas as many cottages are built on scarp slopes.

ix) Thickness and type of organic material:[50] Accumulations of organic material, including surface litter horizons, can limit intensive recreational uses due to their high compactibility and low bulk density. In particular, fine-grained organic soils have low resistance to shearing (sliding) when supporting a load.[51] A thin litter layer, however, helps to protect the soil from compaction and thereby helps to prevent site deterioration in intensively used areas. No intensive recreation use in areas of bogs, fens, or swamps would be likely.

x) Soil Permeability[52] is the quality of soil enabling it to transmit water or air. The permeability rate of soils is related to soil texture and to soil structure (see glossary). Soil permeability is particularly important to the location of septic tank absorption fields because highly permeable soil may allow contamination of nearby water. If soil is not sufficiently permeable (fine grained soils have low permeability) it will not function as an absorption field and may cause the fluid to break out onto the ground or back up into the plumbing fixtures.[53] Soil permeability can be estimated if soil structure[54] and texture are known. The inventorying of soil structure, however, requires detailed field examination.

[49] U.S.D.A., Soil Conservation Service, pp. 29, 59, & 60.

[50] ELUC, p. 79 & 53.

[51] U.S.D.A., Soil Conservation Service, p. 45.

[52] UBC, p. 1: U.S.D.A., Soil Conservation Service, p. 24; Fischer et al., 248; U.S.D.A., Main Agricultural Experiment Station, p. 50.

[53] Douglass, p. 86.

[54] UBC, p. 1.

xi) Soil plasticity[55] "pertains to the effect of water on the strength and consistence (see glossary) of soil materials. As the moisture content of a clay soil is increased from a dry state, the materials change from a semi-solid to a plastic state. If the moisture content is further increased the material changes from a plastic to a liquid state."[56] The bearing strength and settlement of soil on building sites are affected by soil plasticity.[57] Plasticity is measured in the laboratory.

3. Other Biophysical Factors:

1. Depth to water table:[58] "Soils that are wet all year have severe soil limitations for campsites,...and picnic areas."[59] The depth to water table is also a point of consideration when determining soil suitability for cottage development.[60] The U.S.D.A. (1972) reports that the depth to the water table provides a slight limitation for septic tank absorption fields if it is more than 72 inches, a moderate limitation if it is 48 - 72 inches, and a severe limitation if it is less than 48 inches. "Soils that are wet only part of the year or those that have a water table that moves up and down without reaching the surface are not easily detected."[61] Therefore,

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[55] UBC, p. 1.

[56] U.S.D.A., Soil Conservation Service, p. 57.

[57] U.S.D.A., Soil Conservation Service, p. 29.

[58] ELUC, p. 79; U.S.D.A., Soil Conservation Service, p. 23; Fischer, et al., p. 246; J.S.D.A., Main Agricultural Experiment Station, p. 20.

[59] Fischer et al., p. 246.

[60] U.S.D.A., Main Agricultural Experiment Station, p. 20.

[61] Fischer, et al., p. 246.

depth to water table information can only be determined through detailed field study unless the water table is at or above the soil surface.

2. Slope:[62] "A sites steepness or its percent of slope, play a basic role in determining its use for recreational development."[63] Slope affects any excavation for cottage and limits accessibility.[64] The U.S.D.A. (1972) reports that: slopes of 0-8 percent pose a slight limitation to the construction of cottages, slopes of 8-15 percent pose a moderate limitation, and slopes greater than 15 percent pose a severe limitation.[65] Similar limits apply to ratings for septic tank absorption fields. Steep slopes also indicate a high erosion potential which could be aggravated by the increased soil moisture from the filter fields. The ELUC Secretariat (1977) also puts forward slope limitations when it reports that "slopes of greater than 9° (16%) can provide serious limitations to picnic areas, campsites and building development. Slopes greater than 31° (60%) are severely limiting for almost all uses and developments."[66] Douglass (1969) reports that camping units should be built on slopes of less than 10 percent. Both Walmsley (undated) and ELUC (1977) infer that steeper slopes are directly related to high erosion hazard and high construction and maintenance costs. Walmsley notes that:

> slopes of 0 to 15 percent are not considered limiting in terms of most land uses and are generally not susceptible to the standard types of soil erosion such as slumping and sliding. Slopes between 16 and 50 percent encompass a type of terrain which...has limited recreational uses and

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[62] ELUC, p. 79 &56; Mark Walmsley, Shoreline Characteristics of The Greater Vancouver Area, Draft Report, (undated), p. 7; U.S.D.A. Soil Conservation Service, p. 23 & 31; Douglass, p. 87; UBC, p.1; Ian L. McHarg, Design with Nature, (New York, 1969), p. 142; Fischer et al., p. 246; U.S.D.A., Main Agricultural Experiment Station, p. 19.

[63] Douglass, p. 87.

[64] U.S.D.A., Soil Conservation Service, p. 29.

[65] U.S.D.A., Soil Conservation Service, p. 29.

[66] ELUC, p. 56.

> is moderately to strongly susceptible to downslope movement. Slopes in excess of 50 percent are the 'red light' areas in terms of any land use and are considered very strongly susceptible to all types of downslope movement.[67]

Douglass (1969) substantiates these findings.[68] For the construction and layout of septic field absorptions sites, slope affects the risk of lateral seepage and downslope flow of effluent. Flat areas also have hazards as they may be poorly drained and therefore unsuitable for septic field absorption sites, intensive use, or structures.

3. Landform modifying processes[69] are processes which "have modified or are modifying genetic materials and their surface expression."[70] These processes include gullying, failing, piping (see glossary), longshore drift, berm building, cliff erosion, and circulation in bays and lagoons.[71] Bauer (1976) reports that the presence of these processes can limit the construction of buildings and the location of development, including that associated with camping and picnicking areas. For example, Bauer feels that cottages should be built to avoid interference with natural shore processes as well as to reduce the costs of protection from such things as wave attack and inundation. Information about shore processes also allows for proper management of the shore resource which is one of the main attractions for cottage development, camping, and picnicking in the coastal zone.[72] Information about these processes along with other biophysical information

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[67] Walmsley, p. 7.

[68] Douglass, p. 87.

[69] ELUC, p. 54; U.S.D.A., Soil Conservation Service, p. 51.

[70] Robert H. Twiss, "Methods for Environmental Planning of the California Coastline," in Tools for Coastal Zone Management, Proceedings of the Conference, (Washington, 1972), p. 77-78.

[71] ELUC, Terrain Classification System, (1976), p. 25.

[72] Bauer, passim.

such as slopes, materials, soil moisture and vegetation, can lead to an interpretation of erosion or accretion susceptibility and reduced costs of building and maintaining structures.

4. Flooding and inundation hazard:[73] Within the coastal zone, creeks and rivers may overflow their banks during snowmelt and other high runoff periods. Along the shore, during the storm season, backshore areas can be inundated by storm-tide waves breaching protective berms. Both of these situations are limitations to development of organized camping and picnicking sites.

Flooding by storm-tide events or by creeks is not usually a problem in coastal British Columbia during times of the year when beach associated camping and picnicking is popular. Areas of flooding, however, are still pertinent to the location of permanent structures such as cottages and changing rooms associated with organized camping and picnicking areas.

Flooding affects the bearing strength and settlement of soil under buildings. If soils subject to flooding are not protected, they should not be developed for campsites, picnic sites, or vacation cottages.[74] Only rare flood events can be tolerated without posing severe limitations to development of both septic tank absorption fields and buildings.[75] "Flood-waters interfere with the functioning of the filter fields and carry away unfiltered sewage"[76]

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[73] Douglass, p. 88; Department of Regional Economic Expansion p. 46.

[74] Fischer, et al., p. 246.

[75] U.S.D.A., Soil Conservation Service, pp. 23 & 31.

[76] U.S.D.A., Soil Conservation Service, pp. 25.

5. <u>Potable water supply</u>:[77] "Water is an essential ingredient of most recreation areas. It is required for the existence needs of cooking, washing, and drinking...."[78] "Water is less essential to picnicking than it is to camping (and cottaging) because many picnickers come ready equipped for the meal and have a limited need for additional water."[79] "To provide water in a recreation area implies many questions about its physical, chemical, and biological conditions."[80] These include the quantity of water, the quality of water, and the source of water (ponds, flowing water, or groundwater).

6. <u>Debris accumulation</u>: (Backshore Only) Is the material in and on the beach which may require periodic maintenance. In some cases such accumulations (e.g. driftwood and seaweed) form attractive features along the shoreline. However, when they accumulate in areas (particularly backshore areas) used for camping and picnicking they may become a nuisance. The Resource Analysis Branch of ELUC, in their Recreation Capability Inventory (1977) refer to driftwood and seaweed accumulations, and aquatic plants as biological nuisances and inventory them as they affect water-based recreational uses.

7. <u>Backshore and lowland areas</u> indicate the amount of backup shoreland available for intensive recreational use in association with beaches. A top quality beach should have "25 acres of generally level to gently sloping backshore for supporting development of

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[77] U.S.D.A., Soil Conservation Service, pp. 23, 25 & 31; UBC p. 1: Fischer, et al., p. 246; U.S.D.A., Main Agricultural Experiment Station, p. 19.

[78] Douglass, p. 88.

[79] Douglass, p. 155.

[80] Fischer, et al. p. 228

facilities (e.g. access roads, car parks, games areas, sanitary facilities, picnic areas, campgrounds, etc.) within 1000 feet of the beach."[81] Douglass (1969) however, suggests that "a little space and some screening should separate the beach area from picnic grounds" and "picnic grounds should be located at least 150 feet from the waters edge."[82] Camping areas are generally situated more than 200 to 300 yards from the beach so that day-use visitors do not intrude in the campgrounds[83] and serious damage to shoreline areas is prevented.[84]

8. Vegetation density[85] "is defined as the composite density of the shrub layer (under 10 metres) and tree stems within a unit."[86] Vegetation density affects clearing costs for site development. Low vegetation density is a hinderance in camping and picnicking areas where vegetation is desirable. "The buffer zones which usually surround camping units (and often picnicking units) are strips of woodland that have been left to provide privacy and to help protect the soil and vegetation from destruction."[87] The vegetation density can be measured through detailed study in the field, as the percent ground cover by the shrub layer and the number of stems per acre. Aerial photographic interpretation is also useful in measuring vegetation density (refer to the air photo part of this report). It is often simply referred to as open or dense in general surveys of areas (e.g. Bauer, 1976).

[81] Department of Regional Economic Expansion, p. 19.

[82] Douglass, pp. 154 & 241.

[83] Douglass, p. 24.

[84] Douglass, p. 140.

[85] ELUC, p. 80

[86] ELUC, p. 63.

[87] Douglass, p. 137

2.2 Foreshore

1. Foreshore material:[88] The beach material affects the type and amount of recreational use which occurs there and is important from "ecological as well as social points of view."[89] For example, beach materials of silt or clay are normally unsuited to popular recreation activity. The material composing the beach is often a major factor in determining its useability."[90] The Canada Land Inventory (1969) Land Capability Classification for Outdoor Recreation states that a top quality (Class I) beach is "composed of clean, fine-grained materials ranging from pea-sized pebbles to fine sand (ie. it must be comfortable for naked feet to walk and play on)."[91] Douglass (1969) also reports that a beach should have at least 12-inch layer of sand or pea-sized gravel on it to serve both as a play area for children and as a sunbathing spot for adults.[92] The beach materials also reflect the associated shore processes and feed-source composition.

2. Foreshore area[93] indicates the amount of use which a site can sustain at a given time since beaches are "generally stable, tolerant to use for recreation, and free from conflict with other uses."[94] A top quality beach for recreation should include "1000 feet of beach within a $\frac{1}{4}$ mile length of shoreland"[95] since "for everyone, no matter how gregarious, there comes a degree of intensity of use which we will agree is undesirable

[88] ELUC, p. 28.

[89] Walmsley, p. 5.

[90] Walmsley, p. 5.

[91] Department of Regional Economic Expansion, p. 19.

[92] Douglass, p. 241.

[93] Department of Regional Economic Expansion, p. 19.

[94] Department of Regional Economic Expansion, p. 19.

[95] Department of Regional Economic Expansion, p. 19.

crowding, where his satisfactions from the area or activity decline."[96] "The Bureau of Outdoor Recreation plans... 75 square feet of beach for each man-day use."[97] The foreshore area and materials is also important from an ecological point of view.[98]

3. Mean Higher High Tide Level: A beach is one of the main attractions for campers and picnickers in the coastal zone because of the broad range of activities associated with beaches. The mean higher high tide level is required to ascertain if there is any beach (walkable or useable drift berm or backshore zone) during periods of high tide.

4. Shellfish beds: Shellfish beds may be contaminated by sewage filter field placement on nearby shorelands. Shorelands adjacent to shellfish beds are thus unsuitable for (are incompatible with) sewage filter field construction. Information about the location of shellfish beds (above MLLW) mark) is easily collected in the field during low tides. There are many factors that influence the contamination of oyster beds by sewage filter fields. These include water temperature, currents, and tidal flushing. None of these can be reliably measured in the field during a quick inventory survey such as Bauer's, Walmsley's, or E.L.U.C.'s.

2.3 Upland, Scarp, Lowland, Backshore and Foreshore Areas

1. Biophysical and Cultural Factors:

i) Land and Water Use, Land Cover, and Man-Made Features:[99]

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[96] Marion Clawson and Jack L. Knetsch, Economics of Outdoor Recreation, (Baltimore, 1972), p. 167.

[97] Douglass, p. 241.

[98] M.E. Walmsley, Shoreline Characteristics of the Greater Vancouver Area, p. 5.

[99] Recreation Capability Inventory (for B.C.), (no further information given), (1975), p. 15; Peter J. Dooling, Perspectives on Alternative Approaches to and Evaluation Criteria of Recreation--Resource Inventory & Assessment Systems for Provincial, Regional and Site Plans, Wildlands Recreation Conference, (Banff, Alberta, 1977), p. 25; Recreation Capability Inventory (for B.C.), pp. 6&15; Fischer, et al. p. 223.

Land use refers to "man's activities on land which are directly related to land"[100] while land cover refers to "the vegetational and artificial constructions covering the land."[101] Land use considerations should reflect compatibilities and conflicts to potential to support development and use.[102] Some man-made features of the coastal zone complement camping, picnicking, and cottaging use (e.g. access roads and trails, open meadowlands,[103] and Indian middens and petroglyphs). Some land uses, water uses, and man-made features, however, are not compatible with camping, picnicking, and cottaging if found in the same unit (e.g. sewage outfall areas, industrial areas, log booms, urbanized areas, railway yards, etc.). Thus, some man-made features and land and water uses may limit while others may attract campers, picnickers, and cottagers.

Therefore, a planner or manager "should search for accessible areas within a setting that would not be adversely influenced by adjacent developments,"[104] and should be aware of all the cultural improvements that lie on or influence the site. Natural features such as "cliffs, rock outcrops and swamps can be attractions or hazards to recreation development depending on their nature and location."[105]

ii) Attractive and unique features of the coastal zone provide recreational attractions with which campsites, picnic sites, and cottages are invariably associated. These attractive features may vary from

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[100] James R. Anderson, Ernest E. Hardy, John T. Roach, and Richard E. Witmer. A Land Use and Land Cover Classification System for Use with Remote Sensor Data, Geological Survey Professional Paper 964, (Washington, 1976), p. 4.

[101] Anderson, et al., p. 4.

[102] Twiss, p. 78.

[103] Bauer, passim.

[104] Douglass, p. 88.

[105] Douglass, p. 87.

bedrock formations to the presence of wildlife. Just as unique vegetation has recreation attraction, so do other unique features such as historic sites, accretional beaches, middens and petroglyphs, rock formations, etc. Since camping and picnicking are invariably found in association with other recreation features, other unique features are also of importance.

iii) Proximity to streams: These water bodies may also subject surrounding areas to flooding or inundation hazard. Streams draining across foreshore areas also limit the foreshore areas available for certain recreational activities (e.g. sunbathing).

iv) Vegetation Sensitivity: "Usually the most conspicuous feature of an outdoor recreation area is its vegetation."[106] The sensitivity of vegetation to the environmental changes caused by recreational use of a site is related to:[107]

1. habit growth form of the plant species (e.e. its resistance to damage).
2. the ability of the species to recover from damage.
3. the ability of the species to regenerate (seed availability and germination requirements especially for annuals and biennials).
4. plant size.
5. competitive pressures from invading weedy or seral species.
6. site wetness and surface drought.
7. slope.
8. lack of soil cohesion.
9. compaction.
10. nutritional status of the site.
11. evapo-transpiration rate.
12. subsequent erosion following vegetation destruction.

Some of these factors can be noted readily in the field (e.g. slope) however, the others must be ascertained through more detailed field, laboratory, or literature study.

[106] Fischer, et al., p. 223

[107] Fischer, et al., p. 64.

v) Vegetation Hazard or Nuisance refers to the discomfort caused by plant species such as devil's club, blackberry, gooseberry, rose and hawthorn. Some aquatic species of plants can also be a nuisance to those who use beaches. Hence, these species may affect the location of "picnic and campsite areas in which a minimum amount of clearing is anticipated"[108] or may require eradication programs.[109]

For camping areas the canopy must be open to allow for the admission of sunlight and to provide for air movement. This allows for drying out of cloths and camping gear and the escape of smoke, gasoline fumes, and cooking odors from campsites.[110] The amount of wooded or cleared land can also help planners determine the costs of cutting or planting to raise the site-quality to the prescribed levels for camping or picnicking.

vi) Attractive or Unique Vegetation:[111] certain types of vegetation which are unique or particularly attractive to recreationists. Open forests, grassland and meadowlands as well as areas of wildflowers are particularly important in this respect.[112] They are attractive for their natural beauty because they often support large numbers of wildlife, and because they are easy to walk through.

vii) Wildlife Conflict[113] refers to the situations where fish or wildlife populations may be adversely affected by recreational use. Such

[108] ELUC, p. 62.

[109] Douglass, p. 90.

[110] Douglass, p. 139.

[111] ELUC, p. 5; Recreation Capability Inventory (for BC), (1975), p. 7.

[112] Bauer, passim.

[113] ELUC, p. 61.

instances would include:[114]

1. important waterfowl nesting, staging, or wintering areas.
2. important big game mating, birthing, wintering, migration, or mineral-rich areas.
3. habitat of special importance to rare or endangered animal species.
4. important fish spawning habitat.

Shellfish may also be detrimentally affected by sewage leaking from septic tank absorption fields. While the location of shellfish in the foreshore may be readily inventoried in the field, other wildlife conflict observations require more detailed field study.

viii) Land Ownership, Municipal and Regional Zoning, Planning Ordinances, Land Reserves, and Other Legal Constraints all tend to limit the type of use and the area available for use in the coastal zone. Sometimes these factors are based on environmental factors, and sometimes on social or economic factors. None of these factors can be readily determined in the field, although ownership in general terms (e.g. public or private) can sometimes be inventoried.

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[114] ELUC, p. 61.

VI.3 Selected Biophysical Factors Affecting Camping, Picnicking and Cottaging Development

The environmental factors selected for the purpose of camping, picnicking and cottage development are based on a literature review and were further refined for this study on the basis of those factors which could be interpreted from aerial photography or collected in the field without detailed study. Mainly they consist of biophysical factors which may be limiting to development or use; however, recreational camping and picnicking, as well as cottage development do not occur wherever the biophysical limitations are low but are found associated with other attractive features. Some of those features deemed important have been included in the evaluation (ie. beach material and area, unique features, and attractive vegetation). Land and water use, land cover and man-made features (e.g. access trails, roads, etc.) also influence the usefulness of a site for camping, picnicking and cottage development and have thus been included in this list.

3.1 List of Selected Information Requirements

A. For Camping, Picnicking and Cottaging Areas:

Those factors which affect camping and picnicking are the same factors which affect cottage development. Camping has a higher use intensity and is less tolerant of topographic and soil limitations than is cottage development. Thus, some factors have different limits for cottaging than they do for camping and picnicking.

1. Upland, Scarp and Backshore:

1.1 Soil Factors

a) soil texture
b) presence of coarse fragments
c) soil drainage
d) soil depth
e) rockiness

1.2 Slope

1.3 Flooding hazard and inundation

1.4 Vegetation (the need for screening)
    a) hazard or nuisance plants
    b) vegetation density
    c) attractive or unique vegetation

1.5 Lowland areas

2. Backshore:

2.1 Backshore area

2.2 Debris accumulation

3. Foreshore:

3.1 Foreshore area and materials

3.2 Mean higher high tide level

4. Foreshore, Backshore, Lowland, Scarp, and Upland:

4.1 Land and water use, land cover, and man-made features

4.2 Unique and attractive features.

B. For Septic Tank Filter Fields:

1. Upland, Scarp, and Backshore:

1.1 Soils and Surficial Methods
    a) soil texture
    b) soil drainage
    c) soil depth
    d) rockiness
    e) fractured or crevassed bedrock

1.2 Slope

1.3 Flooding or inundation hazard

1.4 Proximity to streams

2. Foreshore:

2.1 Shellfish beds.

CHAPTER VII Study Results

VII.1 An Overview of the Three Selected Classification Systems

1.1 Bauer

This inventory system has genetic bias because it is concerned with processes and how they affect the development of beaches. Silk's comment on genetic classifications of the coastal zone is apolicable to Bauer's classification: "Although the effects of marine erosion are given great attention, the sea itself is usually ignored as is submarine morphology. The use of meteorological factors is restricted to their role in geomorphological processes and biological factors receive scant attention."[1] The processes which Bauer concerns himself are more useful to regional planners than are the systems discussed by Silk because they address events of the past, present, and future and are of a sufficiently detailed scale.

Bauer's system is like the applied coastal zone classifications discussed by Silk because it is based on a genetic approach to beach development with an "emphasis on usage and the necessity for comprehension by inexperienced personnel."[2] The necessity for comprehension by inexperienced personnel is a valuable asset of Bauer's beach classification in areas such as the coast of British Columbia where few experienced coastal zone managers exist.

Bauer's classification is akin to the descriptive coastal zone classifications reviewed by Silk because of the descriptive format which

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[1] Dana D. Silk, (October, 1975), p. 18.

[2] Dana D. Silk, (October, 1975), p. 19.

is used. Thus, while ELUC and Walmsley's systems include information within the rigid framework of a legend or cartographic symbol, Bauer's makes use of a descriptive format to describe each beach unit. This allows for the inclusion of information in addition to that which could fit into systems with rigid frameworks. Like the other descriptive classifications noted by Silk, Bauer's "lacks the basic structure necessary for an orderly comprehensive classification, but illustrates the amount of information that would be lost if no opportunity is made for its inclusion."[3] This same lack of structure appears to be responsible for the inconsistency in amount of detail given by Bauer for each of his units. Silk summarizes by reporting that descriptive classifications provide valuable information when used to fill the gaps left by other classification systems.

Bauer's inventory includes some of the attributes of morphological classifications in his study when he recognizes the processes involved in landform development by noting the resultant landforms (e.g. he mentions a dual-beach tombolo in his unit descriptions but in an appended text refers to the processes which formed that landform). His system does not refer to submarine morphology.

Bauer uses the wave energy zone of the beaches in his inventories and therefore is including information which Silk (October, 1975) says belongs to dynamic coastal zone classification systems. Like other dynamic

[3] Silk, (October, 1975), p. 21

systems, however, Bauer's data is limited by a lack of quantitative information. Bauer only gives qualitative or approximated values for wave energy levels, for the tides of an area, and for littoral movement but does suggest that further studies by set up to provide quantitative information for these parameters.

1.2 Walmsley

This inventory classification has an inflexibly structured symbol legend and map format. It does not give any attention to process and physical forms are not recognized except in very general terms such as foreshore, lowland and bluff. In order to describe the variations that actually exist in the coastal zone, even for those few categories which Walmsley includes, such a large number of symbols would be required that the use of that system would be very cumbersome. Short of this, the actual data collected has to be modified to fit the system (e.g. slope classes and beaches textures of Walmsley's classification) and further modified when being interpreted for use. This system also lacks a "mechanism for incorporating miscellaneous or unique data" and as Walmsley notes, it is of little immediate use to engineers or planners but is to be used in conjunction with other physical environmental information to form a planning tool. Silk notes that "because of the dynamic nature of the coastal zone, and the management need for recognizing functional interrelationships, a classification system must not only involve forms but also processes.... The heterogeneity of the coastal zone, (and) of the data base,... necessitate a flexible system."[4]

[4] Silk, (October, 1975), p. 46.

1.3 ELUC

The ELUC inventory classification system is simply an expansion of the data base of Walmsley's classification and as such has the same inherent limitations. The use of the 1976 Terrain Classification System does give the inventory a genetic emphasis in describing the materials of the scarp and lowland, but does not allow for the description of forms or processes in the shore zone to the degree required for coastal zone planning and management.

As Ehrlich (1970) reports "no one classification fulfills all the requirements in any field; often several systems are needed,"[5] and as McGill (1959) notes "the complexity of most coastal zones precludes a single system from being satisfactory, demanding instead a multiple approach involving several systems,"[6] so it appears that none of the three classification systems evaluated here accomplish the impossible.

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[5] W.A. Ehrlich, Soil Classification In Canada Department of Agriculture, The System of Soil Classification for Canada, p. 9.

[6] J.T. McGill, Coastal Classification Maps : A Review, pp. 1-21 In R.J. Russell Second Coastal Geographic Conference, Coastal Studies Institute (Baton Rouge, Louisiana, 1959) in Dana D. Silk, (October, 1975), p. 29.

VII.2 The Areas Covered by the Three Classification Systems Being Evaluated by the Current Study

Of the three systems being evaluated, none satisfy all the informational requirements chosen for capability and suitability for organized camping, picnicking, and cottage development. This is partly due to the difference in the boundaries of the study areas:

2.1 Frank

The landward boundary of the proposed composite system evaluative study area lies 300 metres inland from the Mean Higher High Tide level while the Mean Lower Low Tide level marks the seaward boundary.

2.2 Bauer

Bauer limits most of his study to the 'Shore-Process Corridor' and to the beach resource of that corridor in particular. The Shore-Process Corridor is the area of variable width directly affected by or affecting the prevailing geohydraulic and geopheumatic systems. The seaward limit of this corridor is approximated on Bauer's maps by the 6-fathom line which forms "an approximation of the aquatic fringe of the Shore-Process Corridor in terms of extreme Pacific storm wave bottom effects, and the relative buffer for wave energy dissipation."[1] The landward limit of his study area is the coastline which he defines as "the highest landward line of long-term erosional attack of marine waters upon the land. This may be active as such only once in fifty years or more under extreme coincident storm and tide surge conditions, or it may be under daily wave erosion."[2]

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[1] Bauer, Western Community Shore Resource Analysis, p. 4.

[2] Bauer, Accretion Beach Inventory, (Undated Copy), p. 41.

The seaward boundary of Bauer's study area includes the seaward limit of the evaluative study. The landward limit of his study, however, may or may not include the inland boundary of the evaluative study. Where the coastline lies within 300 metres of the MHHW level Bauer's classification falls short of the entire evaluative study area. Where the coastline lies more than 300 metres inland of the MHHW level Bauer's inventory includes all of the evaluative study area. Because his data does not give the width of lowland and backshore areas it is difficult to determine if the entire evaluative study area is encompassed in each of his units. Therefore, where Bauer describes materials of the scarp it is difficult to know how far into the upland the description of materials holds true.

2.3 Walmsley

Walmsley's mapped inventory classification uses the lowest low tide mark as the seaward boundary and therefore includes the seaward limit of the evaluative study area. The landward limit of his study areas extends 1000 feet in areas of lowlands and backshores and therefore approximates the 300 metres inland boundary of the evaluative study. Where bluffs occur within 300 meters of the beach, Walmsley's classification falls short of providing the information required because there is no section to allow for the description of backshore or lowland areas. The symboling scheme proposed in his draft report, however, does suggest description of the area between the beach and the scarp. Walmsley's mapped symbols only describe the texture of beach areas and do not describe them in any more detail.

2.4 ELUC

ELUC's system used the suggestions of Walmsley's draft report and provided a section describing the slope,width, texture, and genetic origin of the area between beach and scarp. ELUC has called this area the lowland, but in fact the symboling has included backshore and lowland areas. The distinction between backshores and lowlands is important (refer to section entitled: The Distinction Between Backshores and Lowlands). ELUC also claims to provide textural information for the foreshore and backshore areas. The backshore section of this symbol actually represents narrow drift berms which Wolf Bauer classifies as Class I and II beaches. The large areas of backshore associated with Class I beaches above the drift berms are actually included in the lowland section of the classification symbol.

The boundaries of ELUC's classification are the same as those used for Walmsley's classification and therefore has the same limitations in relation to the boundaries chosen for the evaluative study area.

VII.3 An Overview of the Use of Remote Sensing*

There are almost limitless possibilities for the use of remote sensing in evaluating and inventorying the resources of the coastal zone. The three film types used for this study (color, infrared color and black and white) were all found to be very useful in inventorying the coastal zone according to the classification systems by Bauer, Walmsley, and E.L.U.C. A detailed evaluation of the use of these film types can be found in Chapter IX. Examples of interpretations made from the black and white aerial photography can be seen in Appendix III and slides demonstrating some of the relative advantages of each of the three film types are presented in Appendix VII.

Difficulty in coastal zone classification is due in part to the lack of cooperative effort by all the agencies and individuals interested in the coastal zone to reference remote sensor imagery and other data collected with a central clearing house. This results in much duplication of effort.

The use of aerial photography for this study was found to be necessary because:

1. areas of the foreshore are only exposed for short periods of time during very low tides which occur infrequently during the year.
2. the coastal zone is very extensive and,
3. ground and water access is often limited.
4. the great variety of terrain, climate, and vegetation along the coast is best studied using aerial photographic interpretation, and;
5. broad scale features are often more evident on air photographs than on the ground (e.g. types of sandbars, sand dunes, etc,)

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* refer to evaluation of sensor types Chapter IX.2.

The need for oblique aerial photos was made obvious when attempting to pretype the beach types below steep cliffs and bluffs where shadows and overhanging vegetation obscurred upper foreshore and backshore detail.

VII.4 Resulting Maps and Descriptions

Refer to Appendix II and III for the maps and unit descriptions according to the systems by Bauer, E.L.U.C. and Walmsley.

VIII.1 Selected Information Requirements

1. Upland, Scarp, Lowland and Backshore:	Camping	Picnicking	Cottaging	Sewage Filter Field Placement
1. Soil Factors:				
i) soil texture	X	X	X	X
ii) presence of coarse fragments	X	X	X	X
iii) soil drainage	X	X	X	X
iv) soil depth	X	X	X	X
v) rockiness	X	X	X	X
2. Slope	X	X	X	X
3. Flooding Hazard and Inundation	X	X	X	X
4. Vegetation:				
i) hazard or nuisance plants	X	X	X	
ii) vegetation density	X	X	X	
iii) attractive or unique vegetation	X	X	X	
5. Proximity to Streams				X
2. Lowland Only:				
1. Lowland Area	X	X	X	
3. Backshore Only:				
1. Backshore Area	X	X	X	
2. Debris Accumulation	X	X	X	
4. Foreshore Only:				
1. Foreshore Area and Materials	X	X	X	
2. Mean Higher High Tide Level	X	X	X	
3. Shellfish Beds				X
5. Upland, Scarp, Lowland, Backshore and Foreshore:				
1. Land and Water Use, Land Cover and Man-Made Features	X	X	X	
2. Unique and Attractive Features	X	X	X	
3. Modifying Processes in the Coastal Zone	X	X	X	X

VIII.2 Bauer

2.1 Upland, Scarp, Lowland, and Backshore

1. Soils and Surficial Materials

i) Texture: From the data Bauer provides it is difficult to infer the texture of soils and surficial materials in upland areas particularly along rocky shores and inland from feeder bluffs. The texture of accretional shoreforms (hooks, spits, points, barrier beaches, tombolos, and rollback berms) is readily inferred from the texture of the upper foreshore and drift berms which Bauer often gives. The texture of these shoreforms may also be generally inferred from Bauer's approximation of the wave energy zone in which they occur. In medium to high wave energy zones (within the Strait of Georgia), terminal accretion shoreforms are ususally gravelly in texture while in lower energy zones they are more sandy[1] (refer to section on modifying processes for further information about wave energy zones).

In isolated cases where there is active erosion of the scarp, Bauer may mention the texture of materials in a general way: "several till layers of varying permeability (clay content)...". The scarp materials are mentioned in a general way in the introduction to the study area where he states that the materials are: "predominant(ly) rock outcrops interspersed with small cove beaches of glacial till pockets eroding landward" and "two major drift-sectors of glacial bluffs, terraces and accretion shoreforms."[2] Textures for individual scarps are not usually given but in some cases the gravel content of the feeder bluffs can be approximated from the width and height of the drift berms. This can sometimes be derived from the rate of erosion which Bauer sometimes gives and the height of the scarp which Bauer doesn't usually give.

[1] Wolf Bauer, Western Community Shore Resource Analysis, 1976, p. 18.

[2] Bauer, pp. 1-2.

Bauer does not always give the texture of materials above the scarp or in lowland areas because his study was mainly concerned with the Shore-Process Corridor (see glossary). The Shore-Process Corridor, however, will encroach upon the land in areas of active feeder bluffs and landward eroding scarps of pocket beaches, and thus the materials and textures of materials of uplands and scarps should be inventoried to some estimated erosion-time line representing the limits of the Shore-Process Corridor at a future time. Bauer himself suggests more detailed studies to accompany a zoning effort to identify the Shore-Process Corridor of some future time.[3]

Bauer usually mentions land use in his unit descriptions. Where this land use includes gravel or sand pits, the texture of the material and the availability of contruction aggregate in the immediate vicinity is obvious.

ii) Presence of coarse fragments: Bauer only occasionally mentions scarp material, and his study area is limited to the present-day Shore-Process Corridor. Information about the presence of coarse fragments is not available for most areas. In some instances where Bauer does note coarse fragments in the foreshore materials, the presence of some amount of coarse fragments in the feeder bluff material can be expected.

iii) Soil drainage: "Permeability, level of groundwater and seepage are factors affecting soil drainage, but these are not easily observed or measured in the field." Some soil drainage information may be inferred from slope (depressional areas are more apt to have poor soil drainage) and textural information (finer textured soils tend to have more drainage problems than coarse textured soils). Refer to the sections on slope and texture to see which information is provided by each of the systems.

For the variable area of the coastal zone which Bauer describes (the Shore-Process Corridor) he only mentions soil drainage by identifying salt- and fresh-water marshes and some backshore ponds. Other vegetational

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[3] Bauer, 1976, p. 23.

information which may indicate areas of poor or extremely fast soil drainage is lacking. Bauer gives no soil drainage information in upland areas outside of the Shore-Process Corridor because such information is outside the realm of the purpose of his study and is in fact additional information required for the purposes of this evaluative study.

iv) Soil depth: For upland areas above rocky shores and for areas beyond the Shore-Process Corridor, Bauer does not give any solid information (refer to section VII.2). The depth of materials on accretional shoreforms which Bauer inventories can usually be assumed to be deep (thicker than one metre) unconsolidated material (due to their mode of formation). The depth of materials on lowlands, scarps, and backshores are not given, although in some places they may be inferred from the land use which Bauer often mentions (e.g. the sand pit in Unit #39 of the Nanaimo study area - see Appendix II).

Sometimes Bauer gives the height of eroding banks and feeder bluffs from which material depth and thus the amount of material available for erosion can be extrapolated. The landward distance to which this information can be extrapolated is questionable (see Section VII.2).

v) Rockiness: Of the parts of the coastal zone which Bauer does inventory (refer to Section VII.2) he does not always mention that an area contains bedrock outcrops. Nor does he describe the type of bedrock where it does occur.

2. Slope

Bauer does not give explicit slope information but sometimes mentions that a scarp is steep, a meadow is rolling, or a shoreland is gently sloping. He does not define gently or steeply sloping but merely makes subjective assessments of these. Thus, the slope information provided by Bauer is not suitable for many of the interpretations required for land uses which could take place in the coastal zone.

3. Flooding and Inundation Hazard

Bauer's study explicitly identifies the backshore areas which may be inundated and the berms which may be breached by extreme storm-tide events. He goes much further by explaining that these areas are part of a unique, diminishing, and valuable resource which should not be built up with housing or cottages. The costs of protection from inundation as well as the consequent destruction of this valuable beach resource through the construction of protective structures make such use impractical and costly to society. For example, berms which form the "physical backbone"[4] of accretional shoreforms, are built by extreme storm-tide events which overtop them and thus build them up to act as effective sea dykes against lesser storm-tide events. Thus, beach berms should not be built on or destroyed for fear of inundation and destruction of the real resource: a geophysical and biological entity with a "dual-recreation-biological resource potential."[5]

Bauer identifies ephemeral and perennial streams and in some instances mentions that there is a flooding stage. He does not identigy floodplains on his maps but concentrates on the beach resource. Bauer also identifies fresh and salt-marsh areas and backshore ponds which are subject to flooding at very high tide levels and during high runoff periods.

4. Vegetation

i) Hazard or nuisance plants: Bauer only investigates hazard or nuisance plants above the Mean Lower Low Tide (MLLT) level in areas of backshore salt and fresh water marshes. In a text appended to his Western Community Shore-Resource Analysis report he notes that "from the standpoint of recreation, this dual resource (referring to the recreation and bio-process

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[4] Wolf Bauer, Western Community Shore-Resource Analysis, 1976, p. 36.

[5] Bauer, p. 39.

resources common to accretional shoreforms, the leeward side of which often contain marshes) has fared without major problems thus far...any leeward marshy shores and shallow lagoons have tended to discourage polluting motor boats, or consumptive marine activities."[6] This then, refers to the marshy areas as an impediment or nuisance to intensive recreational uses.

Bauer makes no note of terrestrial hazard or nuisance plants.

ii) Vegetation density: Bauer often notes the vegetation of the backup shoreland to the beach being inventoried. In some cases Bauer does mention vegetation density in a subjective way (e.g. "heavy tree cover"[7] and "heavily wooded"[8]). For many units, particularly pocket beaches, no indication of the vegetation density is given.

In short, Bauer sometimes gives general vegetation density information for lowlands, scarps, and uplands. For many units, however, he gives no vegetation information.

iii) Unique or Attractive Vegetation: Bauer makes a point of mentioning areas of unique or attractive vegetation in or near to the Coastal Process Corridor (including upland areas) by using such phrases as: "open meadow uplands of high recretional and scenic values,"[9] "scenic grassy uplands,"[10] and "this beach environment is further enhanced by the adjacent farmland of open meadow-tree parkland...containing an outstanding open forest environment."[11] From his descriptions it is obvious that Bauer considers natural and man-made meadows, open forest and grassland to be attractive

[6] Bauer, p. 39.

[7] Bauer, p. 8.

[8] Bauer, p. 9.

[9] Bauer, p. 9.

[10] Bauer, p. 17.

[11] Bauer, p. 15.

vegetation. Unique areas of vegetation are also inventoried (e.g. Unit #37b of the Nanaimo study area - see Appendix II)

5. Proximity to Streams

As well as being a limitation to the location of sewage filter field placement, streams are important as sources of potable water for recreational areas. Bauer's base maps include the locations of perennial and most ephemeral streams. His beach inventory descriptions also include the many small ephemeral streams which have a recognizable channel and empty into a beach area (the definition of a stream presents a problem because of an undefined distinction between soil seepage and streams, and between dirty streams and mudflows). The smaller ephemeral creeks entering Bauer's units are not located geographically on his base maps.

2.2 Lowland Only

1. Lowland Area

Bauer only describes lowlands in general terms, if at all, and it is not possible to calculate their area from his description.

2.3 Backshore Only

1. Backshore Areas (Refer to section on the Distinction Between Backshores and Lowlands.)

According to Bauer's beach classification it is easy to pinpoint areas where there may be a backshore of significant area to be used for a camping, picnicking, or cottaging area. The backshore of Class I beaches could vary from very small (where pocket beaches of only 100 feet in length are described) to very large (where accretional shoreforms are described). From Bauer's base map it is possible to calculate the approximate area of the backshore of accretional shoreforms but not of pocket beaches. The backshore of Class II beaches is limited to a marginal drift berm, usually at the foot of banks. Thus they are unsuitable for any permanent development associated with organized camping, picnicking or cottaging. Finally, Class III beaches do not have a backshore.

2. Debris Accumulation

Because Bauer's system is primarily concerned with processes in the coastal zone, it is obvious that by identifying accretion shoreforms, he is also identifying catchments for debris travelling in the longshore current. Bauer also notes large accumulations of driftwood. In the beach classification for recreation,[12] which Bauer gives for each unit, driftwood may be expected in varying concentrations along Class I and II beaches; not in any large accumulations along Class III beaches or along rocky shores. Accumulations of driftwood along beach berms or backshores of pocket beaches have also been inventoried by Bauer although he does not include this in his list of iventory data.[13] Other debris on the beach or backshore is not inventoried by Bauer.

2.4 Foreshore Only

1. Foreshore Area and Materials

Bauer gives the beach materials for some units but not for others. He says little about the distribution of the beach material. The distribution of beach materials is important because it can affect the recreational uses of the beach. For example, a beach which has a sandy upper foreshore and a cobbly lower foreshore will get much more use at above low-tides than a beach with a sandy lower foreshore and a cobbly upper foreshore.

The system used by Walmsley to differentiate foreshore and backshore materials is useful because it allows for some understanding of the distribution of materials on the beach. It is possible in some instances, to determine the texture of the upper foreshore or lower backshore in areas where the beaches are part of a drift-sector for which the material comprising the drift berm is given. In this case, the texture of materials comprising the drift berm can be extrapolated to the drift-sector boundaries.

[12] Bauer, 1976, pp. 28-29.

[13] Bauer, p. 7.

Bauer gives the beach length for all of his units but only gives the width for a few and then only in general terms such as: "medium to shallow foreshore, narrow foreshore, and steep foreshore."[14] The beach area for some units can be subjectively estimated but no definite beach area can be assigned to any unit because Bauer does not define a "steep foreshore", a "narrow foreshore", or a "medium to shallow foreshore".

On his maps, Bauer gives the Mean Higher High Water (MHHW) mark to delineate the upper foreshore, but does not give the MLLW level needed to determine the lower limit of the foreshore.

2. Mean Higher High Tide Level

Wolf Bauer gives the MHHT level (as interpreted from high tide oblique aerial photographs) on his base maps. His beach classification goes even further and tells us explicitly if there is a walkable or useable backshore above the MHHT level.[15]

3. Shellfish Beds

Bauer does not inventory shellfish beds.

2.5 Upland, Scarp, Lowland, Backshore, and Foreshore

1. Land and Water Use

Within the Shore-Process Corridor the land use is often described by Bauer. Where land use affects the natural shore processes (e.g. where a protective dyke is built to protect farmland from inundation), the land use is inventoried. In most cases, however, the land use is mentioned in association with other factors, especially the esthetics of an area

[14] Bauer, passim.

[15] Bauer, pp. 28-33.

(e.g. "...esthetic environment except for visual house impact on west bank," and "...esthetically impacted by dumped car bodies."[16] Land use is not often inventoried for upland areas (see Section VII.2).

Water use is always mentioned by Bauer as it affects the biological and recreational resources and processes associated with the coastal zone (e.g. log booming in Unit #36 of the Nanaimo study area - see Appendix II).

2. Land Cover

Bauer often mentions the land cover of the units he describes. As previously noted however, his inventory mainly covers the Shore-Process Corridor.

3. Man-Made Features

Bauer inventories man-made features which affect the esthetic enjoyment of a shorescape or influence the processes operating in the Shore-Process Corridor (e.g. bulkheads, rip rap, dykes, retaining walls, etc.). He also notes points of access to the beaches (trails and roads). He does not, however, claim to mention all the man-made features in the Shore-Process Corridor.

4. Unique and Attractive Features

Bauer makes a special point of identifying unique and attractive features in the coastal zone. These features often form recreation attractions which add to the diversity and thus the attractiveness of the area. Some of the unique features noted by Bauer include: rollback berms, creek mouths, estuaries, marsh habitat (e.g. Unit #8 of the Saltspring study area - see Appendix II) and intertidal links (tombolos) to rock outcrops and islands in the nearshore or foreshore zones. In an appended text to this report, Bauer argues that accretional shoreforms are unique features due to their limited occurrence and high backshore use potential.

[16] Bauer, p. 8.

5. Modifying Process in the Coastal Zone

The main emphasis of Bauer's study are those processes which are acting in the Coastal-Process Corridor as part of the integrated erosion-transport-accretion beach system. Bauer indicates four major process factors: 1. Areas and types of erosion such as undercutting by wave action, sliding or slumping, or continuous erosion. He does not always give the height of the erosion bluff--this can only be roughly interpreted from his slides of the units. Most topographic maps do not give enough detail to provide this information. 2. Areas of drift where intrusion onto the foreshore could affect the integrated system of erosion-transport-accretion. 3. Areas of accretion (and Class I pocket beaches) where building structures is not recommended because of the vulneribility to storm-wave attack. Bauer emphasizes that the resultant protective structures would cause long term recurring investment, increase building costs, and interfere with the natural processes. This would also deteriorate the resource which attracted development in the first place. Unlike ELUC, Bauer spells out which parts of his units are affected by the modifying processes acting in the Shore-Process Corridor. Where backshores extend 300 metres inland, this process information is all that is required for the purposes chosen. However, where feeder bluffs occur near the water's edge Bauer's study only includes the present day Shore-Process Corridor and does not mention modifying processes in the uplands (see Section V11.2). In some cases, however, Bauer does mention that "houses have been located within less than a hundred feet from the receding bluff rim and their time for replacement or pullback is not far away."[17] Bauer does not give rates of erosion and bluff recession (as they are difficult to estimate readily in the field). Instead, he recommends further studies to determine rates of erosion before allowing

[17] Bauer, p. 18.

development on the bluff tops. 4. Bauer gives the beach orientation and approximate wave energy zone for each beach he inventories. "Low medium and high energyzone approximations are based on beach orientation, nearshore depth in terms of maximum storm wave impacts at high tide, as well as presence or absence of wave-refracting or attenuating headlands or islands. This zoning can also be refined later by adding the wind time-effect via wind-rose data for this location."[18] Bauer's delineation of the nearshore water prism "located between the MHHW tide line and the 6-fathom line"[19] also acts as an approximation of the seaward limit of the Shore-Process Corridor in terms of the extreme Pacific storm wave bottom effect and the relative buffer for wave energy dissipation. This information aids us in determining the intensity of modifying processes (waves, nearshore currents, longshore currents, wind erosion, etc.).

6. Other Relevant Information

Bauer gives the beach orienation for every unit he describes. This beach orientation, in almost every case, closely reflects the aspect of the shoreland and bluffs.

In his description of some beaches, Bauer notes that an area or unit is suited to camping or picnicking: "The high content of coarse gravel in this reach produces high berm porosity and subsequent beach stability. This freedom from erosion is responsible for this amply vegetated berm that is eminently suited to the recreational and esthetic needs of picnicking and beach camping in an original habitat setting."[20] This information is subjective and does not provide the specific information required but it should be noted in view of the fact that Bauer's report was a preliminary study, that some of the units have yet to be finished, and that recommendations for further study have been presented.

[20] Bauer, p. 15.

VIII.3 Walmsley

3.1 Upland, Scarp, Lowland and Backshore

1. Soils and Surficial Materials

i) Texture: The classification symbols mapped by Walmsley[21] give the texture of the soil materials on the bluffs and backshores only. This information is provided because "it is often the material which comprises these bluffs that significantly contributes to the material comprising the beach in the immediate area...and is often a significant factor determining the amount of erosion."[22] The mapped symbols indicate the dominant textures of the material on the scarp face but do not give the genetic origin of the materials (e.g. fluvial, glacial, marine, etc.). Hence some factors which are pertinent to the use of these materials for septic fields or for construction aggregate (e.g. the degree of sorting) cannot be inferred.

