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Volume 6
Part 1

Baseline Thematic Mapping
Present Land Use Mapping at 1:250 000

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Foreword

This report is Part 1 of Volume 6 of a series of documents providing a content reference for the specification and transfer of geomatics data. In the broad field of geomatics, one of the main limiting factors to the wide use of Geographic Information Systems has been the lack of widely applicable data specifications. The current work and its companion volumes describe a set of specifications appropriate for geomatics data management and data sharing.

A way of thinking about geomatics specifications is to establish a common framework encompassing the definition and documentation of (1) a *Reference Series* and (2) a *Content Series*. The *Reference Series* includes methodologies for describing geomatics data and for handling it in various computer and communications environments. The *Content Series* defines the features and attributes, as related to topographic data, cadastral data, forestry data, soils data, and a variety of other themes. The constructs and classes required for the content definitions are supported directly by the reference data model. Thus, the notions of *reference* and *content* are complementary, yet integrated. The two series and the associated approaches to their development describe completely the definition and documentation framework. The current document is *Volume 6 Part 1* of the *Content Series* of the *British Columbia Specifications and Guidelines for Geomatics Data.*

Introduction

The Surveys and Resource Mapping Branch of the Ministry of Environment, Lands and Parks is coordinating the development of a Corporate Land Information Strategic Plan for the Government of British Columbia. The requirements of such a plan will include a common digital map framework for the various land information retrieval systems. This will be provided by the Ministry of Environment, Lands and Parks. The Surveys and Resource Mapping Branch is currently developing a Provincial Digital Atlas based principally on three distinct datasets at various scales; (1) 1:2 000 000 (one map covering the entire province), (2) 1:250 000 (84 mapsheets covering the province), and (3) the 1:20 000 TRIM product (7,000 mapsheets for all of B.C.).

This volume relates to (2) the 1:250 000 scale dataset. Baseline Thematic Mapping (BTM) has several phases, the first phase is Present Land Use Mapping. The Present Land Use Mapping phase results in a thematic map database that is derived from satellite imagery and digital topographic base mapping. The satellite imagery utilized is Landsat Thematic Mapper (TM) data. The topographic data employed has been produced by scanning various lithographic layers of the published National Topographic Series (NTS) mapsheets and structuring the data into a GIS compatible dataset.

This document sets out the specifications for the Present Land Use Mapping phase of BTM at a scale of 1:250 000. The thematic content of Present Land Use is georeferenced to 1:250 000 digital base mapping. It is therefore recommended that users of this document also obtain and become familiar with the British *Columbia Specifications and Guidelines for Geomatics, Content Series Volume 2, Digital Baseline Mapping at 1:250 000*.

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Section 1 - System of Mapping

The mapping coverage produced using these specifications conforms to the National Topographic System of Mapping at a scale of 1:250 000. The National Topographic System (NTS) is a geographic system under which Canada is divided into numbered primary quadrangles. Each quadrangle is 4° latitude by 8° longitude.

Section 2 - Cartographic Framework

All mapping is presented on the Universal Transverse Mercator Coordinate System (based on the 1983 North American Datum). The following points define more closely the map coverage as projected onto this datum.

a. The neat line has been defined in Latitude by the straight line segments joining the geographic sheet corners and calculated at each fifteen minutes of Longitude. The neat line shall be defined in Longitude by the straight line joining the geographic sheet corners.

b. The plane reference grid will be the Universal Transverse Mercator Coordinate System depicted at four centimetre intervals at map scale. The datum used is the North American Datum defined in 1983 (NAD83).

c. The vertical datum will be mean sea level as established by the Geodetic Survey of Canada.

d. For datasets that have a sheet boundary coincident with the 49° or 60° parallel, the 49° or 60° parallel is defined at the corners but the sheet neatline is either the parallel or the surveyed British Columbia boundary or a combination of both such that maximum area is covered. The B.C. boundary is a surveyed line and is not always consistent with the line of latitude. The surveyed line is apparent at times north of the parallel, at times will cross or be coincident with the parallel, and at other times it is evident south of the parallel.