One of the problems with using the symbol format of map unit description as used by Walmsley is that it does not allow the flexibility to describe the materials of heterogeneous units. In addition, Walmsley's system has not identified materials overlying bedrock scarp faces; probably because the emphasis of his classification is on the materials of the scarp which contribute to the beach itself.

Walmsley's classification does not inventory areas where there is a lowland area between the foreshore and the bluff (e.g. Unit #108 of the Saltspring study area). Thus, textures are lacking for these areas. His draft report, however, suggests that a special section of the classification symbol be set apart to give the texture, slope, and width of areas between

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[21] Mark Walmsley, Map of Shoreline Characteristics of the Greater Vancouver Area, Draft Report.

[22] Walmsley, Shoreline Characteristics of the Greater Vancouver Area, Draft Report, p. 7.

the beach and bluff. These areas he has mislabelled as lowlands when in fact they include backshore areas and lowland areas.

In cases where the upland material is the same as the scarp material (e.g. Units #46, 47, and 48 of the Nanaimo study area - see Appendix II) the required textural information is given. Where the materials change from the bluff to the upland, above the bluff, within 300 metres of the shore, the textural information from the bluff cannot always be extrapolated to the upland areas (see Section VII.2). Unless a special section of the symboling is set aside for <u>uplands</u>, there is no way to tell if the bluff materials reflect the upland materials for the full 300 metres inland from the foreshore.

Walmsley's map symbol <u>Su</u> is used where there are a series of <u>sediments</u> outcropping on a steep bluff. This symbol does not provide any textural or genetic information about the scarp materials.

ii) <u>Presence of Coarse Fragments</u>: The presence of coarse fragments in the soil materials of the areas described by Walmsley (see section on soil texture) are not mentioned and there is no symbol for them in the legend provided on the map. In his draft report, Walmsley's legend suggests using the E.L.U.C. Terrain Classification System to describe the scarp materials. In this case the presence of coarse materials in the soil would be mentioned "if they constitute more than 25% of the total volume of the deposit."[23] It is interesting to note that Walmsley's draft report does not suggest using E.L.U.C.'s Terrain Classification System to describe materials between the beach and the scarp.

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iii) <u>Soil Drainage</u>: The map which Walmsley has produced identifies marshy and swampy areas below the erosional bluffs which delimit the inland boundary of his study area. Other than the soil drainage

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[23] E.L.U.C., p. 3.

information which may be interpolated from the slope and textural data given, no soil drainage information is provided by Walmsley's classification.

iv) Soil Depth: Walmsley's classification symbols give the depth of materials on the scarp face only. In cases where upland materials remain the same as on the scarp slope, the soil depth is known for upland areas. In cases where the materials change near the bluff edge, (e.g. Unit #110 of the Saltspring study area - see Appendix II) the soil depth is not applicable to the upland areas. From the classification then, it is not possible to tell the depth of materials in the upland with certainty. This may be because Walmsley's system has been developed for the Fraser River area where dykes do not allow for a physical distinction between uplands and lowlands but is especially true when dealing with areas where marine terraces of variable width occur. Walmsley's map does not cover lowland or backshore areas (except for inventorying backshore materials) but his draft report legend suggests the inventorying of areas between the beach and the scarp. His draft report, however, does not mention inventorying soil depth or using E.L.U.C.'s Terrain Classification System for the areas between the beach and the bluff.

v) Rockiness: Bedrock outcrops are only inventoried by Walmsley's mapped system if they occur on scarp faces or beaches. The type of bedrock (igneous or sedimentary) is also noted,but from the information given there is no way to tell if this material also occurs in the upland. Lowland areas are not described by Walmsley's mapped symbols but his draft report suggests describing the materials of the lowland. In thise case, rock outcrops would be inventoried if they occurred in significant amounts.

2. Slope

Walmsley's mapped classification system gives the scarp slope but not the slope of uplands, lowlands or backshores. This is in part due to Walmsley's statement that "as well as material type, the slope and height of the bluff near the coastline are often significant factors determining the amount of erosion and hence amount of material made available for the beaches."[24]

Walmsley presents bluff slope information in terms of slope classes:

Slope Class I	0-15%
Slope Class II	16-50%
Slope Class III	> 50%

He chose these classes because of erosion and recreational use consequences.[25] These slope classes are very easy to use in the field and help to circumvent the problem of inventorying heterogeneous slopes within a given unit; a problem with which the E.L.U.C. classification adaptation has trouble.

There are many different slope classes suitable for different uses. Walmsley's slope classes are useful because:

> Generally speaking, slopes of 0 to 15 percent are not considered limiting in terms of most land uses and are generally not susceptible to the standard types of soil erosion such as slumping and sliding. Slopes between 16 and 50 percent encompass a type of terrain which generally precludes industrial and commercial use, has limited recreational uses and is moderately to strongly susceptible to downslope movement. Slopes in excess of 50 percent are the 'red light' areas in terms of any land use and are considered very strongly susceptible to all types of downslope movement. Obviously, such generalizations must be taken with a 'grain of salt' due to differences in material type, moisture regimes, etc. but they do indicate areas better suited to particular land uses than others.[26]

The E.L.U.C. Recreation Capability Inventory (1977) reports that slopes of greater than 16 percent can provide serious limitations to picnic sites, campsites and building construction.[27] Walmsley's slope Class I fulfills this requirement for the bluff slopes only. For the

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[24] Walmsley, p. 7.

[25] Walmsley, p. 7.

[26] Walmsley, p. 7.

[27] E.L.U.C., Recreation Capability Inventory (Victoris, 1976), p.

construction of cottages in the coastal zone the United States Department of Agriculture reports that slope classes of 0-8 percent and 8-15 percent would include slight and moderate limitations to constructions while slopes greater than 15 percent would provide severe limitations.[28] In order to provide this information, Walmsley's slope Class I would have to be split in half.

3. Flooding and Inundation Hazard

On the base maps, rivers, major creeks, swamps and marshes are identified. The areal extent of backshore and lowland areas (areas which may be subject to inundation or flooding) is not given although the presence or absence of a backshore is indicated. Walmsley's draft report does suggest setting aside a section for description of the area between the beach and the scarp but his mapped classification does not indicate this. This area may be backshore or lowland and the two are not separated.

Therefore, areas subject to infrequent inundation by storm tide events (backshores) cannot be separated from lowlands which may be subjected to flooding during heavy rains and by creek overflows (see Section entitled "The Distinction Between Backshores and Lowlands").

4. Vegetation

This inventory classification does not give vegetation information with the exception of locating marshes or swamps on the base maps.

5. Proximity to Streams

The perennial creeks and rivers and a few ephemeral streams appear on the base maps used to locate the inventory units. This classification, however, does not inventory smaller streams or note any streams in the classification symbols.

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[28] U.S.D.A., Guide for Interpreting Engineering Uses of Soils (Washington D.C., 1972), p. 36.

3.2 Lowland Only

1. Lowland Area

The draft report by Walmsley, however, did suggest the inventorying of areas between the beach and the scarp but the mapped classification system did not inventory lowland areas.

3.3 Backshore Only

1. Backshore Area

Only the presence or absence of a backshore area is indicated. No indication of backshore area are given.

2. Debris Accumulation

No information is provided regarding debris accumulation.

3.4 Foreshore Only

1. Foreshore Area and Materials

Foreshore length and width are not inventoried by this classification but the beach length can be determined from the base maps as the distance between unit boundaries. The beach width can also be roughly approximated as the distance between the Highest High Tide line and the Lowest Low Tide line which are superimposed on the base maps. The actual foreshore is defined as "the part of the shore lying between the crest of the seaward berm (or upper limit of wave wash to high tide) and the ordinary low water mark, that is ordinarily traversed by the uprush and backrush of the waves as the tides rise and fall.⑪

The inventory of foreshore materials was one of the objectives of this system. The distribution of materials on the foreshore were not inventoried but the distinction between foreshore and backshore materials in this system is useful because it allows for some understanding of the distribution.

Walmsley's system does not have a symbol descriptor for beaches composed of shells. This is probably due to the lack of shell beaches in his study area.

2. Mean Higher High Tide Level

This classification does not give the MHHW mark but it is still possible to tell if there is a backshore because the foreshore and backshore materials are separated in the classification. There is no indication of how wide this backshore area is. In many cases in the study areas it is extremely narrow while in others it is hundreds of feet wide. Bauer's beach classification is much more explicit about the utility of the backshores above MHHT.

3. Shellfish Beds

This classification does not inventory shellfish beds.

3.5 Upland, Scarp, Lowland, Backshore, and Foreshore

1. Land and Water Use

Walmsley's system has six general land use classifications: Commercial, Industrial, Recreational, Agricultural, Urban, and Undeveloped. There are no symbols for other land uses such as military operations, or for water uses such as log booming and small boat anchorage. This is a major limitation when trying to fully describe land and water use. Where land use information is indicated it is not possible to tell how much of the unit is affected. It is possible, however, (refer to definition of land use) to determine which uses are directly related to the land.

Walmsley reports land uses because "land use along the waterfront has implications as to the changes which will occur in proximity of that use.... These six categories (listed above) are intended for background information only, to shed light on the reasons for particular beach materials occurring in a particular unit as well as to indicate the large amount of land alienated along the waterfront to uses which may or may not actually require waterfront land for them to function."[29]

Water use information, in Walmsley's classification, is limited to that presented on the base maps: wharfs ves, piers, piles, dolphins, bridges, and navigation lights; and in the land use section of the symbol legend: wharfs ves, walkways, and shore protection structures (fill, rip rap and dykes). Water uses such as log booming and oyster culture areas (often noticeable in the field by posted signs along the foreshore) cannot be inventoried using Walmsley's classification.

2. Land Cover

Information about most land cover can be extrapolated from the land use data regarding structures associated with commerce, industry, urban

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[29] Walmsley, p. 11.

areas, and agriculture. The natural setting symbols "NS" refer to areas where the natural setting has been maintained but the land cover itself is not described.

3. Man-Made Features

Walmsley's system inventories the following man-made features:

retaining walls
dykes
fill material
roads
railways
walkways
wharfs

Bridges, navigation lights, piles, dolphins and power transmission lines are portrayed on the base maps used for presenting the classification symbols. There are many other man-made features such as access trails, groins, fences, and ditches which should be inventoried as they affect recreational use of shorelands. All of these features cannot be inventoried using the system set out by Walmsley without using a long list of symbols or a more descriptive format.

4. Unique and Attractive Features

This inventory system does not identify unique or attractive features except for the location and description of beaches and backshore areas.

5. Modifying Processes in the Coastal Zone

Walmsley's mapped system does not mention modifying processes in the coastal zone although Walmsley himself claims that his system can be used to indicate areas that are prone to failure. He states that "The susceptibility to failure of these areas is mainly indicated by their slope and material composition but in some cases is also indicated by the beach material present."[30]

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[30] Walmsley, p. 12.

VIII.4 Environment and Land Use Committee SECRETARIAT?

4.1 Upland, Scarp, Lowland, and Backshore

1. Soils and Surficial Materials

→ i) Soil Texture: E.L.U.C.(S)'s system, being similar to Walmsley's, has the same problem with identification of soil texture beyond the scarp face when the scarp is less than 300 metres from the foreshore (see Section VII.2). E.L.U.C. does describe the genetic origin of the bluff materials according to the E.L.U.C. Terrain Classification System (1976)[31] so that some information about the usefulness (e.g. degree of sorting) of that material for construction aggregate or sewage filter field placement may be made.

E.L.U.C.'s classification symbol has a section describing the mode or origin and texture of materials, and the slope and width of the area between the beach and the scarp as suggested by Walmsley in his draft report. Again there is confusion between the backshore and the lowland. In fact, what E.L.U.C. has labelled the lowland,[32] actually includes lowland and backshore areas. This stems from the difficulty of identifying the backshore in some areas, particularly along estuarine beaches. The E.L.U.C. Terrain Classification System is used to describe the genetic origin and texture of materials in these areas.

The undifferentiated symbol "u" used by the E.L.U.C. Terrain Classification System represents "a layered sequence of more than three types of genetic materials outcropping on a steep erosional (scarp) slope...the symbol "u" itself may be written as part of a composite unit where it is judged necessary to indicate the presence of a specific member of the undifferentiated group."[33] In the case of E.L.U.C.'s shoreline

[31] E.L.U.C., Terrain Classification System, pp. 1-53.

[32] E.L.U.C., Shoreline Pilot Project-Oyster River Area-Map, 1976.

[33] E.L.U.C., p. 3.

classification, since the units were all field checked by Frank and Levy and the scale permitted, all the layers of genetic materials were indicated. This allowed for interpretations about erosion and land use (e.g. Unit #96 of the Saltspring study area - see Appendix II).

ii) Presence of Coarse Fragments: E.L.U.C.S.'s pilot coastal classification project uses the E.L.U.C.S Terrain Classification System to describe materials of the lowland, scarp, and the backshore landward of the drift berm. Coarse fragments for these areas could be classified even if they represented less than 25 percent of the total volume of the deposit by using the common clastic terms: 1) "Rubbly: an accumulation of particles with a size range of 2-256 mm. in size, and 2) Blocky: an accumulation of angular particles greater than 256 mm. in size."[34]

iii) Soil Drainage

This system provides the same information sbout soil drainage as Walmsley's mapped system provides. An additional amount of soil drainage information could possibly be derived from the greater amount of textural information given by the adapted E.L.U.C.S Terrain Classification System which was used. This is especially true where materials were given for a scarp with a layered sequence of more than three types of genetic materials outcropping.

iv) Soil Depth: E.L.U.C.S's system describes the depth of bluff materials and lowland and backshore materials in terms of veneers (between 10 centimetres and 1 metre in thickness),[35] and blankets (greater than 1 metre thick).[36] The soil depth of upland areas may or may not be similar to that of the bluffs (see Section VII.2). Therefore, this classification falls short of providing the soil depth information required in upland areas.

[34] E.L.U.C., p. 3.

[35] E.L.U.C., p. 16.

[36] E.L.U.C., p. 14.

v) Rockiness: E.L.U.C.'s system describes the bedrock outcrops if they occur on the scarp face or the beach but this information may or may not be representative of the upland areas within 300 metres of the beach (see Section VII.2). Significant amounts of bedrock outcrops in lowlands and backshores are also described using Walmsley's suggested symbol section and E.L.U.C.'s Terrain Classification System. The definition of bedrock in the E.L.U.C. Terrain Classification System includes rock covered by a thin mantle (less than 10 centimetres thick) of unconsolidated material.[37] In the study areas there were no lowland or backshore areas large enough to be described (having greater than 100 feet of ocean frontage) which contained significant amounts of bedrock outcrops.

2. Slope

E.L.U.C.'s system, like Walmsley's does not give information about slopes of upland areas beyond the edge of bluffs. It does, however, give the slope (in percent) of the lowland, backshore and bluff areas within 300 metres of the beach. When the E.L.U.C. system was being field tested it was decided that since field inspection of the units was being carried out, slopes could be given as accurately as possible. This allows for any interpretations required. Thus, information needed for camping, picnicking and cottage developments is given by E.L.U.C.'s classification (excluding upland areas). The problem with E.L.U.C.'s approach to the inventorying of the slopes was that slopes of the field units varied and a different slope range had to be used for each unit. There was also the problem of deciding how much of a change in slope was required before another shore unit should be delimited.

3. Flooding and Inundation Hazard

Rivers, major creeks, swamps, and marshes are identified on the

[37] E.L.U.C., p. 11.

base maps used to locate inventory units.

The system also notes the distance of slope and materials between the beach and the scarp and notes if there is a backshore. Thus, since backshores are subject to infrequent inundation by storm-tide events and heavy rainfalls may cause flooding in low lying areas (areas between the beach and the scarp) this system provides much of the needed information. However, the amount of backshore subject to inundation cannot be determined from the classification because no backshore widths are given and no wave energy zone approximated.

4. Vegetation

This classification does not supply vegetation information.

5. Proximity to Streams

The perennial creeks and rivers and a few ephemeral streams appear on the base maps used to locate the inventory units, however, smaller streams are not mapped or indicated by the classification symbols.

4.2 Lowland Only

1. Lowland Area

This classification system inventories the area between the beach and the scarp. This area includes backshore and lowland areas together.

4.3 Backshore Only

1. Backshore Area

The width of backshore and lowland areas together (classified as distance between the beach and the scarp) are given. The width of marginal backshore areas are not given.

areal?

If detailed topographic maps were available, the aerial extent of ← lowland and backshore areas could be derived from these. Unfortunately, for most areas these detailed maps are not available.

2. Debris Accumulation

No information is provided regarding debris accumulation.

4.4 Foreshore Only

1. Foreshore Area and Materials

Foreshore areas, lengths or widths, are not inventoried by this classification. The length, however, can be approximated from the base maps as the distance between unit boundaries and the widths can be approximated as the distance between the Highest High Tide and Lowest Low Tide which are superimposed on the base maps.

One of the objectives of this system was to inventory foreshore materials. This was accomplished but the distribution of foreshore materials cannot be inferred from the inventory data.

E.L.U.C.'s system does not have a symbol description for beaches composed of shell due to a lack of shell beaches in the study area and to the lack of description in the T.C.S. The E.L.U.C. Terrain Classification System used in the E.L.U.C. Shoreline Pilot Project does have a symbol for organic genetic materials: "O". This symbol, however, refers to "materials resulting from vegetative growth, decay and accumulation in and around closed basins...",[38] and does not apply specifically to shell material.

2. Mean Higher High Tide Level

The MHH Tide level is not given in this classification except as it may be roughly approximated from the shoreline on the base maps.

3. Shellfish Beds

This system does not inventory shellfish beds.

4.5 Upland, Scarp, Lowland, Backshore, and Foreshore

1. Land and Water Use

E.L.U.C.'s classification provides the same land and water use information as Walmsley's since E.L.U.C. only modified the materials section of Walmsley's classification and subdivided the areas inventoried.

[38] E.L.U.C., Terrain Classification System, p. 10.

2. Land Cover

Information about most land cover can be extrapolated from the land use data regarding structures associated with commerce, industry, urban areas, and agriculture. The Natural Setting symbols "NS" refer to areas where the natural setting has been maintained but the land cover itself is not described.

3. Man-Made Features

E.L.U.C.'s classification being an adaptation of Walmsley's, inventories the same limited list of man-made features.

4. Unique and Attractive Features

Apart from inventorying beaches and backshore and lowland areas this system does not identify unique and attractive features.

5. Modifying Processes in the Coastal Zone

By using modifying process descriptors,[39] the E.L.U.C. Terrain Classification System describes some of the modifying precess in the coastal zone. Those which may apply to the study areas include:

Channelled -E (e.g. Unit #66 of the Nanaimo study area)
Failing -F (e.g. Unit #1 of the Nanaimo study area (see Appendix II)
Piping -P
Bevelled -B
Gullied -G
Washed -W

E.L.U.C.'s system can describe spits, bars and other shore forms only to general terms. For example: sWm indicates a sandy marine feature with "slopes ranging up to 10° and with local relief greater than 1 metre."[40] There are no symbols to indicate what type of accretional shoreforms these are so that the example given may represent a series of beach berms or low sand shore features such as old shore lines. With the use of these modifying process symbols there is no indication of how much of the unit

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[39] E.L.U.C., Terrain Classification System, pp. 25-32.

[40] E.L.U.C., Terrain Classification System, p. 15.

is being affected by the modifying processes described except that where process modifiers are used a "relatively large portion of the map unit is modified."[41] The severity of the processes is not considered as this information can only be given after lengthy observation. There is no symboling provided by E.L.U.C. to indicate materials moving in the longshore current, and no information about the interraction between modifying processes and potential land use development is given.

[41] E.L.U.C., p. 25.

VIII.5 Summary Table*

	BAUER					E.L.U.C.S					WALMSLEY					
	UPLAND	SCARP	LOWLAND	BACKSHORE	FORESHORE	UPLAND	SCARP	LOWLAND	BACKSHORE	FORESHORE	UPLAND	SCARP	LOWLAND	BACKSHORE	FORESHORE	COMMENTS
1. Upland, Scarp, Lowland and Backshore:																
1. Soils and surficial Materials:																
a)texture	N	S	S	M	S	S	A	M	A	A	S	A	N	A	A	-in addition, the composite system must provide textural information for upland areas as well as accomodate shell beaches in the inventory.
b)presence of coarse fragments	N	N	N	S	S	S	A	M	A	M	N	N	N	N	A	-the E.L.U.C. Terrain Classification System should also be used in the composite system to inventory coarse fragments for upland and foreshore areas.
c)soil drainage	N	N	S	M	N	N	N	S	N	N	N	N	N	N	N	-soil drainage information for uplands and foreshores should also be inventoried in the composite system.
d)soil depth	N	S	N	S	--	S	M	M	M	--	N	A	N	N	--	-soil depth information for uplands should also be inventoried according to the system used by E.L.U.C.
e)rockiness	N	N	N	S	S	S	A	M	A	A	N	A	N	S	A	-rockiness of upland areas should also be inventoried and the rock type symbols of Walmsley used in the composite classification system.
2. Slope	S	S	S	S	S	N	A	A	A	N	N	A	N	N	N	-foreshore and upland slope information must also be accomodated by the composite classification system.
3. Flooding and Inundation Hazard	M	S	S	A	--	N	S	N	M	--	N	S	N	S	--	-Bauers'system already provides most of the required information regarding flooding and inundation hazard.
4. Vegetation:																
a)Hazard or nuisance plants	N	N	N	M	S	N	N	N	N	N	N	N	N	N	N	-hazard and nuisance vegetation along foreshores and on land should also be inventoried by the composite system.
b)Vegetation density	N	M	S	M	--	N	N	N	N	N	N	N	N	N	N	-subjective estimates of terrestrial vegetation density as Bauer sometimes gives, should always be inventoried in the composite system.
c)Unique or attractive vegetation	M	A	A	A	A	N	N	N	N	N	N	N	N	N	N	-Bauer's system does an excellent job of inventorying unique and attractive vegetation in the coastal zone.
5. Proximity to Streams	M	M	M	M	A	S	S	S	S	S	S	S	S	S	S	-all ephemeral streams and perennial streams and rivers should be consistently represented in the composite system.
2. Lowland Only:																
1. Lowland Area	--	--	S	--	--	--	--	M	--	--	--	--	N	--	--	-the composite system must allow for the inventorying of lowland areas separate from backshore areas.
3. Backshore Only:																
1. Backshore Area	--	--	--	M	--	--	--	--	M	--	--	--	--	N	--	-the composite system must allow for the inventorying of backshore areas separately from lowland areas.
2. Debris Accumulation	--	--	--	A	--	--	--	--	N	--	--	--	--	N	--	-Bauers' system adequately (although not consistently) inventories debris in backshore areas.
4. Foreshore Only:																
1. Foreshore area	--	--	--	--	S	--	--	--	--	N	--	--	--	--	N	-the foreshore area should be inventoried by the composite system.
2. Mean Higher High Tide Level	--	--	--	--	A	--	--	--	--	S	--	--	--	--	S	-the M.H.H.W. as used by Bauer should also be used in the composite system.
3. Shellfish Beds	--	--	--	--	N	--	--	--	--	N	--	--	--	--	N	-the composite system must provide for an inventory of shellfish beds in the intertidal zone.
5. Upland, Scarp, Lowland, Backshore and Foreshore:																
1. Land and Water Use	M	M	M	M	M	M	M	M	M	S	M	M	M	M	S	-land and water use are represented by all three systems evaluated and should be inventoried in the composite system.
2. Land Cover	S	M	M	M	--	S	S	M	S	--	S	S	M	S	--	-land cover is represented by all three systems evaluated and should be inventoried in the composite system.
3. Man-Made Features	M	M	M	M	M	S	S	M	S	S	S	S	M	S	S	-man-made features are inventoried (to some extent) by Bauer, Walmsley, and E.L.U.C. and should be part of the composite system.
4. Unique and Attractive Features	A	A	A	A	A	N	N	N	S	M	N	N	N	S	N	-Bauer's system does an excellent job of inventorying and describing unique and attractive features of the coastal zone.
5. Modifying Processes in the Coastal Zone	S	M	S	A	A	S	S	N	S	S	N	N	N	N	N	-Bauer's system describes coastal processes of the coastal process corridor while the E.L.U.C. system is also adapted to describe modifying processes in the uplands as well. These two systems should be used together in the composite classification system.

*N=None S=Some M=Most A=All

CHAPTER IX A Proposed Approach

IX.1 A Composite Classification

1.1 Introduction

From the foregoing evaluation it is clear that while much of the required information is supplied by the three systems evaluated, none provide all the information which can be readily collected from conventional aerial photography or in the field, at the detailed inventory level, concerning capability and suitability for organized camping, picnicking and cottaging. The composite system is designed for an inventory of this information.

This composite system is in two parts. Units describing (in symbol format) the more static parameters of the coastal zone are superimposed on units which describe (in a more flexible format) the shore processes of the coastal zone. The more flexible format section of the system is also used to accommodate descriptions of parameters which do not lend themselves to the symbol format of description.

The information collected in an inventory using this composite system will also assist planners by providing some of the baseline data required for other land use studies and interpretations. For example, with information concerning process in the shore zone, and scarp slope, material and height data, areas of potential erosion, accretion, and inundation may be interpreted. This information is basic to many land use planning decisions. Further field work and anlysis beyond the scope of this composite system will enable the definition of more homogeneous units as well as provide a better understanding of how the various components of the coastal zone system function and interrelate.

This system is based on three classifications developed for use in the Strait of Georgia: Bauer (1976),[1] Walmsley (for Environment Canada (Undated)),[2] and Environment and Land Use committee (ELUC) Secretariat (1976).[3] ←

1.2 Description

A. The Non-Symbol Format: This section is intended to be a more structured version of the information provided by Bauer's study with the addition of more information (notably sections 4, 6, 8, 9, 10 and 12).

1. Beach code number: this number is a reference number to refer the user of the base map to the appended description of the unit.

2. Geographic location in terms of the nearest reference point: this section is included to aid the user in orienting himself/herself in relation to the other units and physical features of the landscape.

3. Beach classification: the beach classification is that of Bauer (1976)[4], and is indicated on the base map following the beach code number. This beach classification was chosen because it has many practical applications (refer to evaluation section of this study), and because it has already been used to inventory beaches in British Columbia.

4. Distribution of foreshore materials: this section is used to describe foreshore forms such as sand bars and subtidal spits as well as to → describe the aerial (areal?) distribution of beach materials (e.g. in patches or bands).

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[1] Wolf Bauer, Western Community Shore Resource Analysis.

[2] Mark Walmsley, Shoreline Characteristics of the Greater Vancouver Area, Map and Draft Report, (undated).

[3] ELUC, Shoreline Pilot Project-Oyster River Area-Map.

[4] Bauer, pp. 28-33.

For rock ledges it should be noted if the foreshore is continuous or discontinuous. Some rock ledges are not passible at low tide because they are interrupted by impassible, water-filled incisions. The symbol format section of this system cannot easily accommodate these descriptions.

5. Process components: this section is intended for the description of all beaches, including pocket beaches (some components may not apply).

i) Approximate wave energy zone: a description of any wave attenuating headlands or islands, shallow foreshores, and available fetch, as well as an approximation of the wave energy zone as derived from these. The direction of prevailing and strong winds should also be taken into account. The approximate wave energy zone is also known as the "beach energy level".[5]

ii) Net longshore drift: Under this heading is included a statement of the direction of net longshore drift, the materials moving, and the observation which indicated the direction of longshore drift (e.g. the orientation of a spit or a delta).

iii) Feeder bluffs and streams: note which bluffs are feeder bluffs and which streams contribute water, nutrients, and clastic materials to the longshore current. Describe the type of erosion taking place (e.g. sliding, slumping, ravelling, etc.) and any factors contributing to this erosion (e.g. overloading the bluff top, wave erosion of the bluff toe, seepage waters, etc.). Note any structures in danger of being undermined by bluff erosion.

[5] ELUC Secretariat, Terrain Systems Section, Shorezone Classification, (Undated), p. 3.

Also describe man-made features which impair or enhance the erosion-transport-accretion system by decreasing or increasing erosion of the feeder bluff. The floodplains of creeks and rivers should also be noted where observed and any evidence of riverine processes (including flooding) recorded.

iv) Driftways: although drift-sector beaches are indicated by arrows (in the direction of net longshore drift) on the map which accompanies the descriptions, man-made features such as groins and bulkheads should also be noted and examined in terms of their interaction with the natural process dynamics of the shore as a system.

v) Drift-sector boundaries: Where driftways are bled off into deeper water or where terminal accretion shoreforms are formed, the end of a drift sector is formed. Bauer (1976)[6] uses these to define some of his unit boundaries. Some material may breach the drift-sector boundaries as they are not always absolute. Some boundaries may be storm breached while others may be breached in the regular functioning of the erosion-transport-accretion shore process system. These boundary details should be recorded where they can be readily observed.

The description of sector boundaries should also include accretion shoreforms: tombolos, points, spits, hooks, point bars, barrier beaches, and their associated rollback and drift berms. The description of these shoreforms should include a section which covers the way these shoreforms are currently functioning (imparied or unimparied - After Bauer 1976).

6. Soil drainage: It is not possible to give detailed information regarding soil drainage without detailed field study. The following, however, should be described in this section as they help to indicate areas of poor drainage: swamps, marshes, backshore ponds and lagoons, depressional areas, areas of soil seepage, and areas where high groundwater and vegetation indicate

[6] Bauer, passim.

poorly drained soils.

7. Debris accumulation: Any accumulations of driftwood or large accumulations of seaweed along the shore or in backshore areas should be described in this section. In some cases the driftwood is an integral part of the beach berm and should also be described in the berm description section.

8. Hazard or nuisance vegetation: Note areas of fresh and salt marsh which inhibit the use of that area for intensive recreation uses. Also note the presence of areas of vegetation such as devil's club (*Oploganax horridus*), blackberries (*Rubus* spp.), gooseberries (*Ribes divaricatum*), and wild roses (*Rosa* spp.) which limit recreational use of a unit.

9. Vegetation density: Without detailed investigation in the field it is not possible to inventory vegetation density objectively. Therefore, this section is provided to allow for the subjective evaluation of vegetation density.

10. Land and water use, land cover, and man-made features: Land and water use, land cover, and man-made features of each unit should be described and their effect on the natural shore processes explained.

11. Unique and attractive features: Unique and/or attractive features of a unit (including vegetation) should be described here. Land and water uses and man-made features which detract from or add to a unique or attractive feature should also be noted.

12. Shellfish beds: The location of shellfish beds in the foreshore of units can be inventoried using this section.

13. Miscellaneous information: This section is intended to allow for any pertinent information regarding capability and suitability for camping, picnicking and cottaging which is unique to that site. An example of such information would be :

> a large amount of sulphureous seepage on
> the beach surface which reduces the suitability
> for such things as sunbathing and picnicking.

A.1 Unit Boundaries: The units of this section of the composite system are determined by two parameters: 1) a change in beach classification[7] (a change in the width of the backshore above MHHT--none, marginal, wide), and 2) pocket beach boundaries. Rocky shores are also to be inventoried according to this section of the composite system as they are capable of sustaining recreational use.

B. The Symbol Format:

1. Unit code number: This number refers the user from the base map to the corresponding unit description in an appended text.

2. Foreshore:

1) Material: The ELUC Terrain Classification System (1976) symbols were used to describe the foreshore materials. While the Terrain Classification System (TCS) provides a description of most material textures, mode of origin, depth, and mentions some modifying processes, it does not provide a symbol for beaches composed of shell materials. The composite system completes the description of material texture and mode of origin. The symbol O is used to indicate any organic genetic materials (the "O" designation used by the ELUC TCS refers to desposits "generally consisting of peat, unstratified and locally containing minor amounts of marl and inorganic detritus.")[8] The qualifying descriptor c, used as a superscript, indicates that the organic accumulation is made of $CaCO_3$ shells.

In this composite system, as in the ELUC Shoreline Pilot Project minor textural components can be described by using more than two textural terms.[9]

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[7] Bauer, pp. 28-33.

[8] ELUC Terrain Classification System, p. 10

[9] ELUC Terrain Classification System, p. 3.

If more than two textural terms are used, their percent by volume can be indicated using the connectors which the TCS uses for composite units:[10]

45-55% = 45-55%
55-75% / 30-45%
70-90% //10-30%

It is important that minor textural components be described, especially if they are bouldery or cobbly, because they can affect the type of beach activity as well as the geophysical and biological shore processes.

The TCS used in the ELUC Shoreline Pilot Project does not privde sufficient symbols to describe foreshore forms in enough detail to give an indication of shore processes. For example: parallel bars are relatively stable and only occur on slopes with gradients of .005% or less, in areas of high tidal range and low wave energy. Transverse bars, however, are very long, occur just seaward of low energy beaches which slope .15 to .45%, and tend to migrate in a state of dynamic equilibrium with waves and currents.[11] Using the TCS sandbars could only be described as "sWm", symbols which could also refer to spits and berms. The TCS does provide a sufficient symboling for wave-cut rock platforms: "R1-W".[12] There would have to be a lengthy list of symbols developed to provide for the description of the different foreshore forms using a rigid format similar to Walmsley's classification. It is best if the TCS is used to identify the foreshore forms in a general way according to the symbols already in use, but to leave further description of form, as related to process, to the non-symbol section of this system.

ii) Width and Slope: The width of the foreshore can be derived from an inventory of the foreshore slope (where the tidal range is

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[10] ELUC TCS, p. 34.

[11] Donald R. Coates, Coastal Geomorphology, (1972), p. 109.

[12] ELUC TCS, p. 53.

known) or directly from field or aerial photographic measurements. Neither slope nor width of the foreshore has been quantitatively measured by the classification systems reviewed (refer to the Evaluation section of this study). Foreshore width cannot be accurately measured in the field unless it is inventoried at low tide. The use of aerial photography to inventory this information is therefore necessary. Using conventional vertical aerial photography foreshore width can only be approximated due to scale and shading problems in some instances (refer to the Section IX.2 for the use of aerial photography with this classification). Consequently, to get a better estimate of the real extent of the foreshore, as well as to provide background information for the calculation of beach energy level, the composite system inventories both the width and the slope of the foreshore.

The foreshore width classes chosen are expansions of those used by the Terrain Systems Section of the Resource Analysis Unit in the ELUC Secretariat Shorezone Classification (Undated):

ELUC Secretariat Shorezone Classification Width Classes for Foreshores[13]	Composite System Foreshore Width Classes
A wide foreshore >50' (15.2 m)	A >61 metres (give approximate width)
B moderate foreshore 25-50' (7.6-15.2m)	B 31-61 metres
C little or no foreshore 25' (<7.6m)	C 16-30 metres
	D 8-15 metres
	E <8 metres (give width)
	N No appreciable foreshore

The additions were necessary to allow for a more complete representation of the foreshore detail collected in the field and from aerial photographs.

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[13] ELUC, Shorezone Classification, p.1.

This preservation of detail is important because the calculation of beach area is related to the amount of use which that beach can sustain. The N (no appreciable foreshore) category was added to be consistent with Walmsley's classification.

The foreshore slope is given in percent classes similar to those of ELUC's Shorezone Classification:[14]

	ELUC Secretariat Shorezone Classification Slope Classes for Foreshores	
I	level	0-2%
II	gently sloping	2-5%
III	moderately sloping	5-10%
IV	steeply sloping or precipitous	>10%

	Composite System Foreshore Slope Classes
I	0-2%
II	3-5%
III	6-10%
IV	11-15%
V	>15%

The classes of the composite system were chosen to remedy the ambiguities of the Shorezone Classification. The fourth class was formed to allow for the description of some high energy zone pocket beaches which can have beach profiles between 11 and 15 percent and yet form valuable summer recreation areas.

iii) Length: The foreshore length can be easily measured in the field or from aerial photographs. Metres are to be used as units of measurement.

iv) Orientation: The orientation of the upper limit of the foreshore can be readily inventoried in the field and placed into the rigid format section of this composite classification. For added utility it is suggested that the orientation be given in terms of degrees from north rather than in that format used by Bauer.[15]

3. Backshore and Lowland Components: The ELUC Shoreline Pilot Project did not separate backshores from lowlands. The composite system allows for this separation by the use of a lowland and a backshore section

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[14] ELUC, p. 1.

[15] Bauer, passim.

in the symbol format.

i) Material: The ELUC TCS (1976) used in the ELUC Shoreline Pilot Project was adopted for use in describing the materials of backshores and lowlands. The TCS,[16] well suited to describing materials in terrestrial areas and for standardization purposes, is used here.

ii) Width: The backshore and lowland width classes chosen were formed by adopting (approximately) those of the ELUC Secretariat, Terrain Classification Unit used in their Shorezone Classification (Undated). Adaptation was necessary to accommodate necessary detail where backshores and lowlands with widths greater than 16 metres (50 feet) occurred. Backshores of 16 metres or more in width often occur in association with accretion, drift-sector, and pocket beaches:[17]

Shorezone Classification Width Classes for Backshores			Composite Classification Backshore & Lowland Width Classes
A wide backshore		>50' (>15.2 m)	A >15 metres (give approximate width)
B moderate	"	25-50' (7.6-15.2 m)	B 8-15 metres
C narrow	"	< 25' (<7.6 m)	C <8 metres (give width)

iii) Slope: The slope classes were designed to provide the information discussed in the evaluation section of this report:

Composite System Backshore and Lowland Slope Classes	
I	0-8%
II	9-15%
III	>15%

4. Bluff (Scarp):

i) Material: As for other areas inventoried in this composite system, the bluff materials were described according to the ELUC

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[16] ELUC TCS, passim.

[17] ELUC, Shorezone Classification, p. 2.

TCS (1976) used in the ELUC Shoreline Pilot Project. Where more than three materials outcrop on a bluff slope, all the identifiable layers should be recorded. This information is valuable for interpretations as to slope stability, feeder bluff action, and for building on. Use of the symbol "U",[18] should be avoided because it is important that the texture and origin of bluff materials be known. Any modifying processes that have modified or are modifying genetic materials and their surface expression on the bluff slope can be indicated using the modifying process symbols of the ELUC TCS.[19]

ii) Height: The bluff (scarp) height is given in metres according to the best approximation in the field, from air photographs, or from topographic maps, as it is given in Walmsley's and ELUC's shoreline classification.

ii) Slope: The bluff slope classes were created to provide the slope information discussed in the evaluative section of this study:

Composite System Slope Classes	
I	0-8%
II	9-15%
III	16-30%
IV	31-50%
V	51%+

5. Upland:

i) Materials: The depth or origin, and texture of surficial materials, as well as any modifying processes that have modified or are

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[18] ELUC _Terrain Classification System_, (1976), p. 12.

[19] ELUC, p. 25.

modifying their surface expression in upland areas are described using ELUC's TCS (1976). This is consistent with the rest of the composite system and standardizes this classification with the Terrain Classification System used in British Columbia.

ii) Slope: The slope of upland areas is described using the same slope classes that are used to describe bluff slopes in this system.

iii) Aspect: The aspect of upland areas is not always the same as that of the associated bluff, backshore, or lowland. Consequently, the composite system inventories the aspect of the upland (in degrees from north).

B.1 Unit Boundaries:

The information discussed in this section of the composite system is to be collected over the entire length of the coastal area being studied. The units are defined according to five parameters: 1) beach material, 2) bluff material, 3) bluff height, 4) bluff slope, and 5) presence or absence of a backshore or lowland wider than 8 metres (25 feet). Land use and man-made features are not used to define units. The land use and man-made feature symbols used in Walmsley's system for his purposes and his study area are not adequate for this classification. Such a large number of symbols would be required to adequately represent all the land uses and man-made features in the coastal zone that affect suitability and capability for camping, picnicking and cottaging that their use would be impractical. As a result, their description is left to the more flexible and descriptive section of this composite system.

C. Base Map Information:

This is information relating to the composite classification system which should be recorded on the base maps:

1. The shore configuration with the Mean Higher High Water (MHHW) level forming the delineated boundary of the shore.
2. Rock ledges.
3. The approximated (or known) Mean Lower Low Tide (MLLT) level.
4. Salt and fresh water marshes.
5. The approximate 6-fathom depth line to delineate the seaward boundary of the nearshore zone.
6. The tidal range for available locations.
7. The direction of net drift.
8. Roads.
9. Wharfs.(ves)
10. Piers.
11. Rivers and creeks.
12. Piles.
13. Dolphins.
14. Railways.
15. Bridges.
16. Unit boundaries for the symbol format section of the system (refer to Section B.1).
17. Unit boundaries for the non-symbol format section of the system (refer to Section A.1).

In the case of the shore configuration it may be necessary to go to recent air photo mozaics in order to get the necessary shore detail to allow pin-pointing of small pocket beaches or to account for areas which have accreted or eroded since the last publication of maps. Information about the location of piles, dolphins, and if not observed in the field or on air photos, can be transferred from hydrographic charts. Hydrographic charts can also be used to delineate the 6-fathom line and provide the tidal ranges for an area. Color slides of salient features of the field checked units provide an excellent visual reference source and are also recommended as part of this composite system.

1.3 Limitations of the Composite Classification

This composite classification system is not intended to be a holistic classification of the coastal zone. It is a suggested format for the inventorying of information that be derived from aerial photographs and rapid field survey. The information to be collected is to provide a basis upon which to derive capability and suitability for organized camping, picnicking, and cottaging in the different coastal zone components. More detailed study must be carried out to obtain further information. The geographical area described by this system is that coastal area with a seaward limit of the MLLT level and a landward limit of 300 metres from the MHHT level. As a scale constraint, and to standardize this system with Bauer's (1976) inventory, beaches under 30 metres (100 feet) in length are not inventoried. This composite system can be used with a variety of scales and sizes of map units, although it has been developed for use at scales of 1:10,000 to 1:20,000. The scale used should be determined by the purpose of the study, amount of time and resources available, as long as the intensity of coverage is uniform over the entire inventory area.

1.4 Summary

Where possible, components of the three coastal classification systems studied have been retained in this composite system. These were included in an attempt to standardize the information provided. New classification components were created as deemed necessary according to the evaluative section of this report. These include: distribution of foreshore materials, soil drainage, debris accumulation, hazard or nuisance vegetation, vegetation density, shellfish beds, foreshore width and slope, upland materials, upland slope, and upland aspect.

The non-symbol format section of this classification describes the coastal zone units which are defined on the basis of shore processes, pocket beach boundaries, and Bauer's (1976) beach classification.[20] The less flexible, symbol format section inventories the more static components of the coastal zone according to units defined by changes in bluff material, slope and height, and foreshore materials, as well as the presence or absence of an appreciable backshore or lowland. These two sections of the system mesh where materials and slopes affect the processes in the Shore-Process Corridor.

The paragraph format of Bauer (1976) was not adopted for description of units of the non-symbol part of this system as it was felt that some of the parameters of the classification may be overlooked when recording information. When descriptions are presented in paragraph form, the extraction of specific information is difficult. Rather, the descriptive (sentence) format has been retained but the parameters to be inventoried have been categorized.

[20] Bauer, pp. 28-33.

Summary of the Composite Classification System:

A. The Non-Symbol Format Units:

1. Beach code number:
2. Geographic location in terms of the nearest reference point:
3. Beach classification:
4. Distribution of foreshore materials:
5. Processes: a) approximate wave energy zone:
   b) net longshore current:
   c) feeder bluffs and streams:
   d) driftways:
   d) drift-sector boundaries:
6. Soil drainage:
7. Debris accumulation:
8. Hazard or nuisance vegetation:
9. Vegetation density:
10. Land and water use, land cover, and man-made features:
11. Unique and attractive features:
12. Shellfish beds:
13. Miscellaneous information:

B. The Symbol Format Units (Rigid Format):

Unit number:

1. FORESHORE					2. BACKSHORE		
Materials (after the ELUC TCS)	Width Class	Slope Class	Length (metres)	Orientation (in degrees from north)	Materials (after the ELUC TCS)	Width Class	Slope Class

3. LOWLAND			4. BLUFF			5. UPLAND		
Materials (after the ELUC TCS)	Width Class	Slope Class	Materials (after the ELUC TCS)	Height (metres)	Slope Class	Materials (after the ELUC TCS)	Slope Class	Aspect (in degrees from north)

Foreshore Width Classes		Foreshore Slope Classes	
A	>61 metres (give approx. width)	I	0-2%
B	31-61 metres	II	3-5%
C	16-30 metres	III	6-10%
D	8-15 metres	IV	11-15%
E	< 8 metres (give width)	V	>15%

Backshore and Lowland Width Classes

A	>15 metres (give approx. width)
B	8-15 metres
C	< 8 metres (give width)

Backshore and Lowland Slope Classes

I	0-8%
II	9-15%
III	>15%

Bluff Slope Classes

I	0-8%
II	9-15%
III	16-30%
IV	31-50%
V	51%+

Upland Slope Classes

I	0-8%
II	9-15%
III	16-30%
IV	31-50%
V	51%+

IX.2 The Use of Color, Color Infrared and Black and White Aerial Photography With the Proposed Composite System.

2.1 Introduction

1:15,840 scale black and white (B & W) air photo prints and 1:3,600 scale color and color infrared (CIR) transparencies of the two study areas were studied and interpreted for the information which they provide regarding the selected information requirements for organized camping, picnicking and cottage development. The literature was also consulted to support the findings of this study and to provide further information.

2.2 Sensor Types - 1. B & W Photography:

B & W film "has proved to be the most versatile film for mapping and interpretive purposes and is the most widely used. Data concerning crop patterns, land uses, vegetation, wildlife species and range, geomorphology, soils, geology, hydrology, oceanography, and so on, can be interpreted to various degrees of accuracy from these photographs."[1] This "film has a black-and-white emulsion material with a spectral sensitivity for 0.36 to 0.72 μm. This range of spectral sensitivity is approximately the same as the human eye (0.4 to 0.74 μm)."[2] (See the Manual of Photographic Interpretation by the American Society of Photogrammetry for information about interpretation techniques and applications for B & W photographs).

2. Color Photography:

"Qualified interpreters have found that color does not consistently offer additional data potential over panchromatic black-and-white film. Some studies have indicated that the additional chroma and tonal distinctions that can be made on color film may provide too much detail

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[1] Douglas S. Way, Terrain Analysis: A Guide to Site Selection Using Aerial Photographic Interpretation (Strandsburg, Pennsylvania, (1973), p. 61.

[2] American Society of Photogrammetry, Manual of Remote Sensing, Vol. II, (Falls Church, Virginia, 1975), p. 925.

and may confuse the interpretation because of nonsignificant or non-correlating color changes."[3] Scott and Harding (1975) report "the human eye cannot detect more than 15 tones of grey."[4] The Manual of Remote Sensing (1975) reports that "the human eye can separate more than 100 times more color combinations (hues, values, chromas) than gray-scale values (ratio of 2,000 to 200). This capability permits ready discriminatiion of objects whose apparent color is such that they contrast with their background. Image interpreters detect significantly more targets on normal color imagery than on black-and-white imagery."[5]

Color film is spectrally sensitive to the 0.4 to 0.7 μm (blue, green, and red wave lengths). "Color processing is more expensive and usually takes longer than for black-and-white, although future advances in the technology of automated processing may reduce costs. Furthermore, the visibility-haze conditions for proper color balance are more stringent than those for black-and-white photography since minus-blue haze penetration filters cannot be used."[6]

3. Color Infrared Photography:

"Color infrared photographs offer a wide tonal and hue advantage, similar to that of color photographs, while also having the special quality of being sensitive to the near-infrared spectrum."[7] CIR film is spectrally sensitive from just below 0.3 μm to above 0.9 μm.

"Stream channels can be accurately located, shorelines plotted, high and low water marks defined, soil moisture differences identified, water-vegetation boundaries plotted along marshes and bogs, and so on. However, it should be noted that these identifications can also be made by using

[4] Robert B. Scott and Roger A. Harding, Satellite and Airplane Remote Sensing of Natural Resources in the State of Washington, in Proceedings of the Tenth International Symposium on Remote Sensing of Environment, Vol. II (Ann Arbour, Michigan, 1975), p. 898.

[5] American Society of Photogrammetry, p. 931.

[6] American Society of Photogrammetry, p. 934.

[7] Douglas S. Way, p. 61.

black-and-white panchromatic film. Therefore, the additional flying and handling expenses should be carefully considered before contracting for color infrared. Color infrared is best utilized along with true color film and black-and-white panchromatic."[8]

The American Society of Photogrammetry (1975) suggests that the relative advantages of color versus CIR film vary according to the specific interpretation problem.

> Color is normally best for general interpretations because it more closely records the colors of the natural scene. Color is also more useful for studying underwater conditions, while surface waters are more easily delimited with CIR. CIR has been recognized as superior for certain vegetation studies, including species differentiation and delineating areas of low vegetation density. For the same height of photography, atmospheric scattering and absorption will cause greater losses in information content in color than in CIR photography.[9]

4. Contact Prints and Transparencies:

Positive transparencies reveal the most information of any photographic format. While contact prints do not reveal the most information, they are the most commonly available and widely used format in British Columbia, require no light table in order to be interpreted, and are the most useful format for field use and mapping.

2.3 The Use of 1:15,840 B & W and 1:3,600 Color and CIR Aerial Photography with the Three Evaluated Systems and with the Proposed Classification

1. Beach Classification:

Air photos of many scales and film types can be used to classify beaches according to those classes set out by Bauer (1976). This classification is "based on the presence, absence, or marginal extent of a walkable dry backshore at high tide water level."[10] On the 1:15,840

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[8] Douglas S. Way, p. 61.

[9] American Society of Photogrammetry, pp. 932-933.

[10] Wolf Bauer, Accretion Beach Inventory, (Undated Photocopy), p. 53.

panchromatic and the 1:3,600 color and CIR air photos it is a simple matter to locate Class I beaches, pocket beaches, and rocky shores. There is a difficulty, however, with distinguishing Class II and Class III beaches below steep and vegetated bluffs. Narrow or non-existent backshores are often obscured by vegetation and shadows in vertical aerial photography. Due to the configuration of the coastline, and the requirement for high sun angles, it is not always possible to orient flight lines for vertical aerial photography in order to get rid of shadows near steep bluffs. Oblique aerial photography would provide more accurate information regarding beach classification in such areas.

Large scale photography is much more useful than smaller scale (1:15,840) photography in areas where shore protection structures such as rip rap, retaining walls, and bulkheads have been built. These structures can be located and used to identify the beach classification as changed from the natural beach type.

2. Processes in the Shore-Process Corridor:

i) Approximate Wave Energy Zone: Using any of the three film types it is difficult to see all of the parameters which help estimate the wave energy zone. Using vertical aerial photographs at a scale of 1:15,840 or 1:3,600 it is a simple task to:

1) approximate the width of the foreshore (and therefore the depth and distance available for wave energy classification);

2) locate rocks and headlands which are near to or part of the coastline and help to attenuate wave energy;

3) measure beach orientation (can also be read from topographic maps for the area although often the shoreline detail of the maps is not sufficient).

Wind fetch (see glossary) is an important parameter in determining using only 1:15,840 or 1:3,600 aerial photography due to the small area covered by each photograph. This information, can be gathered in the field or when the large scale aerial photography is used in combination with much smaller scale aerial photography or with topographic maps.

The best way to estimate wave energy would be to have a series of air photographs during storm events and to study the wave impact upon the coastline. While this is possible with certain types of film and imaging devices, it is not possible with B & W, color or CIR film due to lack of sunlight, excess wind, and rain during such events.

Color photography is superior to CIR and B & W photography for wave energy zone approximation. It provides greater water penetration and hence a greater amount of shore-bottom detail for wave-energy attenuation interpretations.

In some areas it is possible to ascertain the wave energy zone of a beach by erosional and accretional shore-forms. All three film types appear useful for this purpose, although the larger scale photography provides more detail and therefore more exact information.

ii) Net Longshore Drift: The net longshore drift of materials can be derived from the shape of deltas, accumulations of driftwood, orientation of sand bars, accretion shoreforms, changes in beach materials, knowledge of prevailing winds and shore orientation. In areas of near-neutral net longshore drift it is often difficult to determine the direction of net longshore drift without quantitative measurements.

All three types of photography examined were found to be useful in assessing net longshore drift. The 1:15,840 B & W photography was useful in pre-typing study areas and was invaluable in providing clues to the direction of net longshore drift. In areas of near-neutral net longshore drift, however, it did not provide the required detail. The color and the CIR photography, however, did provide much of the detail necessary. This was due, in part, to the larger scale of this photography. The CIR was particularly useful in determining net longshore drift at the base of actively eroding bluffs because slide areas (appearing silver-white) contrasted well with vegetated areas (appearing magenta). The distribution of this slide material in the longshore current could be seen through the narrow gaps along the vegetation-shielded shoreline. The color photos were also useful but the contrast between slide material and overhanging vegetation was not as great. Color and CIR photography revealed accumulations of driftwood much better than did the B & W photography (see section on Debris Accumulation).

Color photography can be helpful in determining the net longshore drift in areas where the only clues are subaqueous spits and bars. It has superior water penetrating ability to both B & W and CIR photography.

Oblique aerial photographs could be useful in determining the net longshore drift along the base of steep bluffs hidden from view by vegetation and shadows on vertical aerial photography.

iii) Feeder Bluffs and Feeder Streams: Feeder bluffs can be located by the presence of slides, leaning trees, contrasting materials on the foreshore (e.g. boulders or cobbles appearing on a drift sector beach when none were found further updrift), and younger or different areas of vegetation.

Some feeder bluffs could be located on the 1:15,840 B & W aerial photography but CIR and color were found to be better suited for this purpose. The CIR film was best suited to the location of feeder bluffs because:

i) it was at a scale (1:3,600) large enough to permit location of even small areas of slipping, slumping and mass wasting;

ii) the contrast between slide material (silvery white) and vegetation (magenta) was greater than on either color or B & W film, and

iii) areas of younger vegetation or vegetation of a different species than the surrounding vegetation which indicate locations of previous slides were more obvious than on color or B & W film because of the great difference in hues of magenta, purple and pink.

Avery (1977) notes that "both color and infrared color photography have proven valuable for monitoring coastal erosion and vegetation destruction."[11]

CIR was more useful than the other two film types for locating feeder streams. Although the feeder streams could be located at the shoreline on the B & W and color photography by the material deposited at the stream mouth, it was difficult to follow the streams inland for any distance because they were obscured by vegetation and shadows. On CIR photography, the magenta color of the vegetation contrasted with the stream (dark band). If the stream was completely obscured by vegetation or shadow, however, any of the three film types is equally useful as the stream is best located using land use patterns.

iv) Driftways and Drift Sector Boundaries: B & W, color and CIR photography (at the scales used) were all useful for the identification of driftways and drift sector boundaries. Due to its water penetrating capability normal color photography was considered to be the most useful for locating the extent of drift sector boundaries which were partially or wholly submerged. Color was especially valuable in locating subaqueous storm-breached drift sector boundaries and subaqueous spits, tombolos and bars.

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[11] Thomas E. Avery, <u>Interpretation of Aerial Photographs</u>, (Minneapolis, Minnesota, 1977), pp. 308-309.

3. Foreshore Materials; Type and Distribution:

Using 1:15,840 B & W air photos it is possible to delineate areas of sand, silty clay, and larger sized particles along beach foreshores. Sandy foreshores can be readily identified by characteristic bar shapes, tones and drainage patterns. Silty-clay areas can be identified by their low energy zone positions and by their drainage patterns and dark tone (high water content). Gravelly and cobbly areas are more difficult to separate because of the lack of characteristic drainage patterns, form, or tone. Areas of cobbles and boulders can often be delineated in developed areas by the piles left when clearing for private boat launching sites.

Using 1:3,6000 scale photography, all beach materials and their distribtuion can be accurately delineated. The distinction between cobbles and boulders can be seen as a difference in texture and in some cases, the individual boulders can be seen. Areas of sand and silt can be identified by characteristic drainage patterns, tone, form, and energy zone. Gravels appear as bluish-gray, fine-textured dots. Color transparencies provide for easier interpretation of foreshore material than do color infrared transparencies which mask materials which a magenta color wherever intertidal vegetation occurs.

Beaches composed of broken shell material (see Appendix VII) are not easily identifiable on B & W photography due to the small change in tone between a dry sand or gravel beach (white) and a shell beach (white). On the color and CIR photography, however, the shell beaches stand out as bright white as compared to the less reflective gravels, sands, etc.

The upper foreshore below steep bluffs is often obscured by shadows or by vegetation. Thus, it is difficult to see if there is a drift berm or band of drift material at the high tide level. This information must be derived from field study or from a series of oblique aerial photographs.

The American Society of Photogrammetry (1975) reports that although active beach features are evident on all three sensor types, "the beach shape and extent were most obvious on color-infrared photographs because of the distinctive hues produced by water or moist soil. Color infrared was superior to color in that soil-vegetation-water contacts are more distinctive."[12]

4. Foreshore Lengths, Widths, and Slopes:

With photography flown at low tide at a known scale, it is a simple matter to measure the length and width of beaches to the degree of accuracy necessary. Using stereoplotters ~~(very expensive)~~ it is possible to compute heights (and ultimately slopes) to ±1/10,000th of the flying height. Stereoplotters, however, are very expensive and often unavailable. Therefore, more conventional slope and height measurement methods should be used. Using the Model T-22 Condor Reflecting Mirror Twin Stereoscope and a parallax bar (more conventional equipment) it was difficult to measure height differences of ±5 feet. Thus, it was concluded that short of using more expensive equipment and/or a highly skilled interpreter (not always available), field checks of foreshore slope would be required. The calculation of foreshore slope from hydrographic charts was not considered because of the lack of sufficient detail over much of the British Columbia coast.

The findings of this study are consistent with a summary of recent European studies on the accuracy of height measurements on aerial photographs as reported by the American Society of Photogrammetry (see table on next page).

[12] American Society of Photogrammetry, p. 1329.

Accuracy of Height Measurements on Aerial Photography--A Summary of Recent European Studies[13]

Film	Scale	Average Height Error (metres)	Species
panchromatic (p)	1/10,000	1.20	Pine (p)
P	1/20,000	1.70	p
p	1/5,000	1.10	Conifer (c)
p	1/5,000	1.27	Hardwood (h)
CIR	1/5,000	1.54	c
CIR	1/5,000	0.66	h
p	1/10,000	1.86	c
p	1/10,000	1.32	h
CIR	1/10,000	1.23	c
CIR	1/10,000	1.57	h
Color (c)	1/10,000	1.52	c
c	1/10,000	1.64	h
p	1/8,500	1.44	Oak/conifer
p (winter)	1/5,200	3.09	h
p (winter)	1/5,200	2.09	Popular

5. MHHW and MLLW Marks:

If flown at low tide the mean lower low water mark can be readily approximated directly from the aerial photography. For this purpose, the CIR photography was the most useful of the three film types because of the sharp contrast it produced between water and land.

The interpretation of the MHHW level is somewhat more complex. If aerial photographs are flown to provide foreshore detail, they ~~they~~ will not show the MHHW mark except as it may be indirectly mapped from algal bands or seaweed accumulations. The shadows and overhanging vegetation which often obscures the high water mark on vertical aerial photography further increases the problem with mapping the MHHW mark. To circumvent these problems, Bauer (1976)[14] flew a special series of high tide oblique aerial photos from which he interpreted the MHHW level. Howard (1970) reports: "color photography is being increasingly employed by the U.S. Coast and Geodetic

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[13] American Society of Photogrammetry, p. 1332.

[14] Wolf Bauer, Western Community, *Shore-Resource Analysis* (Victoria, 1976).

Survey for detailed maps of the low and high-water shorelines..."[15] Gieth (1972) reports that "In areas where the tide line is not visible on a photograph due to heavy vegetation (called wetlands, marshes, swamps, etc.), I do not know of any sure system for displaying the line (MHHW)."[16]

6. Shellfish Beds:

Shellfish beds cannot be located on any of the three photographic types examined. This is because the shellfish beds, although present, were not populated densly enough to change the spectral reflectance of intertidal beaches, because most of the high concentrations of shellfish ? camouflaged them. If dense enough concentrations of shellfish did occur in the intertidal zone and were not comouflaged, they could be readily identified on the large scale color or CIR photography because beaches composed of broken shell are very noticeable on these types of photography.

7. Land and Water Use, Land Cover, and Man-Made Features:

As Anderson et al., (1972) note, "most land use mapping from aerial photographs uses cover (usually vegetation) as a surrogate for land use."[17] Thus, since CIR film offers excellent resolution and tonal contrast for most vegetation, land use and land cover interpretations are necessarily enhanced.

For the reason that more detail can be seen on the larger scale photography, it was of more help in determining land use, land cover and man-made features for the units mapped in this study. For example, many shore protection features (e.g. low retaining walls and bulkheads) were overlooked and/or not separted from more general classifications because they could not be resolved on the 1:15,840 B & W photographs. On the 1:3,600 scale photography, however, this was not a problem and even the

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[15] John A. Howard, Aerial Photo-Ecology (London, England, 1970), p. 212.

[16] Jack E. Gieth, The National Ocean Survey Coastal Boundary Mapping, In Tools for Coastal Zone Management, Proceedings of the Conference, (Washington, 1972), p. 67.

[17] J. R. Anderson quoted in American Society of Photogrammetry, p. 847.

numbers of people using a particular beach or park could be counted. Color photography had the advantage of giving true color representation of land uses, covers and man-made features. CIR was also useful in revealing differences in vegetation types, vigor, and also in giving excellent contrast between some features (e.g. green roofed cabins and green trees) which appeared to be of similar color on the normal color film.

Land use is not always discernable from aerial photographs except by very skilled interpreters. For instance, areas of natural vegetation may in fact be nature preserves or natural parks (e.g. Page Lagoon Park near Nanaimo). Thus, some field checking is necessary to insure accurate mapping. As reported in the Manual of Remote Sensing "the most valuable form of ground data that can be obtained is that represented by the knowledge of a professional interpreter with experience in both the geographic and subject areas of operation. When the interpreters knowledge is supplemented by partial field checking and information on the phenologic development of major plants and associations, additional ground data are seldom needed."[18]

Where vegetation and shadows shield the high water mark from view on vertical aerial photography, oblique aerial photography or field checking is necessary to locate man-made features, especially shore protection structures.

Nunally (1974) notes that "since particular land uses have "unnatural" expressions in the landscape, land use in particularly susceptible to study by remote sensing techniques."[19] He also reports, however, that "virtually nothing is known as to the effects of accuracy of land use data caused by variations in scale and resolution.... Little or nothing has been done

[18] American Society of Photogrammetry, p. 847.

[19] Nelson R. Nunally, Interpreting Land Use From Remote Sensor Imagery, IN Remote Sensing: Techniques for Environmental Analysis, ed. John E. Estes and Leslie W. Senger (Hamilton, 1974), p. 167.

to evaluate the training and ability of persons involved in interpreting land use. On the basis of evidence collected...the level of training and ability of many interpreters is a matter of serious concern."[20] Since land and water use and land cover patterns vary with locality along the coastline, a familiarity with the land uses and cultural activities in a region is a valuable asset. The interpreter therefore, makes a big difference in the accuracy of interpreted information.

8. Slopes of Backshores, Lowlands, Bluffs and Uplands, and Width of Backshores:

As with the widths and lengths of foreshore areas, the widths and lengths of backshore, lowland, and upland areas can be easily measured to the required accuracy from any of the air photos studied. Using a parallax bar and the Model T-22 Condor Reflecting Mirror Twin Stereoscope, heights were measured to within ±5 feet on the 1:3,600 scale color and CIR photography. The 1:15,840 was totally inadequate for height measurements. While this method of obtaining slopes and heights is accurate enough for estimates of high banks (30 feet) there are obvious limitations to using it for a preliminary differentiation of backshores from lowlands or of measuring beach scarps. Such information would have to come from detailed topographic maps (unfortunately, for most of British Columbia coastline there are no detailed topographic maps), from stereoplotter data, or from field information).

The measurement of slopes using the parallax bar or wedge is not accurate enough even on the 1:3,600 scale photography for the slope classes of the proposed classification.

9. Materials of Backshores, Lowlands, Bluffs, and Uplands:

Zissis (1974), in a comparison of different film types for geologic interpretation found that: (1) Color photographs are only marginally better than B & W and then only if taken soon after rain. (2) Infrared offers little

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[20] Nunally, p. 167.

little advantage over B & W. (3) Color and infrared offer slight advantages for study of superficial deposits. (4) Even under relatively unfavorable conditions, normal black-and-white photography can be of great value.[21]

The use of aerial photography to identify and map geologic and geomorphic surface materials has been well documented by many authors: Way (1973); U.S. Army Coastal Engineering Research Centre (1973); American Society of Photogrammetry (1975); Lacate (1966); Keser (1976); Hills (1950); Clayton, et al. (1959); Avery (1977), and many others (see Table II).

The 1:15,850 B & W aerial photography was found to be suitable for the identification of surficial deposits, landforms and geology. This was in part, due to the interpreters familiarity with mapping landforms and soils on similar photography and because the smaller scale view of the area being mapped was helpful in assessing landforms. The use of B & W photography in landform and soil mapping has been widely accepted while the use of color and CIR photography has not been as widespread. Certain advantages, however, are evident. "More promising and reliable results are now being obtained with color photography.... Photo scales of 1:6,000 or larger are usually preferred."[22] Color photographs have the advantage of showing true colors of which the interpreter can see more hues, chromas, and value of than he or she can of gray tones. Some soils have characteristics colors which can be readily identified. "In black-and-white photographs, the tone of two differently colored soils may record similarly and differences can only be shown up by the taking of color photographs. Color photographs help not only in correct identification, but also in more accurate and quicker boundary delineations."[23] CIR photography is advantageous because it

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[21] Anonymous, A Comparison of Black-and-White, Color and Infrared Photographs for Geologic Interpretation in Wilvlei, South/West Africa, In Remote Sensing of Environment, ed. George J. Zissis (New York, 1974), III, p. 29.

[22] American Society of Photogrammetry, p. 940.

[23] John A. Howard, Aerial Photo-Ecology (London, England, 1970), p. 214.

differentiates between types of vegetation better than B & W or color. Often the vegetation types give clues to an area's geology or geomorphology (especially texture, soil depth, and topographic position). Consequently, if large scale CIR and color photography are to be used they should be used in combination with smaller scale B & W.

Bluff materials are often discernable by erosion, tone, gulleys, drainage, vegetation, and land uses. Howard (1970) reports that "gullies are probably the most important single class of feature in providing valuable data relating to the parent rock, soil and landform. Usually photographs at a scale of 1/8,000 to 1/10,000 or larger are required when examining gulley shape. As well, soil and vegetation types on ravine slopes are more easily discernable on photographs at 1/5,000 than 1/10,000."[24]

Where there is a series of materials in sequence on a bluff slope (as there often is along glacial terraces which occur frequently along British Columbia's coastline) or where vegetation is so dense that it masks the materials, vertical aerial photography is not always sufficient. Since it is important that the materials composing scarp slopes be known (to estimate erosion potential and potential material sources to beaches) other methods of gathering this information must be used. These would usually entail the taking of oblique aerial photographs or field checking the bluff slopes for information about the materials of which they are made. As Hubbard and Grimes (1972) note: "Low oblique photography often provides more information than vertical aerial photography. In fact, in many practical instances low oblique aerial photographs provide the only practical means of examining a cliff face."[25]

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[24] Howard, p. 206.

[25] C.E. Hubbard and B.H. Grimes, Coastal Vegetation Surveys In Proc. Bristol Symposium on Remote Sensing, ed. by E.C. Barrett and L.F. Curtis (Bristol, 1972), p. 140.

Evans (1972) reported that "soil changes may be seen on air photographs as changes in tone related to differences in soil-surface color or texture, or to differences in crop response. The time to record these variations are either when the ground is bare of crops or when crops are in full growth."[26] "Soils are defined by their type and profile; and, as it is impossible to recognize profiles on the aerial photograph, they have been identified by examining the geology, geomorphology, vegetation and tone or color of the surface soil."[27]

Along the humid British Columbia coastline, soils are usually hidden by vegetation and must therefore be interpreted indirectly from the vegetation types which are closely associated with soil types.[28] In cases where vegetation and soil moisture are influencing criteria, CIR is superior to color film. "The advantages of color photography for soil interpretation become apparent only when those specific soil characteristics associated with soil color are considered."[29]

Valentine et al. (1971) studied the accuracy of using B & W, color and CIR aerial photographs for mapping and describing soil and terrain features. They report that "black and whi~~l~~te film gave a soil mapping accuracy of 72% and was just as good as color or infrared (color) film for the description of specific terrain features of mountain lands. The accuracy of the soil map in the mountain lands and the description of terrain features in an alluvial valley increased to over 80% with the color film. Infrared (color) film...gave slightly more accurate soil

[26] R.Evans, The Time Factor in Aerial Photography for Soil Surveys in Lowland England, in Proc. Bristol Symposium on Remote Sensing, Ed. by E.C. Barrett and L.F. Curtis (Bristol, 1972), p. 77.

[27] Howard, p. 214.

[28] Howard, p. 214.

[29] American Society of Photogrammetry, p. 1331.

maps in the valley."[30]

Table II: Evaluation of Remote Sensors as a Means of Identifying Narrow Landforms for Detailed Study[31]

Landform	Panchromatic Photo (B & W)	Color Photo	Color IR Photo
Active Beach	G	G	E
Marsh	F	G	E
Terrace	G	E	G
Backswamp	G	G	E
Natural leaves	G	E	E
Abandoned Channels	G	E	E
Point Bars	G	E	E
River Bars & Islands	G	E	G
Spoil Banks	G	G	G

E = Excellent G = Good F = Fair

10. Debris Accumulation:

Driftwood is visible on all three film types. On the B & W 1:15,840 photographic prints driftwood is visible on the most exposed sites, but the white color of the logs blends with the light colored beach and backshore areas. Below steep bluffs any driftwood is obscured by shadow and by overhanging vegetation. Driftwood appears very bright white in contrast to the background on the color and the CIR photography and is easy to map. At the 1:3,600 scale used, driftwood can often be located along the base of steep bluffs between breaks in the overhanging vegetation.

No accumulations of aquatic vegetation or other organic materials except shells were evident on the air photos studied. Oblique air photos (color or CIR) would be helpful in locating areas of debris accumulation where they would otherwise be obscured by shadow or vegetation on vertical aerial photographs.

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[30] K.W.G. Valentine, T.M. Lord, W. Watt, and A.L. Bedwany, Soil Mapping Accuracy from B & W, Color and Infrared Aerial Photography, (Vancouver, 1971), p. 1.

[31] American Society of Photogrammetry, p. 1331.

11. Soil Drainage and Moisture:

All three types of aerial photographs analysed were valuable in studying surface drainage, soil moisture, and seepage lines. Areas of moist soil appear darker than surrounding areas on B & W photographs. The color photographs showed soil drainage and moisture very clearly where souls were bare. CIR photography in areas of high moisture content on bare soils were a dark brown color. Photo interpretation also supported the statement by Gagnon (1975) that "color infrared photography can provide additional information on surface drainage, infiltration lines and groundwater mainly through vegetation analysis."[32] Areas of seepage in the foreshore zone were obvious on all types of photography as dark areas. The identification and delineation of areas of seepage in the foreshore are important since they decrease the area of beach surface available for certain types of recreational use. Such areas may also pinpoint potential or actual sewage contamination sites.

12. Vegetation:

"Most types of foliage are not very different from one another in spectral reflectance in the visible region of the spectrum.... However, the generally high reflectance of vegetation in the infrared region and the great differences in reflection which may occur explain the value of a film sensitive in this region for detecting differences in foliage conditions and between varieties of foliage."[33]

Lang and Link (1977) found that "the sensor types best suited to assessment of the aquatic environment are color, color infrared, and

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[32] Hugues Gagnon, Remote Sensing of Landslide Hazards on Quick Clays of Eastern Canada, in Proceedings of the Tenth International Symposium on Remote Sensing of Environment, Vol. II (Ann Arbor, Michigan, October 1975), p. 804.

[33] Way, p. 61.

black-and-white infrared film, which furnish consistently high contrasts between aquatic plants and their surroundings."[34] They agree with Haegele and Hamey (1976) that, due to its water penetration, color photography shows fringe areas of aquatic vegetation. For many types of aquatic and intertidal vegetation CIR film produced the best discrimination.

Bauer (1976) reported that on the basis of vegetation spectral reflectance patterns, surge plains, can be separated from the marine environment using color infrared photography.[35] Research needs to be done to determine the best film-filter combinations to differentiate each species of vegetation.

"The degree to which cover types and plant species can be recognized depends on the quantity, scale, and season of photography, the type of film used and the interpreters background and ability. Species identification accuracy can usually be improved by use of conventional color or infrared color photography."[36]

i) <u>Hazard or Nuisance Vegetation</u>: The CIR photography was found to be the most useful of the three film types for delineating areas of vegetation growth in the intertidal zone as well as floating aquatic vegetation. Haegele and Hamey (1976) used this same photography to map (without field checking) the distribution of five types of seaweed for the purpose of recording and assessing herring spawnings.[37] They used the 1:3,600 color photography to determine outer vegetation boundaries because of the great water penetration afforded by the color film. The

[34] R.S. Lang and L.E. Link, Jr., <u>Remote Sensing of Aquatic Plants</u>, in Proceedings of Eleventh International Symposium on Remote Sensing of Environment, (Ann Arbour, Michigan 1977), p. 817.

[35] Wolf Bauer, Westwater Lecture, (Vancouver, 1975).

[36] Avery, p. 237.

[37] Carl W. Haegele and Mary-Jo Hamey, <u>Shoreline Vegetation Maps of Nanoose and Ganges Herring Management Units</u>, (Pacific Biological Station, Nanaimo, 1976), passim.

aquatic or intertidal vegetation appears as faint green to green on color photography and a readily identifiable magenta on the CIR photography. On the B & W photography the intertidal vegetation is not always visible. Where the vegetation is very dense it appears as a dark gray. Terrestrial hazard vegetation was not described through the use of air photos in this study because detailed study is required to correlate spectral reflectance patterns with species identification.

ii) Terrestrial Vegetation Density: Using crown density scales in a comparative method of analysis,[38] the percent of cover of tree crowns (one measure of vegetation density) can be calculated. Other methods of vegetation density measurement require a combination of air photo typing and ground checking of these types. The CIR photography proved to be the most useful film type and scale for the identification of vegetation because of the wide variation in spectral reflectance of different plant species in the infrared region. Coniferous trees appear dark red and have a characteristic form, while deciduous trees appear a lighter red or pink and also have a characteristic form. Refer to Zsilinsky (1966) for methods of photographic interpretation of tree species.

Way (1973) notes that vegetation density may be more easily determined using CIR film especially when detecting areas of sparse vegetative cover over bare rock and soil. Thus, coastal areas can be observed to determine the amount of stabilizing vegetation present.[39]

[38] American Society of Photogrammetry, p. 847.

[39] Way, p. 61.

mine using CIR film especially when detecting areas of sparse vegetative cover over bare rock and soil. Thus, coastal areas can be observed to determine the amount of stabilizing vegetation present.[39]

Avery (1977) reports that further measurements of vegetation density (quantity of foliage) are possible only on the ground, and thus, aerial photographs are used to complement, improve, or reduce field work rather than take its place.[40]

13. Attractive and Unique Features:

Areas of attractive vegetation are identifiable on all three types of film. Areas of grassland and of open forest (parkland type of vegetation) were easily identified on all three types of photography. Certain types of parkland-type vegetation were best identified on the 1:3,600 CIR photography due to the sharp contrast between the deep red color of the trees and the light yellow-brown of the underlying grass. Pure groves of Garry Oak or Arbutus were most easily identified on the 1:3,600 CIR photography because of their characteristic spectral reflectance and form.

Other attractive and unique features such as accretion shoreforms above high tide level (spits, tombolos, bars, etc.) were identifiable on all three film types. The small area covered by each of the 1:3,600 scale photography however, made mapping areas of unique or attractive vegetation more tedious than when using the 1:15,840 scale photography.

Conclusion:

The use of aerial photography with the suggested composite classification of the coastal zone is necessary. The amount and type of information which can be interpreted depends on the type of film, the scale, and the skill and experience of the interpreter.

[40] Avery, p. 227.

The type of film or film combination and scale chosen depends on the amount of money available. All other things being equal, more detail is available using large scale rather than small scale photos. The time available is another consideration which must be taken into account. It is important to note that the accuracy and reliability of interpreted information and thus the amount of field checking necessary using a given film type at any scale depends largely on the interpreters experience and skill. However, little is known about the accuracy of interpreted information from different film/scale combinations. This is currently the topic of much research.

The three film types and two scales studied for use in a detailed coastal zone inventory for planning and management of camping, picnicking, and cottaging sites should be used to complement one another. The use of any one film and scale without the other two would increase the amount of field work necessary to provide the required information. Flying low-level oblique photography would further reduce the amount of field work necessary by revealing information about bluff faces and areas below bluffs which are not visible on vertical aerial photography due to vegetation screening or shadows.

The timing of aerial photography is critical in obtaining information which is only available at certain times of the day and year. Due to the climate, sun angles, and tides in British Columbia most aerial photography (particularly color) will be taken in the summer. The photography must coincide with very low tides in order to reveal foreshore detail, and with proper sun angles to reduce shadows below steep bluffs.

2.5 Summary Table*

	1:15,840 Black and White Prints	1:3,600 Color Transparencies	1:3,600 Color IR Transparencies	COMMENTS
Beach Classification	F-G	G	G	-problems with classifying beaches below steep cliffs due to shadows and overhinging vegetation.
Process Information:				
a)Approximate Wave Energy Zone	G	G	G	-color photography is preferred to get water penetration below low tide; smaller scale is useful for measuring fetch.
b)Net Longshore Drift	G	E	E	-larger scales preferred to observe evidence of material movement in near-neutral net drift areas and evidence of slumping and sliding on vegetated bluffs.
c)Feeder Bluffs and Streams	F	G	E	-color infrared is preferred for locating streams and for distinguishing slide areas and materials below vegetation on slopes.
d)Driftways and Drift Sector Boundaries	G	E	G	-1:3,600 scale preferred to see drift material below vegetation which overhangs beach. Color preferred for its water penetration.
Foreshore Materials	F	E	E	-color and color infrared at the 1:3,600 scale are preferred over 1:15,840 Black and White for identifying coarser textured materials and to distinguish shell beaches.
Foreshore Length, Width	G	E	E	-the larger scale imagery is more accurate for width and length measurements; pocket beaches are more easily delimited on 1:3,600 then on 1:15,840 photography.
Foreshore Slope	P	P	P	-direct slope measurements using a parallax bar or wedge are not accurate enough for purposes of this study.
Mean Higher High Water Mark	F-G	F-G	F-G	-problems with interpreting the MHHW mark due to vegetation and shadows at the base of steep bluffs and due to vegetation obscuring the MHHW mark in estuarine backshore areas.
Mean Lower Low Water Mark	G	G	E	-color infrared is preferred due the sharp land/water boundary it produces.
Shellfish Beds	P	P	P	-could not locate shellfish beds on any scale or type of photography used.
Land and Water Use, Land Cover and Man Made Features	G	E	E	-color infrared is preferred because vegetation is better represented (interpreted) on this film type and because vegetation is often used as a surrogate in land use mapping.
Slopes of Backshores, Bluffs and Uplands	P	F	F	-for areas of gently sloping land slope measurements are often not accurate enough using the parallax bar or wedge; slope measurements are accurate enough for bluffs ≥10 M. high.
Backshore Width	F	G	G	-problems with backshores lying below steep cliffs which may be obscured by overhanging vegetion or by shadows.
Materials of Backshores, Bluffs and Uplands	G	G	G	-the use of black and white photography for terrain analysis is well documented; all three film types have advantages and are therefore best used together.
Debris Accumulation	F	E	E	-color infrared film is prefered for the high contrast between the bright silvery-white of driftwood and the majenta of backshore vegetation.
Soil Drainage and Moisture	G	G	G-E	-color infrared film is preferred due to the sharp contrast between water and land and where vegetation is affected by soil drainage patterns.
Vegetation	F	G	E	-color infrared film is best for vegetation studies due to large variations in spectral response from vegetation in the infrared portion of the spectrum.
Hazard or Nuisance Vegetation	P	G	E	-further research into identifying hazard and nuisance vegetation according to such parameters as texture, shape and spectral reflectance. Color infrared is preferred for this purpose.
Terrestrial Vegetation Density and Type	F	G	E	-color infrared film is preferred for vegetation typing due to the spectral response of vegetation in the infrared region. Black and white photography has been widely used in density work.
Attractive and Unique Features	G	E	E	-certain types of parkland-type vegetation were best identified on the 1:3,600 color infrared photography due to the sharp contrast between trees and grass on this film type.

* P=Poor F=Fair G=Good E=Excellent

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APPENDIX I

GLOSSARY OF TERMS

Accretional Shoreform - a shoreform (e.g. tombolo, spit, point, etc.) resulting from the accumulation of materials from longshore currents, nearshore currents and waves.

Backshore - "the zone above the swash of normal high spring tide extending from the berm back to the farthest point reached by waves. It may be a narrow storm berm or it may constitute a broader complex of berms, marshes, meadows or dunes landward of the high tide line."[1]

Bar - "a submerged or emerged embankment of sand, gravel, or other unconsolidated material built on the sea floor in shallow water by waves and currents."[2]

Baymouth Bar - "a bar extending partly or entirely across the mouth of a bay."[3]

Beach - "The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves)."[4]

Beach Scarp - "an almost vertical slope along the beach caused by erosion by wave action."[5]

Beach Width - "The horizontal dimension of the beach measured normal to the shoreline."[6]

Bearing Strength - "ability of a soil to support a load."[7]

Berm - "nearly horizontal ridge or terrace of sand and/or gravel brought ashore by waves. In the summer the berm may be low and wide, in the winter higher and narrower."[8]

Breakwater - "A structure protecting a shore area, harbour, anchorage, or basin from waves."[9]

Bulk Density - "the mass of dry soil per unit bulk volume including the air space."[10]

Bulkhead - "A structure or partition to retain or prevent sliding of the land. A secondary purpose is to protect the upland against damage from wave action."[11]

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[1] Terrain Systems Section, Resource Analysis Unit, Environment and Land Use Committee Secretariat (TSSRAU ELUC) <u>Shorezone Classification</u> (Undated), p. 3.

[2] United States Army Coastal Engineering Research Center, p. A-2.

[3] United States Army Coastal Engineering Research Center, p. A-2.

[4] United States Army Coastal Engineering Research Center, <u>Shore Protection Manual</u>, Vol. III (Washington, 1973), p. A-3.

[5, 9, 11] United States Army Coastal Engineering Research Center, p. A-5, A-5, A-31.

[6] United States Army Coastal Engineering Research Center, p. A-2.

[7] David W. Fischer, John E. Lewis, and George B. Priddle, <u>Land and Leisure</u> (1974), p. 247.

[8] TSS RAU ELUC, p. 3.

[10] Harry O. Buckman, N.C. Brady, The Nature & Properties of Soils (London, 1969)P602

Campground - "sites primarily developed for overnight use by campers. Campgrounds are improved areas that provide campers with attractive sites, sanitary facilities, and safe fire areas."[12]

Coastline - "This is the highest landward line of long-term erosional attack of marine waters upon the land. It may be active as such only once in fifty years or more under extreme coincident storm and tide surge conditions or it may be under daily wave erosion."[13]

Consistence - of a soil is "(1) the resistance of a material to deform or rupture. (2) The degree of cohesion or adhesion of the soil mass."[14]

Dolphin - "a cluster of piles."[15]

Drift - "short form of littoral drift--the sedimentary material moved in the littoral zone under the influence of waves & currents."[16]

Drift Sector - "an integrated and independently operating erosion-transport-accretion beach system separated from adjacent shores or sectors by natural or artificial boundaries, or by shore direction changes, - each system containing one or more material sources (feeder bluffs (or stresm)) supplying one or more intermediate and/or terminal accretion shoreforms."[17]

Driftway - "Corridor (mainly between lower backshore and upper foreshore) in which currents generated by waves striking the beach at an an angle transport material along shore (longshore currents)."[18]

Estuary - "an estuary is a semi-enclosed body of water which has a free connection with the open sea and within which sea water is measurably diluted with fresh water derived from land drainage."[19]

Failing - "Modification of surfaces by the formation of tension fractures or by large consolidated or unconsolidated masses moving slowly downslope."[20]

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[12] Robert W. Douglass, Forest Recreation (second edition), (New York, 1975), p. 121.

[13] Wolf Bauer, Accretion Beach Inventory (Undated photocopy), p. 41.

[14] Robert L. Hausenbuiller, Soil Science, Principles & Practices, (Bubuque, Iowa, 1973), p. 464.

[15] United States Army Coastal Engineering Research Center, p. A-11.

[16] United States Army Coastal Engineering Research Center, p. A-20.

[17] Wolf Bauer, Shore Resource Overview, Critique on the Corps of Engineers' Washinton State Environmental Reconnaissance Inventory, (Undated photocopy), p. 17.

[18] TSS RAU ELUC, p. 3.

[19] D. W. Pritchard, What is an Estuary, in G.H. Lauf (Ed.), Estuaries (1967), p.3.

[20] Environment and Land Use Committee, Terrain Classification System, (Kelowna, 1976), p. 26.

Feeder Bluff - "a source of beach material. Material is removed by (1) hydraulic and pneumatic pressure of water moving at high velocity; (2) impact of water laden with rock or wood fragments."[21]

Fetch - "a stretch of open water over which wind is blowing."[22]

Floodplain - "flat land bordering a river and subject to flooding."[23]

Granulation - the fineness to which the soil mineral fraction has been divided.

Groin - "a shore protection structure built (usually perpendicular to the shoreline) to trap littoral drift or retard erosion of the shore."[24]

Gullying - "the modification of surfaces by fluvial erosion resulting in the development of parallel and subparallel, steep-sided and narrow ravines in both consolidated and unconsolidated materials."[25]

Hook - "A spit or narrow cape of sand or gravel which turns landward at the outer end."[26]

Infiltration - "The downward entry of water into soil."[27]

Jetty - "...a structure extending into a body of water, and designed to prevent shoaling of a channel by littoral materials, and to direct and confine the stream or tidal flow. Jetties are built at the mouth of a river or tidal inlet to help deepen and stabilize a channel."[28]

Lagoon - "A shallow body of water, as a pond or lake, usually connected to the sea."[29]

Land Cover - "the vegetational and artificial constructions covering the land."[30]

[21] TSS RAU ELUC, p. 3.

[22] TSS RAU ELUC, p. 3.

[23] TSS RAU ELUC, p. 3.

[24] United States Army Coastal Engineering Research Center, p. A-15.

[25] ELUC, Terrain Classification System, p. 28

[26] United States Army Coastal Engineering Research Center, p. A-16.

[27] Robert L. Hausenbuiller, p. 470.

[28] United States Army Coastal Engineering Research Center, p.A-19.

[29] United States Army Coastal Engineering Research Center, p.A-19.

[30] J. R. Anderson, E. E. Hardy, J. T. Roach, and R. E. Witmer, A Land Use and Land Cover Classification System for Use with Remote Sensor Data, (Washington, 1976), p. 4.

Land Use - "man's activities on land which are directly related to tha land."[31]

Littoral Zone - "an indefinite zone extending seaward from the shoreline to just beyond the breaker zone."[32]

Longshore - "parallel to and near the shoreline."[33]

Longshore Current - "The littoral current in the breaker zone moving essentially parallel to the shore, usually generated by waves breaking at an angle to the shoreline."[34]

Man-Day of Use - "a full day's use by one individual."[35]

Mean Higher High Water (MHHW) - "The average height of the higher high waters over a 19-year period."[36]

Mean Lower Low Water (MLLW) - "The average height of the lower low waters over a 19-year period.... Frequently abbreviated to Lower Low Water."[37]

Microclimate - "the local weather conditions that exist at one small area and are influenced by the conditions in that area...."[38]

Modifying Processes - "those geologic processes that have modified or are currently modifying genetic materials and their surface expressions."[39]

Mudflow - "a flowage of heterogeneous debris (including much silt-clay matrix) lubricated with a large amount of water usually flowing in a former stream course."[40]

Nearshore - "an indefinite zone extending seaward from the shoreline well beyond the breaker zone. It defines the area of nearshore currents."[41]

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[31] Anderson et al. p. 4.

[32] United States Army Coastal Engineering Research Center, p. A-20.

[33] United States Army Coastal Engineering Research Center, p. A-20.

[34] United States Army Coastal Engineering Research Center, p. A-3.

[35] Douglass, p. 241.

[36] United States Army Coastal Engineering Research Center, p. A-21.

[37] United States Army Coastal Engineering Research Center, p. A-22.

[38] Douglass, p. 82.

[39] ELUC, p. 25.

[40] ELUC, p. 46.

[41] United States Army Coastal Engineering Research Center, p. A-23.

Nearshore Current - "a current in the nearshore zone."[42]

Nearshore Water Prism - "...is located between the MHHW tide line...and the 6-fathom line. This coastal fringe zone marks the variable extent of the nearshore shelf in terms of shipping lanes, recreational (non-scuba) skin diving limits, subtidal aquatic habitat horizons, as well as an approximation of the aquatic fringe of the Shore-Process Corridor in terms of extreme Pacific storm wave bottom effects, and the relative buffer for wave energy dissipation."[43]

Oblique Aerial Photographs - "...are exposures made with the camera axis pointed at an angle between the vertical and the horizon. Although obliques are useful for panoramic views, they are not easily adapted to stereoscopic study."[44]

Offshore - "extends from the uppermost point always covered by water to a depth at which substantial movement of beach materials ceases under normal circumstances (usually about 36 feet below the low tide level)."[45]

Panchromatic - "Sensitive to light of all colors."[46]

Permeability - "...soil permeability is that quality of soil that enables it to transmit water and air."[47]

Picnic - "a picnic is an outdoor meal where the members of the party consume the food they brought along with them. Picnicking tends to be family organized groups that use tables and other facilities in a developed recreational area."[48]

Piping - "is subsurface erosion that causes the formation of tunnel-like cavities. The presence of such cavities or susceptibility to their formation can be & frequently is a limitation or hazard to building."[49]

Pocket Beaches - "...are residual or "in situ shore deposits, rather than longshore-drifted accretion forms."[50]

Points - "are low profile shoreline promontories of more or less triangular shape, with one side forming the backshore coastline as a baseline, and the apex extending seaward. Points may be the wave-cut shelf remnant of a headland bluff, or they may be a last-phase purely accretional deposit that had its beginning in a hooked spit, and which subsequently closed its lagoon gap.... Points are characterized by the dyke-like berm that the storm tides have heaped along the high tideline of the two converging beaches and which berms enclose a central inter-tidal lagoon, brackish pond or marsh, or an older salt or dune-grass meadow."[51]

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[42] United States Army Coastal Engineering Research Center, p. A-23.

[43] Wolf Bauer, Western Community Shore-Resource Analysis, (Victoria 1976), p. 4.

[44] Thomas E. Avery, Forest Measurements, (New York, 1967), p. 184.

[45] TSS RAU ELUC, p. 3.

[46] The New Merriam-Webster Pocket Dictionary, (Springfield, 1964), p. 35

[47] U.S.D.A., Soil Conservation Service, Interpretation of Soils for Engineering, (Washington, 1972), p. 12.

[48] Douglass, p. 163.

[49] U.S.D.A., p. 51.

[50] Wolf Bauer, Accretion Beach Inventory, p. 1.

[51] Wolf Bauer, Accretion Beach Inventory, p. 1.

Puddling - Refers to the loss of soil structure because of use when too wet or too dry.

Beach - a length of coastline which is physiographically homogeneous when compared to adjacent reaches.

Riprap - "A layer, facing, or protective mound of stones randomly place to prevent erosion, scour, or sloughing of a structure or embankment."[52]

Scarp - "A more or less continuous line of cliffs or steep slopes facing in one general direction which are caused by erosion or faulting."[53]

Septic Tank Absorption Field - "a soil absorption system for sewage disposal--it is a subsurface tile system laid in such a way that effluent from the septic tank is distributed with reasonable uniformity into the natural soil."[54]

Sewage - "human excreta that has been mixed with water; however, in the field of forest recreation where water systems are not always used, sewage has become a synonym for excreta."[55]

Shear Strength - "of a soil indicates the relative resistance of that soil to sliding when supporting a load."[56]

Shoreline - "The intersection of a specified plane of water with the shore or beach. (e.g. the high water shoreline would be the intersection of the plane of mean high water with the shore or beach.)"[57]

Shore-Process Corridor - "That earth-water diffusion zone which straddles the extreme surge limits of riverine, lacustrine, estuarine, and marine waters, including those adjacent terrestrial and aquatic fringes that can directly affect, or that are affected by the prevailing geohydraulic and geopneumatic systems."[58]

Sorting - "refers to the variation of particle sizes within a sedimentary unit; statistically it is a measure of the spread of the particle size distribution on either side of the mean. Well Sorted - particles of uniform size."[59]

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[52] United States Army Coastal Engineering Research Center, p. A-30.

[53] United States Army Coastal Engineering Research Center, p. A-13.

[54] U.S.D.A., Soil Conservation Service, p. 25.

[55] Douglass, p. 220.

[56] U.S.D.A., Soil Conservation Serive, p. 45.

[57] United States Army Coastal Engineering Research Center, p. A-33.

[58] Wolf Bauer, Shore Resource Overview, p. 16.

[59] ELUC, TCS, p. 47.

Spit - "A small point of land or a narrow shoal projecting into a body of water from the shore."[60] Is usually wave-built of sand and gravel with a windward and sometimes leeward beach berm and lagoon, marshy leeward shore.

Storm Tide - "A rise above normal water level on the open coast due to the action of wind stress on the water surface."[61]

Stream Order - "stream order is a measure of the position of a stream in the hierarchy of tributaries. Each non-branching channel segment is designated a first-order stream. The second order streams are those which have as tributaries only first-order channels and so on for all the channel segments."[62]

Structure - soil structure is "the combination or arrangement of individual soil particles into definable aggregates, or peds, which are characterized and classified on the basis of size, shape, and distinctness."[63]

Terrace - "a horizontal or nearly horizontal natural or artificial topographic feature interrupting a steeper slope, sometimes occurring in a series."[64]

Texture - "Soil texture is the relative proportions of individual-size groups of mineral soil particles in a soil."[65]

Tombolo - "A bar or spit than connects or 'ties' an island to the mainland or to another island."[66]

Unconsolidated - "refers to geological materials that are not lithified or cemented; cohesion between particles is weak or absent and individual particles may be easily separated by hand."[67]

Upland - the area of the coastal zone extending from the highest level of land reached by storm-tide inundations (the backshore) to the inland limit of the coastal zone.

[60] United States Army Coastal Engineering Research Center, p. A-36.

[61] United States Army Coastal Engineering Research Center, p. A-36.

[62] Greater Vancouver Water District, Seymour Watershed (Undated, Hydrology Maps, Landscape Unit Maps), p. 2.

[63] Hausenbuiller, p. 479.