Section 3 - Digital Data Files

3.1 Product Description

The following digital data files are provided:

File 1 - Graphic File
File 2 - Database File

The graphic file subdivides the map into polygons based on Present Land Use as defined in Section 7. Limited planimetry from the structured 1:250 000 base maps is included in the graphic file. The planimetry includes all roads, trails, rivers, creeks, lakes, coastlines and map grids. The database file contains the Present Land Use attributes for each and every Present Land Use polygon in the graphic file. The two files can be linked using the polygon identifier number field in the database.

3.1.1 Graphic File

File 1 has the following characteristics:
It is "clipped" to the neat line as defined in Section 2a.
It is in 2D form (Easting and Northing only).

All 1:250 000 mapsheet data files are completed to international and provincial boundaries as outlined in Section 2d.

All files contain positionally correct UTM coordinates precise to the nearest metre.

Each polygon has a unique polygon identifier number (TAGID).

The minimum size for any polygon represented in the graphic file is 15 hectares (see notes of exception Section 7.2).

The Graphic File is supplied in Intergraph Graphic Design System (IGDS) format, with a global origin offset for both x and y of -2147483648 (working units are in metres).

The IGDS levels of the Graphic File contain the following data:

Level 1	LAND_USE	Present Land Use vectors and database identifier numbers.
Level 2	LU_WATER	Water bodies greater than or equal to 15 hectares.
Level 3	LU_COMB	Combined vectors from Levels 1, 2 and 63.
Level 10	LAKES	Lakes and shoreline from the 1:250 000 structured base map.
Level 11	RIVERS	Rivers/Streams and Canals from the 1:250 000 structured base map.
Level 12	ROADS	Roads and Trails from the 1:250 000 structured base map.
Level 61	20_GRID	Reference grid containing 100 BCGS NAD83 1:20 000 neatlines that cover the target map area.
Level 62	50_GRID	Reference grid containing 16 NTS NAD83 1:50 000 neatlines that cover the target map area.
Level 63	250_GRIDThe	NTS NAD83 1:250 000 reference grid neatline.

3.1.2 Database File

The Database File is supplied in dBase III+ format.

The database file contains the attributes for each BTM Land Use polygon represented in the graphic file. A unique database polygon identifier number (TAGID) for each BTM Land Use polygon provides the link between the database file and the graphic file.

3.1.2.1 Database Attributes

The following attributes are contained in the database for every BTM Land Use polygon. The schema for these attributes are detailed in Section 6.1 Database Schema - Fields, Definitions and Format.

- polygon identifier number
- polygon area
- polygon perimeter
- present land use code
- elevation mean
- minimum elevation
- maximum elevation
- standard deviation of elevation
- slope mean
- minimum slope
- maximum slope
- standard deviation of slope
- aspect (8 classes plus flat)

3.1.2.2 Number of Polygons

The minimum size for any BTM polygon is 15 hectares. This implies that there could be as many as 220,000 polygons for a single map. In practice most of the polygons are much greater in area than this minimum, usually resulting in a total of less than 3500 polygons per map.

Section 4 - Data Accuracy

4.1 Positional Data

4.1.1 Datum

The 1983 North American Datum (NAD83) is the datum for BTM Present Land Use mapping.

4.1.2 Image Data

Landsat TM data as recorded has a 30 x 30 metre pixel size. At full resolution this implies an image file size of approximately 30 Mbytes for coverage of a 1:250 000 map (for each band employed and each derived image). The selection of ground control points for image to map registration is best accomplished with full resolution image data. For thematic mapping at 1:250 000 full resolution imagery contains information redundancy. Therefore after image rectification has been accomplished it is permissible to decimate the Landsat TM imagery up to a pixel size of 50 x 50 metres for reasons of processing efficiency.