[64] United States Army Coastal Engineering Research Center, p. A-39.

[65] Buckman and Brady, p. 625-627.

[66] United States Army Coastal Engineering Research Center, p. A-39.

[67] ELUC, TCS, p. 48.

Water Quality -	"is the relative bacteriological physical, radiological and chemical characteristics of water in relation to its safe and orderly desirable use by humans."[68]
Wharf -	"a structure built on the shore of a harbor, river, or canal, so that vessels may lie alongside to receive and discharge cargo and passengers."[69]

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[68] U.S. Public Health Service, Manual of Individual Water Supply Systems, (Washington) in Douglass, p. 216.

[69] United States Army Coastal Engineering Research Center, p. A-43.

APPENDIX II

MAPS OF THE NANOOSE AND SALTSPRING STUDY AREAS

APPENDIX III

DESCRIPTION OF UNITS

NANOOSE BEACH INVENTORY AFTER BAUER (1976)

A. Departure Bay

#1 Northwest of the Departure Bay ferry terminal. 955 metres of Class III intruded beach. Rip rap and some drift logs along the base of the scarp. The foreshore is wide and composed of 30 to 80 metres of cobbly gravels and some boulders with some bedrock outcrops and muddy areas at the southeast end. Lower down in the foreshore are some parches of sand which are exposed at low tide. The treed glacial till scarp has a high clay content and is eroding in a sliding and slumping manner. There is some bedrock at the north end. Some yards are being reduced in size by the bluff recession. Several trails down the scarp face access this beach. Northfield Creek enters this unit at the southeast end right next to the ferry terminal and provides some of the gravels and sands which form the beaches of Departure Bay. The estuary of this creek is a good viewing area for waterfowl, gulls and raptors. The beach faces northeast into a medium to low energy zone, protected by Newcastle Island. (Private).

#2 At the head of Departure Bay. A Class II intruded beach 700 metres long. Rip rap, bulkheads and retaining walls line the foreshore of this unit. The upper foreshore is gravelly with cobbly gravels in the southeast portion. The lower foreshore is sandy and a few parallel sandbars have developed. Gravels and sands in this unit are augmented by longshore drift from the southeast and by Departure Creek which is culverted in the north end of this unit. Material supplied by erosion of the low bank has been minimized by shore protection features such as rip rap and retaining walls. There is a diving wharf in the bay in the summer months and small boats use this area as a summer boat anchorage. The foreshore to the southeast is intruded by several launching pads and rail tracks for launching small boats. The lowland is built up with urban housing and there is a municipal park and parking lot at the head of Departure Bay with change houses and lawns. The estuary of Departure Creek is also a good viewing area for people interested in birds. Facing northeast into a medium energy zone protected by Newcastle Island and a wide foreshore. (Public and Private).

#3 North of the outlet of Departure Creek. A Class III beach 450 metres long. The foreshore is made of gravels and cobbly gravels from the deposits of Departure Creek and there is some bedrock outcrops in the foreshore at the north end of the beach. Bulkheads, retaining walls, and some rip rap have been built along the bottom of the scarp. The scarp is used for residential housing. Two piles of rock in the foreshore are actually foundations for old wharfs. Faces southwest into a medium energy zone. (Private).

#4 Southeast of the Pacific Biological Station in Departure Bay. A narrow Class III beach with cobbly gravels very low in the foreshore which are exposed only at low tide. The upper foreshore consists mainly of extrusive bedrock ledge with some cobbly areas near the

Pacific Biological Station. The scarp is bedrock. Facing southwest into a medium energy zone protected by Brandon Island. (Private).

→#5 Immediately north of the Pacific Biological Station. A small creek entering the ocean has formed 250 metres of Class III beach with an extrusive bedrock upper foreshore and a cobbly and gravelly lower foreshore. The westerly foreshore is intruded by rip rap and fill protecting the Pacific Biological Station. The scarp is used for residential housing. Faces southwest into a medium energy zone protected by Jesse and Brandon Island. (Public and Private).

#6 Below Horsewell Bluff. A Class III beach is 500 metres long. The upper foreshore is a steep bedrock ledge and the lower foreshore is made of bouldery cobbles and gravels. The steep bedrock scarp is used for residential housing. Four small wharfs have been built out across the narrow foreshore. Facingssouth but receiving moderate to high energy waves refracted around Horsewell Bluff. (Private).

#7 Below Horsewell Bluff. 61 metres of Class III beach with a cobbly bouldery foreshore 30 to 40 metres wide and a steeply sloping bedrock scarp. There is a municipal park situated on the scarp behind a row of privately owned properties. Facing northest of north into a medium to high energy zone. (Private with a public access trail nearby to the south).

B. Page Lagoon Drift Sector

#8 Below Horsewell Bluff. 500 metres of Class II beach forming the drift sector beach which provides materials to the accretion terminal tombolo at Page Lagoon. At the southwest end of this unit the foreshore is made of cobbly gravels with some bedrock ledge. The low berm at high tide is made of driftwood covered gravels. The northeasterly portion of this beach is made of cobbly gravels with a sandy gravelly drift berm. The scarp in this unit is made of extrusive bedrock and fluvial sands and gravels which supply materials to the longshore current. Facing northwest into a medium to high energy zone. (Private).

#9 The tombolo at Page Lagoon. The tombolo at Page Lagoon joins Lagoon Head to Horsewell Bluff and forms an accretion terminal Class I beach. Material from the Horsewell feeder bluff moves along the drift sector beaches to feed the tombolo and allow for maintenance of the storm berm. The tombolo protects a lagoon area and only allows waves to access the lagoon during coincident high tides and storms. The most southerly part of the tombolo has a wide backshore with three small houses and a parking lot on it. The upper foreshore in this area has been bulkheaded and rip rapped in the past but the protection has been worn away. The foreshore varies from cobbly and gravelly in the south to gravelly and sandy in the north. Some sandbars have formed in the lower foreshore. There is a heavy driftwood accumulation on the upper foreshore and drift berm. The supply of gravels and sand to the tombolo appears to be adequate at the present but further bulkheading along the drift sector beaches to the south must be avoided. The storm berm is built up 2.5 metres above the high tide mark and is vegetated with salt grasses and domestic grasses. A trail along the berm access Lagoon Head which is a popular recreation (hicking, picnicking, sketching, and viewing) area. There is a concentration of Great Blue Herons which find refuge in the limbs of the virgin Douglas-fir on the Lagoon Head. The tombolo, lagoon, and Lagoon Head are all part of a municipal park. This beach faces east into a medium to high energy zone. (Public).

C. Lagoon Head

#10 On the northeast side of Lagoon Head. A 60 metre wide Class II pocket beach with a cobbly foreshore and a gravelly, driftwood covered drift berm in the upper foreshore. The scarp is composed of bedrock with a glacial till capping. Part of this beach is composed of a 2 metre high storm berm of gravels and sand which is 22 metres long built as a result of waves penetrating the pocket beach. Trails connect this beach with the rest of the park. Facing northeast into a medium to high energy zone. (Public).

#11 On the northeast side of Lagoon Head. A 37 metre long cobbly Class II pocket beach adjacent to Unit #10. Connected to the rest of the park by trails. There is a driftwood covered, low gravel drift berm. The steep scarp is made of extrusive bedrock. The vegetation of Lagoon Head is very appealing with large areas of Douglas-fir and Garry Oak over grass near the ocean and Douglas-fir over salal and ocean spray in the interior of the head. This unit faces northeast into a medium to high energy zone. (Public).

#12 On the north side of Lagoon Head. As 80 metre long Class III cobbly beach with many outcroppings of bedrock in the foreshore and a steep bedrock scarp 5 to 8 metres high capped with glacial till. Park-like vegetation similar to Unit #11. Trails connect the upland of this beach to the rest of the park. Facing north into a medium to high energy zone with storm waves from more easterly sources refracting into this bay. (Public).

#13 On the northwest side of Lagoon Head. A Class III beach with a bouldery cobbly upper foreshore 100 metres long. The lower foreshore is made of cobbly gravels. The steeply rising bedrock scarp is capped with glacial till and the upland is similar to Unit #12. Gravels from this beach are moved to the south by the longshore current created by waves from the north and east refracting into this beach. Facing northwest into a medium energy zone. (Public).

#14 At the outlet of Page Lagoon. A Class I spit beach 100 metres long with a steep wave-built beach berm on the northwest side and a more gently sloping backshore towards the interior of Page Lagoon. Wind waves approaching from the northwest and waves refracting around Lagoon Head from more easterly directions move materials along the lower foreshore from Unit #13 and along with materials from the outlet of Page Lagoon are built into this small spit. The spits growth to the south is truncated by the inlet-outlet flow of salt water from Page Lagoon. At very low tides the gravelly lower foreshore of this unit is connected with that of Noname Islands. The spit is 44 metres wide at its widest point and is covered with grass. This spit is part of the muncipal park.

D. Page Lagoon

#15 The interior of Page Lagoon. The lagoon is protected from severe erosion by the tombolo on its easterly side, Lagoon Head to the north and a small spit and point on the west side. The narrow tidal prism and short fetch also preclude any severely erosive waves to build within the lagoon. The inlet-outlet channel is well scoured and an outlet delta has built up to 150 metres from the narrow outlet. The interior of the lagoon forms 1200 metres of shoreline varying from Class I erodable shores to Class III shores with rock scarps. It must be noted that the southwest side of the lagoon is public property with one public access point,while the rest of the lagoon shores are part of the municipal park. Pollution of this lagoon is not an immediate problem since all the residences nearby are connected to sewer lines.

#15a This is the lagoon shore segment along the inside of the spit Unit #14 and forms 90 metres of erodable Class I beach of pea gravel and sand with a driftwood accumulation above the high tide mark. The lower foreshore is composed of the pea gravel and sand of the lagoon bottom. (Public).

#15b 325 metres of Class III shore. At high tide there is only a bedrock scarp above water while at low tide the foreshore is made of the lagoon bottom gravels and sands. This vegetation in the upland of this unit is park-like with a fringe of grassland on the rocky scarp and then Douglas-fir and Garry Oak over grass in the upland. There are several trails along the scarp and some picnic tables in the upland. A 25 metre segment of this unit is part of a high gravel storm berm which has been formed by high energy waves approaching from the other side of Lagoon Head at Unit #10 and joins the two rock isles which together form Lagoon Head. (Public).

#15c The lagoon side of the tombolo connecting Horsewell Bluff with Lagoon Head. This is a Class I erodable shore 377 metres long which because of its protected position in the lee of the tombolo berm has become marshy and covered in marsh-type grasses in the muddy gravels and sand of the upper foreshore. The south part of this unit has been intruded by the park parking lot. (Public).

#15d The southwest side of Page Lagoon is 510 metres of Class II shore. The gravel exposed in the upper foreshore at high tide is wide near the lagoon outlet and becomes almost non-existent at the southeasterly end of this unit. The scarp rises 1 to 12 metres and is made of marine and fluvial sands and gravels and some bedrock outcrops. Houses line the lagoon here and some retaining walls have been built to prevent erosion of the banks (especially at the southwest end which receives waves from the full length of the lagoon due to the winds from the north). The upland here is of variable steepness, but is all developed for residential housing. The access roads to the lagoon park penetrate this unit along the scarp. (Private).

E. Hammond Bay

#16 In Hammond Bay. A 250 metre Class II beach fed by gravels and sands from the outlet of Page Lagoon and by erosion of the low scarp. Materials at the northeast end of this unit have built up into a small point supplied by the drifting gravels of Units #15d and #16. This small point almost joins with the spit of Unit #14 to seal Page Lagoon. The ebb and flow of water in and out of Page Lagoon, however, prevents erosion of the fluvial sands and gravels making up the scarp. A paved boat ramp intrudes across the foreshore at the west end of this unit. There is a small ephemeral creek entering the ocean next to this boat launching ramp and the City of Nanaimo has built a beach access trail near some rocks outcropping in the lower foreshore in the west part of this reach. The foreshore here is pebbly and the near-shore is ued as a summer boat anchorage for small boats. Faces northwest into a low-medium energy zone protected by Noname Islands and Hammond Bay. (Private).

#17 Two rock outcrops on the northeast side of Hammond Bay which are connected by a dual-beach tombolo. The beaches of this unit have been derived from erosion of the bedrock and minor glacial till capping and by some accumulation of materials from Lagoon Head and the outlet of Page Lagoon. At very low tides this unit is connected or almost connected by above-tide gravels, cobbles, and bedrock with Units #13 and 14. The narrow tombolo and Class II beaches of this unit have been built up with beach cabins and boat houses by private owners even though this is public land. Some rip rap has been built to protect these cabins and boat houses, but storm waves can easily breach this protection.

#17a A Class III beach with a bedrock upper foreshore and a cobbly and gavelly lower foreshore. There is a short (20 metre)stretch of Class II beach in this unit where a small beach cabin has been built.

#17b The dual-beach tombolo 65 metres long connecting the two Noname "Islands". The berm is made of gravels built up by storm waves from both sides. The berm is covered, full length, with private boat houses and cabins. There is a dense concentration of driftwood along the gravelly drift berm. The foreshore is cobbly with some boulders.

#17c A Class II beach with a narrow gravelly and cobbly drift berm and moderate driftwood accumulation. The foreshore has quite a few rock outcrops and is made of bouldery cobbles.

#18 Below Piper Crescent Road on Hammond Bay. A 200 metre Class II beach with a gravelly foreshore and narrow driftwood covered drift berm. There are some bedrock outcroppings in the lower foreshore. At times of high gravel supply, material from this beach has a net movement to the south and can move low in the foreshore of this unit, and Unit #16. The sandy and gravelly scarp (4 to 6 metres high) is protected from erosion by a retaining wall and the supply of gravels to this beach and beaches to the southwest is reduced from what it was when a natural process environment existed. There is a public access trail to this beach, but the scarp top is privately owned.

#19 Below the turnoff to Morningside Road off of Hammond Bay Road and is part of Hammond Bay. A Class II intruded pocket beach 162 metres long. The foreshore and small drift berm are made of gravelly sands.

A bulkhead, some rip rap and some landfill have all intruded the upper foreshore of this beach and decreased the supply of gravels and sand to the beach. The sand and gravel scarp rises to a height of 8 metres and is incised by a small ephemeral creek which does supply some sand and gravel to the beach. Houses have been built all along the scarp. Access to the beach is possible by road. There is a sewage outfall here. (Private).

F. Neck Point

#20 On the northeast side of Hammond Bay. A 75 metre long Class I intruded pocket beach. The foreshore and low beach berm is made of gravels. There is a 100 metre wide grassy backshore here, but the residential houses are built along the top of the storm berm and midden. (Private).

#21 At the head of Neck Point. A 140 metre long Class I pocket beach accessed by a road and surrounded by a bedrock scarp. The foreshore and low drift berm are made of pebbles and there is a heavy accumulation of driftwood. The storm berm is composed of pebbles and has some midden material in it. Cabins which were built on the storm berm are being torn down to make way for new development. The backshore has some bedrock outcrops and very attractive vegetation of Douglas-fir and Garry Oak over grass. At low tide you can walk to the bedrock outcrops in the foreshore. Apart from the road and old foundations of the dabins, this area seems to be in a natural state with an excellent backshore area suited to camping and picnicking and a good area to view seals and some waterfowl. Faces northeast of north into a medium to high energy zone. (Private).

#22 At the head of Neck Point. A Class I pocket beach 91 metres long. Houses which were located on top of the storm berm have been torn down to make way for new development. The storm berm has been bulldozed and the upper foreshore has been intruded on by fill material in an attempt to "reclaim" this area. Much of the backshore has also been bulldozed and planted to grass. Further back, the backshore is forested with Douglas-fir over salal and grass. The vegetation on the upland is very attractive Douglas-fir, Garry Oak and Arbutus over grass. Another attractive feature of this site is the intertidal dual-beach tombolo connecting Neck Point with offshore rocks. This tombolo is made of gravel and is accessible only at low tides. The pocket beach faces northwest of north into a medium to high energy zone. (Private).

#23 On the westerly side of Neck Point. A Class I pocket beach 100 metres long. The 90 metre wide foreshore is gravel and the low drift berm is covered in driftwood. There is little or no storm berm on this beach because of its protected position between rocky headlands and bedrock outcrops in the lower foreshore which absorb wave energy. The cabins which were built at the top of the foreshore zone are being torn down to make way for new development. The backshore is forested with Douglas-fir and cedar over salal and grass. The rock knobs in the upland are covered in park-like vegetation of Arbutus, Garry Oak and Douglas-fir over grass. There is a sewage treatment plant situated on the other side of the rock bluffs to the west of this beach. This beach faces northwest into a medium to low energy zone. (Private).

G. Sunrise Beach

#24 One mile west of Unit #23. A 61 metre long Class II pocket beach with a bedrock ledge lower foreshore and a gravel upper foreshore. There is a heavy accumulation of driftwood here. The scarp is 2 to 5 metres high and made of bedrock with some areas of fluvial sand and gravels over bedrock. A road penetrates the scarp right to the foreshore at this beach. Houses have been built on the scarp. Facing northeast of north into a medium to high energy zone. (Private).

H. Icaris Drift Sector - This drift sector has a very long feeder bluff system,most of which is receeding very slowly due to the broad sandy foreshore and porous gravel upper foreshore. Most of it is treed and acts in a sliding and slumping manner.

#25 West from Unit #24. A Class III beach forming the beginning of the long Icaris drift sector. The very narrow and discontinuous upper foreshore rim of gravels and cobbles is made almost impassible by pieces of large driftwood and branches from the trees which slump onto the foreshore from low on the feeder bluffs. The feeder bluffs provide materials to the net longshore drift to the west and are composed of deep glacio-fluvial sands with some layers of glacial till. At the easterly end of this reach the scarp is 2 to 5 metres high but rises to 20 to 30 metres high in the west. This beach is 1850 metres long. In some places along this beach there is a narrow gravel drift berm along the upper foreshore, but these areas are very small and limited in extent. The foreshore is made of bouldery cobbles over most with some sand very low in the foreshore. There is a public access trail and small park at the westerly end of this reach. The feeder bluff scarp and beach are in natural-process condition and the upland is used for residential housing (this is in the City of Nanaimo) and some agriculture but is mainly forested. Facing north into a medium to high energy zone and relying on the shallow foreshore to attenuate wave energy. (Private over most except for small public park at the westerly end).

#26a West from Unit #25 to Icaris Point. An 1175 metre reach of Class II drift sector beach. The feeder bluff scarp of this unit is made of steeply sloping and 25 to 30 metre high glacio-fluvial sands (and some gravels) over glacial till (low in gravel). This scarp is contiguous with the scarp of Unit #25 and is mainly vegetated. There is a public access trail at the easterly boundary of this reach. The upper foreshore of this unit is made of bouldery cobbles and has a narrow gravel and cobble berm which is covered in driftwood. The lower foreshore is made of sand with some sand bar development. The removal of vegetation along the lip of the scarp in the past has activited some areas of the feeder bluff and endangered developed property along the scarp face. These areas are evidenced by concentrations of deciduous tree species. The gently sloping upland has some houses on it but the "natural" character of the beach has been maintained. Facing northeast of north into a medium to high energy zone. (Private).

#26B West of Icaris Point. A Class II beach 1825 metres long with a 30 metre high scarp (lowering to 3 metres in the west) composed of glacio-fluvial sands and some glacial till which is part of the extensive feeder bluff system reaching to the east. This beach has an extremely wide foreshore (up to 350 metres wide) of multiple parallel sandbars which form a highly attractive recreational beach resource. These parallel bars are relatively stable and sand accumulated here moves at a slow rate to the west. Unfortunately, this entire section of upland is privately owned and public access to the beach from the scarp is limited. Several private trails and stairways do access the beach from the scarp top. The sandbars in this unit are the result of sand accumulating from the drift sector beaches and feeder bluffs to the east as well as in this unit. Only small areas of the feeder bluffs are actively eroding as most of the scarp has been stabilized be vegetation. The upper foreshore of this unit has a rim of cobbles and a very narrow and low cobbly gravel drift berm. This berm is made impassible in many places during high tide by accumulations of large pieces of driftwood. The natural-process condition of this beach has been maintained except for one small bulkhead built by the owner of scarp-top property. The gently sloping upland in this area is vegetated mainly with Douglas-fir and arbutus over salal and is accessed by several roads. Recreational and residential houses line parts of the scarp top. This beach is excellent for swimming as the shallow water gets very warm in the summer months. Clams are plentiful here. Facing north into a medium energy zone protected from high energy waves by the broad, shallow foreshore. (Private).

#27 At Lantzville. A Class I beach 575 metres long supplied with gravels from the longshore current from the east and by gravels from Bloods Creek which enters this unit. This beach has a .5 to 1 metre berm. The foreshore is up to 95 metres wide and made of gravelly cobbles with a low drift berm of sandy gravels and driftwood. Some sand is evident at the lower extremity of the foreshore. The net longshore drift is to the west. The backshore is 125 metres wide and has been developed for a trailer park, housing and a playing field. This reach faces north into a medium to high energy zone and relys on its wide foreshore to attenuate wave energy. (Private). Fortunately, no bulkheads have been built to protect the backshore in this area and thus the beach is maintaining itself.

#28 West of Unit #27. 175 metres of intruded Class III beach. Log bulkheads and some large rip rap have been built to protect private houses and property built into the shore process zone. This has resulted in the degrading of the beach from a Class I or II natural-process beach to a Class III beach. Faces north into a medium to high energy zone. (Private).

#29 West of Unit #28 460 metres of Class II beach. Part of this beach has been rip rapped or contained behind retaining walls, but most of it is still functioning naturally. The foreshore is made of sandy gravels and cobbles and the drift berm has a heavy layer of driftwood on it. Some sand is evident very low in the foreshore. The materials on this beach are derived from the longshore current from units to the east as well as from some erosion of the scarp. The scarp of this unit rises gently from the shore to 3 to 8 metres. A sandstone bedrock outcrop at the west end of this unit restricts longshore drift of gravels and sand to the west, but some materials do pass this barrier low in the foreshore. This beach faces north to northeast into a medium energy zone. This area is privately owned but there are several public access points to the beach.

#30 West of Unit #29. 340 metres of Class II beach. This beach is situated between two sandstone bedrock outcrops but does receive some sands and gravels from the east in the longshore current. Some bulkheading has intruded this beach. Thegravel drift berm is covered with drift logs. The scarp is .3 to 1.5 metres in height and slopes gently towards the shore. The foreshore is made up largely of sand with some gravel in the upper part. There are some parallel sandbars low in the foreshore. The sand for these sandbars came from sand which was 'trapped' in this beach by sandstone bedrock outcropping from Blunden Point. There is public access to this beach. (Private).

I. Blunden Drift Sector

#31 West of Blunden Point. 1325 metres of Class III beach with some small areas of Class II beach. The scarp of this unit rises from 5 metres in the east to 15 to 22 metres in the west and is made of fluvial sands and gravels over bedrock. The scarp top is lined with residential housing and a highway (Lantzville Road). The foreshore is extremely wide (up to 400 metres wide) with an upper rim of cobbly gravels and sandbars. Individual transverse sandbars are up to 450 metres long and appear to be migrating towards the west. The sand making up these sandbars is derived from erosion of the scarp in this unit as well as from sand travelling in the longshore current from east of Blunden Point. (At extremely low tides you can walk from Lantzville along sandy beach to Entrance Rocks Jetty.) The boulders in the foreshore come from several points along the steep bluffs in this unit. Some small areas of this feeder bluff scarp have been bulkheaded to protect it from erosion, but the natural shore processes are still functioning with little interruption. Further bulkheading, however, should be avoided so as not to increase down-drift erosion or decrease the supply of materials to the beaches which are the main resource for this area. There are several private trails to the beach from the cliff top. Thevegetation on the scarp top is mainly Douglas-fir over salal but on the scarp face there are more cedars and deciduous tree species. Facing north into a medium to low energy zone protected by Blunden Point and a very wide and shallow foreshore. (Private).

#32 West of Unit #31. If natural shore processes were still operating in this reach, the entire beach all the way to Entrance Rocks would be a Class I beach with exceptional capability for recreation because of the broad sandy foreshore and thelevel backshore with a protective storm berm. However, as in many other attractive beach settings, development has taken place in the backshore and on the berm of this unit and has degraded the beach to a mix of Class II, III and I beaches. The beach has been degraded to a maze of Class II and III beaches by rip rapping, bulkheading and the construction of retaining walls. Knarston Creek which used to flow along the inside of the natural storm berm is now flowing in its old course but is contained by rip rap and cement at several points. In order to try to rebuild the beaches destroyed by bulkheading, groins have been built out into the foreshore to catch gravels moving in the longshore current. Boat ramps have also been built from the top of the bulkheads down to the foreshore. The lower foreshore of this unit is composed of transverse and a few parallel sand bars which are migrating towards Entrance Rocks Jetty. The upper foreshore is made of cobbly gravels with some areas of gravels. Faces north into a low to medium energy zone protected by its broad foreshore. (Private).

#33 There is a small area of Class I beach near the mouth of Knarston Creek where the longshore current from the east has accumulated gravels to form a small barrier beach or spit. This unit has the same foreshore as Unit #32 but it is unintruded. (Private).

#34 West of Knarston Creek. This is a continuation of the unit to the east of Knarston Creek but the entire length of this unit has been degraded to a Class III shore by the addition of bulkheads, rip rap, and retaining walls. The entire area is developed for residential and recreational housing which extends the full width of the broad backshore. The foreshore is wider here than it is to the east because the sand bars migrating to the west accrete against Entrance Rocks and Entrance Rocks Jetty. (Private).

#35 East of Entrance Rocks Jetty. Now forms the end of the Blunden Drift Sector. 325 metres of Class I accretion beach with an ephemeral creek entering. The foreshore and backshore of this unit are continuations of the units to the west. The storm berm is well developed at the westerly and against Entrance Rocks Jetty where, since the construction of the jetty, much gravel moving to the west in the longshore current has built up into a Class I beach and has left the old storm berm quite a distance from the new shore. The backshore of this unit has quite a bit of driftwood scattered on it especially at the west end where there is not protective storm berm. There is salt grass at the front of the backshore and marshy areas with tree and shrub vegetation to the landward side of the backshore. The sand moving westward in the longshore current towards Entrance Rocks is accreting against Entrance Rocks and the Entrance Rocks Jetty and 'spilling' around the tip of the jetty in the form of a large intertidal spit which becomes exposed at low tide. (Indian Reserve).

J. Entrance Rocks Drift Sector

#36 West of Entrance Rocks Jetty. The east end of the Entrance Rocks Drift Sector. Before the Entrance Rocks Jetty was built, the longshore current from the east and from the west built beach gravels into an accretional point with a Class I beach. Since the jetty was built, however, accretion on the east side of the point has stopped, although the Class I gravel beach remains. The westerly side of the point, however, still exposed to winds and waves from the west, has been bulkheaded and rip rapped to protect a road and housing development and has resulted in a degrading of the Class I beach to a Class III beach. Thus, the gravelly foreshore of this unit is made of 200 metres of Class I beach and 200 metres of class III beach. The foreshore of this point as well as part of the point itself is used as a log sorting and booming operation. (Indian Reserve).

#37a West of Unit #36 is the end of the Entrance Rocks Drift Sector. 825 metres of intruded Class III beach with minor inclusions of Class II beach. Almost the entire length of this beach has been rip rapped or bulkheaded, resulting in inactivation of the feeder bluff and erosion of Fleet Point. The foreshore is pebbly with some areas of cobbles. The easterly 290 metres of beach are fronted by a scarp of fluvial sands and gravels over bedrock rising at 30 to 40 percent. The westerly 535 metres, however, have a remnant backshore up to 100 metres wide. The rip rap and bulkheads have caused this beach to be degraded from a Class I to a Class III beach. The backshore is developed for residential housing and is composed of sands and gravels with some areas of midden materials. The net longshore current in this unit is to the east. An old ferry terminal dock is left standing in the foreshore of the westerly part of this unit. There is a highway and a railway in the upland. The unit faces north into a low to medium energy zone. (Indian Reserve and Private).

K. Nanoose Drift Sector

#37b Alongside the Vancouver Island Highway on the south side of Nanoose Bay. 1380 metres of intruded Class III beach. The entire length of this beach except for a few hundred feet in the west half have been rip rapped with large rock to protect the Esquimalt and Nanaimo Railway from eroding into the ocean. This has resulted in inactivation of much of the feeder bluff. The scarp of glacio-fluvial sands and gravels falls from 27 metres in the east to 2 metres in the west. The foreshore is held in lease by the C.P.R. The foreshore is of variable width (22 to 30 metres wide in the east and up to 65 metres wide in the west) and is made of cobbly gravels. This is a near neutral drift zone. The upland of this unit has a unique forest of Arbutus and Douglas-fir over salal--the richest concentration of Arbutus trees in this study area. Faces north into a medium energy zone. (Private).

#38 West of Unit #37b. A Class I beach, 200 metres long with a backshore up to 40 metres wide. The backshore is intruded by the E.N.R. This unit is actually a small accretional point which has been built up in the past both by man (as a place for housing workers for the now non-existent sawmill to the west) and by nature. There is a thick drift wood accumulation of the east facing side of this point. The foreshore is made of finer gravels and some sand. Several old pilings are evident in the foreshore and foundations of old buildings can be found in the backshore. The upland of this unit is built up with residential housing and the Vancouver Island Highway and E.N.R. are built on the scarp face. Faces north into a medium energy zone. (Private).

#39 West of Unit #38. An intruded Class III beach. The Esquimalt and Nanaimo Railway and Island Highway intrude immediately above the foreshore. Rip rapping and a wooden sea wall have been placed along the entire 300 metres of shore to protect the railway and highway. The narrow foreshore is made of cobbly coarse gravels and some boulders. Net longshore drift is to the west, although this stretch of shore is starved of materials due to the extensive rip rapping here and to the east. Across the road from this unit is a sand pit and a rest area where travellers on the Vancouver Island Highway can relax. (Private and Public).

#40 West of Unit #39. This shoreform is the remnant of an area built up as a foundation for the now extinct Straits Lumber Company sawmill. The small creek entering this unit from the glacio-fluvial sand and gravel upland also provides material for this area and its associated foreshore. The resulting shoreform is an area of Class I beach with a backshore of variable width intruded by the E.N.R. and the Vancouver Island Highway. The net longshore current is to the west here and is maintaining the easterly part of the beach as well as building a subtidal spit in the offset of the west end of this unit. There is some erosion along the centre portion of this unit, however, where the docks from the old sawmill were built. There are quite a number of old pilings in the foreshore here. A lagoon dug as a log pond for the Straits Lumber Company sawmill is still functioning as a tidal lagoon, although the bottom is still thickly layered with bark and wood chips. The foreshore here is made of cobbly gravels and is up to 200 metres wide. (Private).

#41 East of the end of Nanoose Beach Road. 900 metres of intruded Class III beach with rip rap all along the base of the glacio-fluvial sand and gravel scarp except for the most westerly 150 metres where the lower part of the scarp is bedrock. The rip rap is to prevent erosion of the scarp because the railway (E.N.R.) is built right next to the foreshore on the scarp. This unit is part of the longshore drift sector providing gravels to Unit #42. The foreshore varies from 80 metres wide of gravels and cobbles to the east to 6 metres wide of cobbly gravels along the rocke scarp in the west. The upland of this unit is used for agriculture (grazing) and forest production. Faces northeast of north into a medium energy zone. (Private).

#42 On the south side of the head of Nanoose Bay. A Class I beach with areas of intruded Class II beach. Gravels moving in the longshore current from the east are building a spit at the end of this barrier beach accretional shoreform. The flow of materials in the longshore current, however, is less than what it was under natural-process conditions because of the rip rap to the east. The backshore is over 300 metres wide and has been developed for agriculture and recreation and is the home of the Pentecostal Church summer camp and a trailer park. Some areas of the backshore have been filled to level the topography and rip rap has been placed along the shore to protect it from erosion. The upper foreshore is gravel and pea gravel while th lower foreshore is composed of pea gravels and sands from the extuary at the head of Nanoose Bay in Unit #43. There is public access to the beach. (Private).

L. Nanoose Bay

#43 The head of Nanoose Bay. The estuaries of Bonell and Nanoose Creeks fuse at the head of Nanoose Bay to create an area of marshland, surgeplain, and tidal flat which extends many hundreds of metres seaward of the highway at the head of Nanoose Bay. Ditching and diking has been carried out to stop the storm-tide plain from extending to the highway. This has been successful although extreme high tides and coincident storm surges still flood the farmland behind these protections. Part of this area has been brought back into the public sector with public funds when it was realized just how important to the food chain--to waterfowl and fish and ultimately man, estuarine areas are. There is a typical progression of salt intolerant to salt tolerant plants as one proceeds from the brush covered marsh through the distributary zone to the nearshore zone.

#44 On the north side of Nanoose Bay. Over ¼ mile of Class I beach and beach backshore at the mouth of Nanoose Estuary. This unit includes a gravel point over 110 metres wide which has been cleared and fenced for agricultural use. The rest of the unit is in natural condition and is covered in thick forest at the back of the backshore. The lower foreshore is part of the estuary bottom and is composed of muddy sands and pea grawels. There is a strip of saltgrass at the front of the backshore and some areas of swamp in the backshore. The point (barrier beach) has been eroded by Nanoose Creek on its easterly side and built up by waves and gravels on its westerly side. (Private).

#45 To the east of Unit #44 on the north side of Nanoose Bay. A Class III beach 950 metres long with some areas where a narrow drift berm is present for short distances but not accessible from the scarp. The foreshore of this unit is very wide (over 130 metres in some places) and is made of cobbly gravels and gravels. In the north part of this unit there are some rock outcrops in the foreshore and the scarp is up to 12 metres high and very steep with fluvial sand and gravel over glacial till and some areas of bedrock. Net longshore drift in this unit is to the southwest. In the south part of this unit the scarp is 13 to 22 metres high of sandstone, and trails off to 1 to 2 metres of midden materials and then rises again to being 8 metres high and composed of glacial till and fluvial sands and gravels. Some boulders appear in the foreshore at the southwest end of this unit. The vegetation of the upland is variable but contains areas of Douglas-fir and Arbutus over grass and areas of denser forest. The area is accessed by three roads on top of the scarp and is developed for residential housing. The foreshore is part of a private oyster lease. There is a dock associated with the foreshore oyster lease built out into the foreshore in the centre of this unit. Faces south and southeast of south into a medium energy zone but the extensive foreshore dissipates much of the wave energy. (Private).

#46 At the north end of Unit #45. 80 metres of Class I barrier beach built at the mouth of a small creek by wave action on the gravels eroding from the scarp to the south and materials provided by the creek itself. The creek estuary forms an extensive gravelly foreshore which is richly covered in oysters and clams. The backshore of gravels varies from 15 to 60 metres in width and is in its natural state except part of it is used as a garden and a house imposes itself immediately above the grassy backshore on the scarp. There is private road access to this beach. (Private).

#47 Department of National Defense (D.N.D.) operations wharf on the north side of Nanoose Bay. The westerly 250 metres of this unit form a Class III intruded beach. A large wharf in the foreshore and extending into the nearshore is the tie-up and servicing area for military operations at Nanoose Bay. The lowland has been extended into the foreshore with gravel and sand fill and is rip rapped in places. Some of the gravel moving in the longshore current accumulates here and builds the small point at the D.N.D. operations. The lowland is covered with military developments and parking lots and permission is required for access. The west end of this near-neutral drift sector is reached just to the west of the D.N.D. development where deeper water is encountered. This part of the unit faces southwest into a medium energy zone but is protected from wave attack by the D.N.D. wharfs.

The eastern 600 metres of this unit form a Class III drift sector beach (with small areas of Class II shores) composed of gravel (especially in the westerly portion) and cobbles with some areas of low bedrock outcrops throughout. The beaches are below a continuous scarp of marine and glacial materials (shallow) over metamorphic bedrock rising 2 to 6 metres to an upland of park-like vegetation of Douglas-fir, Bigleaf Maple and Garry Oak over grass. A paved road high up in the upland is not visible from the beach but the busy D.N.D. wharf to the west is easily visible. There is a net flow of gravels to the west in this unit. Faces south into a medium energy zone to a high energy zone. (D.N.D.).

#48 Immediately west of the D.N.D. airplane dock on the north side of Nanoose Bay. A Class II beach with a gravelly foreshore 180 metres long. Some of the gravels on this beach have been transported here by the longshore current from the southwest and are protected from being moved in the direction of net longshore current (to the east) by the airplane breakwater. (D.N.D.).

#49 Immediately east of the D.N.D. airplane dock and breakwater. A series of Class III cobbly beaches interspersed with bedrock outcrops below a steep metamorphic bedrock scarp 5 to 8 metres high. There is a trail along the top of the scarp. The beaches are in natural process condition but the view is intruded by the D.N.D. breakwater. Facing south into a medium to high energy zone. (D.N.D.).

#50 Northeast of Unit #49. A 100 metre long Class II pocket beach with a low gravel berm and a cobbly gravel foreshore. The forest in this unit is quite dense and composed of Douglas-fir, Arbutus, and Garry Oak over oregon grape. Some midden material on the scarp top. There is a trail along the top of the 2 to 4 metre high bedrock scarp. (D.N.D.).

M. Richard Point

#51 Southwest of Richard Point. A Class II, low-bank, pocket beach 80 metres long with a wide foreshore of bouldery cobbles and some gravels. Eroding midden material less than a metre high forms the beach scarp and the gently sloping lowland extends about 50 metres to the forested and grassy upland. There is a trail from this beach to the beach in Unit #50. Faces 50° east of south into a medium to high energy zone. (D.N.D.).

#52 At Richard Point. A Class I pocket beach almost 200 metres long with a well developed storm berm and a large midden extending the full length of the beach. The backshore area is quite extensive and grades into a rolling upland of rock knobs. The entire area is in natural condition with park-like vegetation of Douglas-fir, Arbutus, and Garry Oak over grass. The area is accessed by an old road and has been used for camping and picnicking. It forms an ideal camping and picnicking spot with good opportunity for viewing waterfowl and seals. There is a heavy driftwood accumulation on this beach. Faces east into a high energy zone. (D.N.D.).

N. Wallis Point

#53 Near the tip of Wallis Point. An area of Class III cobbly gravel beach which is between the tip of Wallis Point and an intertidal island right on the end of Wallis Point. Gravels supplied from some erosion of small pockets of glacial till in the scarp as well as cobbles from the wearing down of the fractured bedrock in this area form the beach here. At low tide the island is joined to Wallis Point by bedrock. There is an area of Garry Oak over grass on the small island. (D.N.D.).'

#54 On the north side of Wallis Point. 30 metres of Class III cobble beach facing into a high energy zone. Southeasterly waves are refracted around Wallis Point and scour the rock ledge surrounding this unit. There is a trail along the top edge of the low scarp. (D.N.D.).

#55 West-southwest of Wallis Point. Dual Class II pocket beaches totalling over 120 metres in length and separated by a rock outcrop. The more northerly beach has a foreshore of boulders and cobbles over bedrock and a narrow drift berm of driftwood covered gravels. The bedrock scarp rises 2 to 5 metres to a level, forested upland. An old road (overgrown) accesses these beaches. The more southerly beach has a shingle upper foreshore (upper 10 to 15 metres) while the lower foreshore is cobbly gravels. The scarp here, of glacial till and bedrock rises gently to the upland. Faces east into a medium energy zone.

#56 600 metres north along the shore from Unit #55. A 35 metre long Class II pocket beach. The narrow drift berm is virtually covered in driftlogs and the beach and scarp are in natural condition. Access is by annarrow trail from a dirt road in the upland. The upper foreshore is composed of gravelly cobbles while the lower foreshore is boulders. The scarp is vegetated with Douglas-fir and Arbutus over dense salal with a few moss or grazs covered rock outcrops. Faces east into a medium energy zone and is partially protected by some small islands in the offshore zone. (Private).

#57 ¼ mile southeast of Schooner Cove. 100 metres of Class II low-bank pocket beach. Some attempts at bulkheading have almost changed this into a Class III beach but a narrow gravel and sand drift berm persists. The low bank of fluvial sands and gravels is stabilized with vegetation and recreational and residential housing occupies the lowland area immediately above the beach. The upper foreshore is composed of gravelly cobbles. (Private). Faces east into a medium energy zone.

O. Ballenas Channel

#58 Schooner Cove. This cove is heavily developed with residential and recreational housing as well as condominiums, a marina with associated breakwater and wharfs, and a paved road which intrudes into the foreshore at the head of the cove. The area of Class III beach that does exist in the protected waters of the cove are composed mainly of bedrock withppatches of cobbles and boulders over bedrock. The rocky foreshore is intruded by private boat launching pads. (Private).

#59 ¼ mile northwest of Dolphin Beach. A Class I pocket beach 175 metres long composed of gravels, sand and some cobbles. The backshore has been developed for recreational and residential housing. The gravel drift berm is well developed and has a moderate accumulation of driftwood on it. The bay is used as a summer boat harbour. The bay faces northwest of north into a medium energy zone. (Private).

#60 Dolphin Beach. Dual Class I and II pocket beaches separated by a rock outcrop. The more easterly Class I beach is 120 metres long and has a well developed drift berm under driftwood. The foreshore materials vary with the season and with the position on the beach. The southeast end of this beach at the time of inspection was coarse gravelly to cobbly while the northwest end was of fine pear gravels, indicating the effect of the predominant southeasterly wave direction. The south beach is about 80 metres long and cobbly. The rock scarp rises 4 to 9 metres. Both beaches have houses built on their scarps but the Class I beach even has housing in its backshore zone. The bay is a popular recreation spot with many small boats using it for summer anchorage. Some of the houses in this unit are within the area which could be inundated during a storm surge coincident with a high tide. The vegetation in this area of Douglas-fir and Arbutus over grass and salal and the view of Georgia Strait and the offshore islands makes this a very attractive site although impaired by the dense subdivision throughout the area. Faces northwest of north into a medium energy zone but is partially protected from large waves by rocky headlands and offshore islands. (Private).

#61 Northwest of Unit #60. Two Class II pocket beaches over 125 metres in combined length and split by a rock outcrop. The beaches are made of cobbles and gravels and have a narrow drift berm of gravels and driftlogs. The bedrock scarp rises for 6 to 8 metres from the drift berm. This beach faces northeast of north into a medium energy zone. (Private).

#62 Northwest of Unit #61. Over 240 metres of Class II pocket beach with a gravelly foreshore and narrow drift berm at the base of the rock scarp which rises steeply for 10 to 22 metres. The outlet of Enos Creek also supplies materials to this beach. There are at least two boat and equipment sheds built in the upper foreshore of this unit and are in severe danger of being damaged during storm events. There is a diving platform in the bay during summer months and many small boats use the bay for summer anchorage. No developed public access was evident although a small park area has been set aside by developers on top of the scarp. Houses are built on the scarp. Faces northwest of north into a medium energy zone. (Private).

#63 Southeast of Arab Cove. 300 metres of Class II pocket beach composed of approximately equal amounts of bedrock and boulders and cobbles and gravels. The drift berm is made of coarse gravels under driftwood and the scarp is made partly of bedrock and partly of colluvium, glacial till and gravels of marine origin. At low tide the rocks in the bay are are above water making small boat anchorage risky. Some houses have been built on the scarp but no intrusion onto the foreshore has been made. At the southeast end of this reach is an aesthetically appealing grove of Garry Oaks, Douglas-fir and Arbutus over grass which extends up onto the high bluffs to the southeast where open grassland with krumholtz of Douglas-fir and Garry Oak result from the exposed location. There are trails throughout this area snd the view from the bluffs adjacent to this unit is spectacular. Facing northwest of north into a medium energy zone. (Private).

#64 Arab Cove. Is a small pocket cove consisting of two lengths of Class II beach separated by a rock outcrop. At low tide the cove is virtually dry while at high tide it is protected from wave impact by several rock outcrops at the mouth of the cove. The westerly lobe of beach is over 300 metres long and is made of some bedrock outcrops with cobbles and gravels inthe upper foreshore and gravels and some sand and mud in the lower foreshore. There is a diving platform and log wharf in this part of the cove. The foreshore of the easterly lobe of beach is mainly bedrock and boulders but there is a 6 metre wide drift berm at the base of the bluff, thickly covered with drift logs. The scarp in this cove is composed of glacial till with moderate gravel content, and bedrock. This area has been developed as a recreational site by the United Church of Canada. The natural character of the area has been well preserved. (Private).

WALMSLEY--NANOOSE

#1	G-C-S	Ri-Sscl·22-29·III	G-S	Ri·25·III	#2
	Fx·R	U-NS-R	Fx·C·R	U-R	
#3	G-S		G-C-N	Ri-Rs·16·II	#4
	R·C·Fr	C-U-R	C·Fx·R	U	
#5	R-N	Ri-Sscl·4-9·II	R-C-G-N	Ri·6-12·II	#6
	C·Fx·R	U-NS	W·R	U-NS	
#7	R-N	Rs·23·III	R-N	Ri·12·III	#8
	W·R	U-RB	W·R	U-NS	
#9	R-G-N	Rs-Ri·5-15·III	C-G	Ri·12-15·III	#10
	R	RB-NS	R	U-NS	
#11	R-C-G-N	Ri-Ssg·12-15·III	R-C-G	Sgs-Ri·15·III	#12
	R	U-NS	R	RB-NS	
#13	G-C-S	Ri-Sgs·12-15·III	G-S		#14
	R·C·Fx	R-U-NS	R	R-NS	
#15	R-C	Ri·1-3·III	C-G	Ri·1-4·III	#16
		R-NS		R-NS	
#17	R-C-N	Ri·4-9·III	B-C-R-N	Ri·4-7·III	#18
		R-NS		R-NS	
#19	G		G-S		#20
		R-NS		R-NS	
#21	G-S-N	Ri·3-8·II	G-S-Cl		#22
		R-NS	R	R-NS	
#23	G-S	Ssg-Ri·2-12·II	G	Ssg-Ri·6·II	#24
	C	RB-U	C·Fgs·R	U-R	
#25	R-N	Ri·1-3·II	R-C-G	Ri·1-2·III	#26
		R		R	

#27
$$\begin{array}{r|l} \text{G-C} & \\ \hline & \text{R} \end{array}$$

#28
$$\begin{array}{r|l} \text{R-C-G} & \text{Ri}\cdot\text{1-3}\cdot\text{III} \\ \hline & \text{R} \end{array}$$

#29
$$\begin{array}{r|l} \text{N} & \text{Ri}\cdot\text{1-4}\cdot\text{III} \\ \hline & \text{R} \end{array}$$

#30
$$\begin{array}{r|l} \text{G} & \text{Ssg}\cdot\text{6-9}\cdot\text{II-III} \\ \hline \text{BL}\cdot\text{C}\cdot\text{Fx}\cdot\text{R} & \text{U} \end{array}$$

#31
$$\begin{array}{r|l} \text{R-G-N} & \text{Ri}\cdot\text{3-4}\cdot\text{III} \\ \hline \text{R} & \text{U} \end{array}$$

#32
$$\begin{array}{r|l} \text{G-R} & \text{Ri-Ssg}\cdot\text{6}\cdot\text{II} \\ \hline \text{R}\cdot\text{C} & \text{U} \end{array}$$

#33
$$\begin{array}{r|l} \text{R-B-N} & \text{Ri-Ssg}\cdot\text{2-9}\cdot\text{III} \\ \hline \text{R} & \text{U} \end{array}$$

#34
$$\begin{array}{r|l} \text{S-G} & \text{Ssg}\cdot\text{8}\cdot\text{II} \\ \hline \text{Fr}\cdot\text{C}\cdot\text{Fx}\cdot\text{R} & \text{U-RB} \end{array}$$

#35
$$\begin{array}{r|l} \text{R-N} & \text{Ri}\cdot\text{9}\cdot\text{III} \\ \hline \text{R} & \text{RB} \end{array}$$

#36
$$\begin{array}{r|l} \text{G} & \\ \hline \text{R} & \text{RB-R} \end{array}$$

#37
$$\begin{array}{r|l} \text{R-C-B-N} & \text{Ri}\cdot\text{6}\cdot\text{III} \\ \hline \text{R}\cdot\text{C} & \text{RB-NS} \end{array}$$

#38
$$\begin{array}{r|l} \text{G-R} & \\ \hline \text{R} & \text{R-NS} \end{array}$$

#39
$$\begin{array}{r|l} \text{N-G} & \text{Ri}\cdot\text{8}\cdot\text{II-III} \\ \hline \text{R} & \text{NS-RB} \end{array}$$

#40
$$\begin{array}{r|l} \text{G} & \text{Ri}\cdot\text{1-6}\cdot\text{II} \\ \hline \text{R} & \text{NS} \end{array}$$

#41
$$\begin{array}{r|l} \text{N} & \text{Ri}\cdot\text{3-8}\cdot\text{III} \\ \hline \text{R} & \text{NS} \end{array}$$

#42
$$\begin{array}{r|l} \text{G-C} & \\ \hline \text{R} & \text{RB-NS} \end{array}$$

#43
$$\begin{array}{r|l} \text{N} & \text{Ri}\cdot\text{3-15}\cdot\text{III} \\ \hline \text{R} & \text{NS} \end{array}$$

#44
$$\begin{array}{r|l} \text{R-C-G} & \text{Ri}\cdot\text{2-4}\cdot\text{III} \\ \hline \text{R} & \text{NS-RB} \end{array}$$

#45
$$\begin{array}{r|l} \text{C-B-G-N} & \text{Su}\cdot\text{16-27}\cdot\text{III} \\ \hline \text{R} & \text{NS-U-RB} \end{array}$$

#46
$$\begin{array}{r|l} \text{S-C-B-N} & \text{Su}\cdot\text{32}\cdot\text{III} \\ \hline \text{R} & \text{RB-NS} \end{array}$$

#47
$$\begin{array}{r|l} \text{S-C-G} & \text{Ss}\cdot\text{32}\cdot\text{III} \\ \hline \text{R} & \text{RB-NS} \end{array}$$

#48
$$\begin{array}{r|l} \text{G-C-S} & \text{Ssg}\cdot\text{6}\cdot\text{I} \\ \hline & \text{U-RB-A} \end{array}$$

#49
$$\begin{array}{r|l} \text{S-G-C} & \text{Ssg}\cdot\text{3-8}\cdot\text{I-II} \\ \hline \text{Fx}\cdot\text{C}\cdot\text{R} & \text{U-RB} \end{array}$$

#50
$$\begin{array}{r|l} \text{R-G-S} & \text{Ssg-Rs}\cdot\text{1-3}\cdot\text{I} \\ \hline \text{C}\cdot\text{R} & \text{RB} \end{array}$$

#51
$$\begin{array}{r|l} \text{S-G} & \text{Sgs-Rs}\cdot\text{2-7}\cdot\text{II-III} \\ \hline \text{R}\cdot\text{C} & \text{RB} \end{array}$$

#52
$$\begin{array}{r|l} \text{N} & \text{Ssg-Rs}\cdot\text{3-8}\cdot\text{III} \\ \hline \text{R} & \text{RB} \end{array}$$

#53	G-C-B	Rs-Ssg·12-27·III	R·C	RB-NS-A
#54	S-G-C-N	Ssg·6-8·III	Fx·Fr·C·R	RB-NS
#55	S-G	Ssg·5-16·II	J·R·Fx	I-RB
#56	S-G-C-N	Ssg·5-10·II	Fx·R·C	RB
#57	S-G-C-N	Ssg·5-15·II	Fx·R·Ra·W·C	RB
#58	G-C-N	Ssg·19-31·III	Ra·R	NS-RB
#59	C-G-N	Ssg·2-3·III	Fx·R·Ra	RB-NS
#60	G-S-C	Ssg·6-10·III	R·Ra	RB-NS
#61	G-C-N	Ssg·16-19·III	Ra·R·Fx·C	NS-R
#62	G-C-S	Ssg·30·III	R·Ra	NS
#63	G-C-N	Ssg·25·III	Ra·Fx·R	NS
#64	R-G-C-N	Rs-Ssgcl·3-4·III	R·Ra	A-RB-NS
#65	G		Fr·C·Fx·R	R-A-RB
#66	G-S		R	A-RB-NS
#67	G-S	Ssg·10·II	R	NS-RB-C
#68	G-C-B-N	Ssgcl-Ri·2-8·III		NS-RB
#69	G-C	Ssg-Rs·6·II-III	R·W·	RB-NS-C
#70	G-C-S-B	Ss-Rs·13-22·III	R	RB-NS-C
#71	G-C-R-N	Su-Ri·12·III	R	NS-C-RB
#72	G-C-R-N	Ri·6·III	R	NS-C
#73	G-C	Sscl-Ri·8·II	R	RB-NS
#74	R-G-C-N	Ri·12-23·III	R	RB-NS
#75	N	Ri·160·III		NS
#76	R-C-G-N	Rm·3-5·III		NS-D.N.D.
#77	G-S-N	Rm-Sg·100·II	R·W·BL·Fgs	D.N.D.
#78	G-R-C	Rm-Sg·5·II	R	D.N.D.-NS

#79	G-C-R	Rm·3-5·III	G	Rm·0-5·III	#80
	R	NS		D.N.D.-NS	
#81	G-C-R	Rm·5-8·III	G-C	Rm-Sg·5-8·III	#82
	W·J·R	D.N.D.	R	D.N.D.-NS	
#83	G-C-R	Rm·5-8·III	R-B-C-N	Ri·8-15·III	#84
		D.N.D.-NS		NS	
#85	C-G-B		R-B-C-N	Ri·8-15·III	#86
		NS		NS	
#87	R-G	Ri·2-6·III	G-C	Ri·6·II	#88
		NS	R	NS	
#89	R-C-N	Ri.6-18.III	C-G-R-N	Ri·2-5·III	#90
		NS		NS	
#91	R-C-B-N	Ri·3-5·III	C/R-N	Ri.2-3.II-III	#92
		NS		NS	
#93	R-C-B	Ri·3-7·III	G-C-B/R	Ri-Sg·2-9·II-III	#94
		NS		NS	
#95	R-B-N	Ri·5-6·II-III	R-N	Ri·5-8·III	#96
	R	R-NS	R	NS	
#97	B-C-G-N	Ri·5-6·II	R-B-N	Ri·5-9·III	#98
	R	NS-R	R	NS	
#99	R-B-N	Ri·5·III	N-R	Ri·5-8·III	#100
	R	RB-NS	R	RB-NS	
#101	G-S-C	Ssg·1-3·III	R-B-C-N	Ri·5-9·III	#102
	R	RB-R	BL·J·W·R	RB	
#103	G-S-C	Ri·15·II-III	R-N	Ri·5-8·III	#104
	R	RB	R	RB-NS	

#105	G-C	R	Ri·5-9·III	RB
#106	R-N	R	Ri·5-8·III	RB
#107	G-C	R	Ri·6-8·III	RB
#108	N	R·C	Ri·5-9·III	RB
#109	G	R	Ri·10-23·II-III	RB-R-NS
#110	R-N	R	Ri·19-22·III	NS
#111	G-R-C	R	Ri-Ssg·2-5·III	RB-NS
#112	R-N	R	Ri·3-8·III	RB-NS
#113	R-C-G	R	Ri·10·II-III	R-NS-RB
#114	N	R	Ri·3-10·III	NS-RB

E.L.U.C.--NANOOSE

1.	kg//s:kg	--------------------	scMb-F·22-29·65-150	Fx·R	U-NS-R
2.	s//g:s//g	sgFb·10-60·0-10	R/scMv-b·25·60-120	Fx·C·R	U-R
3.	s//g:s//g	sgFb·300+·0-5	------------------------	R·C·Fr	C-U-R
4.	g//kg:---	--------------------	R·16·40	C·Fx·R	U
5.	R:-----	--------------------	R//scMv-b·5-9·20-50	C·Fx·R	U-NS
6.	bR//sg:---	-----------------	R·6-12·25-50	W·R	U-NS
7.	R:-----	-----------------	R·23·110	W·R	U-RB
8.	R:-------	-----------------	R·12·55	W·R	U-NS
9.	R//g:-----	-------------------	R·5-15·100-200	R	RB-NS
10.	k:kg	--------------------	R·12-15·150-200	R	U-NS
11.	R//kg:-----	-------------------	R·12-15·150-200	R	U-NS
12.	k=R:g	--------------------	$\frac{gFv-b}{R}$·15·65	R	RB-NS
13.	kg:sg	sgWm·0-50·0-5	$\frac{gFv-b}{R}$·15-18·60-80	R·C·Fx	R-U-NS

14.	sg:sg	sgWm·3·0-5	----------------------	R	R-NS
15.	R/R:R	----------------------	R·1-3·60-150	----------------------	R-NS
16.	gk:g	----------------------	R·1-4·60-150	----------------------	R-NS
17.	kR:-----	----------------------	R·4-9·70-200	----------------------	R-NS
18.	Rk:-----	----------------------	R·4-7·60-150	----------------------	R-NS
19.	g:g	sgWm·10-40·0-5	----------------------	----------------------	R-NS
20.	gs:sg	sgWm·10-40·0-5	----------------------	----------------------	R-NS
21.	sg:-----	----------------------	R·3-8·20-50	----------------------	R-NS
22.	sg/c:sg	sgWm·3·0-5	----------------------	R	R-NS
23.	sg:g	----------------------	$\frac{gFv-b}{R}$·2-12·30	C	RB-U
24.	g:g	----------------------	$\frac{sgF//sgW}{R}$·6·20-30	C·Fgs·R	U-R
25	R:-----	----------------------	R·1-3·15-50	----------------------	R
26.	Rk:gk	----------------------	R·1-2·55-75	----------------------	R

27.	kg:kg	gWm 5 0-5	------------------------	------------------	R
28.	gc=R:gc	--------------------	R·1-3·50-150	----------------------	R
29.	-------------	--------------------	R·1-4·50-150	---------------	R
30.	g:g	--------------------	sgFb·6-9·45-60	BL·C·Fx·R	U
31.	gR:------	--------------------	R·3-4·60-90	R	U
32.	g:gR	--------------------	$\frac{\text{sgFb}}{\text{R}}$·6·20-50	R·C	U
33.	bR//s:-----	--------------------	$\frac{\text{sgFv-b}}{\text{R}}$·2-9·100	R	U
34.	gs:gs	--------------------	sgFb·8·30-40	Fr·C·Fx·R	U-RB
35.	R:------	--------------------	Rs·9·160	R	RB
36.	g:g	gF/gW·300+0-10	----------------------	R	RB-R
37.	kR:------	--------------------	Rs·6·150-200	R·C	RB-NS
38.	g//R:g	sgF=sgW//R·300·0-10	-----------------------	R	R-NS
39.	R//g:-------	--------------------	Rs·8·40-60	R	NS-RB

40.	g:g	sgF/sgW·120·1-10	R·1-6·20-50	R	NS
41.	-----------	--------------------	Rs·3-8·100	R	NS
42.	kg:g	sgW=sgF·300·5-10	----------------	R	RB-NS
43.	-----------	--------------------	Rs·3-15·100	R	NS
44.	R//bk:gR	--------------------	Rs·2-5·100-150	R	NS-RB
45.	bk:-----	--------------------	$\frac{\frac{sgFo}{scMb}}{\$Fv}$·16-27·70-90	R	NS-U-RB
46.	bk:-----	--------------------	sFs·32·70-90	R	RB-NS
47.	s//k:gk	--------------------	sFs·32·70-90	R	RB-NS
48.	gk:gs	sgF=sgW·100-230·0	sgF·6·10-20	----------------------	U-RB-A
49.	gs=k:gs/k	--------------------	sgF·3-8·5-30	Fx·C·R	U-RB
50.	bR:gs	--------------------	$\frac{sgWv}{R}$·1-3·25	C·R	RB
51.	gs:g	--------------------	$\frac{sgWv}{R}$·2-7·30-80	R·C	RB
52.	R//s:-----	--------------------	$\frac{sgWv}{R}$·3-8·200	R	RB

53.	kg:bk	------------------	gsFs Rs·12-27·70-200	R·C	RB-NS-A
54.	s//kg:------	gsW=gsF·250-300·0-5	gsF·6-8·60	Fx·Fr·C·R	RB-NS
55.	gs:gs	sgW·10-125·0-5	gsF·5-10·35-45	J·R·Fx	I-RB
56.	s//kg:------	--------------------	sgF·10·30-40	Fx·R·C	RB
57.	s//kg:------	gsW·25-100·0-5	gsF·5-15·40-50	Rx·R·Ra·W·C	RB
58.	kg:------	------------------	sgFs·19-31·90	Ra·R	NS-RB
59.	gk:------	--------------------	sFs·2-3·180	Fx·R·Ra	RB-NS
60.	kg:gs	gsW·6-40·0-10	sgFs·6-10·85	R·Ra	RB-NS
61.	g//bk:------	--------------------	sFs·16-19·80	Ra·R·Fx·C	NS-R
62.	kg:sg	sgW·15-100·0-5	gsFs·20·75	R·Ra	NS
63.	kg:------	--------------------	gsFs·25·55	Ra·Fx·R	NS
64.	kg/R:------	------------------	gFv-b Rs ·3-4·150-180	R·Ra	A-RB-NS
65.	g:g	gFb=gWb·300 · 0-2	--------------	Fr·C·Fx·R	R-A-RB

66.	sg:sg=$	$\frac{\text{\$F}}{\text{gF}}$-E·300 · 0-2	--------------------	R	A-RB-NS
67	gs:g	gW·130·0-2	gsFb·10·25-50	R	NS-RB-C
68.	kg//b:------	--------------------	scMb//gFb·s-8·100-200	---------------	NS-RB
69.	kg:g	--------------------	$\frac{\text{sgWv-b}}{\text{R}}$·6·40-90	R W	RB-NS-C
70.	g//bk:gs	--------------------	$\frac{\text{sF}}{\text{Rs}}$·13-22·60-110	R	RB-NS-C
71.	kg//R:------	--------------------	$\frac{\text{sgWb-v}}{\frac{\text{scMb}}{\text{R}}}$·12·100-150	R	NS-C-RB
72.	kg//R:------	--------------------	Rs·6·100-150	R	NS-C
73.	kg:g	gW·16-62·0-5	$\frac{\text{scMb}}{\text{R}}$·8·35-45	R	RB-NS
74.	kg/R:------	--------------------	Rs·12-23·40-100	R	RB-NS
75.	------------	--------------------	Rs·160·70-120	--------------	NS
76.	R/gk:------	--------------------	R·3-5·50-100	------------------	NS-DND
77.	sg:------	gsW/gsA·100·0-5	R//$\frac{\text{gW}}{\text{R}}$·2-3·25-40	R W BL Fgs	DND
78.	kg//R:g	--------------------	$\frac{\text{gWv}}{\text{R}}$·5·30-40	R	DND-NS

79.	kg//R:g	--------------------	Rs·3-5·150
	R		NS
80.	g:g	--------------------	R·0-5·50-150
	--------------------------------		DND-NS
81.	kg//R:g	--------------------	Rs·5-8·150-200
	W·J·R		DND
82.	kg:g	--------------------	$\frac{gWv}{Rs}$ · 5-8·100
	R		DND-NS
83.	kg//R:g	--------------------	Rs·5-8·150-200
	--------------------------------		DND-NS
84.	R//bk:------	------------------	Rs·8-15·120-200
	--------------------------------		NS
85.	bk/g:kg	gWb·100·0-10	--------------
	--------------------------------		NS
86.	R//bk:------	--------------------	Rs·8-15·120-200
	-------------------------------		NS
87.	g=R:g	--------------------	Rs·2-8·150-200
	--------------------------------		NS
88.	kg:g	gW/R·100·±10	R·6·15-40
	R		NS
89.	R//kg:-----	--------------------	Rs·6-18·150-200
	R		NS
90.	bk=kg:-----	--------------------	Rs·2-5·100
	--------------------------------		NS
91.	R/kg:------	-------------------	Rs·2-5·100
	--------------------------------		NS

92.	$\overset{k}{R}$/R:-----	--------------------	Rs·2-3·40-150	----------	NS
93.	R/bk:R	--------------------	Rs·3-7·150-200	-----------	NS
94.	kg/R:-----	--------------------	$\frac{gWv}{R}$·9·20-80	----------	NS
95.	R//b:-----	--------------------	R·5-6·20-90	R	R-NS
96.	R//b:-----	--------------------	Rs·5-8·60-200	R	NS
97.	b/kg:-----	--------------------	R·5-6·40-50	R	NS-R
98.	R//b:-----	--------------------	Rs·5-9·60-150	R	NS
99.	R/b:-----	--------------------	Rs·5·50-150	R	RB-NS
100.	-----:R	--------------------	Rs·5-8·150-200	R	Rb-NS
101.	gs/k:g	sgF·300+·4-8	sgF·1-3·150	R	RB-R
102.	R/bk:-----	--------------------	Rs·5-9·90-200	BL·J·W·R	RB
103.	sg/k:gs	sgW·40·0-10	Rs·15·40-80	R	RB
104.	R:-----	--------------------	Rs·5-8·100-200	R	RB-NS

105.	kg:g	sgW·0-15·0-20	Rs·5-9·50-90	R	RB
106.	R:-----	-------------------	Rs·5-8·100-200	R	RB
107.	kg:g	-------------------	Rs·6-8·60-80	R	RB
108.	------------	-------------------	Rs·5-9·150-200	R·C	RB
109.	g:g	-------------------	Rs·10-23·30-60	R	RB-R-NS
110.	R:-----	-------------------	Rs·19-22·180	R	NS
111.	kg=bR:g	-------------------	Rs/sgC=gW·2-5·150-200	R	RB-NS
112.	R:-----	-------------------	Rs·3-8·150-200	R	R-NS-RB
113.	bR=gk:g	-------------------	R·10·20-80	R	R-NS-RB
114.	------------	-------------------	Rs·3-10·25-95	R	NS-RB

SALTSPRING BEACH INVENTORY AFTER BAUER (1976)

A. Athol Peninsula

#1 South side of the tip of Athol Peninsula, Class II pocket beach bounded by sandstone scarps rising 5 to 8 metres on both sides. The beach is 55 metres long with a 25 metre wide foreshore of cobbly, sandy, shells. Some parkland and open meadow upland of recreational and aesthetic value (parkland consists of a tree cover, usually of Douglas-fir, Arbutus, or Garry Oak over grass linked by trails to access roads.) Rock outcrop in lower foreshore has partial tombolo effect. This area is rich in terrestrial wildlife particularly deer and racoons. Middens in the lowland form an archaeological or historic site. Beach faces 57° east of north and is of low energy due to rock outcrops and islands in the baymount. (Private).

B. Long Harbour

#2 North side of Long Harbour, north of the British Columbia Ferry terminal. Dual pocket beach separated by narrow bedrock outcrop. Class III erosional beach. Foreshore a total of 75 metres long of gravelly shells. 1 - 2 metre bedrock scarp with some midden. Incredible concentrations of broken and unbroken clam shells in the foreshore. Faces west-southwest into medium to low energy zone. (Private).

#3 Northwest of Unit #2 on Athol Peninsula, Class III low-bank beach with gravelly, sandy shell foreshore. Bounded on two sides by steep sandstone scarps 3 - 8 metres high. Middens in the lowland. Accessed by gravel road from power transmission line. Intruded by cabin in lowland. Warm afternoon picnicking and swimming location. Faces 19° west of north into medium to low energy zone. (Private).

#4 Northwest of Unit #3 on the Athol Peninsula. Class III beach of shallow cobbles and gravels over bedrock and bedrock outcrops and over 600 metres long. (Natural setting except for a grown-over gravel road in tuding a low spot in the scarp.) Scarp rises steeply for 10 to 30 metres. Upland vegetation includes large areas of parkland of Douglas-fir and Arbutus over grass. Faces 26° west of south into a medium energy zone. (Private).

#5 Northwest of Unit #4 in Long Harbour. Class II pea gravelly beach with some shale bedrock ledge, with a length of over 120 metres. The sandstone scarp rises 3 to 10 metres immediately above high tide. Quite a heavy accumulation of driftlogs in the upper foreshore. Incredible accumulations of jellyfish in Long Harbour particularly in September (see slides). Gravels moving low in the foreshore of Unit #4 accumulate to supply the beach of Unit #5. Facing 20° west of south into a medium to low energy zone. (Private).

#6 Northwest of Unit #5 at the head of Long Harbour. Class III drift sector beach with 137 metres of steep gravel beach followed by a rip-rap and fill dike, more gravel beach, a rock ledge with gravel in the lower foreshore and ending in a small accretional spit. The gravel source is by in-situe erosion of the 1 to 4 metre rock and gravel bank and from the eroding rocky shoreline to the east. The rip rap and fill dyke seals a man-made or enhanced lagoon capable of being tidal or non-tidal according to whether or not an inlet-outlet culvert is open or shut. The foreshore and lowland is intruded by two docks, a house built right into the foreshore, and a large lawn area. Small log booms are sometimes stored in behind the small spit which is mainly subtidal. Facing 32° south of west into a low energy zone. (Private).

#7 The north side of the entrance to the tidal lagoon at the head of Long Harbour. 3/4 of a mile of Class III pebbly and bedrock beaches. The road low down on the scarp is shielded from view by the dense jungle of vegetation. Some areas of steep rock scarp 1 to 12 metres high rise from the waters edge. This unit combined with the lagoon itself forms a unique recreational resource for canoeists as the waters are calm, the area is secluded and the setting is mainly natural. Tidal ebb and flow currents are responsible for redistributing the gravel supplied by two small ephemeral streams entering the lagoon outlet. Facing 40° west of south into a low energy zone. (Private).

#8 Tidal lagoon at the head of Long Harbour. Almost a mile of erodable Class III beaches which are not passible on foot due to the soft silty clay texture of the sediments. The entire lagoon drains at low tides, leaving an interesting drainage pattern in the lagoon bottom. Two ephemeral creeks entering the lagoon could be used as a water source, but well water is also available. Wave fetch and water depth are so minimal that they do not allow for much shore erosion, but rather the lagoon acts as a settling pond for fine sediments which are now settling out as far as part way down the lagoon outlet. This indicates that the lagoon is progressing towards a climax stage of infilling where the tidal prism is decreasing to a critical depth. The bedrock nature of the outlet prohibits any lowering in elevation and hence the flushing efficiency will decrease and any pollution entering the lagoon will be increasingly damaging. If any further development (in addition to the house, wharf and surrounding pasture) recreational or otherwise, outlet channel dredging may become a necessity to maintain proper flushing action.

#8a North shore of the lagoon. Class III low bank shores formed by the lagoon bottom. The lowland made of silt and clay near the lagoon and sand and gravel over bedrock further upland. This unit is intruded by a boat wharf, house, and hobby farm which detracts from the natural setting of the outlet-lagoon-estuary system. Even though this is a low energy zone, removal of shore vegetation has resulted in some shore erosion by the ebb and flow currents and by small waves. Rip rap has been placed along the shore to prevent further erosion, but detracts greatly from the natural setting. (Private).

#8b Low bank (½ metre high) Class III shore of silt and clay. Level lowland area with seasonal swampyness. Dense vegetation especially along theshore. Dense vegetation hides the old road in the lowland. (Private).

#8c Class III shoreline with a tree covered bedrock scarp rising 5 metres. Old road on the scarp is hidden by the vegetation and hence the natural appearance of this unit is maintained. (Private).

#8d Includes the major freshwater input into the lagoon with a perennial (bordering on ephemeral in dry years) stream and a surgeplain freshmarsh environment and very small estuarine creek mouth during high flow conditions. Unfortunately the surgeplain marsh and meandering streamway are cleared of natural vegetation for a power transmission line right of way and a road. The clearing is now used for grazing and cannot sustain intensive recreational use. Further removal of or damage to vegetation along the tidal creek could result in increased erosion of stream banks during maximum runoff periods and result in a greatly increased rate of infilling of the lagoon. (Private).

#8e A series of steeply sloping rocky scarps rising from the Class III silty clay lagoon bottom shoreline and including an ephemeral creek which flows across bedrock and supplies little material other than fresh water to the lagoon. This unit includes a rocky point covered with park like vegetation of Douglas-fir and Garry Oak over grass. An accumulation of silts and clays is building behind this point into the outlet channel. (Private).

#9 On the south side of the lagoon outlet at the head of Long Harbour. A Class III pebbly and pea gravelly beach, 300 metres long with some mud in the lower foreshore in the lagoon outlet. There are some areas of bedrock outcrop in the foreshore, and the foreshore narrows to the northwest. The sandstone scarp rises steeply for 12 to 20 metres from the unintruded beach. Facing east northeast into a low energy zone. (Private).

B. Long Drift Sector

#10 West of the end of Ontario Place road. Class I beach of pebbly gravels with rock outcrop at the westerly end. The berm is vegetated with saltgrass near the ocean and the backshore is forested with some areas covered in fresh water swamps. Some of the materials supplied to units to the east. Due to the coarseness of the berm material and low to medium energy of the waves this far up Long Harbour, the berm has become well vegetated and is well suited to the recreational and aesthetic requirements of camping and picnicking. Nearby housing, both residential and recreational intrude the natural setting of the unit but open grassy areas across the narrow channel enhance the vista. (Private).

#11 Due west of the British Columbia ferry terminal. A series of rock ledges and areas of Class III gravelly beaches. This reach is a near-neutral longshore drift zone due to the protected position in Long Harbour but the net drift of gravel is to the west. The supply of gravel to this beach area is very small and is evidenced by the many areas of bare rock ledge. There is however, enough gravel to supply the beach at Unit #10 with gravels and to maintain recreational drift sector beaches at the westerly end of this unit. The beaches tend to have more gravels as one progresses to the west of this unit. The scarp is composed of sandstone and shale and rises steeply from the high tide line. Access along most of the unit is limited to times other than high tide. Houses have been built at the west end of this sector on the scarp face, several small boat wharfs have been built into the foreshore zone, and road access penetrates the scarp face at two points. In the easterly section of this reach, however, only one trail accesses the beach at the small point. This point also contains eroding midden materials and constitutes an archaeological site. There is also a small, intertidal spit building towards the west at the tip of this small point. (Private).

C. Welbury Bay

#12 At the head of Welbury Bay. 150 metres of Class I gravel and cobble beach. Eelgrass concentrations in the lower foreshore andnearshore attract many diving and dabbling ducks on their flight along the Pacific Flyway. The whole of welbury Bay is rich in marine life including seals, sea stars, crabs, clams, oysters, kelp, eel grass and rockweed. Well water is available at this site and the area is easily accessible by road. The gently sloping lowland and backshore make it an ideal area for camping and picnicking although this use is presently precluded by two houses built just above the narrow backshore and a small house right onto the backshore. Facing ESE into a medium to low energy zone. (Private).

#13 North side of Welbury Point in Welbury Bay. Rich in shellfish and marine and bird life. The foreshore is mainly a narrow bedrock ledge with some areas of broken shell, boulder and gravel Class III beach. Residential housing and road in upland. Large commercial wharf in this unit. Faces NE into a medium to low energy zone.

D. Welbury Point

#14 West of Welbury Point. The foreshore is up to 22 metres wide of Class III cobble, boulder and bedrock beach. The scarp here constitutes a low area (rising only 8 to 11 metres) in the generally continuous scarp. Residential housing in the upland. Some bulkheading in the upper foreshore along the scarp bottom and private stair access down the scarp face. This unit is approximately 100 metres in length. Faces southeast into a medium energy zone. (Private).

E. Chain Islands Drift Sector

#15 A couple of Class III beaches surrounding a Class II beach, forming part of a slow-moving longshore drift sector.

#15a Due north of Deadman Island. A Class II beach, of cobbles, boulders and bedrock (bedrock shallow over most). Steeply rising sandstone scarp. There are residential houses and a road on the scarp top. Oysters, crabs and starfish are abundant here. Access to beach is very limited due to steepness of scarp. Medium energy zone beach. (Private).

#15b West of Unit #15a. A Class III beach. The upper part of the foreshore is mainly a sandstone bedrock ledge with a few boulders but the lower foreshore (only exposed at low tides) is made of gravel and shells which have a net longshore movement to the west in the longshore current. The beach is approximately 800 metres long, and the sandstone scarp rises 3 to 8 metres. Several small wharfs have been built out into the foreshore and recreational and residential housing lines the scarp top. Some hobby farming and orcharding is also situated on the scarp. Facing south into a medium energy zone protected from large waves by the Chain Islands. (Private).

#15c A Class II pocket beach situated in the middle of Unit #15b with a length of over 110 metres. Although most of the foreshore is bedrock it has a 10 to 15 metre wide lower foreshore of cobbly gravels and a 3 to 5 metre wide gravel and pea gravel berm with some saltgrass vegetation established further back. The 2 to 3 metre high scarp is composed of midden and bedrock and constitutes an archaeological site of significant size. The attractive upland forest of Douglas-fir and Arbutus over salal and grass is accessed by many private trails but the natural setting has been lost due to housing development on the scarp and wharfs in the foreshore. Faces SW into a medium energy zone. (Private).

#16 Northwest of Unit #15. 120 metres long a Class III beach of gravel, sand, shells and mud varying in width from 65 to 22 metres. Small shell tombolo (intertidal) building behind a rock outcrop in the foreshore. The appearance of mud in the foreshore is due to fine textured materials in the lowland settling out in the quiet spots in the foreshore. Rip rap and bulkheading at the base of the scarp has decreased the supply of gravels and sands to thellongshore drift. The scarp is 3 metres high and is composed of bedrock and midden material with some fluvial sands and gravels. Clams and oysters are abundant in this area although pollution is becoming a problem since residential and recreational housing has been built in the lowland. Faces south into a medium to low energy zone protected by rock outcrops in the foreshore and the Chain Islands to the south. (Private).

#17 Due north of the middle of Goat Island. Class II intruded (bulkheaded) gravel and sand and shell beach 85 metres long. The net movement of materials on this beach is from east to west. The 100 metre wide lowland above the 2 to 3 metre scarp of sands, gravels and midden material. Oysters and clams at certain times of the year become marginally harvestable due to water pollution. Faces SSE into a low to medium energy zone protected by the Chain Islands. (Private).

#18 Northwest of Unit #17. This is the westerly terminus of the drift sector to the east. There is a 120 metre long Class III beach of gravel and mud. Some of the gravel has built out into the water in the form of a spit which isuunderwater at high tide. Class II beaches in this reach have been degraded to Class III beaches by extensive bulkheading with a cement retaining wall to stop erosion of the scarp which forms the face of an extensive lowland area used for residential housing. The small creek entering this unit is well contained in its bedrock channel and supplies little gravel to the estuary. The small spit and Class III beach along the easterly side of the small creek estuary are in contrast to the Class III beach of muddy gravels and cobbles and bedrock outcrops on the westerly side of the estuary. Here the scarp of bedrock and some silts and clays is eroding to augment the muddy deposits in the estuary. The estuary is rich in oysters, starfish and crabs. The estuary is a low energy zone. (Private).

F. Ganges Harbour

#19 At the head of the small bay to the northwest of Goat Island. Materials supplied by the creek at the head of the bay are redistributed by the longshore current to form Class III beaches to the southwest and a Class I barrier beach at the creek mouth. The Class I barrier beach with a

.5 to .8 metre gravel berm protecting the grassy backshore from frequent inundation by storm waves. The beach is 180 metres long and forms a potential picnicking or camping site and viewing area. The natural vista is intruded by houses built on the nearby scarp to the north. A small footbridge has been erected across the creek. Trees have established themselves in the southerly portion of the backshore area indicating the stability of this shoreform. The lower foreshore is composed of the muddy gravels of the estuary bottom and is rich in sea stars, crabs and oysters. (Private).

#20 Southwest shore of the small bay to the northwest of Goat Island. 370 metres of Class III beach which at its most easterly point is made of muddy gravels and cobbly gravels with some bedrock outcrops. The sandstone scarp rises steeply for 3 metres and is covered in recreational and residential housing. At the westerly end of this unit the upper foreshore is 18 metres wide of cobbly gravels while the lower foreshore is an extensive area of muddy sand forming the bottom of the estuary. Here the scarp rises 22 metres and is unintruded. (Private).

F. Chain Islands

#21 The Chain Islands form a series of very attractive sandstone bedrock isles due to the small size, bedrock formations, vegetation (Douglas-fir, Arbutus, and Garry Oak over grass and salal) and the rich sea life of seals, oysters and many types of birds often in flocks of several hundred (particularly in August, September and October). There are many cormorant nests apparent on the steep sided islands. There are very few beaches and few access points although there are private wharfs and cabins on some of the islands. (Private).

#21a On the westerly tip of Third Sister Island. A Class II spit beach made of broken shells accumulating around several rock outcrops. The longshore current tends to move shell material from the rich oyster and clam beds around the island to this end of the island. Thebeach is 75 metres long and is unintruded. (Private).

#21b On the north side of Goat Island. 32 metre long Class II pocket beach. The foreshore is composed of cobbly gravels and mud while the low berm is of pebbly send. The bay is protected from storm waves by rocks outcropping in the bay mouth. This beach is intruded by a cabin on the scarp and some rip rap. (Private).

F. Ganges Harbour (Cont'd.)

#22 Northwest of the tip of Goat Island. 173 metres of intruded Class II and III gravel and sand beach. The scarp is 2 - 5 metres high of midden material, marine deposits and glacial till. Much of the scarp has been protected by a cement retaining wall. The scarp mainly composed of midden , forms an archaeological site and a cemetary. There is road access to the scarp top and a staircase to the beach. The foreshore is up to 80 metres wide and faces southeast into a medium energy zone partially protected by Goat Island. (Mainly private with a public access).

#23 At the head of Ganges Harbour. An 80 metre wide Class II pocket beach of cobbly gravels with some sand and boulders and a pea gravel and bedrock upper foreshore. A low pea gravelly berm is evident at high tide. The beach is intruded by an old boat house built out onto the narrow berm. The scarp rises steeply for 6 metres and is made of midden material with some bedrock and areas of glacial till. The upland is cleared for agriculture. Faces southeast into a medium energy zone. (Private).

#24 At the head of Ganges Harbour. A Class III beach 100 metres long of cobbles and gravels shallow over a sandstone bedrock ledge with much bedrock ledge outcropping. The scarp rises steeply for 12 to 21 metres with no shore access except along the foreshore. Farm in the upland. Faces southeast into a medium energy zone. (Private).

#25 At the head of Ganges Harbour. A heavily intruded Class I beach. Material from an ephemeral creek entering this unit has been built up by wave action to form a dry backshore Class I beach. The backshore area has since been developed for commercial boat repair and launching facilities. The foreshore has been developed as a large private boat dock. This is part of Ganges proper and as such there are roads, houses, and a hotel immediately above the backshore area. Late in the summer, the beach here smells of sewage as most of Ganges is on septic field. Low energy zone. (Private).

#26 Next to Unit #25. Dual Class III gravel beaches with some bedrock outcrops in the foreshore which divide the two beaches. The southwest beach is 45 metres long while the northwest beach is 95 metres long. The scarp is mainly bedrock and has a highway on the top. Facing southeast into a low to medium energy zone.

G. Ganges Drift Sector

#27 At the mouth of a small culverted creek in the southwest lobe of the head of Ganges Harbour. Materials from the creek as well as materials moving along the beach from Unit #28 have produced a small area of Class II gravel beaches which have been intruded by commercial buildings and bulkheads. These bulkheads have caused some erosion of the beach material on the south side of the creek. The creek is badly polluted and filled with garbage and is quite unattractive. Extensive areas of mud and sand are infilling the head of Ganges Harbour in this area and will make periodic dredging of the boat basin and boat launch nearby, a necessity. (Private).

#28 Southwest along the shore from Unit #27. 800 metres of Class II beach with a narrow berm and some areas of Class III beach. Layers of till have concentrated water seepage from upland areas to create planes of weakness along this unstable bluff. The upper foreshore is cobbly gravels and some sand in a band and there are extensive areas of sandy mud in the lower foreshore. The mud contains small layers of dark greasy material and decomposing detritus. Materials are supplied by several ephemeral creeks entering this unit, from the 12 to 22 metre high sand and glacial till scarp, and by wave erosion of this scarp at several places along the shore. The scarp top is built up in some areas with residential housing while other areas are still under natural forest vegetation. (Private).

#29 Next to Unit #28. What used to be a Class I beach is now a mix of Class I and II beach due to bulkheading. The gravelly backshore area is 30 to 45 metres wide and has houses on it. The upper foreshore is gravelly while the lower foreshore is mud. The beach is about 100 metres long and is in a neutral drift zone. (Private).

#30 Southwest of Sundown Spit. A Class III beach 425 metres long with a sand and gravelly sand foreshore in the east and a cobbly and bouldery (with some areas of gravel and mud in the lower foreshore) foreshore in the west of this unit. In the east part of this unit there is a private wharf built across the foreshore and some of the scarp face has been bulkheaded. Some small groins have been added to the upper foreshore to hold the sand and pea gravel from moving. Net drift in this unit is to the east as evidenced by the direction of the gravel bars built at the mouth of the ephemeral creek at the easterly boundary of this unit. The 2 to 5 metre scarp is partly cleared for residences while some of it is still forested. Faces north into allow to medium energy zone protected from southeasterly storm approach waves by Sundown Spit. (Private).

H. Sundown Lagoon

#31 The lagoon behind Sundown Spit. Units #31a, 31b, and 31c are different shore segments totalling over ½ mile of erodable shores in the low energy zone of this lagoon behind Sundown Spit called Walter Bay. Some shore erosion does occur due to waves penetrating the bay from the west as was evidenced by a .3 metre erosional lip at the high tide line in Unit #30. The bay is rich in oyster and clams and also in waterfowl at certain times of the year. Part of this bay has been set aside as a bird sanctuary.

#31a This is the lagoon shore segment along the inside of the spit and is a Class I low energy zone beach partially vegetated and made of gravel and sand in the west and mud and sand in the east. This unit has been intruded by a boat dock built out across the foreshore in the lee of the spit recurve. (Private).

#31b This is a Class III shoreline with the foreshore being composed of extensive areas of mud. There is a very small creek entering this unit at the head of Walter Bay.

#31c Another ephemeral creek enters Walter Bay in this unit due south of the tip of Sundown Point. This creek has supplied gravels and sands to the longshore current (which in this area is to the east) and has formed a small Class I beach at its mouth. This beach has been intruded by a house and road low down on the nearby scarp. (Private).

I. Sundown Drift Sector

#32 Sundown Spit. A Class I spit beach which forms the terminus of the drift sector beaches to the east. This reach is 3/8 of a mile long and forms the longest Class I berm beach in this study area. The spit has a landward recurve at its western terminus and has a steep foreshore. The foreshore is composed of gravels except at the easterly end where the lower foreshore is becoming "clogged" with sand and mud and eel grass. This indicates that most if not all of the gravels supplied to the spit travel in the upper foreshore and therefore the spit's gravel supply may be diminished by the construction of groins and bulkheads along the developed shoreline updrift, although, the spit appears to be stable at present. The berm itself (on the ocean side of the spit) has been fenced for pasture and most of the natural vegetation has been removed. The area is privately owned and the spit along with its protected lagoon form a bird sanctuary.

#33a At the end of Price Road. A long Class II beach with a bouldery cobbly gravel upper foreshore and sandy lower foreshore. The narrow berm is made of gravel and pea gravel and has some drift logs on it. The sandstone scarp rises 5 to 12 metres directly behind the narrow beach berm and then falls back to a lowland area of farmland. The beach is narrower than to the southeast due to the point of land which protrudes here. To the west, around the point andin the bay, the scarp falls off and is less than 2 metres high, made of midden material over glacial till. The foreshore with a low beach berm of sand, pea gravels and shells. There is rip rap in several places to slow the erosion of the bank. A small ephemeral creek enters the ocean in this reach. The net longshore drift in this unit is to the east. (Private).

#33b At the end of Singer Road. A 500 metre long Class II beach with a scarp varying in height from 3 to 4 metres of sandstone in the south east to 1 to 2 metres of clay, middens and glacial till. The upland slopes at 10 to 20% and is used for residential housing and agriculture. The gravel berm is low and covered in drift logs. The lower foreshore is very wide and made of mud and sand and in some areas mud and sand over clay. Sand and mud influenced by the longshore current is accumulating in the lower foreshore and nearshore here due to the influence of the point at the end of Price Road. The beach faces east-northeast into a medium energy zone. (Private).

#34 Immediately east of Singer Road terminus. 750 metres of Class III beach. The upper 12 to 20 metres of the foreshore is bouldery cobbles and gravels while the lower foreshore is sand and muddy sand. Net longshore drift of gravels and sand is to the west. People have put small groins in the upper foreshore to take advantage of the longshore drift and trap some of the gravels. In doing so they have created small areas of ClassII beach. To the west part of this unit the foreshore has some bedrock ledge in the upper foreshore. The sand and mud in the lower foreshore is being partially stabilized by eel grass. Some natural groins in the form of trees falling from the scarp into the foreshore have created small gravel and pebble peaches. Facing northeast into a medium energy zone. (Private).

#35 3/4 of a mile southeast of the end of Singer Road. 600 metres of Class II beach composed of boulders cobbles and bedrock with a low gravel and cobble berm covered in drift logs. Steep sandstone scarp rises 10 to 13 metres to a forested upland. Materials in the upper foreshore have a net longshore drift to the west. The beach faces northeast of north into a medium energy zone. (Private).

J. <u>Outer Ganges Harbour</u>

#36 Due south of the tip of Welbury Point across Ganges Harbour. A 44 metre long Class II pocket beach with an upper foreshore and low berm of gravel and shells and a lower foreshore of cobbles. Natural setting. Rocky scarp rises steeply from the beach to the forested upland. Faces east into a medium to high energy zone. (Private).