4.1.3 Registration Accuracy

4.1.3.1 Relief Displacement

Landsat TM imagery is acquired in a 185 km. wide swath running north to south. At the edge of the image swath the view angle of the sensor is 7.47 degrees off vertical. This off vertical view angle produces a geometric distortion over areas of high relief. An elevation change of 210 metres at the edge of the image swath results in a 30 metre horizontal displacement of features in the image. In the most extreme case this would result in a horizontal displacement of 660 metres (eg. the edge of an image swath falling on Mount Fairweather, elevation of 4663 metres). The average amount of maximum relief displacement on a 1:250 000 mapsheet basis would be approximately 250 metres (one millimetre at map scale). Therefore, correction for relief displacement is not required.

4.1.3.2 Geocoding

As noted in section 4.1.2 the image to map registration will be accomplished with full resolution data. A minimum of 24 ground control points (GCP) will be used. These GCP's should be evenly distributed over the map with at least 8 arranged near the four boundaries of the map. The root mean square error of the GCP residuals after registration shall be less than 150 metres. The mathematical transform calculated from the GCP's will be restricted to 12 or fewer terms (i.e. a second order polynomial or lower). Because of the relief displacement present for areas of high relief imaged at the edge of an image swath, it is recommended that GCP selection be limited to a restricted elevation range where possible (within 500 metres).

4.1.4 Thematic Vector Data

The thematic vector data for Present Land Use mapping consists of line string segments (see Section 5.1.2) depicting the BTM Land Use polygons within the graphic file. This line work is derived from image interpretation or processing. The positional accuracy of these features depends upon:

- the resolution of the image data
- the accuracy of the base map used for image registration
- the accuracy of the registration

Given 50 metre pixel size image data, 500 metre map accuracy and 150 metre registration accuracy the resultant overall positional accuracy will be approximately 530 metres. In most cases the accuracy of the positional data will be better than this as the base map accuracy and the registration accuracy stated represent worst case situations.

4.1.5 Topographic Data

The derivation of the digital elevation model (DEM) utilized for Baseline Thematic Mapping is documented in *British Columbia Specifications and Guidelines for Geomatics, Content Series Volume 2, Digital Baseline Mapping at 1:250 000*. In general the DEM is a representation of the surface of the earth. The drainage of this surface is consistent with the hydrographic network because of the use of hydrographic and other features in the construction of the DEM. The elevation attributes in the database are derived from a raster elevation model that is created from the DEM. Slope and aspect attributes in the database are derived from slope and aspect rasters which are created from the raster elevation model.

4.2 Quality Assurance

Quality assurance of the Present land Use classes is achieved using an independent classifier. A random sample of every second 1:60 000 or 1:70 000 aerial photograph is used as the basis for assessing the thematic accuracy. This sample is further supplemented by identifying classes having limited representation and locating a minimum of 10 such sites per class on the aerial photographs for inclusion in quality assurance. The random and supplementary areas identified on the aerial photographs are reviewed by an independent classifier and the results are presented in an error matrix (also called confusion tables).

An error matrix is described as a square array in which the column and row for each position indicate the actual class of a number of sites and the class to which those sites were assigned by a given classifier. The sum of all cells equals the number of sites being examined. If the classification results were perfect, all cells off the main diagonal would be filled with zeros. Values off the diagonal below a column heading indicate errors of commission (erroneously including a pixel from another class, also called producer's accuracy), where as values off the diagonal along a row heading indicate errors of omission (erroneously excluding a pixel from a class, also called user's accuracy). The sum of the main diagonal divided by the matrix total is the overall accuracy.

The error matrix allows assessment of accuracy, not only for the classification as a whole but also for each individual class.

The minimum acceptable user's or producer's accuracy for any individual Present Land Use class is 65%.

The minimum acceptable overall accuracy is 80%.