WALMSLEY--SALTSPRING

#1	B-N	Rs·12-30·III
	R	NS
#2	N	Rs·7-11·III
		NS
#3	N	Rs·15-21·III
		NS
#4	N	Rs·15-20·II
		NS
#5	R-N	Rs·5·III
		NS
#6	N	Rs·25·III
	R	NS-R
#7	S-C	
		NS
#8	N	Rs·1-5·III
		R-NS
#9	N	Rs·25·III
	R	NS-R
#10	N	Rs·3·III
		NS
#11	G	Rs·2-12·III
		NS
#12	N	Rs·15-20·III
		NS
#13	N	Rs·3·III
		NS-R
#14	S-G	
	R	NS-R
#15	R-N	Rs·8-14·III
		NS
#16	R-C-G	Rs·6-12·III
		NS
#17	G-C-R	Rs·9-30·III
		NS
#18	R-G-N	Rs·18-30·III
		NS
#19	G-R	Rs·4-9·III
		NS
#20	R-N	Rs·9-12·III
		NS-RB
#21	R-N	Rs·3-5·III
	R	NS-RB
#22	G	Rs-Sscl·20-30·II
	W·C·Fx	RB-R
#23	R-G	Rs·2-4·III
	W	RB
#24	G-R-C	Rs-Ssg·2·III
	W	RB-NS-I
#25	R-G-Cl-N	Rs·2-12·III
	R	NS
#26	Cl/R-N	Rs-Ssg·30·II-III
	R	NS

#27	Cl-N	R•W	Rs•Ssg•III	RB-A
#28	Cl-N	R	Rs•30•II	NS-RB
#29	Cl-N	R	Rs•13-16•II-III	NS
#30	Cl-N	R	Rs•15-22•II-III	A-NS
#31	Cl-N		Rs•16-30•III	NS
#32	Cl-G-N		Rs•15-20•II-III	NS
#33	Cl-N		Rs•15-25•III	NS
#34	Cl-N		Rs•4-5•II	NS
#35	R-Cl-N		Rs•5•III	NS
#36	R-G-Cl-N		Rs•3-15•III	NS
#37	G-Cl-R-N		Rs•19-30•III	NS
#38	G-R-B		Rs•24-27•III	NS
#39	G			NS
#40	G	C•R	Rs•40•II-III	RB
#41	G-R	W•R•C	Rs•4-9•III	RB-NS
#42	R-G-N		Rs•30•III	NS
#43	G-R		Rs•80•II-III	NS
#44	R-N		Rs•80•III	NS
#45	R-N		Rs•60•III	NS
#46	R-G-N	Fx•W•J	Rs•10-18•III	RB-NS
#47	R-B-N	R	Rs•5-18•III	RB-NS
#48	R-N	R	Rs•3-20•III	RB-NS
#49	R-N	R	Rs•14•III	RB-NS
#50	R-N	R	Rs•5-9•III	RB-NS
#51	G-C	R		RB
#52	G-C-R-N	R•W	Rs•4-8•III	RB-NS-I

#53	N	Rs·3-6·III	R-N	Rs·15-21·III	#54
	R·W	RB-NS-R	R	RB-NS	
#55	B-G-R-N	Rs·8-11·III	R-N	R·15-21·III	#56
	R	RB-NS	R	RB-NS	
#57	R-N	R·3-5·III	C-B-R-N	Rs·5-15·III	#58
	W·C	RB	R	RB-NS	
#59	R-G	Rs·2-3·III	R-G-C	Rs·2-3·III	#60
	W·R	RB-NS	R·W·Wa	RB-NS	
#61	R-B-G-N	Rs·5-8·III	G-S-Cl	Rs·3·III	#62
	R	RB-NS	Fx·C·R	RB-R-A	
#63	R-G-N	Rs·3·III	G-S	Rs-Ssg·12·II-III	#64
	R	RB	C·R	RB	
#65	R-G-N	Rs·3·III	G-Cl-N	Rs-Ssg·2-3·III	#66
	C·R	RB	C·R	RB-NS	
#67	G-Cl-N	Rs-Scl·1-3·III	R-G-Cl-N	Rs·4-6·III	#68
	Fx·R	RB-NS		NS-RB	
#69	R-G-C-N	Rs·5-6·III	G-C-Cl-S		#70
	R	NS-RB	R	NS-RB	
#71	G-C-Cl-S	Rs·22·III	G-C-R-N	Rs·3-21·III	#72
	R	NS	R	NS-RB	
#73	G-Cl-C-N	Rs·3-6·III	N	Rs·8-15·III	#74
	R	RB-R	R	RB-R-NS	
#75	N	Rs·6-20·III	N	Rs·12-24·III	#76
		R-NS		NS-R	
#77	G	Rs·0-9·III	N	Rs·12-24·III	#78
		NS-RB-R	W	NS-RB-R	

#79	N	W	Rs·3-8·III	NS-RB-R
#80	R-N	W	Rs·3-8·III	R-NS-RB
#81	G-C-Cl-S		Rs-Scl·1·III	RB-NS-R
#82	R-G-N	R	Rs·3-4·III	RB
#83	G-S	C·R	Sscl·2-5·III	RB-NS-A
#84	R-N	C	R·3-5·III	RB-U-NS
#85	R-G-N		Rs-Ss·14-28·III	NS-RB
#86	G-C-R		Rs·6·III	A-RB-NS
#87	C-G/R	R	Rs·6-21·III	RB-NS-A
#88	G-R	W·R·BL	Rs-Scl·3·III	C-U
#89	G-R	R·Fx	Rs·1-3·III	C-U
#90	R-G	W·R	Sscl-Rs·3-6·III	I·R·U
#91	N	Fr·Fx·W·R	Ssg·2-4·III	C-U-I
#92	R-N	R·W	Rs·5-12·III	C-U-I
#93	N	R	R·4-7·III	U-RB-NS
#94	N	Fx·W·R·BL	sg·1-3·III	R-U-C
#95	Cl-S-G	C	Fill·1-3·III	C-U
#96	C-G-S-Cl	R	Su·15-22·III	RB-NS
#97	Cl-G-C	C	Su·15·III	RB-R-NS
#98	Cl-G-C-B		Su·3-5·III	RB-NS
#99	S-G-B-N	W·C	Scl·1-2·III	NS
#100	Cl-G-C	R	Scl·1-2·III	NS-RB-A
#101	Cl-S-G	R	Sgcl·0-2·II	NS-A-RB-R
#102	G-K-S-Cl	W·R		A-NS
#103	G	R		NS-A
#104	Cl-S-G-B	Fx·R	Sg·0-2·III	A-RB

#105

G-S-Cl	Rs-Sscl·1-6·III
R	RB-A

#106

S-Cl-G	Sscl·0-2·III
Fx	RB-A

#107

Cl-S-G-C	Rs·5-12·III
R	RB-A

#108

Cl-S-G	Sclsg·1-2·I-II
Fx·C·R	A-RB

#109

S-Cl-G-C	Rs·3·III
R	RB

#110

S-Cl-G-C	Rs·6-9·III
R	RB-NS

#111

B-C-R-G	Rs·11-14·III
R	RB-NS

#112

R-B-N	R·5-19·III
	NS

#113

C-G	Rs·6-9·III
	NS

#114

R-B-N	R·6-9·III
	NS

E.L.U.C.--SALTSPRING

1.	b:-----	-------------------	Rs·12-30·110-170	R	NS
2.	-----------	-----------------------	Rs·7-11·180	-----------	NS
3.	-----------	-------------------	Rs·15-20·140-160	------------	NS
4.	-----------	---------------------	Rs·15-20·30-40	-----------	NS
5.	R:-----	-------------------	Rs·5·100-130	-------------	NS
6.	-----------	---------------------	Rs·25·55-80	---------------	NS-R
7.	ks:s	sgW·100·0-5	-------------------	-------------	NS
8.	-----------	---------------------	R·1-5·80-180	-----------------	R-NS
9.	-----------	---------------------	Rs·25·55-80	R	NS-R
10.	-----------	---------------------	Rs·3·100	--------------	NS
11.	g:g	$\frac{sWv}{scMb}$·80·19	Rs·2-12·80	---------------	NS
12.	-----------	---------------------	Rs·15-20·85	-------------	NS
13.	-----------	----------------------	Rs·3·80-110	-------------	NS-R

14	gs : gs	gsWm · 30M · 10%	—
	R		NS-R
15	R : —	—	Rs · 8-14M · 65%
	—		NS
16	R/gk : g	—	Rs · 6-12M · 100-150%
	—		NS
17	Kg/R : g	—	Rs · 9-30M · 80%
	—		NS
18	R/g : —	—	Rs · 18-30M · 80%
	—		NS
19	g/R : g	—	Rs · 4-9M · 100-150%
	—		NS
20	R : —	—	Rs · 9-12M · 110-200%
	—		NS-RB
21	R : —	sgW/sgF · 30-70M · 10-15%	Rs · 3-5M · 110-200%
	R		NS-RB
22	g : g	sgW/sgF · 30-70M · 10-15%	$\frac{sc\ Mb\text{-}u}{Rs}$ · 20-30M · 30-40%
	W · C · Fx		RB-R
23	g/R : g/R	—	Rs · 2-4M · 100-150%
	W		RB
24	g/R : g/R	sgW · 30-60M · 0-5%	$\frac{sgW}{Rs}$ · 2M · 100-150%
	W		RB-NS-I
25	R/sc = g : —	—	Rs · 2-12M · 100%
	R		NS
26	$\frac{sc}{R}$: —	$\frac{scW}{R}$ · 9-15M · 10-20%	$\frac{sgWv}{R}$ · 30M · 30-50%
	R		NS

27	$c : —	$cW · 10-20M · 0-10%	$\frac{\text{sgW}}{\text{Rs}}$ · 25M · 30-50%	R · W	RB—A
28	$c :	$cW · 200M · 0-7%	Rs · 30M · 25-45%	R	NS - RB
29	$c : —	—	Rs · 13-16M · 40-60%	R	NS
30	$c : —	$cW · 75M · 0-5%	Rs · 15-22M · 40-60%	R	A - NS
31	$c : —	—	Rs · 16-30M · 60-110%	—	NS
32	$c/g : —	—	Rs · 15-20M · 25-60%	—	NS
33	$c : —	—	Rs · 15-25M · 85%	—	NS
34	$c : —	—	Rs · 4-5M · 30-50%	—	NS
35	$c : —	—	Rs · 5M · 110%	—	NS
36	R/$c=g: —	—	Rs · 15-22 · 40-60%	—	NS
37	g/$cl=R : —	—	Rs · 19-30M · 60-110%	—	NS
38	g/bR : g	—	Rs · 24-27M · 140%	—	NS
39	g : g	gW · 300M+ · 0-5%	—	—	NS

40	g : g		C · R	Rs · 40M · 40-70%	R B
41	R/g :		W · R · C	Rs · 4-9M · 110%	RB-NS
42	g=R :			Rs · 30M · 120%	NS
43	g//R : g			Rs · 80M · 40-150%	NS
44	R :			Rs · 80M · 65-150%	NS
45	R :			Rs · 60M · 80%	NS
46	R/g :		Fx · W · J	Rs · 10-18M · 150%	RB-NS
47	R//b :		R	Rs · 5-18M · 80%	RB-NS
48	R :		R	Rs · 3-20M · 100-200%	RB-NS
49	R :		R	Rs · 14M · 50-200%	RB-NS
50	R :		R	Rs · 5-9M · 90%	RB-NS
51	g//k :	sgW · 30-60M · 0-5%	R		RB
52	R/g=k :		R · W	Rs · 4-8M · 100-200%	RB-NS-I

53 —— : —— | —————— | Rs · 3-6M · 100-200%
R · W | RB-NS-R

54 R : —— | —————— | Rs · 15-21M · 100%
R | RB-NS

55 kb/R=g : —— | —————— | Rs · 8-11M · 100%
R | RB-NS

56 R : —— | —————— | Rs · 15-21M · 100%
R | RB-NS

57 R : —— | —————— | Rs · 3-5M · 100%
W · C | RB

58 K/b=R : —— | —————— | Rs · 5-15M · 85-110%
R | RB-NS

59 g/R : R | —————— | Rs · 2-3 M · 60-120%
W · R | RB-NS

60 R/kg : g | —————— | Rs · 2-3M · 60-120%
R · W · Wa | RB-NS

61 R/b=g : —— | —————— | Rs · 5-8M · 150%
R | RB-NS

62 sg/c : —— | sgF/sgW · 120M · 5-18% | Rs · 3M · 140%
F_x · C · R | RB-R-A

63 R/g : —— | sgF/sgW · 100M · 0-10% | Rs · 3M · 200%
R | RB

64 gs : sg | sgF/sgW · 100m · 0-10% | $\frac{sgWv}{Rs}$ · 12M · 40-60%
C · R | RB

65 R/G : —— | —————— | Rs · 3M · 100-140%
C · R | RB

66	$cg : —	—	s$W/sFb Rs · 3M · 80-200%	C · R	RB - NS
67	$cg : —	—	Rs//$cWv-6 · 1-3M · 60-100%	Fx · R	RB - NS
68	R/$c=g : —	—	Rs · 4-6M · 100%	—	NS - RB
69	R/b=K : —	—	Rs · 5-6M · 100%	R	NS - RB
70	Kg/$cs : g	sgWb · 15-50M · 0-15%	—	R	NS - RB
71	Kg/$cs : —	—	Rs · 22M · 80%	R	NS
72	Kg/R : —	—	Rs · 3-21M · 90-150%	R	NS - RB
73	cg/R : —	—	Rs · 3-6M · 95-180%	R	RB - R
74	— : —	—	Rs · 8-15M · 95-180%	R	RB - R - NS
75	— : —	—	Rs · 6-20M · 65-180%	—	R - NS
76	— : —	—	Rs · 12-24M · 70-200%	—	NS - R
77	g//R : g	gWm · 0-15M · 0-10%	Rs · 0-9M · 70-100%	—	NS - RB - R
78	— : —	—	Rs · 3-6M · 50-150%	W	NS - RB - R

79	—— : ——	——	Rs · 3-8M · 80-120%	W	NS - RB - R
80	R : ——	——	Rs · 3-8M · 50-140%	W	R - NS - RB
81	Kg/\$c : gs	$\frac{\$cWv\text{-}b}{R}$ · 50M · 0-10%	$\frac{\$cWv\text{-}b}{R}$ · 1M · 100-200%	——	RB - NS - R
82	R//g : ——	——	Rs · 3-4M · 150%	R	RB
83	g//s : g	——	sWb/\$cWb · 2-5M · 150%	C · R	RB - NS - A
84	R : ——	——	Rs · 3-5M · 120-190%	C	RB - U · NS
85	R//g : ——	——	$\frac{sCv}{Rs}$ · 14-28M · 80-180%	——	NS - RB
86	Kg : R/g	——	Rs · 6M · 90%	——	A - RB - NS
87	$\frac{kg}{R}$/R : kg	——	Rs · 6-21M · 90-150%	R	RB - NS - A
88	g//R : g	sgW · 60M · 0-7%	$\frac{\$Wb}{Rs}$ · 3M · 40-150%	W · R · BL	C - U
89	g//R : g	——	$\frac{KbA}{Rs}$ · 1-3M · 90%	R · Fx	C - U
90	R/g : g	——	$\frac{sW}{\frac{s\dot{c}Mv\text{-}b}{Rs}}$ · 3-6M · 150-180%	W · R	I · R · U
91	—— : ——	sgA · 300M+ · 0-5%	sgA · 2-4M · 80%	Fr · Fx · W · R	C - U - I

92	R : —	—	Rs · 5-12M · 80-150%	R · W	C-U-I
93	— : —	—	Rs · 4-7M · 160%	R	U-RB-NS
94	— : —	—	sgA · 1-3M · 80%	Fx · W · R · BL	R-U-C
95	c/sg : g/R	sgA · 300M · 0-18%	sgA/sgF · 1-3M · 80-90%	C	C-U
96	$g/kg=s : sg	—	sgWv/scM/$sF-F · 22M · 60-95%	R	RB-NS
97	$c/kg : g	—	sgWv/scM/sF · 15M · 60-95%	C	RB-R-NS
98	$c/bk : g	—	sgWv/scM/sF · 3-5M · 80-90%	—	RB-NS
99	gs/ks : —	—	$cW · 1-2M · 160%	W · C	NS
100	$c//kg : g	—	$cW · 1-2M · 100%	R	NS-RB-A
101	$c/bs : g	sgW/$cW · 10-300M · 0-15%	sCW · 0-2M · 25-40%	R	NS-A-RB-R
102	s$/g=s : g	gWm · 1-3M · 0%	—	W · R	A-NS
103	g : g	gWm · 3-5M · 0-2%	—	R	NS-A
104	cs/g : gs	$cW · 300M · 0-10%	gW/gF · 0-2M · 80-120%	Fx · R	A-RB

105	$s /bg : sg	$c/sW · 300M · 0-10%	$W · 1-6M · 100-120%	R	RB - A
106	$c/gs : sg	—	$W · 0-2M · 80-100%	Fx	RB - A
107	$c /kb : g	—	Rs · 5-12M · 90-150%	R	RB - A
108	$c /gs : gs	scW/sW · 300M · 0-5%	$cW/sgW · 1-2 M · 10-30%	Fx · C · R	A - RB
109	K/gs : g	—	Rs · 3M · 120-180%	R	RB
110	$c/Ks : g	—	Rs · 6-9M · 100-175%	R	RB - NS
111	6k/R : Kg	—	Rs · 11-14 · 100-175	R	RB - NS
112	R/kb : —	—	Rs · 5-19M · 90-150	—	NS
113	gK : g	—	Rs · 6-9M · 150%	—	NS
114	6R : —	—	Rs · 6-9M · 150%	—	NS

APPENDIX IV

SLIDES OF UNITS FOR THE NANOOSE AND SALTSPRING STUDY AREAS

APPENDIX V

THE USE OF REMOTE SENSING IN COASTAL PROCESS ZONE CLASSIFICATION AND MANAGEMENT

THE USE OF REMOTE SENSING IN COASTAL PROCESS ZONE CLASSIFICATION AND MANAGEMENT

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Course: Frst. 543
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TABLE OF CONTENTS

List of Figures

List of Diagrams

List of Graphs

THE USE OF REMOTE SENSING IN COASTAL PROCESS ZONE CLASSIFICATION AND MANAGEMENT IN BRITISH COLUMBIA

Introduction

In the next few years British Columbia's government will be embarking on a program of coastal process zone management. This program has been sparked by the realization that the dynamics of the coastal process zone are not well understood and yet it is a focal band of develop~~e~~ment and interest from many resource agencies and industries.

Hubbard and Grimes (1972) define the coast as a zone extending landwards from low water of equinoctal spring tide to an arbitrary limit dependant on the nature of the shore. This definition, however, falls short of the definition of a coastal process zone which is the belt roughly following the shoreline which is influenced by coastal processes. This indicates that from the zone of wave influence on the ocean bottom (approximately three times the surface wave amplitude for practical purposes) to where the waves cease their influence inland, is the coastal process zone. The problem of defining the coastal process zone then becomes one of time scale since, one hundred years from now, the waves may well have eroded or deposited areas of materials and coastal processes may have ceased or commenced to influence other areas. In Watcom County, Washington, the coastal process zone is defined for planning purposes as the area which will be influenced by coastal processes in the next one hundred years. Here in British Columbia, although our coastline is almost 17,000 miles long, there is no planning definition for coastal process zone classification and it is obvious that this is because of the realization that the coastal process zone will change for each time span and beach material which is considered. For the purposes of this paper I will consider the coastal process zone to extend from a depth of three times the amplitude of winter waves at low tide, to 300 yards inland from high tide line. Qualitative assessments of relative degrees of future wave erosion and deposition and expected shoreline retreat or progradation can be documented using sequential photography. Avery (1977) reports that conventional color photography is preferred for this purpose, where available, because of its superior water penetration quality.

It is because of the confusion over which agency has jurisdiction over the coastal process zone and yet the great interest in the use of that zone that its study and management has been neglected in British Columbia. Through the use of remote sensing it may be possible to inventory and monitor the resources and processes of the coastal process zone and to use the information derived from this work for a truly informed management program in British Columbia. This type of an approach is necessary so that man's use of nature's resources may be adjusted to the limitations and requirements which nature sets for us.

Hubbard and Grimes (1972) report that the main problems of coastal survey are associated with the expanses of the coast uncovered only for short periods during the tidal cycle, the instability of certain surfaces, and the absence of ground control on the majority of sites. Another problem of importance in British Columbia is the lack of a coordinated effort to find out what information is desired by the many interested and user parties.

In the following sections the use of remote sensing to help in collecting information about some of the important parameters of the coastal process zone will be examined.

Vegetation

In British Columbia's coastal process zone, ground surveying and mapping of vegetation is not always possible because of inacessibilty, tides, and surface instability. These problems are accentuated on mudflats, salt-marshes, shingle beaches, cliffs and sand dunes.

The use of aerial photography as a means of analysing vegetation of coastal process zones has been well proven. Aerial photographs have been used to study the distribution and structure of vegetation and the impact of man on these plant communities. The use of aerial photography in inventories and observations of forestry and agricultural crops is well documented (see Avery, 1977).

Hubbard and Grimes (1972) report that coastal vegetation is characterized by a number of species which are found only in the coastal zone and in certain instances are adapted to the saline enviroment. "Zonation of plants with distance from shore is also a characteristic of certain coastal habitats," (Hubbard and Grimes, 1972, p. 131).

Aerial photography of the inter-tidal region is a particularly difficult and expensive task because: 1. The lower levels of the inter-tidal zone are only exposed for short periods of time at the low water of equinoctal spring tides; 2. The photography must be done during daylight hours while the tides must not; 3. Even when a low tide is expected it may not be as low as predicted due to weather conditions as much as three days previous; 4. Weather conditions on the day of flying must be good; 5. Flight lines must be short and fragmented due to the irregularity of British Columbia's coastline; 6. There is a virtual absence of ground control in the inter-tidal region except for markers on piers, and; 7. The density of the vegetation to be photographed varies with the season of the year. Thus, it may be necessary to keep an aircraft waiting for suitable conditions for a long period of time, making the cost of photography excessive.

Mudflats:

Hubbard and Grimes (1972), studying filamentous growths of algae and Eel Grass in England report that it is difficult to distinguish plant material from mudflat surface because of a lack of difference in relief and tone and because of specular reflectance from the surface of residual pools of water and the wet mud surface. They found that Infrared Ektachrome was the most useful aid to the identification of mudflat vegetation because the plants showed up as magenta patches. The infrared color film also gave some water penetration but suspended sediment made it difficult to estimate depth.

Salt-Marshes:

In their study, Hubbard and Grimes (1972) found that surveys of salt-marshes from aerial photography presented fewer problems than in other coastal habitats because large areas of level surface are often covered by a single plant species. Access to salt-marshes is usually a problem~~s~~, however, because of dissection of the marsh by water-filled creeks floored by soft mud (the Salmon River estuary at Kelsey Bay, British Columbia, is a classic example of this). Hubbard and Grimes found that October was the best season of the year for the interpretation of salt-marsh vegetation using panchromatic vertical photography because the distinction between species was most obvious at this time of year. A scale of 1:5,000 was recommended.

Information Canada, in a report titled: "Report No. 8, Water Resources", in the Resource Satellites and Remote Airborne Sensing for

Canada series, states that the near infrared part of the spectrum combined with the visable, is useful for determinations of various aquatic growths because of the strong reflectivity by chlorophyll in the 0.8 micron region. Chlorophyll concentration can also be used as an indication of e~~x~~stuarine salt water intrusion according to Report No. 8, (1971).

It is not only possible to assess the acreage of certain species of salt-marsh vegetation, but also to observe the rate of colonization or disintegration of marshes by noting the size and shape of the plant colonies. For example, Hubbard and Grimes (1972) found that numerous small, evenly-sized units suggested a newly but rapidly colonizing area of Cord Grass, Poacea spartina (Schreber); a fringe of young plants lying seaward of a continuous marsh was indicative of the continued extension of the marsh.

Using past photography of areas of the coastal process zone (since many areas of the British Columbia coastal process zone have been photographed in the past--particularly estuaries), a record of changes in estuarine development or coastal development may, in some cases, be compiled. This type of study would be particularly valuable in relating vegetative changes to geomorphological processes of the coastal process zone.

Thermal infrared scanning of salt-marsh vegetation was carried out at Bridgewater Bay, Somerset in 1970 from 2000 feet above sea level in the 3-5 and 8-14 micron wavebands (Unpublished study cited in Hubbard and Grimes, 1972, p. 137). It was possible to detect patches of Scirpus palidosus var. maritimus (Nelson), and Spartina marsh through tonal differences. Thermal infrared imagery, however, has not been widely used for this purpose.

Stingelin (1968) studying at Bear Meadows Bog, Pennsylvania, found that although conventional aerial panchromatic photography will produce much of the same vegetative information, thermal infrared imagery also records the response of vegetation to changing air temperatures and thus, is useful for delineating certain plant species under specific meteorological and seasonal vegetative conditions. Thus, thermal infrared imagery is most useful as a supplement to aerial photograph interpretation for vegetation in the coastal process zone.

Shingle Beaches:

Shingle beaches are often very narrow fringe areas, spits, or successive ridges with salt-marshes in between. Some larger areas of shingle beach occur where a series of beach ridge~~d~~s lie parallel to one another.

At a shingle beach at Dungness, Kent, Hubbard and Grimes (1972) identified False Oat Grass <u>Poacea</u> <u>arratnatherum</u> (Beauvois) as a coarse texture of dots at a scale of 1:5,000. At a scale of 1:2,5000, using color photography willow, reed and sedges could also be identified. They found that it was only possible to distinguish shingle beach vegetation and shingle beach at scales larger than 1:10,000. Although research is continuing into the use of color and color-infrared photography for photo-interpretation of shingle vegetation, Hubbard and Grimes (1972) report that color film may be useful for mapping certain species during the period of flowering. This concept of season is a very important one in the photo-interpretation of shingle-beach vegetation because a number of the plants are annuals or biennials and appear in profusion for only a limited period of the year.

"Ground based stereo photography of a fixed area of shingle can be used to study population dynamics of small areas of vegetation" (Grimes and Hubbard, 1969, p. 3).

Sand Dunes:

The use of aerial photography to study vegetation of sand dunes is not widely known. Grimes and Hubbard (1972) report that bracken, bramble, gorse and heather can be identified on sand dunes by their texture, tone or location, but do not report what scale or type of film was used. Using 1:15,840 black and white photography to map the coastal process zone of Courtenay and Comox, British Columbia, in the summer of 1976, Frank and Levy found that areas of stabilized dunes could be easily distinguished from unstabilized areas. Shrubs could be distinguished from grasses and the latter from other weed species although it was not possible to distinguish between species of grasses or weed species.

Cliffs:

Due to the physical problems of surveying cliffs and because of a lack of variety of plant species, cliff vegetation has not been studied extensively. The vegetation present on cliffs depends very much on the character of the cliff (slope, aspect, materials, hydrology, location relative to other vegetation sources, stability, etc.).

For obvious reasons, vertical photography does not provide as much detail about cliff vegetation as does low-level oblique photography. Stereo-oblique photography would be especially useful for the study of vegetation on vertical cliff faces where access is limited to mountain climbers and where vertical air photos would not reveal the vegetation. Hubbard and Grimes (1972) suggest that the best photographic results are achieved when taken from a fast aircraft to avoid camera-angle fluctuations. A telephoto lens is also desirable to allow the aircraft to fly at a distance from the cliffs, thus avoiding air turbulence when taking low-level oblique photographs.

Aquatic Vegetation:

Lukens (1968), carrying out research in the Finger Lakes of New York state and in Cheasapeake Bay of Maryland, concluded that color photography provides a rapid economical and practical tool for the identification and mapping of submerged, emersed and floating species associations in large aquatic communities. Color photography is ideally suited for relatively clear water but areas such as here in coastal British Columbia will require research to determine the optimum film-filter combinations of underwater features.

Robinove (1968) concur~~r~~s with Lukens (1968) and states that two factors in particular make color film ideal for use in water resources studies; these are depth penetration through water and excellent descrimination of water indicators such as vegetation. Robinove concludes that plankton and algae can be mapped and identified in water by both color and infrared-color photography.

Workers at the Federal Fisheries Research Station in Nanaimo are currently using color and color infrared aerial photography at a scale of 1:3,600~~0~~ to classify and map 'kelp' beds for herring spawn studies along the coast of Vancouver Island and some of the Gulf Islands.

Thermal infrared imagery, by delineating current patterns could also be useful for predicting the spread of aquatic plants that propagate by means of floating seed (Lukens, 1968).

Water Penetration

"Aerial color photography and multi-spectral imaging (air - or spaceborne) operating in the blue-green portion of the spectrum are capable of water penetration to a depth of 65 feet, although haze penetration in this spectral band is a problem", (Information Canada, Report No. 8, Water Resources, p. 17). Features can be identified using remote sensing devices to penetrate water include: bottom morphology, vegetation, schools of fish, sediment patterns and turbidity features.

Hickman et al. (1969) report that the new high powered pulsed neon blue-green laser (5,401 A°) could penetrate water to a depth of 26 feet and thus be valuable in oceanographic studies to delineate nearshore and coastal morphology, identify and map plankton distribution, measure and determine water turbidity and track surface and subsurface water currents. Investigations as to the practicality of using such a device in the field are still underway.

Yost and Wenderoth (1968) of Long Island University, New York, report that due to the great variability in the apparent clarity of coastal waters from one time of observation to the next, the comparison of remote sensing techniques on a controlled basis is difficult. In their study, the multispectral aspect of the experiment reduced the temporal variability by using simultaneous photography from the same prospective centre. They found that although the band of maximum penetration of the clearest natural water is known to peak at 480 microns, dirty northern waters (such as exist near estuaries of the British Columbia coastal process zone) are difficult to penetrate to any significant depth due to the high amounts of suspended matter. This causes a shift of the band of maximum light transmission from the blue to the green or the yellow-red part of the spectrum because the suspended and dissolved matter in coastal waters frequently consist of yellow solutes from plant and animal decomposition.

Using four spectral bands in the 360 to 980 micron spectral band, Yost and Wenderoth (1968) clearly established that the exposure for maximum penetration of the water was not the best for the imaging of the water surface. The optimal exposure of an underwater target was found to exist when ambient surface exposure is placed such that a relative log. exposure of 1.2 above the aerial exposure speed results. This large exposure is required to give the maximum underwater exposure latitude because at a water depth of 10 feet the maximum surface brightness was attenuated by 70 percent but the minimum surface brightness was attenuated by 35 percent. A surface exposure latitude of 1.8 relative log. exposure units was compressed by ten feet of particle-laden coastal water for each spectral band as follows:

Green	.375 log. relative exposure units
Red	.175 log. relative exposure units
Blue	.125 log. relative exposure units

This means that the green spectal band has twice the water penetrating capabilty of the red and three times that of the blue (see Figure 1 on following page). Unfortunately, the data from the study by Yost and Wenderoth was only valid to a depth of ten feet due to algal growth on the subsurface targets used.

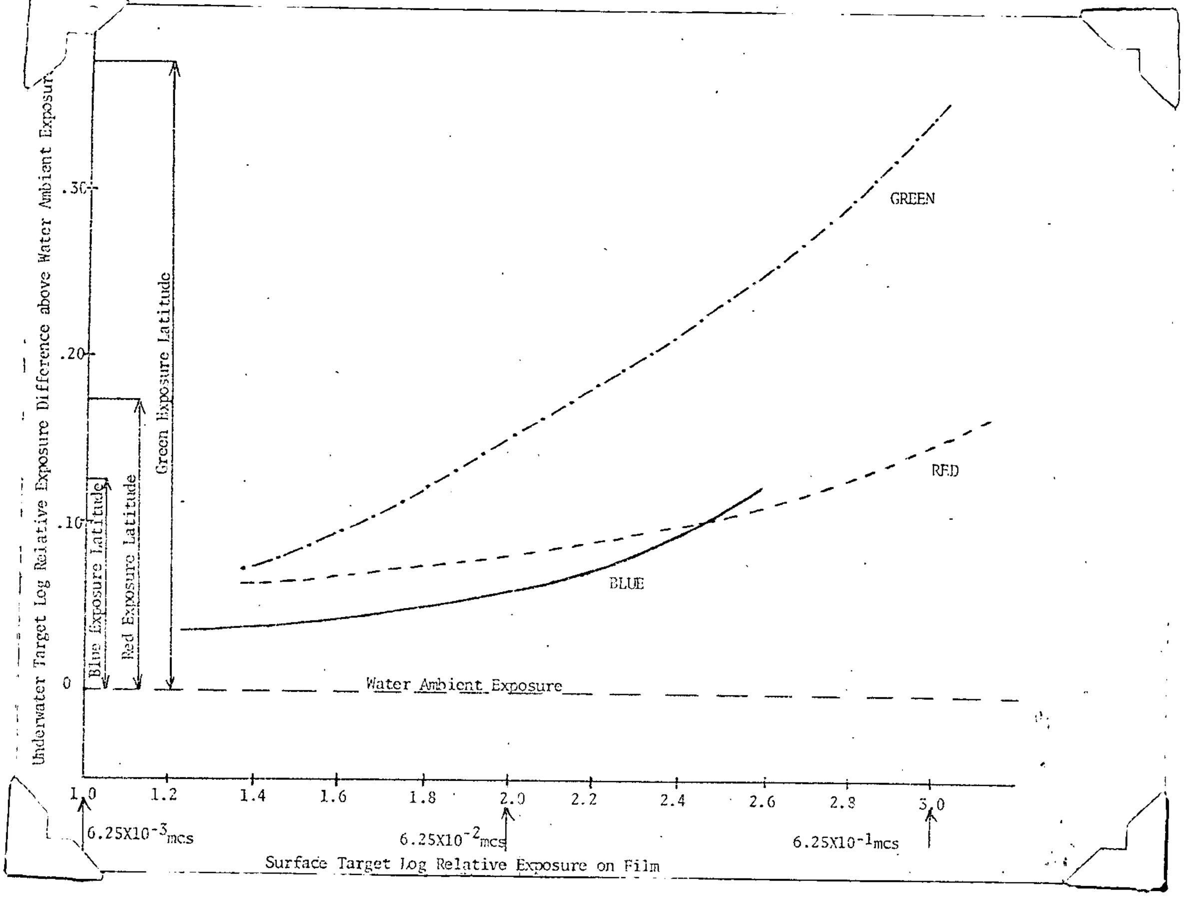


Figure 1. Exposure data of three spectral images used in the study by Yost and Wenderoth (1968). These curves indicate the relative advantages of each filter band to penetrate water. (From Yost and Wenderoth, 1968, p. 585.)

Bailey (1966) has developed a multispectral photgraphic and data reduction system and has processed multispectral photography of Lake Tahoe, California to clearly show bottom features at water depths of over 40 feet. Usually, however, due to the difficulty of reducing the large quantities of data, multispectral photography has been little used.

Soils and Geomorphological Features of the Coastal Process Zone

Analysis of terrain from panchromatic aerial photography has been practiced for a number of years and is well documented. Using geologic principles related to geomorpholgy and physiology the division of the non-water part of the coastal process zone into components having inferred material properties is possible.

Among the coastal geomorphic and cultural features which can be seen using panchromatic aerial photography are: (According to Mollard 1976).

Scale	Feature
1:31,680	Raised beach ridges
1:15,840	Sand dunes
1:31,680	Baymouth bars
1:31,680	Bayhead deltas
1:31,680	Sediment distribution
1:47,510	Delta morphology
1:63,360	Bar patterns
1:31,680	Composition of materials on alluvial fan beaches ←
1:47,520	Marinas, boat launches, bathing beach sites
1:15,840	Dendritic drainage on mud flats
1:63,360	Bedrock control of depositional landforms

Scale required may change with the scale of the feature.
For photographic examples see Mollard (1976).

The identification of glacial and fluvial landforms not necessarily related in their formation, to the coastal process zone, but which occur in the coastal process zone (eg. drumlins) is well documented and need not be discussed here.

Coastal features and materials must be understood in terms of their genesis. Offshore storm events, water depth, prevailing winds, currents and factors operating from the inland side of the coastal process zone such as surficial materials, vegetation and topography all influence the morphology. When interpreting remotely sensed data, this genetic understanding (and preferrably a genetically based classification) is valuable for interpretation and planning. For example, a single photograph of a beach may indicate a sandy texture while someone who understands the genesis of that beach may be able to suggest how much the texture of that beach may change with season of the year and wave amplitude.

Just as in the engineering interpretation of aerial photographs for soils purposes where the surficial materials can be grouped into repetitive natural and recognizable patterns using: landforms, drainage patterns, gulley shapes, slope, photo grey tones, vegetation, land use and special features, so too can coastal process zone features be recognized (see Table 1 for film/filter combinations and techniques used in terrain investigations).

Evans (1972) reports that the timing of aerial photography to record soil variability by tonal differences in bare soil or by differential growth of vegetation is important. This is particularly true in estuarine and tidal marshes which are under cultivation as they are masked by crops in mid-to late-summer. Evans also insists that to eliminate the effects of aircraft movement causing unsharp photographs, panchromatic film must be exposed for not more than 1/300th second.

Edgerton (1968) of El Monte, California has carried out research which suggests that microwave radiometers may be used to measure temperature differences between soils and thus, perhaps to classify soils. Large dfferences in radiometric responses in the field were attributed to differences in soil moisture, particle size and surface roughness. Particle size and surface roughness variations influence the shape and slope of the radiometric temperature versus antennna viewing angle graphs while moisture content causes the curves to shift along the temperature axis. (see Diafram 1 and Graphs 1, 2, 3, and 4).

APPLICATIONS OF FILM/FILTER COMBINATIONS

<u>Landform</u>
    Pan conventional (1/20,000 and 1/9600 scales)
    Color MS (1/4800 and 1/2400)
    Color infrared (1/1800 and 1/2400)
<u>Drainage System</u>
    Color infrared (1/9600)
    Pan infrared (1/9600) poorly drained areas are plapointed after
<u>Gully and Erosional Features</u>
    Color MS
    Pan infrared (1/9600) gully areas with water are outlined

Photo (Gray) Tones
- Conventional panchromatic (1/9,600)
- Color MS (1/9,600 and 1/2,400)

Vegetation
- Color infrared
- Pan infrared/89B filter

Landuse
- Color and infrared color
- Conventional panchromatic

Special Features
- Color infrared and/or panchromatic infrared are used to find wet saturated soils.

COMBINATIONS OF TECHNIQUES FOR TERRAIN INVESTIGATIONS

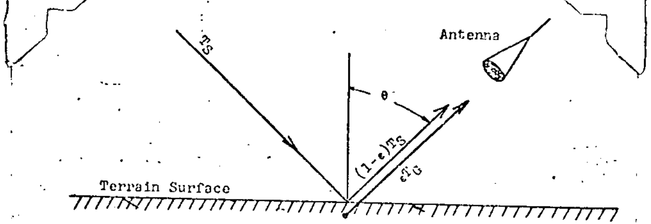
For Thin Residual Soils
- Photo interpretation, seismic refraction and core borings

For Glacial Soils
- Photo interpretation, electrical resistivity and seismic refraction surveys, and power-augered soil samples.

For Landslide-Susceptible Slopes-Stratigraphy
- Photo interpretation of conventional pan film (Wratten 38A filter, scale 1/2400), electrical resistivity surveys and selected core borings.

For Landslide-Susceptible Slopes - Shapes, Extent and Classification of Failed Slope
- Photo interpretation of pan infrared film (Wratten 21 filter, scale 1/2400), electrical resistivity surveys and selected core borings.

Table I. Applications of Film/Filter Combinations and Combinations of Techniques for Terrain Investigations. After Minzter (1968).

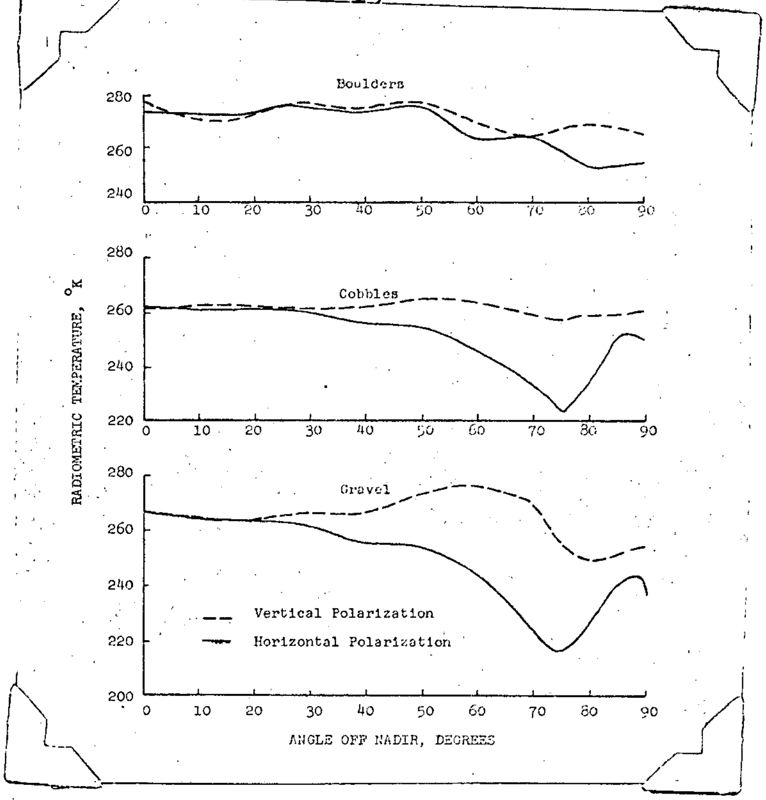


$$T_A = \epsilon T_G + (1 - \epsilon)T_S$$

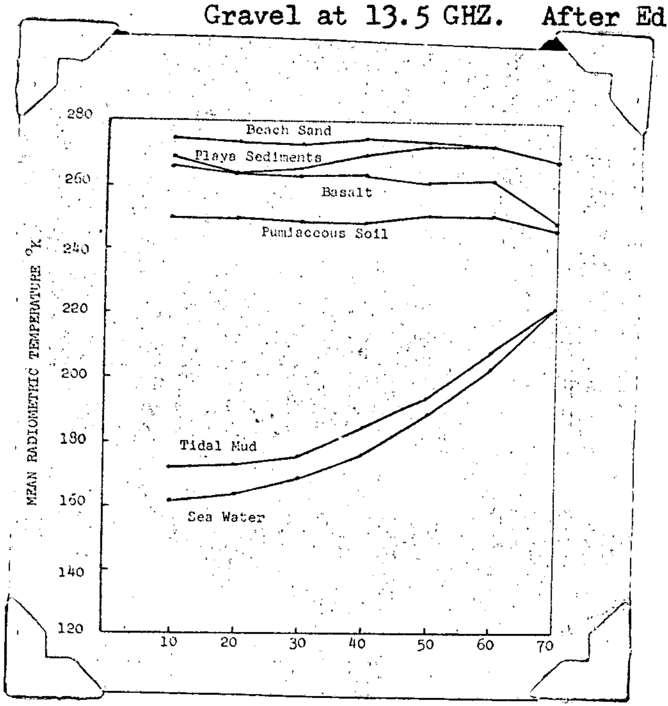
where:

T_A = apparent brightness temperature (degrees Kelvin)
T_S = brightness temperature of sky (degrees Kelvin)
T_G = thermometric temperature of ground (degrees Kelvin)
ϵ = emissivity (dimensionless)
$1-\epsilon$ = reflection coefficient (dimensionless)
= antenna viewing angle

Diagram I. Sources of Measure Energy Used in Microwave Radiometry. After Edgerton (1968). The different emmissivities of various types of terrain is the primary cause for diverse radiometric signatures in microwave region.



Graphs 1, 2, and 3. Radiometric Temperature Profiles of Boulders, Cobbles Gravel at 13.5 GHZ. After Edgerton (1968).



Graph 4. Comparison of Radiometric Temperatures, 37 GHZ Vertical Polarization After Edgerton (1968)

Edgerton (1968) also found that microwave temperature differences between tidal mud and soils of low water content are in the order of 120 ° Kelvin and that there is a useful qualitative relationship between radiometric brightness temperature and the bearing strength of soils. "This relationship has particular significance in the field of soils engineering" (Edgerton, 1968, p. 711).

Stereoscopic aerial photography is the best sensor imagery for terrain investigations where only one sensor image type is available. However, adverse weather conditions impose severe limitations on aerial photography. Early and late day photography results in longer shadows and haze; fog and clouds reduce terrainal contrast. Side Looking Airborne Radar (SLAR) imagery, however, overcomes these limitations and its imagery is uniform throughout periods of darkness as well as daylight. The resolution of radar imagery is less than that of a photographic image and therefore is only good for terrain information at medium scales. For detailed and specific work such as coastal process zone classification and mapping for planning, radar imagery has major limitations.

Mintzer (1968) reports that each soil type has a multi-spectral response signature but that these signatures are not necessarily unique. There also appears to be a relationship between the spectral reflectance of rocks and the properties of the rocks. Mintzer found that shaley siltstone exhibited strong tonal differences in the blue-green part of the spectrum, but little contrast in the red end of the spectrum. Minzter suggests that aerial color photography (especially as a replacement for black and white) would be an aid to the interpreter who is mapping rock types. Romanova (1964) cited in Mintzer (1968) suggests, however, that spectrometers and statistical techniques are needed to determine the photometric properties of all rock.

Infrared thermal techniques could aid soil exploration although this has not been well developed. Advances in in instrumentation technology will increase the recordable thermal detail and consequently its usefulness in recording thermal information about the terrain. Dr. Peter Crown of the Canada Department of Agriculture, studying in Alberta, however, found that zonal and intrazonal soils could be recognized on thermal imagery with the aid of some ground information. This may, in the future be extrapolated more extensively to soils in the coastal process zone both terrestrial and subaqueous in occurrence. Thermal infrared imagery in the 8-14 micron band has already been used for mapping of soil-moisture patterns, buried stream channels (Simonett, 1969), and sites of groundwater discharge into marine coastal waters. Dr. Peter Crown, however, pointed to the many factors which may influence thermal infrared imagery and indicated that a good knowledge of the proper techniques and procedures of thermal infrared imaging and image interpretation is necessary to be able to derive the most information. He also concluded that daytime and pre-dawn thermal imagery could be used to complement each other during image interpretation.

Water Quality

Evaluation of water quality in the coastal process zone is of primary importance to recreation, urban, and other resource planning. Water pollution studies are concerned with the changing characteristics of water that render it unfit or undesirable for human use. Among the principle sources of water pollution are sewage and oxygen consuming wastes, industrial by-products dumped into streams and lakes, radioactive substances and agricultural pesticides. Log storage is another major source of water pollution in coastal British Columbia. "Increases in the temperature of water as a result of its use for industrial cooling purposes may also be regarded as a form of pollution where the aquatic environment is endangered as a result (Avery, 1977,p. 304).

Avery (1977) states that although infrared color films and images producing thermal sensors are often desirable for making detailed water surveys, some types of water pollutants can be seen on panchromatic film exposed through a minus-blue filter. Pollutants which enter the coastal process zone from point sources (eg. sewage outfall) are easily located on aerial photographs, but an understanding of coastal processes such as currents and tides is essential to the interpretation of the effects of these outfalls on water quality further along the coast.

Avery (1977) reports that color or infrared color film processed at scales of 1:5,000 to 1:10,000 are often recommended for studies of water quality. Conventional color photography is preferred for detection of turbidity, sedimentation and sewage outfalls whereas infrared color is recommended for evaluations of thermal pollution.

Scherz and Van Domelen (1973) studying dirty water entering Lake Superior found that although other parameters do correlate for any one particular day, it is only the water quality parameter of turbidity that correlates with aerial imagery on all days. The correlations of reflectance with color and solid suspended matter changed as the character of the dirty water changed due to settling and mixing. They found that next to aerial photographs, the red band of ERTS imagery (Earth Resources Technology Satellite imagery), showed the dirty water best because the suspended matter was mainly red clays.

Non-photographic sensors such as multispectral and thermal scanners can be ideal for monitoring water quality. For example, oil spillage into the coastal waters of British Columbia is becoming more frequent and is causing much concern. Rapid detection and monitoring of oil slicks is desirable. Airborne multi-spectral scanning in the ultraviolet and thermal infrared parts of the spectrum can be used to locate oil spills but do not as yet, tell one type of oil from another. Information Canada Report No. 8 (1971) reports that surveys of the Arrow shipwreck in Chedabucto Bay, Nova Scotia in early 1970, successfully used color, infrared color and panchromatic film (filtered to pass blue) to detect surface oil. Panchromatic film and infrared scanning imagery produced the best results. The report also contends that microwave radiometry can show temperature anomalies when oil is present and that laser spectroscopy may be used for locating oil slicks and identifying oil type, although both of these techniques are still in the experimental stage.

Aircraft carrying infrared imaging equipment have been used to trace fresh water and pollution discharge into salt water largely on the basis of temperature differences. Bailey (1966) also reports that infrared imagery is useful for mapping the heated outfalls from sewage plants, power plants, industrial outfalls and other sources as well as in mapping currents.

The measurement of surface water temperature is particularly useful for oceanographic and limnological purposes. Surface temperature data discloses information about currents and heat exchange and ecological conditions characterized by thermal properties.

Airborne infrared thermal scanning and thermometric surveys in Canada by the Meteorological Survey of Canada detected emitted energy in the 8-14 micron range from surface water. The thermometric devices achieve accuracies better than 1°C. Nimbus High Resolution Infrared Radiometer systems detecting in the 1.4-4.2 micron range resolve temperature to 5°C but as with airborne systems, cloud penetration is negligable. Thermal infrared imaging showing relative differences of 0.1°C. is presently being used for locating groundwater and industrial influents in large water bodies and for observing thermoclines in estuarine locations below the junctions of large rivers.

Newell (1968) summarizes the use of remote sensing to acquire sea surface temperature information when he reports that sea surface temperature gradients and discontinuities have been studied from aircraft in the visable, infrared and microwave regions of the spectrum. The visable and infrared regions are available for sensing only during cloudfree conditions while the infrared is useful at night as well as in daylight and the microwave is useful under all conditions including cloud cover.

Also important to the coastal process zone, the remote sensing of surface-water hydrology parameters is more complicated since signals are produced by radiation from enviroments where water forms only a fraction of the field of view. Thus, at least initially, a considerable amount of supplementary information regarding the local enviroment may be required to arrive at valid conclusions in interpretation of remote sensing imagery. Powell et al. (1970) cited in Information Canada, Report No. 8 (1971) found that even small-scale photography and imagery from space and very high altitude aircraft is a useful tool for hydrolgeology and even for determining areas of groundwater movement.

Sea State

The observation and monitoring of sea state (character of the oceans's surface) is important not only for shipping,fishing and meteorological purposes but also to aid in understanding dynamics of the coastal process zone.

Sea state remote sensing methods have incorporated electromagnetic, radar and microwave sensors. The electromagnetic sensor identifies the change in magnetic flux due to the particulate movement of the water through the earths magnetic field. This method is applicable to the measurement of low-frequency waves with great wavelengths. Radar and microwave sensors make use of the change in reflectivity of the sea surface due to change in roughness. "Problems areas lie in the differentiation of factors other than roughness which influence the reflectivity by affecting the emmisivity. These include foam, spray, surface temperature and surface contamination such as oil slicks. Cloud cover attenuation of low microwave frequencies is negligable and hence this method is advantageous for its all-weather capability." (Information Canada, Report No. 8 (1971).

Although actual measurement of individual surface wave amplitude statistics requires a much higher resolution than ERTS imagery, sensors for sea state seem feasible for future satellites. "Microwave scatterometry and interferometry are also of potential use in the coastal enviroment for determining sea state parameters" (Information Canada, Report No. 8 1971 p. 5). Also reporting on the use of microwave and radar, Zaitzeff and Sherman (1968) found that the airborne profiler (a special sensor which uses radar) can measure wave height and frequency and corrects for aircraft vertical movement. The sensor resolves ocean wavelenths from 30 to 2,000 feet and measures wave heights between 2 and 50 feet to an accuracy of plus or minus 10 percent or 0.5 feet, whichever is greater.

Zaitzeff and Sherman (1968) also report that repetitive flying of thermal infrared line scan imagery can be used to establish relationships between wind direction and wind speed and shelter effects. This implication has great possibilities in the area of water-and land-use planning in the coastal zone.

Conclusion

As can be seen from the broad scope of this essay, the possibilities for using remote sensing in coastal process zone classification and management are almost limitless. Very few oceanographic programs, however, are presently using remote sensing technology while the study of the coastal zone could certainly benefit from wider usage of remote sensing. Sensors operating at different scales and at different wavelengths, from satellite imagery to on-the-ground photography all have their place in this broad field of study. Much research is still needed to be able to use even the most common imagery (eg. panchromatic aerial photographs) to obtain the most information about a given locality because of the dynamic nature of the coastal process zone and many of the resources within it.

In British Columbia, a cooperative effort is required to bring all the interested agencies and industries together to find out what information is required and to fund studies which will not only satisfy current needs but future needs for information as well. Thus,a genetic understanding of the morphology of the coastal process zone and an understanding of the processes involved is necessary.

Due to the immensity of the British Columbia coastal process zone and the inaccessibility of much of the area, remote sensing has a valuable role to play in coastal resource management and classification, but effective use of remote sensing data will require further development of interpretation and sensing techniques. It must be remembered, however, that even though the cost of remote sensing has been decreasing (especially aerial photography) and the price of field work increasing, information obtained by remote sensing techniques supplement but do not replace information obtained from maps, reports and field and laboratory investigations.

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APPENDIX VI

EXAMPLES OF AIR PHOTO INTERPRETATIONS

LEGEND TO AIR PHOTO OVERLAYS

Overlay #1 Present Land and Water Use

Roads	
High Tide Line	
Railways	
Agriculture	🔴
Natural Vegetation	🟢
Natural Grassland	🔴
Areas of Unique Vegetation	◌
Recreational Boat Tie-ups	🔵
Residential	⚫
Utilities (Power Lines)	🟡
Industrial & Commercial	⚪

Overlay #2 Scarp Slopes and Materials (Surficial Geology)

Slopes: 0-15%	🟨
16-50%	🟦
50%	🟥

Overlay #3

Surface Water	〰
Shore Width (1.6 mm. = 25 metres)	- - - - - - - - L.T. ———— H.T.
Areas of Accretion	🔵
Areas of Erosion	🔴

Overlay #4 Beach Materials + Beach Types

Beach: gravels	🔴
rockledge	🔴
sand	🟢
sands + gravels	🟡
cobbles + boulders + sand + gravels	🔵
areas of fill	⚪
Drift Sector Beach	⟶
Pocket Beach	x x x x x

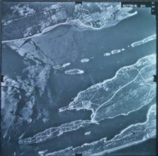
APPENDIX VII

SLIDE DOCUMENTATION OF THE USE OF COLOR, BLACK AND WHITE AND COLOR INFRARED PHOTOGRAPHY IN THE COASTAL ZONE

NOTE:

- -shell beaches
- -rocky shores
- -scale difference

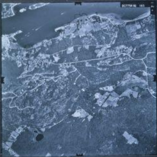
Ganges Harbour
(Chain Islands)

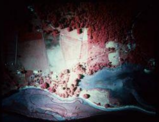


NOTE:

- -accretion shoreforms
- -lagoon silts
- -gravel & sand
- -overview on B & W

Ganges Harbour
(Goose Spit)


BC7794 8L 163



NOTE:

- -depth penetration
- -driftwood
- -accretion shoreform
- -foreshore seepage and drainage areas

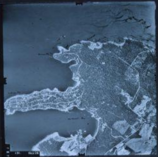
Pipers Lagoon
(Nanaimo)


BC7754 RL 218

NOTE:

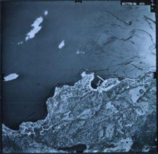
- -vegetation (parkland type)
- -pocket beaches
- -upland materials
- -aquatic vegetation

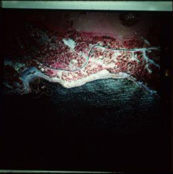
Near Northwest
Bay (Nanoose)



NOTE:
-soil types
-land use

Schooner Cove
(Nanoose)


BC7754 NL 173

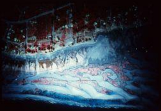


NOTE:

- -land use
- -shore protection structures
- -land/water interface
- -foreshore detail

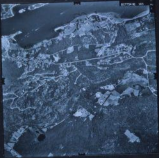
Lantzville


BC7781
155



NOTE:
- -soil patterns
- -land use
- -accretion shore-forms

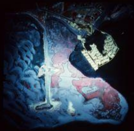
Goose Spit
(Ganges Harbour)


BC7754 NI 181

NOTE:

- transverse sandbars
- land and water use
- land/water interface

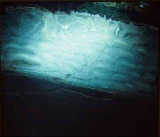
Entrance Rocks
(Nanoose Harbour)



NOTE:

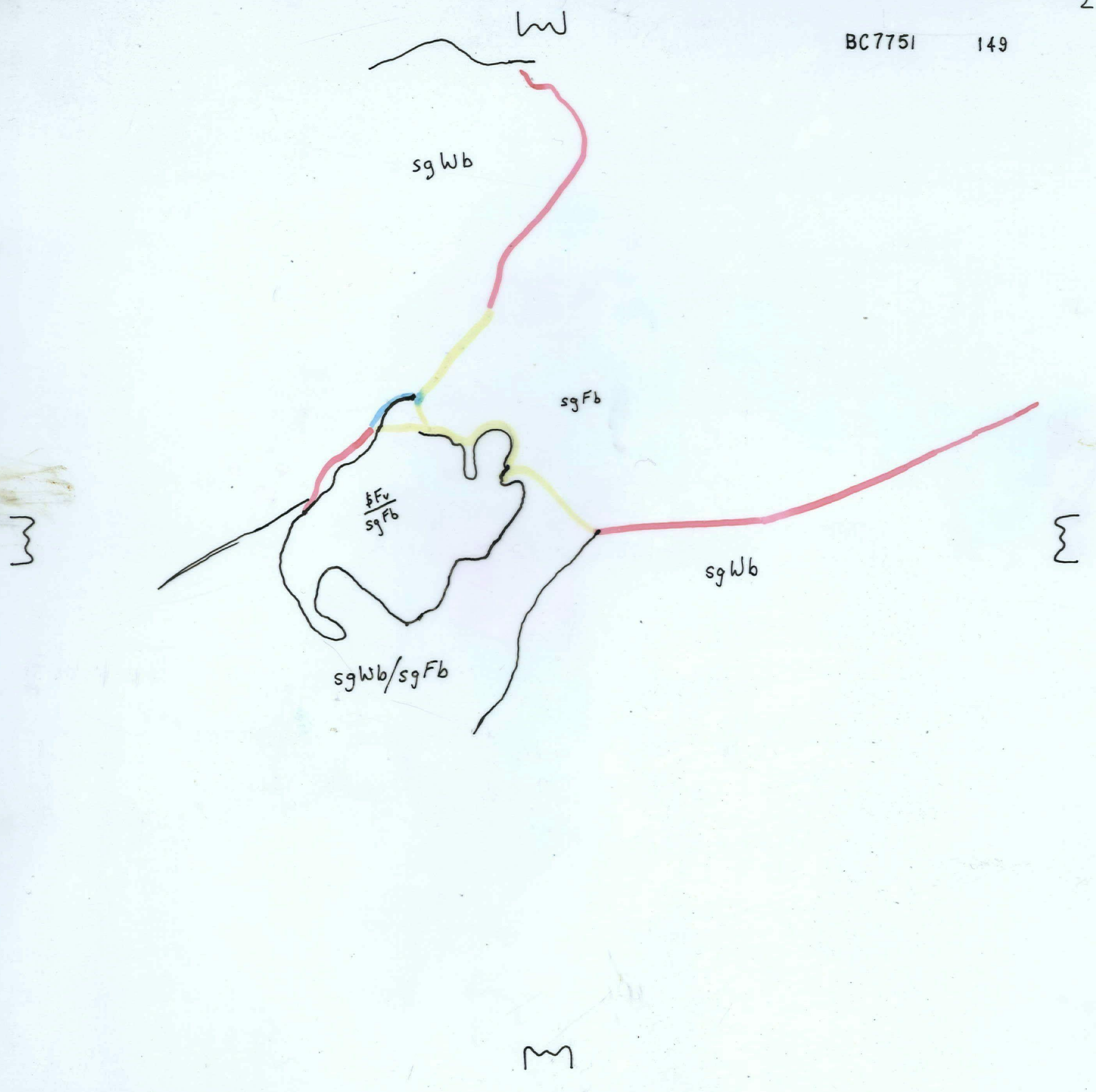
- -feeder stream and feeder bluff
- -the need for oblique air photo for obtaining cliff-base information

Lantzville

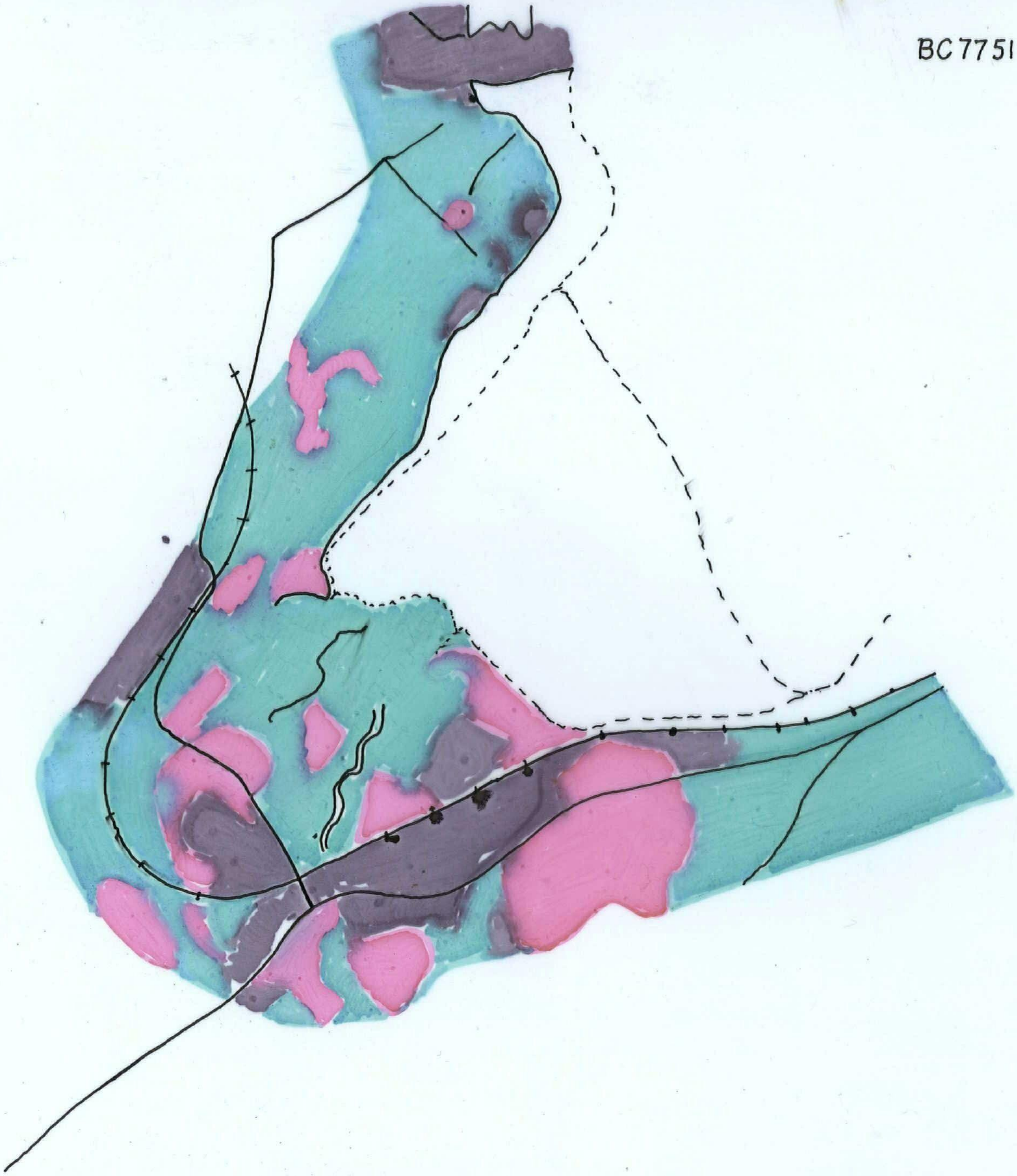


2

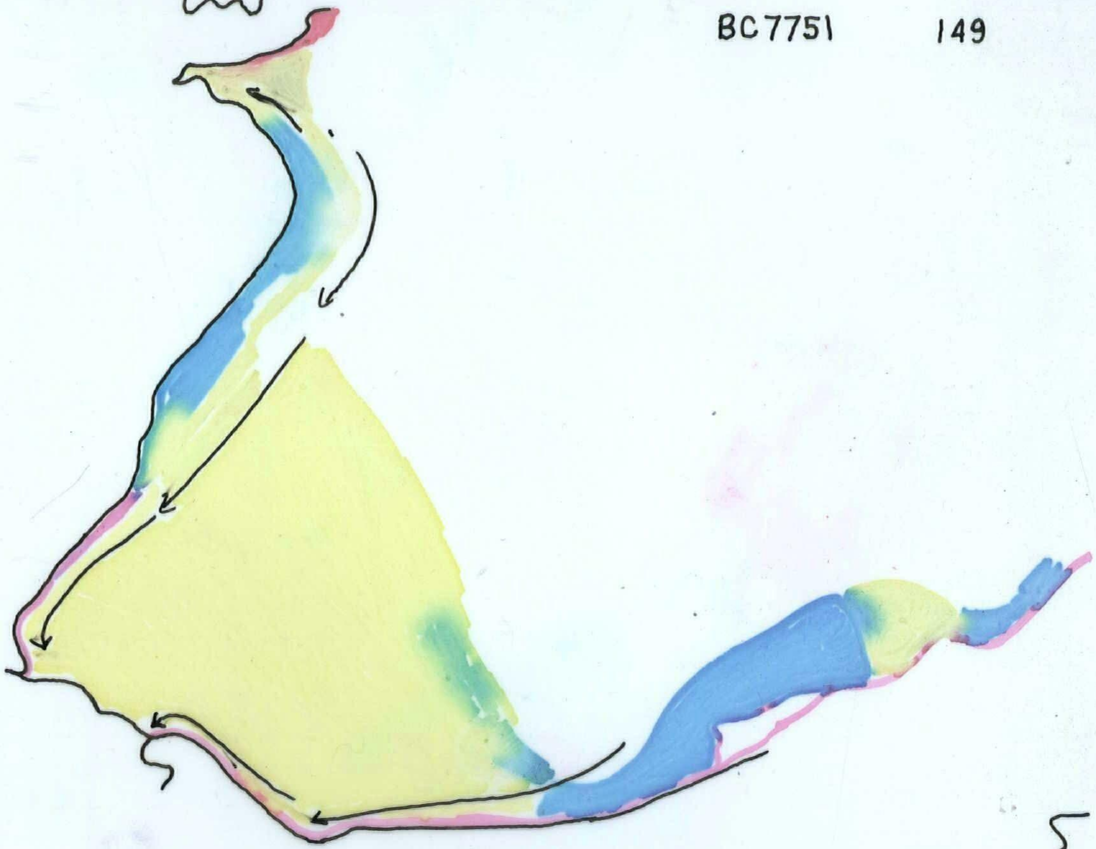
BC7751 149



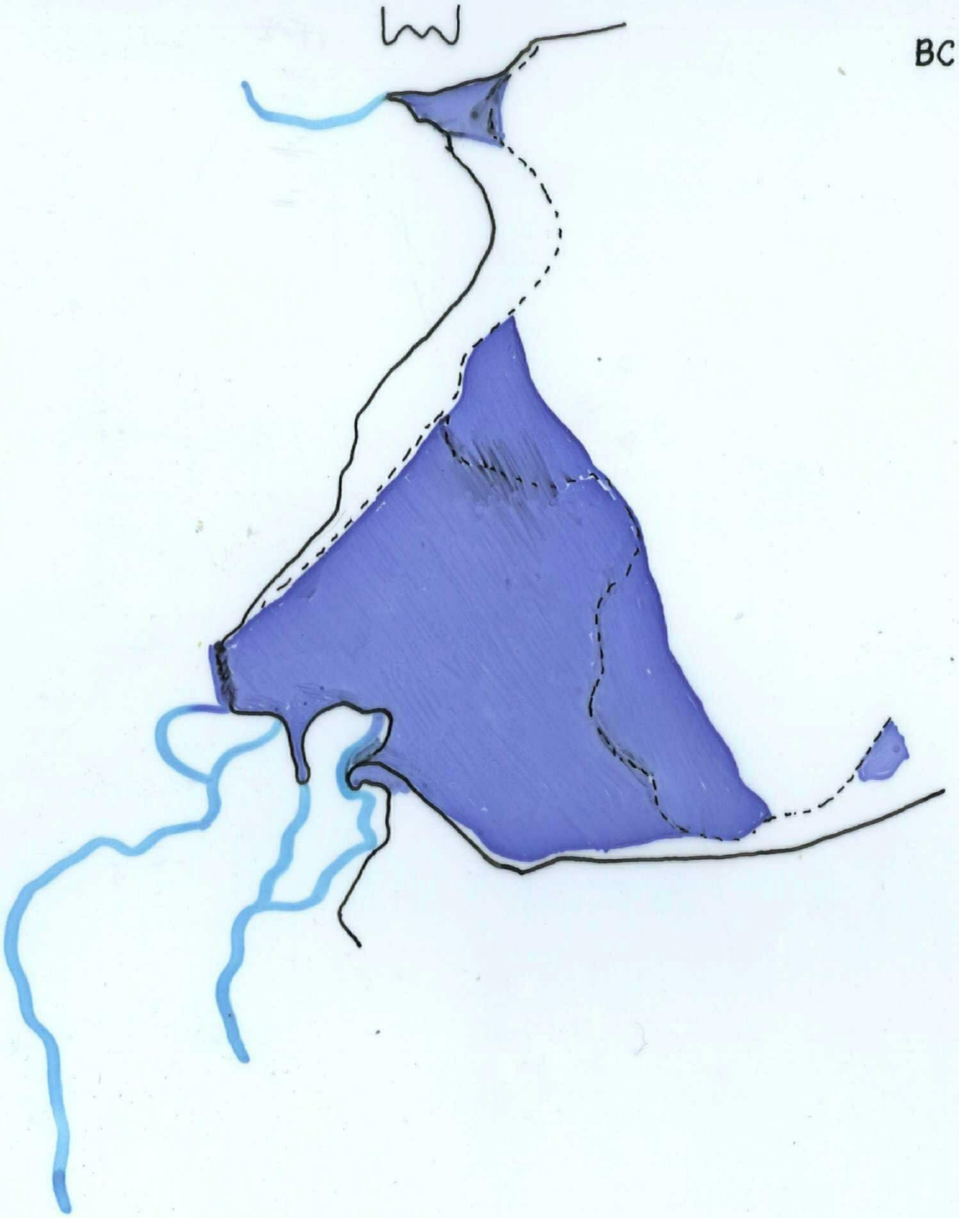
BC7751 149 1



BC7751 149 4

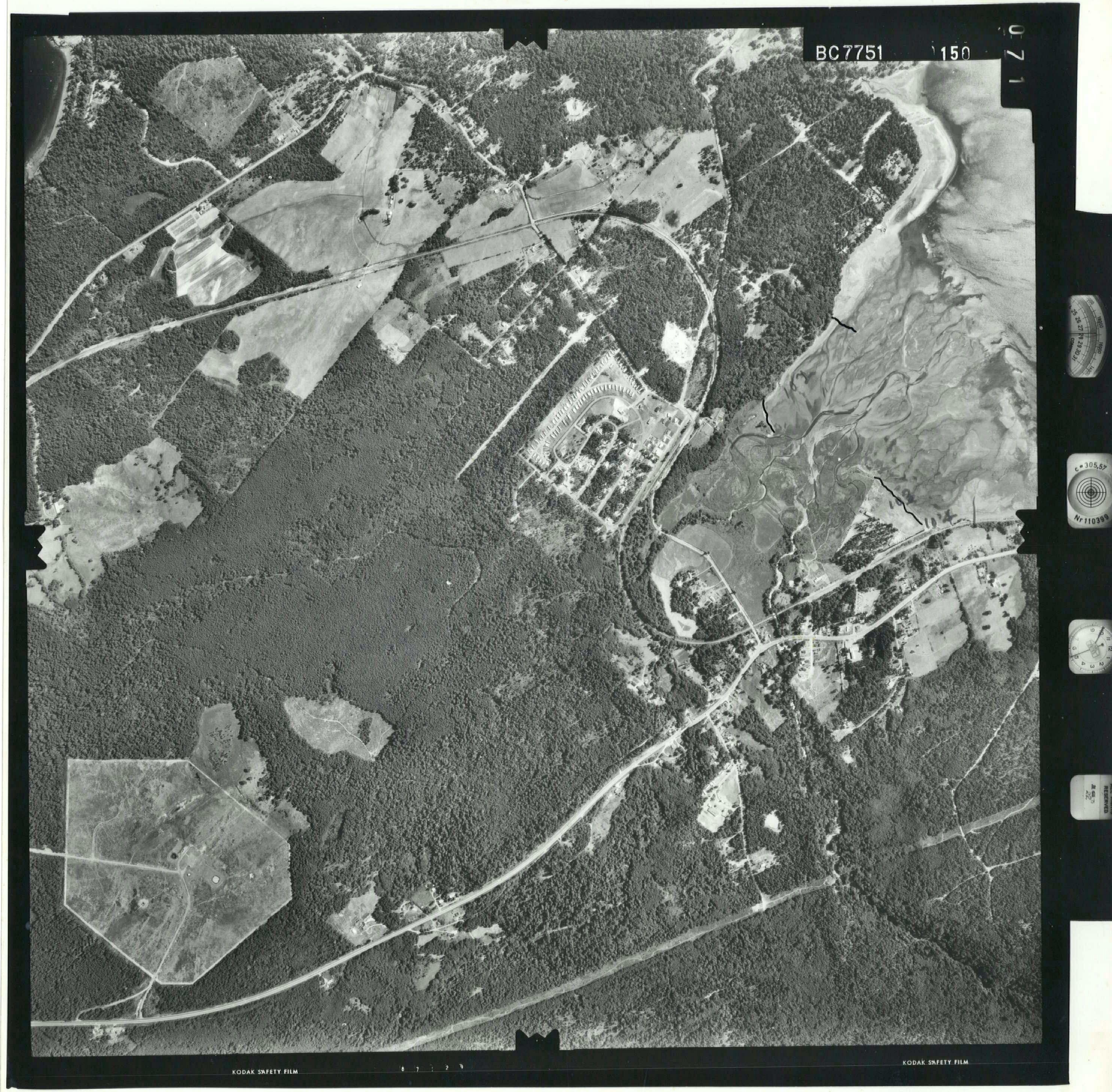


BC7751 149 3




BC7751
149
070
Nanoose Harbour.
20
21
21a
22
101
KODAK SAFETY FILM

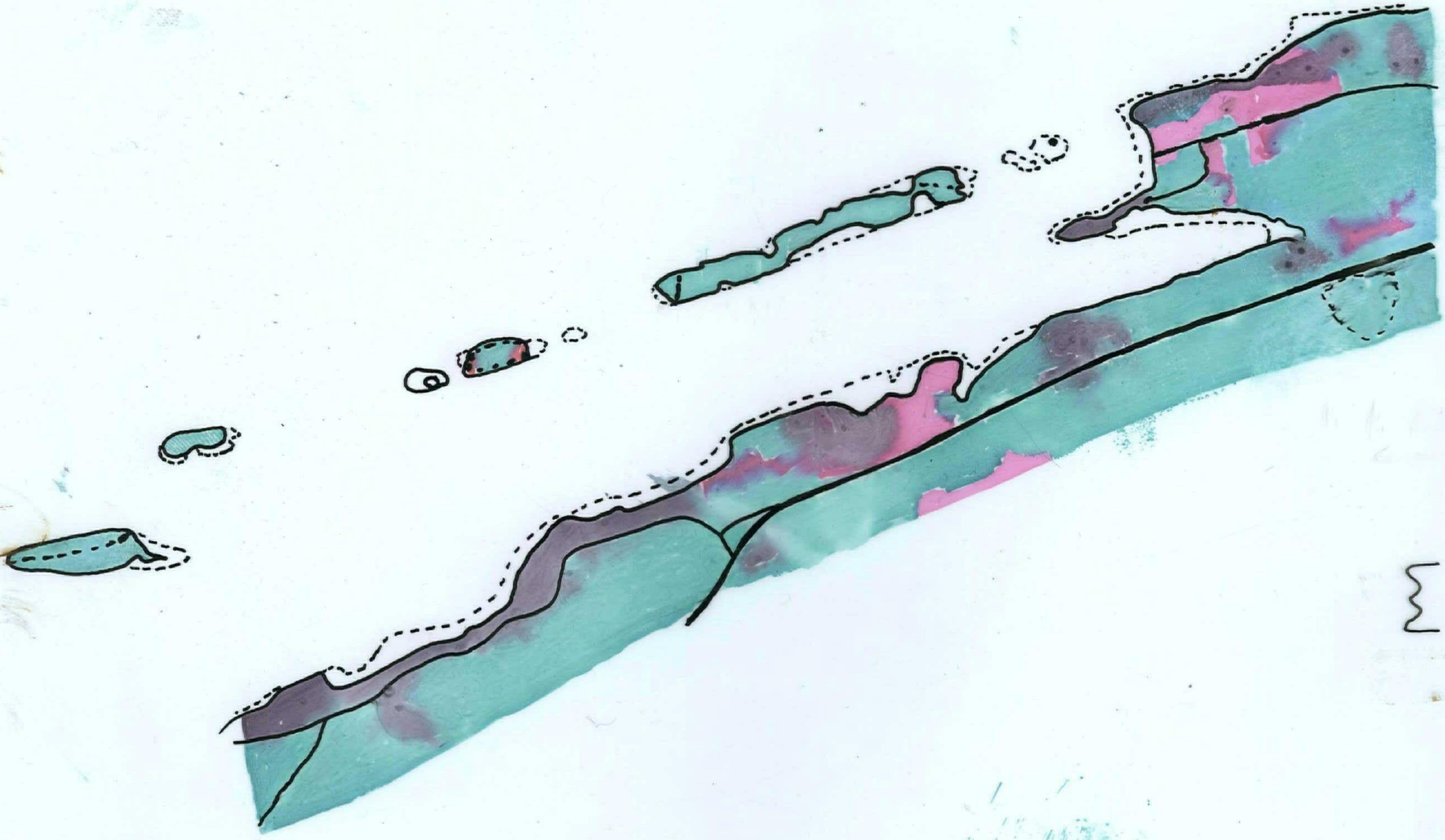

BC7751
148
099
Nanoose Harbour
4
105
5
106
7
107
1
2
3
c = 305,57
Nr 110399
KODAK SAFETY FILM
8 7 1 2 7

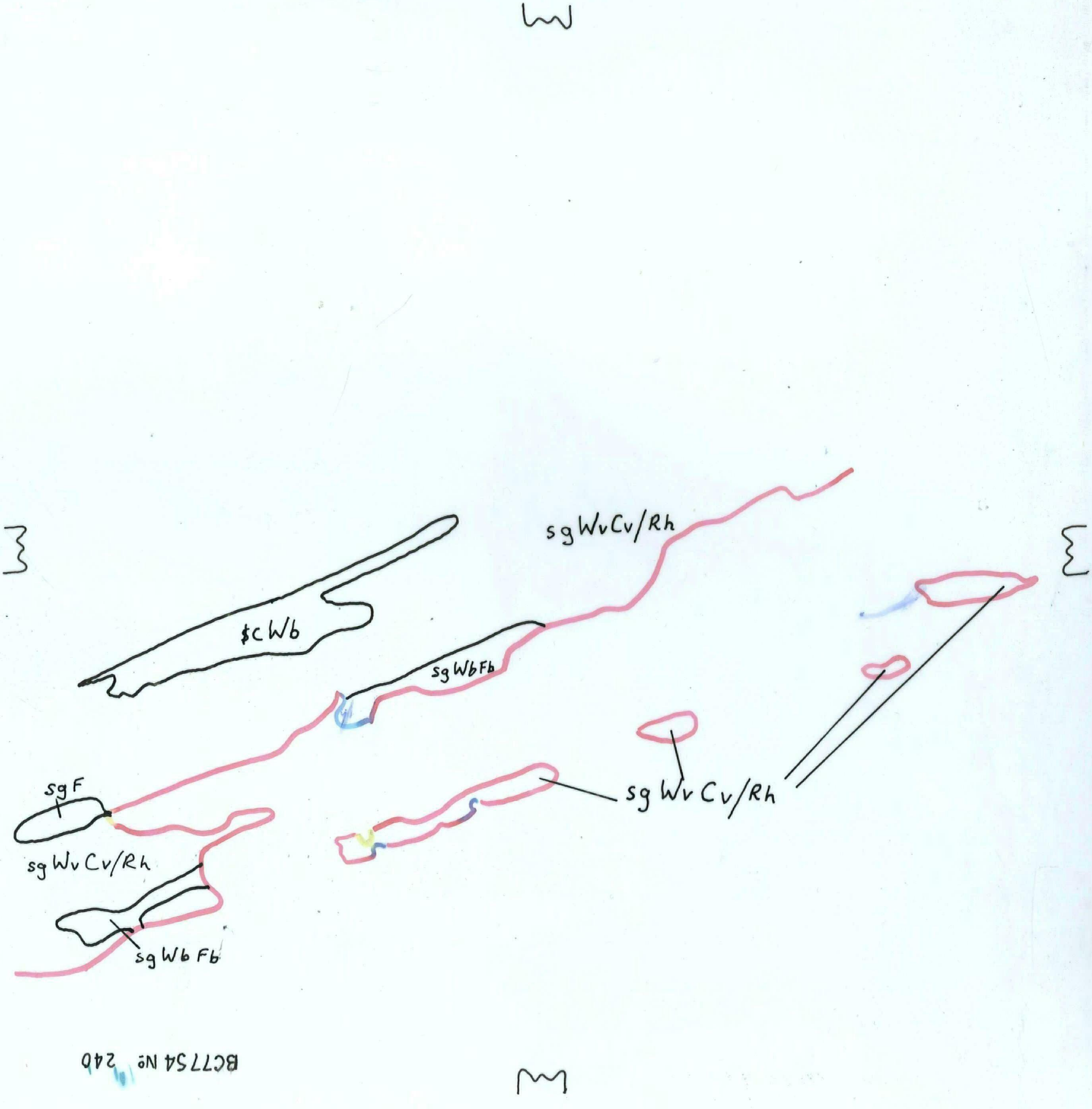

BC7751
150
071
c = 305,57
Nr110399
KODAK SAFETY FILM
KODAK SAFETY FILM

PRESENT LAND AND WATER USE

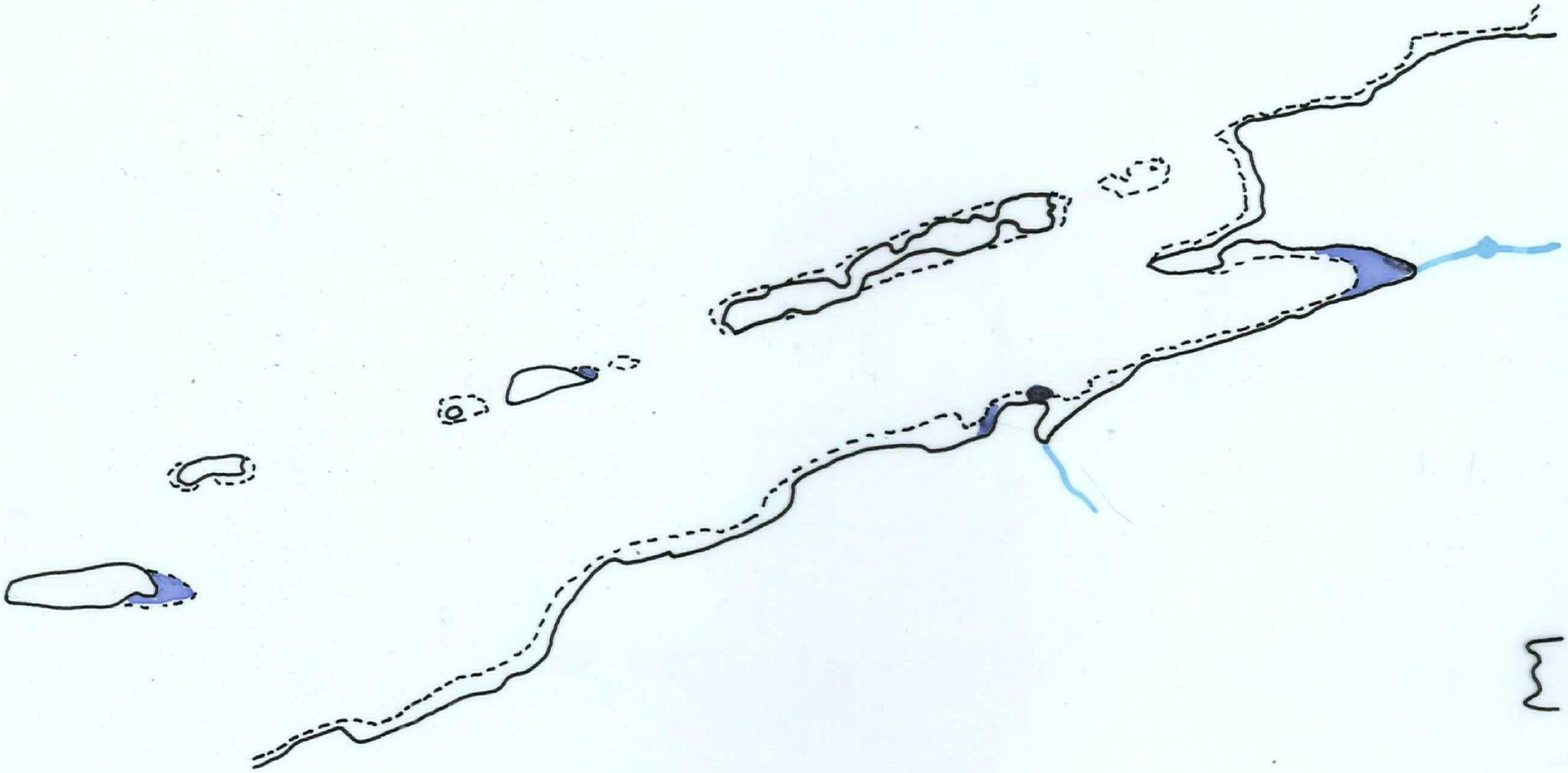
BC7754 № 240

1



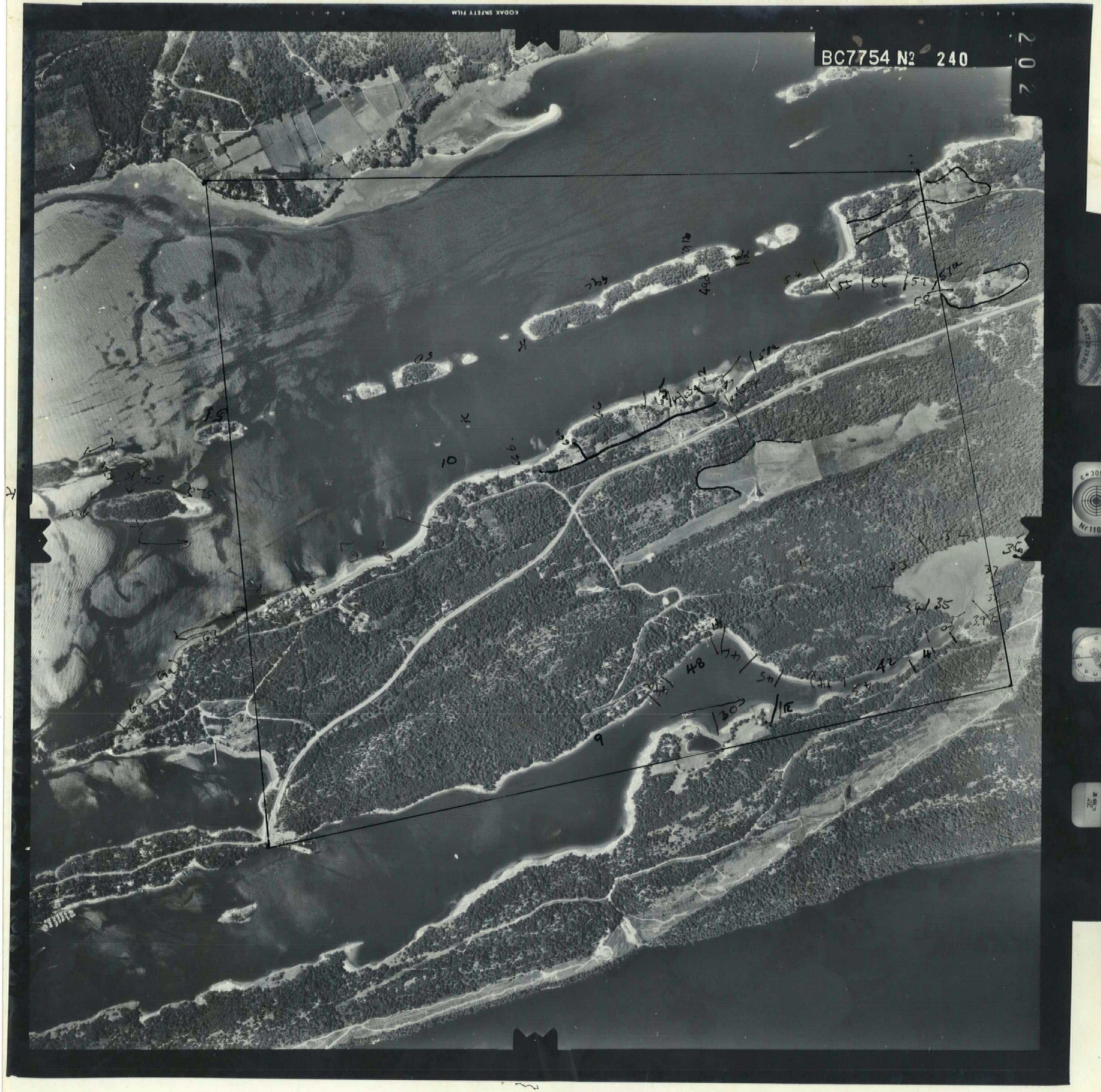

sgWvCv/Rh
$cWb
sgWbFb
sgF
sgWvCv/Rh
sgWvCv/Rh
sgWbFb

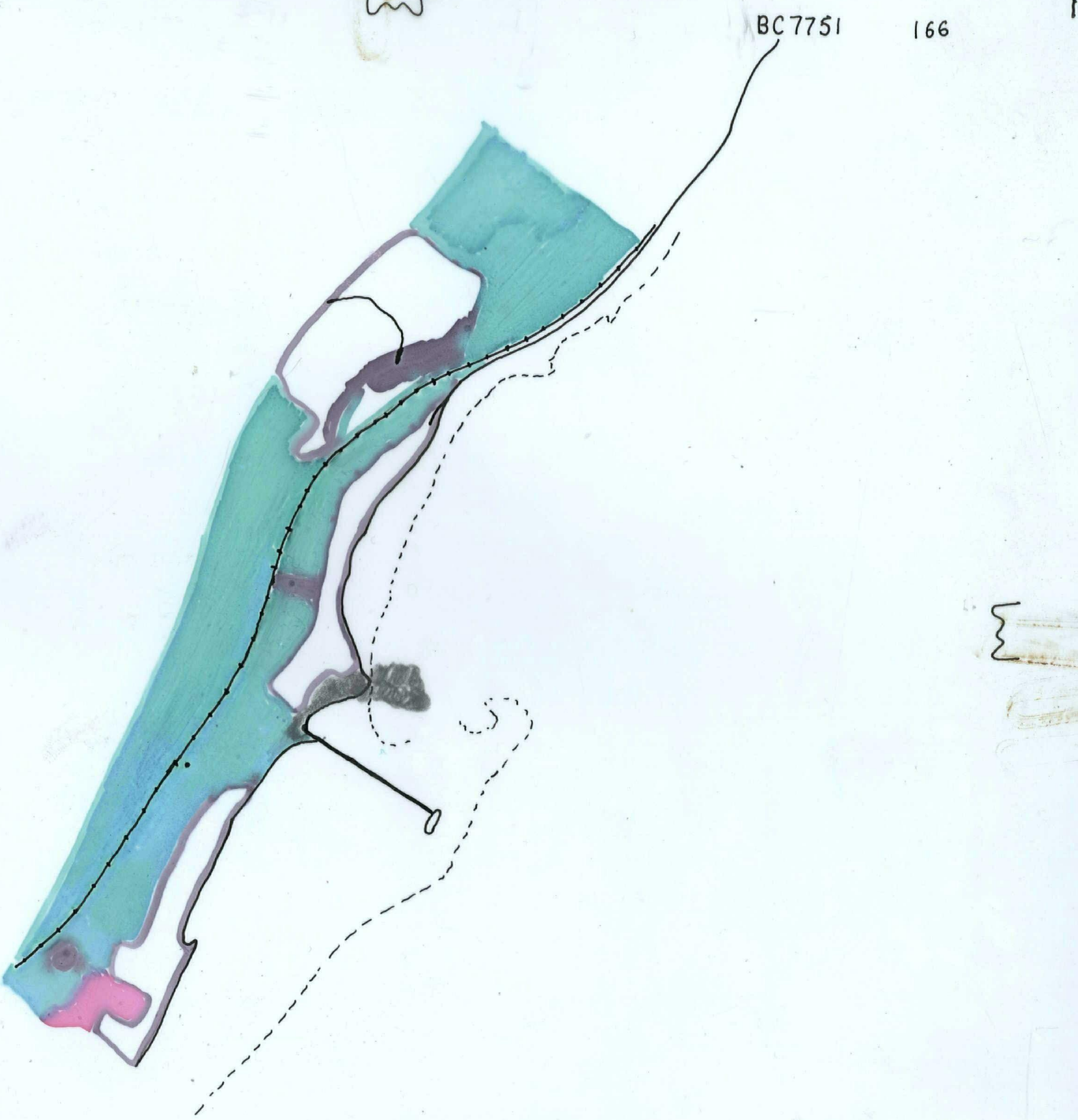
ВС7754 № 240 3



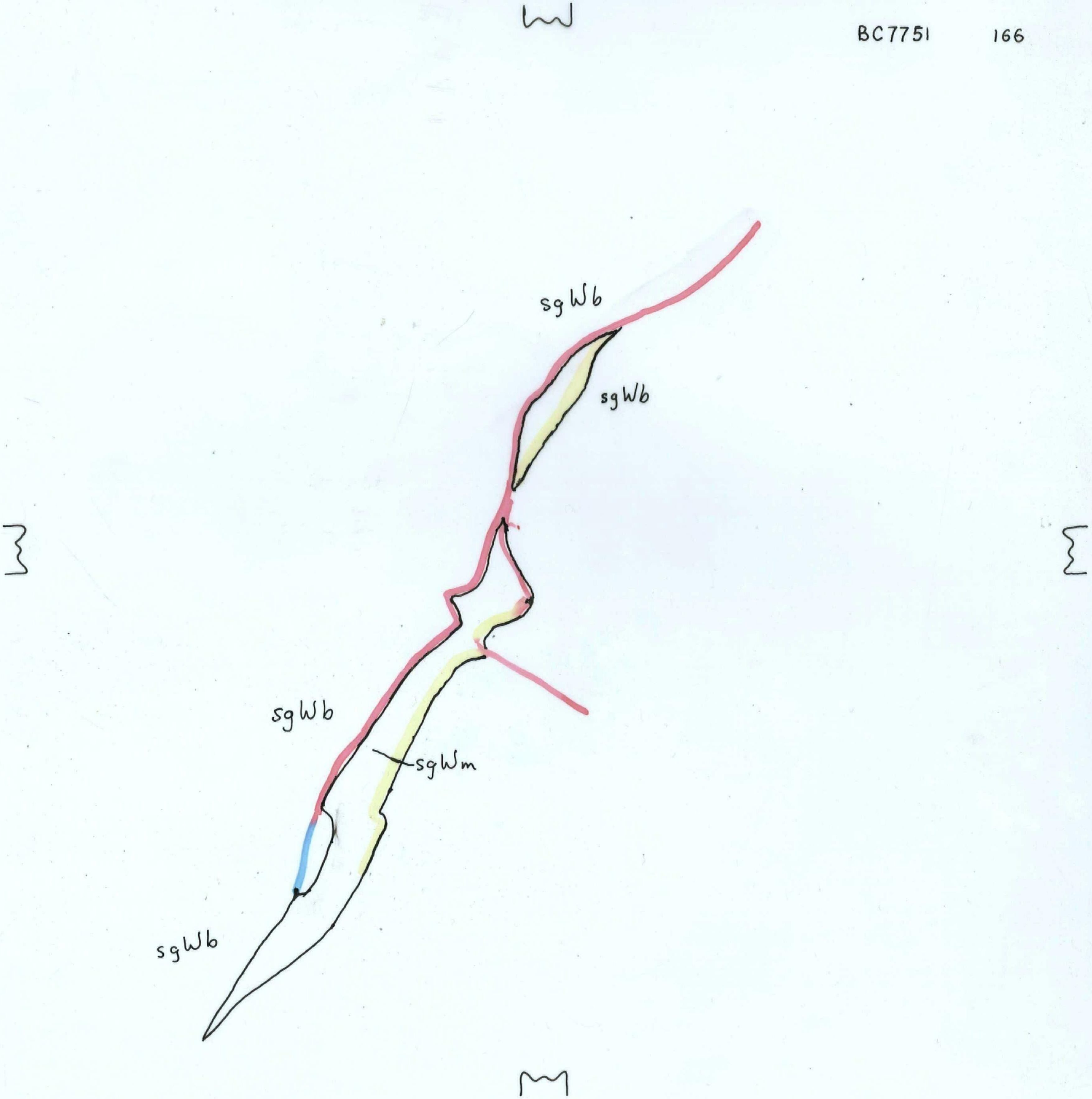
BC7754 № 240

BC7754 № 239

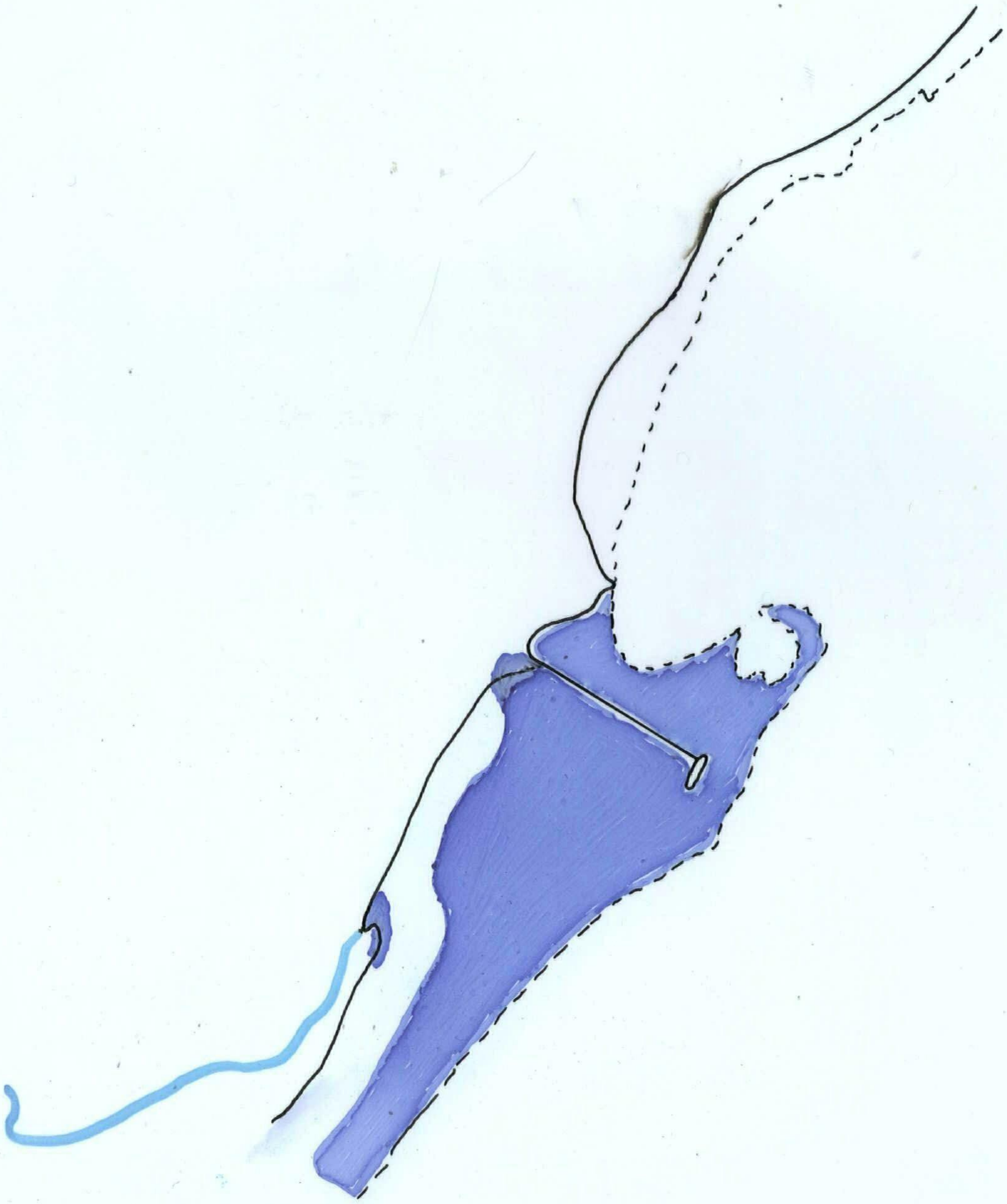

BC7754 Nº 240
KODAK SAFETY FILM
c = 305,57
Nr 110399
54
55
56
57
57a
58
10
9
48
42
41
30
33
34
35
37
36a
39
40
44
45
47
69
69a
53