The following **Table 4 - 1** is a sample error matrix that includes seven of the possible nineteen Present Land Use classes.

Table 4 - 1 Sample Error Matrix for Present Land Use

Note: Zero fields have been left blank for clarity.

	AGR	ALP	FY	FO	ICE	LOG	URB	Row Tot.	User Acc.
AGR	**21**					1		**22**	**95%**
ALP		**23**	1					**24**	**96%**
FY		3	**42**	3		1		**49**	**86%**
FO			1	**27**				**28**	**96%**
ICE					**11**			**11**	**100%**
LOG	2					**36**		**38**	**95%**
URB							**11**	**11**	**100%**
Col. Tot.	**23**	**26**	**44**	**30**	**11**	**38**	**11**	**183**	
Prod. Acc.	**91%**	**88%**	**95%**	**90%**	**100%**	**95%**	**100%**		**93%**

Overall Accuracy (Diagonal Sum / Grand Total) = 171/183 **= 93%**

Section 5 - Data Structure

5.1 Spatial Object Types

5.1.1 Point

A point is a single coordinate pair that defines the location of the Polygon Identifier Number (TAGID).

5.1.2 Line String (Vectors)

Line strings (vectors) have a start point and an end point and may have one or more additional points of deflection (vertices). A straight line joining the constituent points of a line string defines the true position of the feature (within 1:250 000 BTM dataset accuracies).

5.1.3 Polygon

A bounded area. A polygon consists of one or more line strings which together completely bound a single, contiguous area.

5.1.4 Polygon Identifier Number (TAGID)

A unique polygon identifier number associated with each BTM Land Use polygon. This value is the key used to establish the link between the polygons in the graphics file and their corresponding database attributes.

5.2 Data Structure Rules

5.2.1 Polygon Rule

All polygonal features forming a bounded area will be explicitly closed.
Note: Delimiting boundaries do not cross.

5.2.2 Connectivity Rule

All line strings (vectors) which intersect with other line strings and all line strings that close on themselves will do so at numerically and mathematically exact coordinated junction points or nodes. These nodes divide continuous features into discrete segments which begin and end at nodes.

5.2.3 Data Collection

The boundaries of Present Land Use polygons are derived from interpretation and/or digital processing of Landsat TM imagery. The coarsest image resolution allowed is 50 metre pixel size (see Section 4.1.2). Thus boundary lines may be filtered to reduce data redundancy provided the resulting filtered line does not deviate from the sampled line by more than 25 metres.

Section 6 - BTM Present Land Use Database Schema

6.1 Database Schema - Fields, Definitions and Format

6.1.1 TAGID

A unique polygon identifier number associated with each BTM Land Use polygon. The TAGID is a positive whole number. This value is the primary key used to establish the link between the polygons in the graphics file and their corresponding database attributes.
Format: Character string, length 20

6.1.2 POLY_AREA

The total area of a BTM Land Use polygon in hectares.
Format: ASCII integer, length 12

6.1.3 PERIMETER

The perimeter of a BTM Land Use polygon in metres.
Format: ASCII integer, length 12

6.1.4 PLU_LABEL

A code representing the Present Land Use assigned to a BTM Land Use polygon. This is primarily through image interpretation or image processing but may result from ancillary information such as base mapping or anecdotal knowledge. See Section 7.2 for a detailed specification of the Present Land Use classes.
Format: Character string, length 4

6.1.5 ELEVATION

This is the mean elevation in metres above mean sea level and is based on the number of raster elevation values that fall within the polygon. This value is rounded to the nearest metre and is based on a 16 bit raster of elevation.
Format: ASCII integer, length 4

6.1.6 ELEV_MIN

The minimum elevation in metres above mean sea level based on the raster elevation values that fall within the polygon. This value is rounded to the nearest metre.
Format: ASCII integer, length 4

6.1.7 ELEV_MAX

The maximum elevation in metres above mean sea level based on the raster elevation values that fall within the polygon. This value is rounded to the nearest metre.
Format: ASCII integer, length 4

6.1.8 ELEV_SD

One standard deviation expressed in metres, of the raster elevation values that fall within the polygon. The standard deviation calculation assumes a normal distribution of values.
Format: ASCII integer, length 4

6.1.9 SLOPE

This is the mean of slope in degrees based on the number of raster slope values that fall within the polygon. This value is rounded to the nearest degree. (0° = flat, 90° = vertical)
Format: ASCII integer, length 2

6.1.10 SLOPE_MIN

This is the minimum slope in degrees based on the number of raster slope values that fall within the polygon. This value is rounded to the nearest degree. (0° = flat, 90° = vertical)
Format: ASCII integer, length 2

6.1.11 SLOPE_MAX

This is the maximum slope in degrees based on the number of raster slope values that fall within the polygon. This value is rounded to the nearest degree. (0° = flat, 90° = vertical)
Format: ASCII integer, length 2

6.1.12 SLOPE_SD

One standard deviation expressed in degrees, of the raster slope values that fall within the polygon. The standard deviation calculation assumes a normal distribution of values.
Format: ASCII integer, length 2

6.1.13 ASP_N

The areal percentage of the polygon that falls within the class where aspect is ± 22.5° of North based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent *(referenced to Grid North, Slope > 2°).*
Format: ASCII integer, length 3

6.1.14 ASP_NE

The areal percentage of the polygon that falls within the class where aspect is ± 22.5° of Northeast based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent *(referenced to Grid North, Slope > 2°).*
Format: ASCII integer, length 3

6.1.15 ASP_E

The areal percentage of the polygon that falls within the class where aspect is ± 22.5° of East based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent *(referenced to Grid North, Slope > 2°).*
Format: ASCII integer, length 3

6.1.16 ASP_SE

The areal percentage of the polygon that falls within the class where aspect is ± 22.5° of Southeast based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent *(referenced to Grid North, Slope > 2°).*
Format: ASCII integer, length 3

6.1.17 ASP_S

The areal percentage of the polygon that falls within the class where aspect is ± 22.5° of South based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent *(referenced to Grid North, Slope > 2°).*
Format: ASCII integer, length 3

6.1.18 ASP_SW

The areal percentage of the polygon that falls within the class where aspect is ± 22.5° of Southwest based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent *(referenced to Grid North, Slope > 2°).*
Format: ASCII integer, length 3

6.1.19 ASP_W

The areal percentage of the polygon that falls within the class where aspect is ± 22.5° of West based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent *(referenced to Grid North, Slope > 2°).*
Format: ASCII integer, length 3

6.1.20 ASP_NW

The areal percentage of the polygon that falls within the class where aspect is ± 22.5° of Northwest based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent *(referenced to Grid North, Slope > 2°).*
Format: ASCII integer, length 3

6.1.21 ASP_FLAT

The areal percentage of the polygon that falls within the class where slope is ≤ 2°, this is considered a flat class regardless of true aspect and is based on the number of raster aspect values that fall within the polygon. This value is rounded to the nearest percent.
Format: ASCII integer, length 3

Section 7 - BTM Present Land Use

7.1 Definition of Present Land Use

Present Land Use is defined as a combination of land use (activity on the land) and generalized ground cover. Human activity on the land includes development and modification of the landscape. Generalized ground cover (e.g. Alpine, Old Forest) is important in interpreting patterns of use and their impacts on the land. This definition of Present Land Use is critical to a comprehensive baseline inventory of human activity and natural resources.

7.2 Class Definitions, Database Codes and Minimum Areas Mapped

Note: **Present Land Use** classes are identified by their database codes which are in **UPPER CASE** letters.