BC7751
166
1

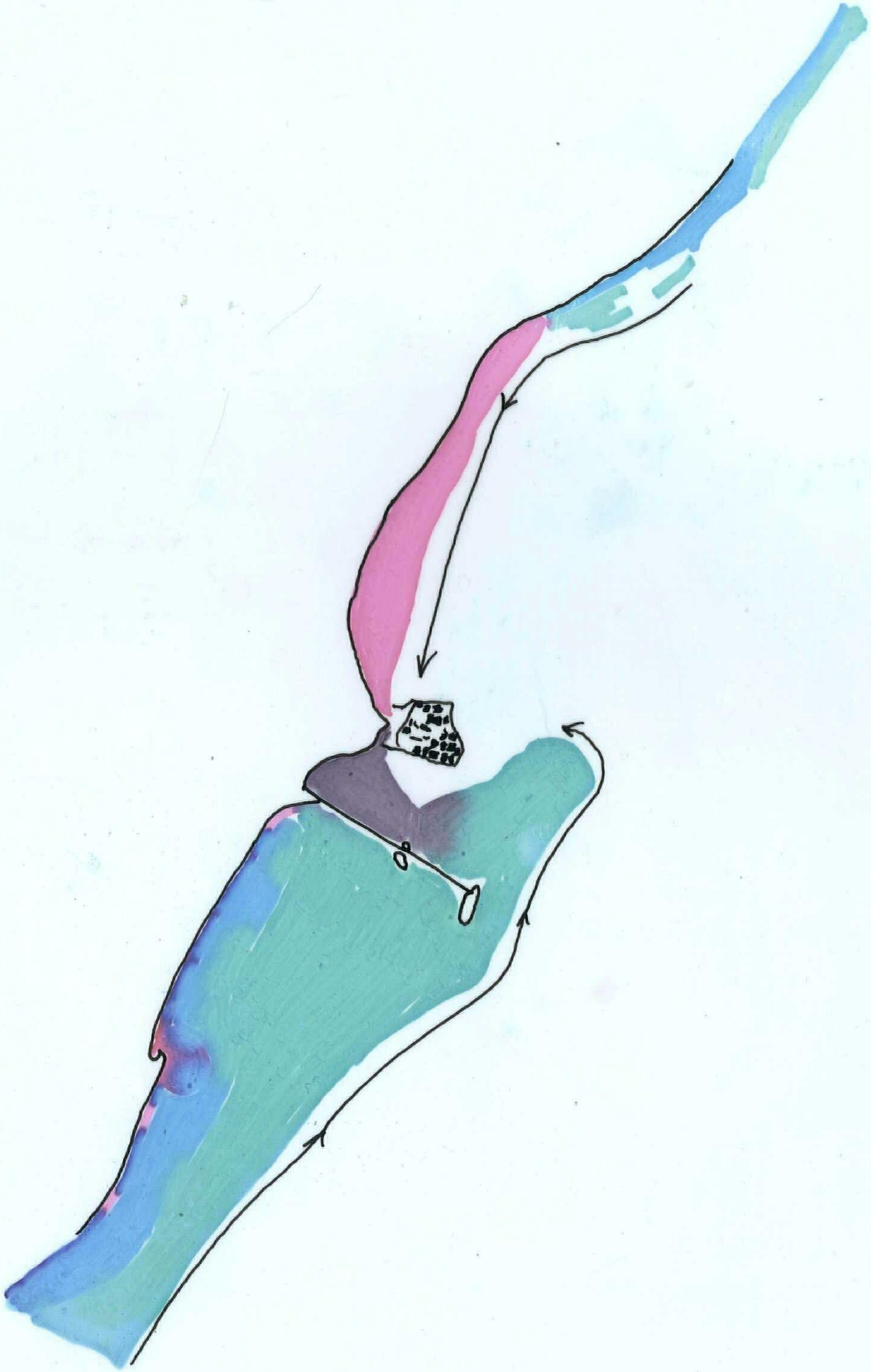
BC7751 166 2



BC7751 166 3



BC7751 166




BC7751
166
080
c = 305,57
Nr 110399
28
KODAK SAFETY FILM
KODAK

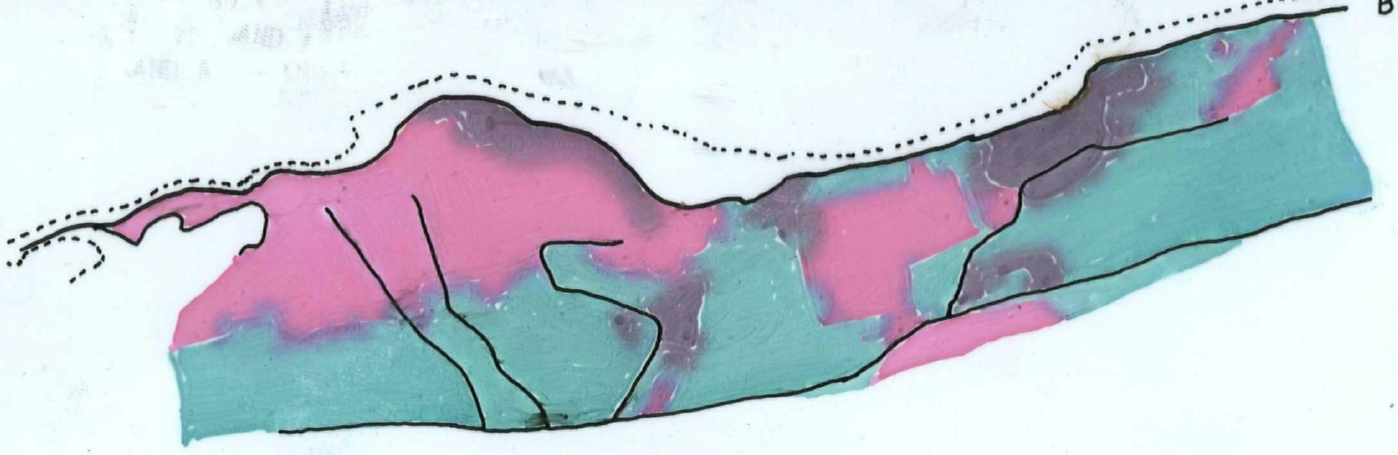

KODAK SAFETY FILM
Enos Lk.
89
88
87
85
83
84
83
82
81
80
78
12
Fleet Pt.
28
27
25
Nanoose Harbour
BC7751
165
087


Fleet Pt.
BC7751
167
089
KODAK SAFETY FILM

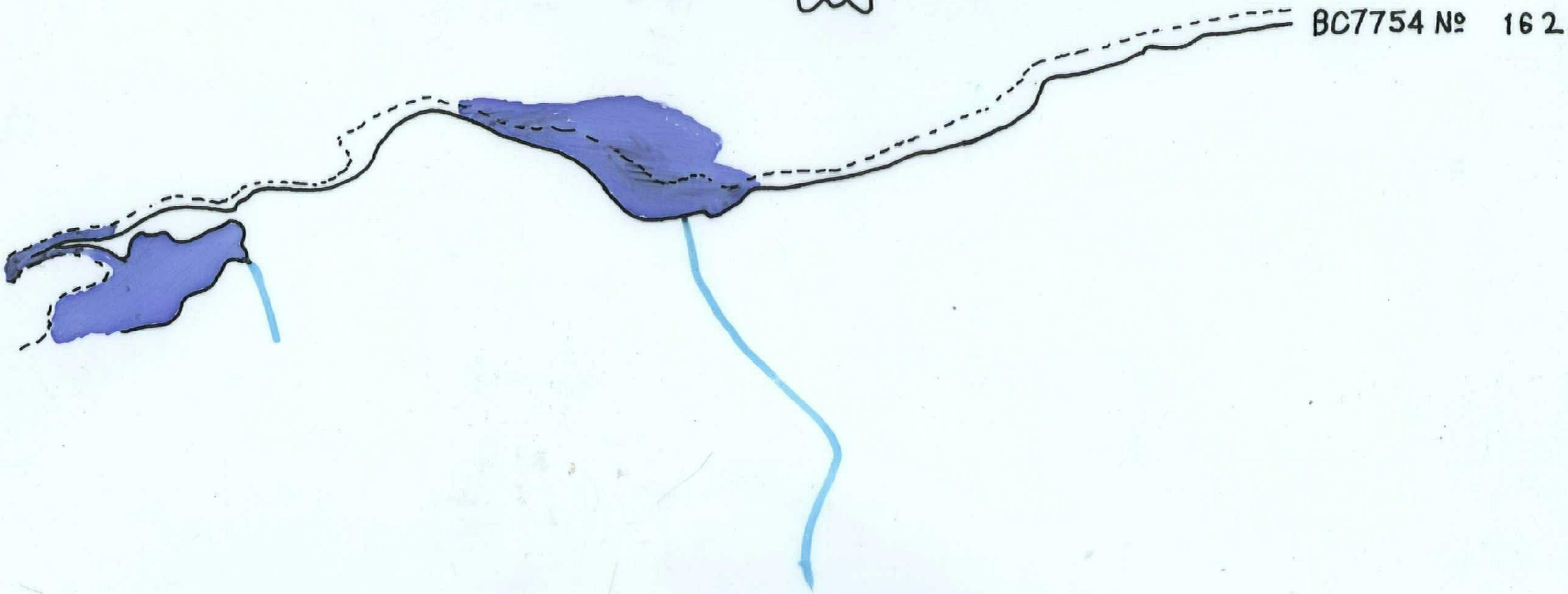
PRESENT LAND AND WATER USE

BC7754 № 162

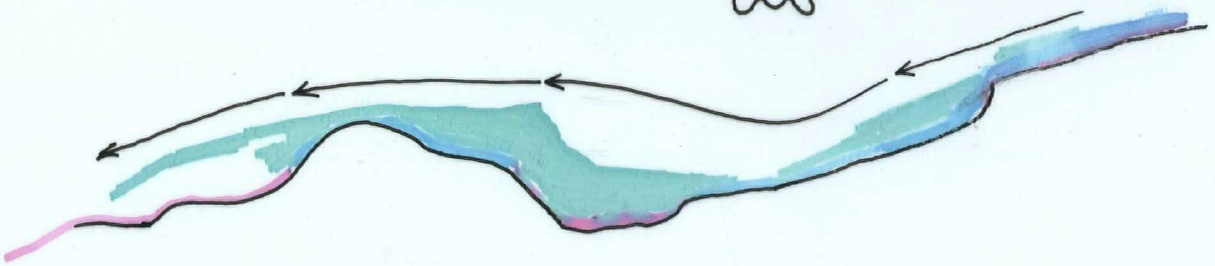
1




BC7754 № 162
sgWv-b
sgWm
$cWb//sW
sgWb
sgWvCv
sgWb


BC7754 № 162

BC7754 №: 162



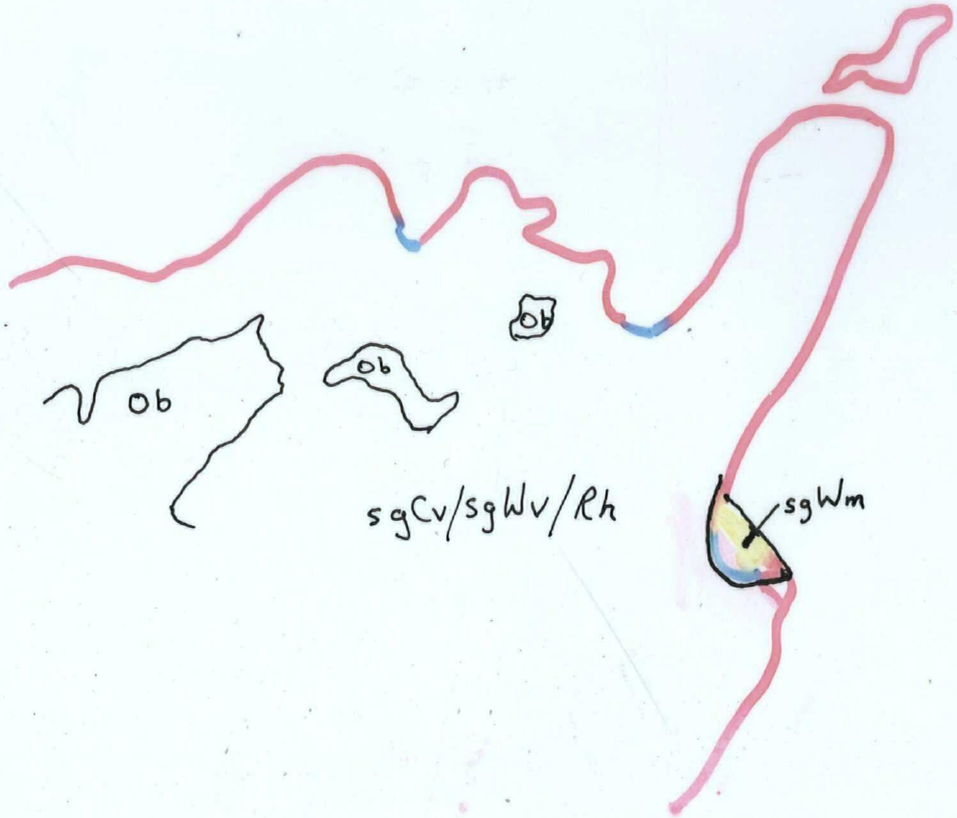

sWb
sWb
scWb//sW
BC7754 Nº 162
1 2 3
KODAK SAFETY FILM


BC7754 Nº 163
1:24
KODAK SAFETY FILM
Nº 110399
c = 305.57
82
81a
87
74
76
73
72
71
71
70

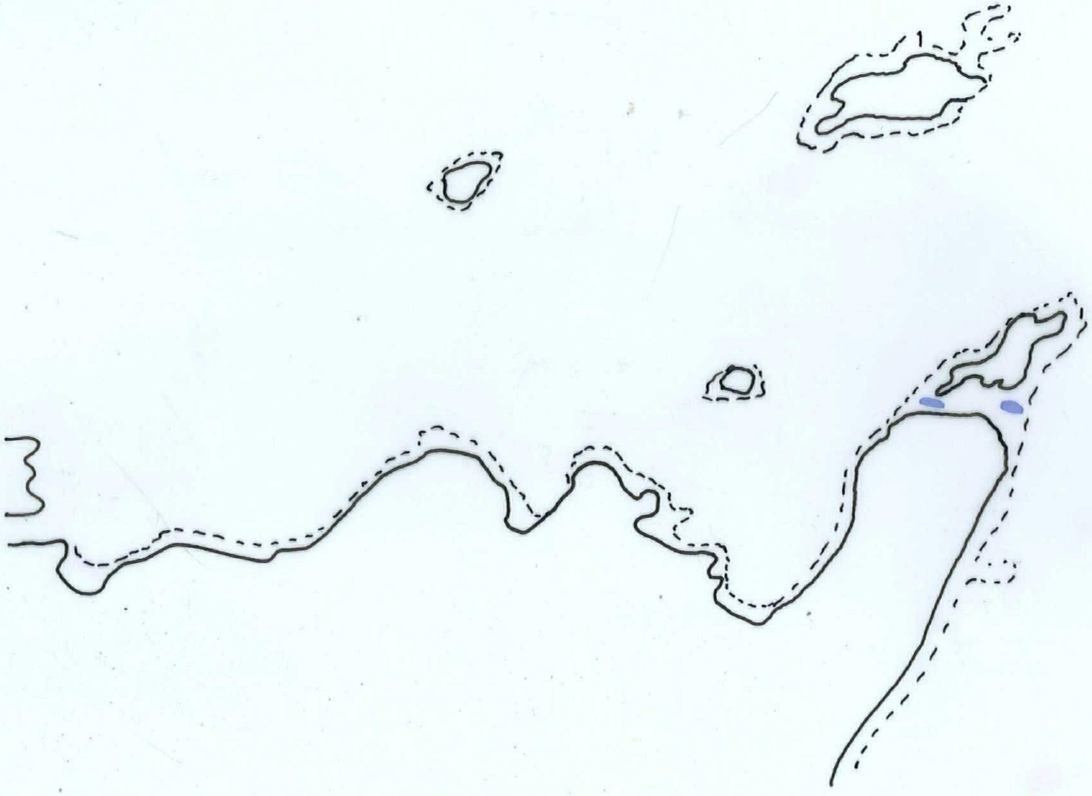

r K
K
1
K
1b
Vesper pt.
Arab Cove
2
3a
3
4
5
PAR
1a
Dorcas Pt.
Cottam Pt.
Northwest Bay
ALL RIGHTS RESERVED
Nr 110399
c=305.57
BC7751
161
083

BC7754 № 071   1

BC7754 № 071 2



BC7754 № 071 3



4

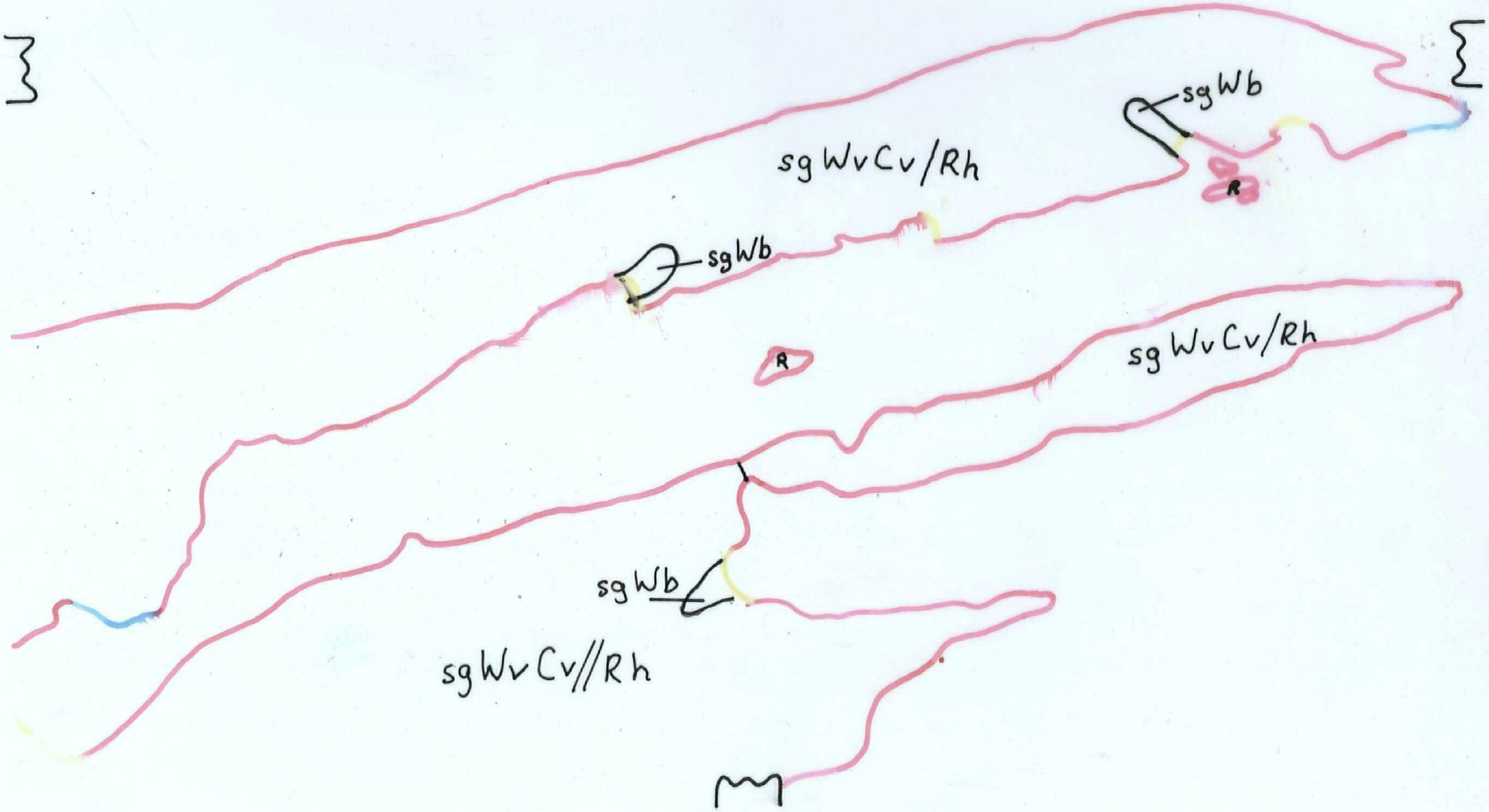
BC7754 № 071
Southey Is.
Wallis Pt.
Richard Pt.
Entrance Rocks
94
95
96
97
98
c = 305,57


BC7754 № 070
0-30
c = 305,5
Nr 11039


BC7754 № 072
0-32

BC7754 № 265

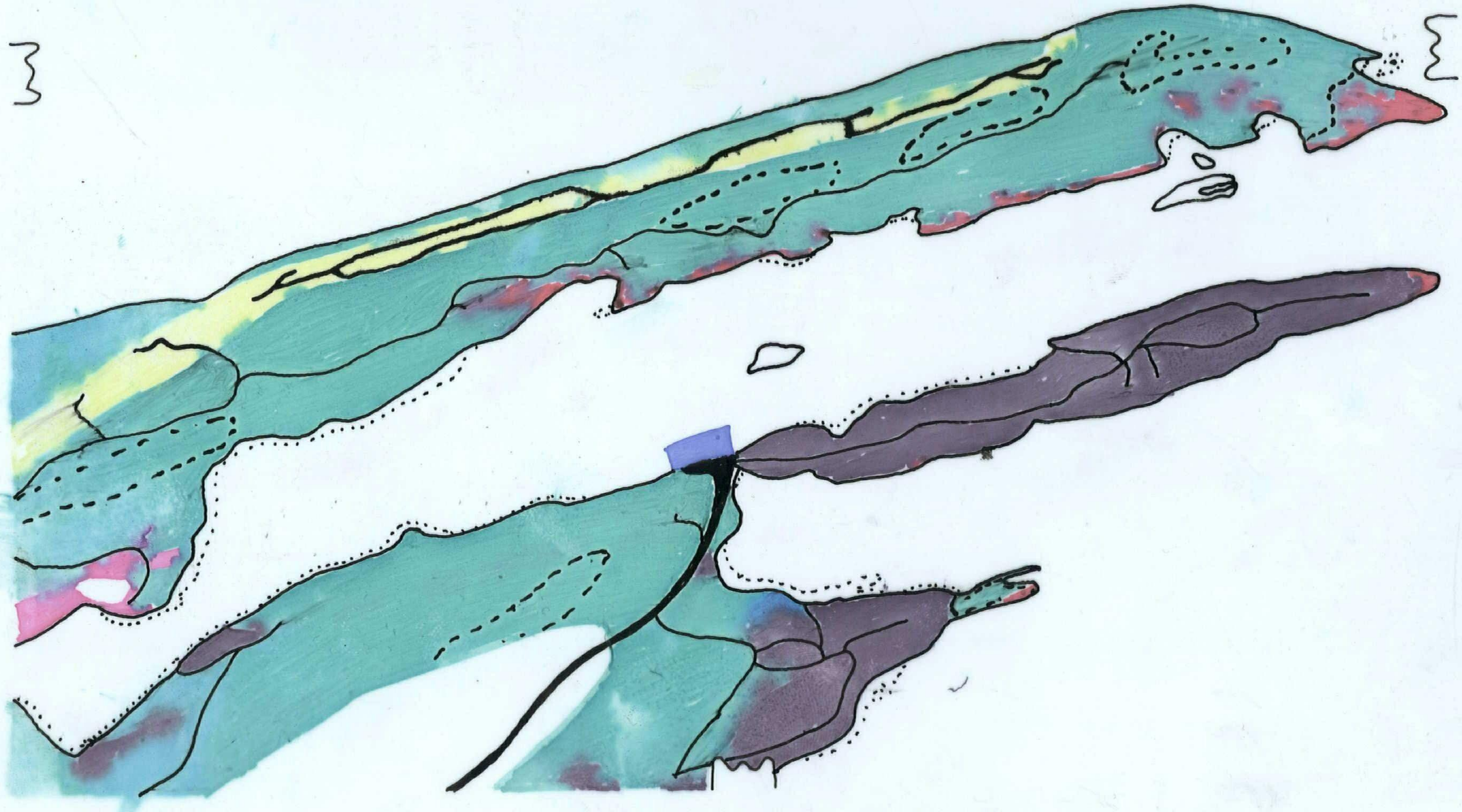
2



BC7754 № 265

PRESENT LAND AND WATER USE

BC7754 № 265 /




BC7754 № 265
227
14
K
30
14
10
15
16
19
19c
19d
K
drift
drift
10
11
12
13
28
29
complex
no kelp just rockweed
rockledge
K
K

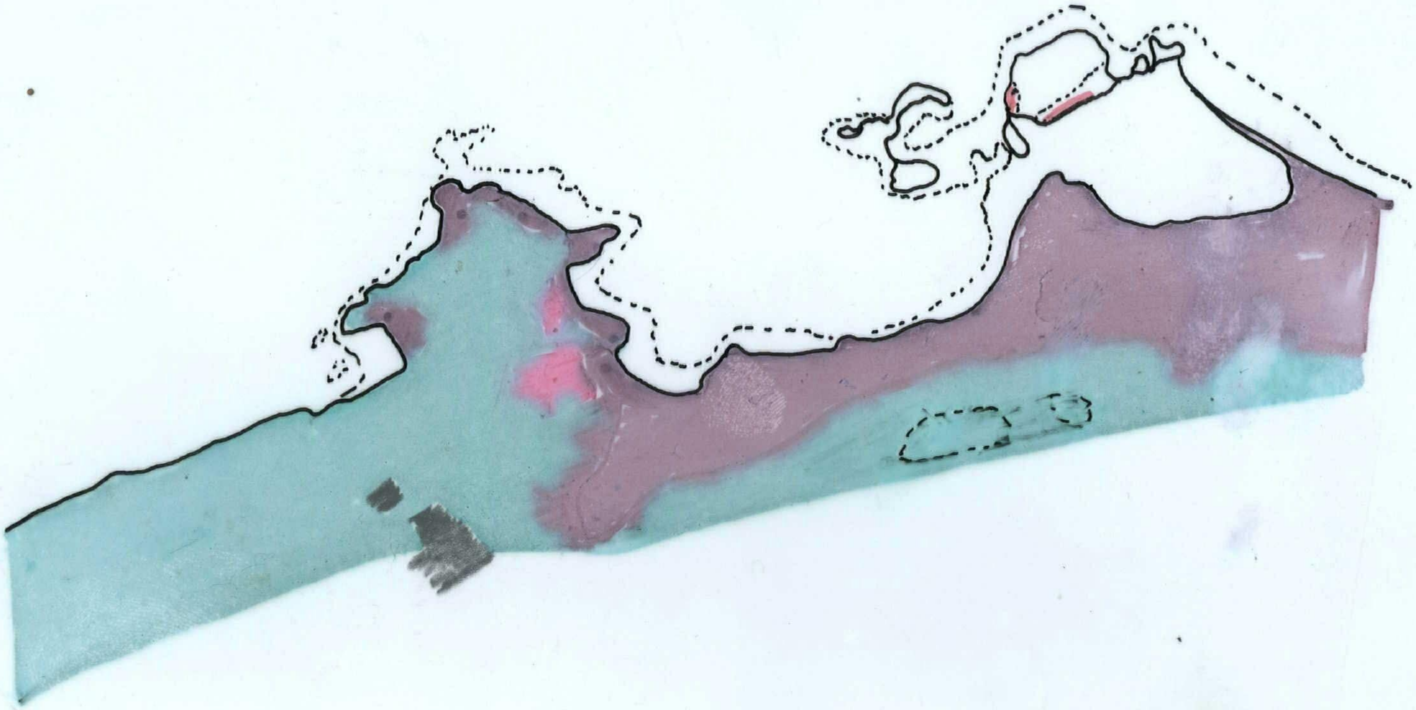
4

BC7754 № 201

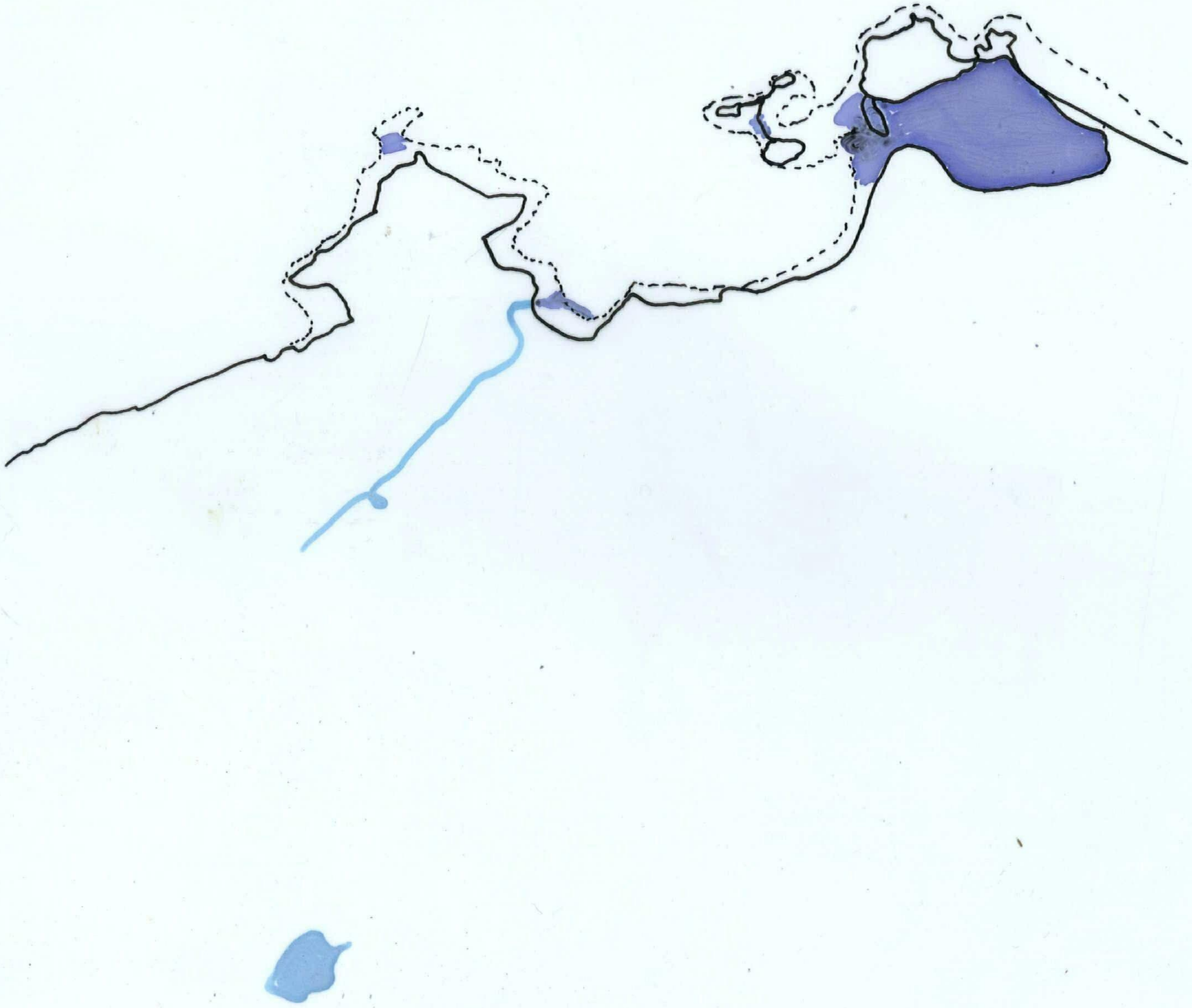
PRESENT LAND AND WATER USE

1

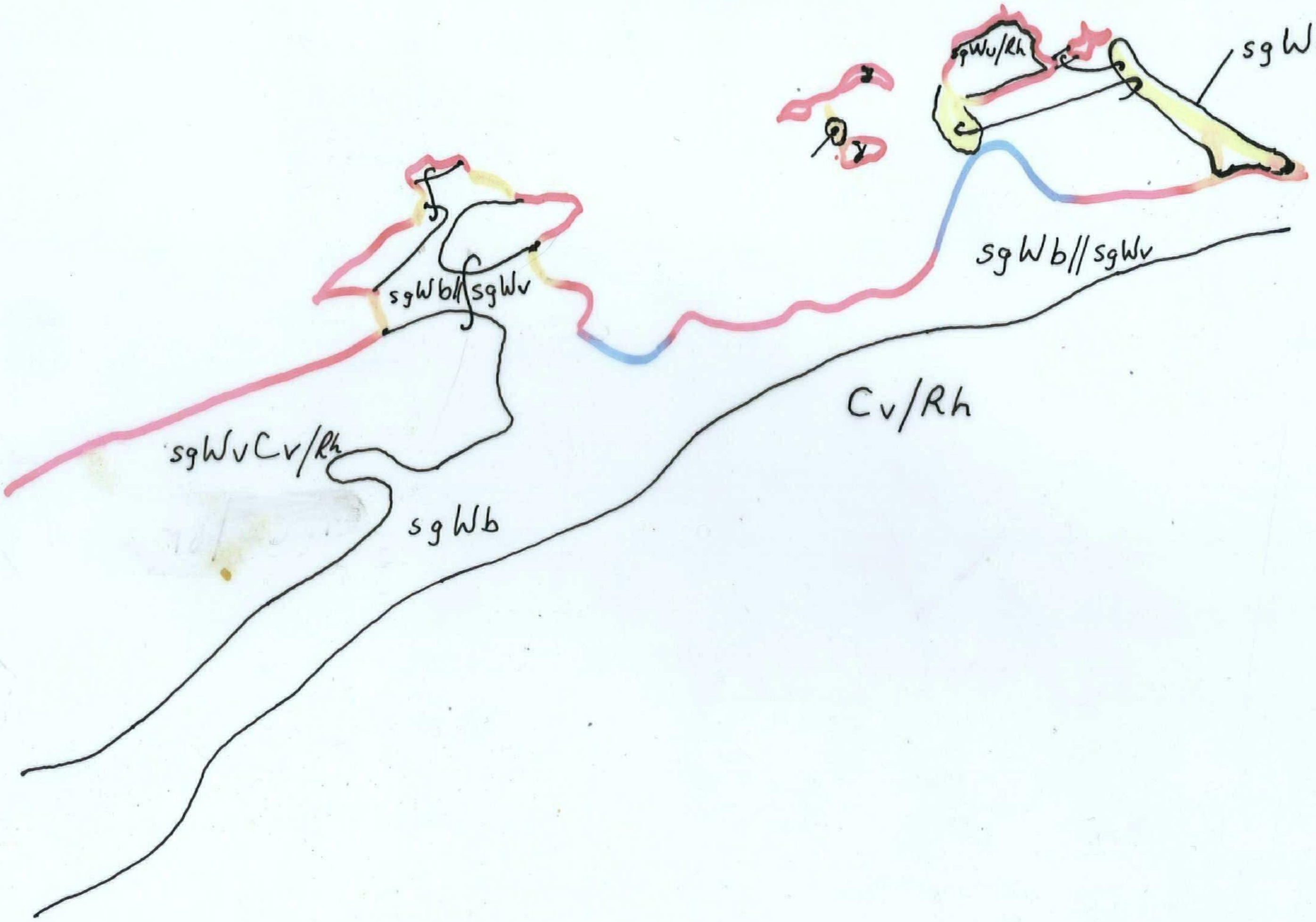
BC7754 № 201



BC7754 № 201 3

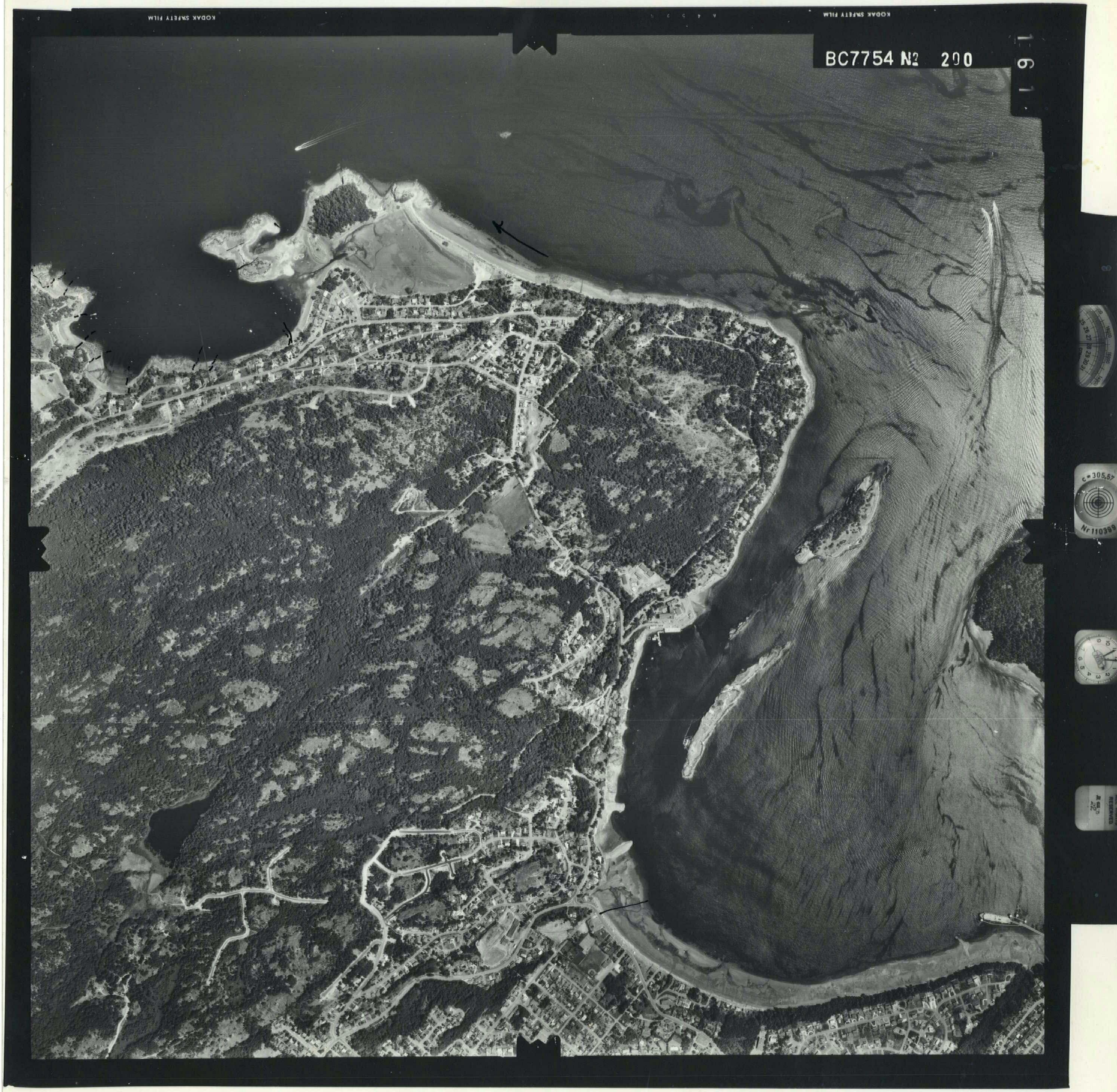


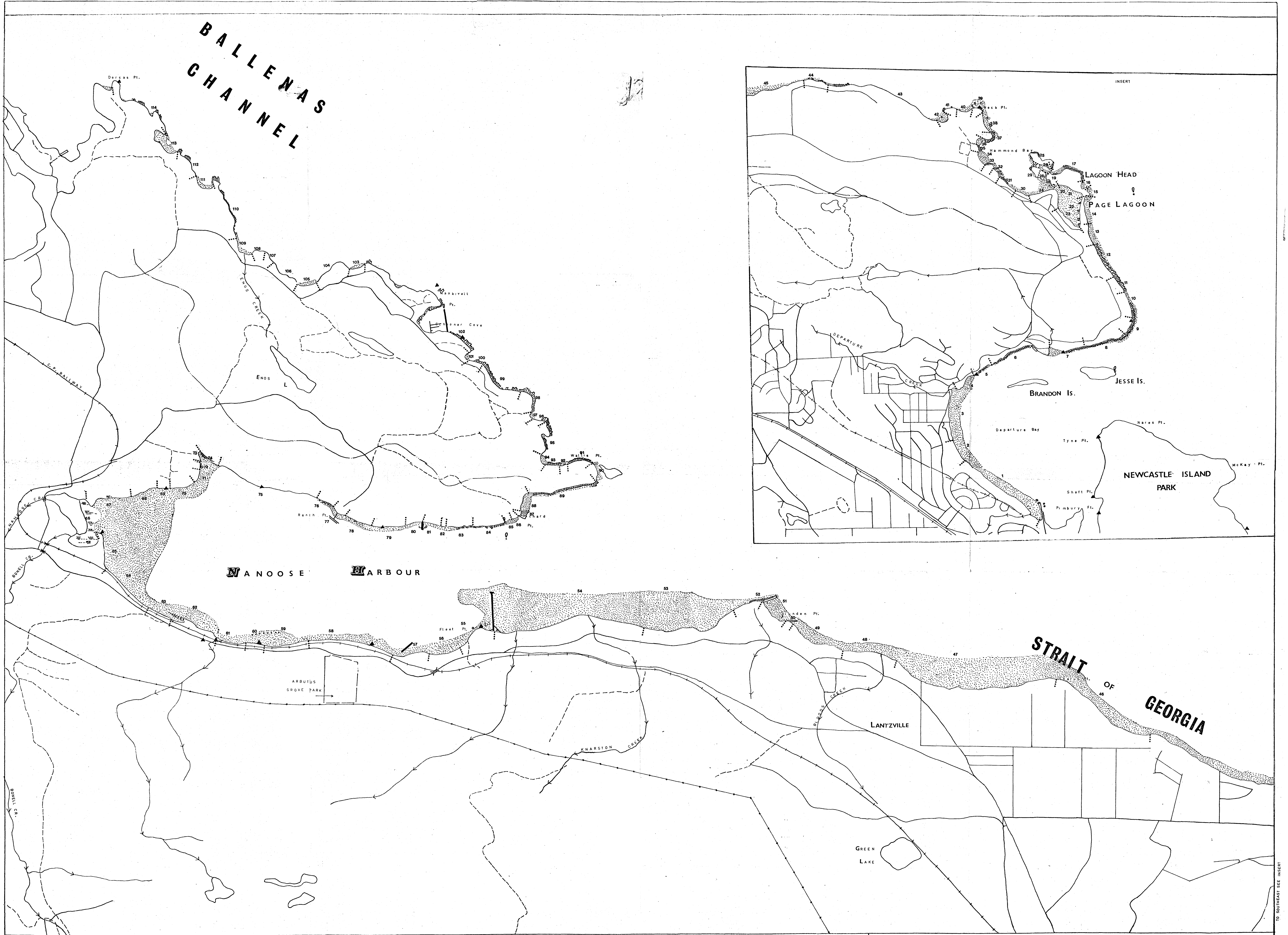
BC7754 № 201




BC7754 № 201
162
Neck Pt.
Hammond Bay
NoName Islands
Lagoon Hd.
57
55
54
54a
71
60
69
53
52
51
50
PAT
43
42
41
40
44
c = 305,67
Nr 110399


KODAK SAFETY FILM
BC7754 Nº 202
163
c = 305,57
Nr 110399
ALL RIGHTS RESERVED


BC7754 № 200
161
KODAK SAFETY FILM
c = 305,57
Nr 110399
RESERVED



Base map compiled from interim base maps produced by the Air Survey Division, Survey and Mapping Branch, Department of Lands, Forests and Water Resources, 1969.

EXAMPLE OF SYMBOL

BEACH MATERIAL	SCARP MATERIAL HEIGHT SLOPE CLASS
MAN MADE FEATURES	GENERAL LAND USE

beach material:
no foreshore — N-G — gravel backshore
Ssg - 100 - 1
scarp material; sand and gravel
scarp height above beach (metres)
scarp slope*
Dsg - Fr - Ra
sand and gravel dyke
random fill material
railway near shoreline
I - C
land use
commercial
industrial

*Slope Class
0 – 15 %
16 – 50 %
51 + %

SYMBOL CONNECTORS
- undifferentiated complex
· connection of related features
/ one beach material overlying another

Unit Boundary

SYMBOL LEGEND

BEACH DEPOSITS

CLAY	Cl
SILT	St
SAND	S
GRAVEL	G
BOULDERS	B
~~COBBLES~~	C
BEDROCK	R
NO APPRECIABLE BEACH	N

BLUFF (within 300 metres of shoreline)

SEDIMENTS	S
UNDIFFERENTIATED	u
CLAY AND SILT	cl
SAND	s
GRAVEL	g
~~BEDROCK~~	R
SEDIMENTARY	s
IGNEOUS	i
METAMORPHIC	m

MAN MADE FEATURES

RETAINING WALL	C
DYKE MATERIAL	D
SAND OR GRAVEL	sg
RANDOM MATERIAL	r
RIP RAP	x
FILL	F
SAND OR GRAVEL	sg
RANDOM MATERIAL	r
RIP RAP	x
ROAD	R
RAILWAY	Ra
WHARF	W
WALKWAY	Wa

GENERAL LAND USE

COMMERCIAL	C
INDUSTRIAL	I
RECREATIONAL	R
AGRICULTURAL	A
URBAN	U
UNDEVELOPED	NS
RURAL BEACH DEVELOPMENT	RB

CARTOGRAPHIC LEGEND

Scale 1:15,840

- HEIGHT OF LAND
- STREAM
- RAILWAY
- POWER TRANSMISSION LINE
- MAIN ROAD
- ~~GRAVEL ROAD~~
- LAKE
- TRIANGULATION STATION ▲
- PILES • • •
- DOLPHIN
- NAVIGATION LIGHT
- BRIDGE
- HIGHEST NORMAL TIDE (HIGH WATER LINE)
- ROCK LEDGES
- SWAMP OR MARSH
- WHARF
- LOWEST NORMAL TIDE (LOW WATER LINE)

Mapping By Ronald Frank for Lands Directorate, Environmental Management Service, Department of Fisheries and Environment, Vancouver. After Mark Walmsley for Lands Directorate. (Undated).