Table 7 - 1 BTM Present Land Use Class Definitions Database Codes and Minimum Areas Mapped

Minimum Areas Mapped	DBASE CODE	Land Use	Definition
15 ha	**AGR**	**Agriculture**	Land based agricultural activities undifferentiated as to crop (ie. land is used as the producing medium).
15 ha	**AGMX**	**Residential Agriculture Mixtures**	Areas where agriculture activities are intermixed with residential and other buildings with a building density of between 2 to 0.2 per hectare.
50 ha	**ALP**	**Alpine**	Areas virtually devoid of trees at high elevations.
30 ha	**AVA**	**Subalpine Avalanche Chutes**	Areas below the tree line that are devoid of forest growth due primarily to snow avalanches. Usually herb or shrub covered.
30 ha	**BARE**	**Barren Surfaces**	Rock barrens, badlands, sand and gravel flats, dunes and beaches where unvegetated surfaces predominate.
30 ha	**BURN**	**Recently Burned**	Areas virtually devoid of trees due to fire within the past 20 years. Forest less than or equal to 15% cover.

Minimum Areas Mapped	DBASE CODE	Land Use	Definition
15 ha	**EST**	**Estuaries**	Salt water mud flats and intertidal areas at the mouth of rivers and creeks where the vegetation is influenced by frequent flooding (at least yearly).
50 ha	**FO**	**Old Forest**	Forest greater than or equal to 140 years old and greater than 6 meters in height. Areas defined as Recently Logged and Selectively Logged land uses are excluded from this class.
50 ha	**FY**	**Young Forest**	Forest less than 140 years old and greater than 6 metres in height. Areas defined as Recently Logged and Selectively Logged land uses are excluded from this class.
50 ha	**ICE**	**Glaciers and Snow**	Glaciers and permanent snow. Depending on the date of imagery, ephemeral snow may be included in this class.
15 ha	**LOG**	**Recently Logged**	Timber harvesting within the past 20 years, or older if tree cover is less than 40% and under 6 metres in height.
30 ha	**LOGS**	**Selectively Logged**	Areas where the practice of selective logging can be clearly interpreted on the Landsat TM image and TRIM aerial photography.
15 ha	**MINE**	**Mining**	Land used now (or in the past and remains unreclaimed) for the surface extraction of minerals or quarry materials.
30 ha	**RANG**	**Rangelands**	Unimproved pasture and grasslands based on cover rather than use. Cover includes drought tolerant grasses, sedges, scattered shrubs to 6 metres in height and less than 35% forest cover. Sparse forest stands are included with their understorey of drought tolerant shrubs and herbs.
30 ha	**REC**	**Recreation Activities**	Land used for private or public outdoor recreational purposes. Ski resorts and golf courses are included. This class does not include recreational areas within built-up portions of cities, towns and villages, which are mapped as urban areas. This class includes waterfront cottage areas if they are at least 200 metres wide.
15 ha	**URB**	**Urban**	All compact settlements including built up areas of cities, towns and villages as well as isolated units away from settlements such as manufacturing plants, rail yards and military camps. In most cases residential use will predominate in these areas. Open space which forms an integral part of the urban agglomeration, e.g. parks, golf courses, etc. are included as urban.

Minimum Areas Mapped	DBASE CODE	Land Use	Definition
15 ha	**WET**	**Wetlands**	Wetlands including swamps, marshes, bogs or fens. This class excludes lands with evidence or knowledge of haying or grazing in drier years.
15 ha	**WFRE**	**Fresh Water**	Fresh water bodies (lakes, reservoirs and wide portions of major rivers).
15 ha	**WSAL**	**Salt Water**	Salt water (oceans). Areas defined as the Estuaries land use are excluded from this class.

NOTES: 1) Islands have a minimum areas mapped size of 15 ha and any valid land use class is acceptable regardless of the minimum areas mapped sizes stated above.

2) Polygons on map boundaries may be below the minimum areas mapped size. This is the case when joining adjacent mapsheet polygons of the same class results in polygons that meet the minimum areas mapped requirements.