British Columbia
Specifications and Guidelines for Geomatics:

Gridded Digital Elevation Model Product Specifications

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1 INTRODUCTION

The BC gridded Digital Elevation Model (BC DEM) consists of eight distinct raster products, presented in two different common planar projections, in file formats appropriate to the file content:

File Projection	File Contents	File Format
BC Albers	Elevation grid	USGS DEM
	Elevation grid	ESRI ASCII Grid
	Slope grid (percentage)	ESRI ASCII Grid
	Slope grid (degrees)	ESRI ASCII Grid
	Aspect grid	ESRI ASCII Grid
	Black & white hill-shade (315°)	24 bit TIFF / TFW
	Black & white hill-shade (225°)	24 bit TIFF / TFW
	Elevation coloured hill-shade (315°)	24 bit TIFF / TFW
	Elevation coloured hill-shade (225°)	24 bit TIFF / TFW
UTM	Elevation grid	USGS DEM
	Elevation grid	ESRI ASCII Grid
	Slope grid (percentage)	ESRI ASCII Grid
	Slope grid (degrees)	ESRI ASCII Grid
	Aspect grid	ESRI ASCII Grid
	Black & white hill-shade (315°)	24 bit TIFF / TFW
	Black & white hill-shade (225°)	24 bit TIFF / TFW
	Elevation coloured hill-shade (315°)	24 bit TIFF / TFW
	Elevation coloured hill-shade (225°)	24 bit TIFF / TFW

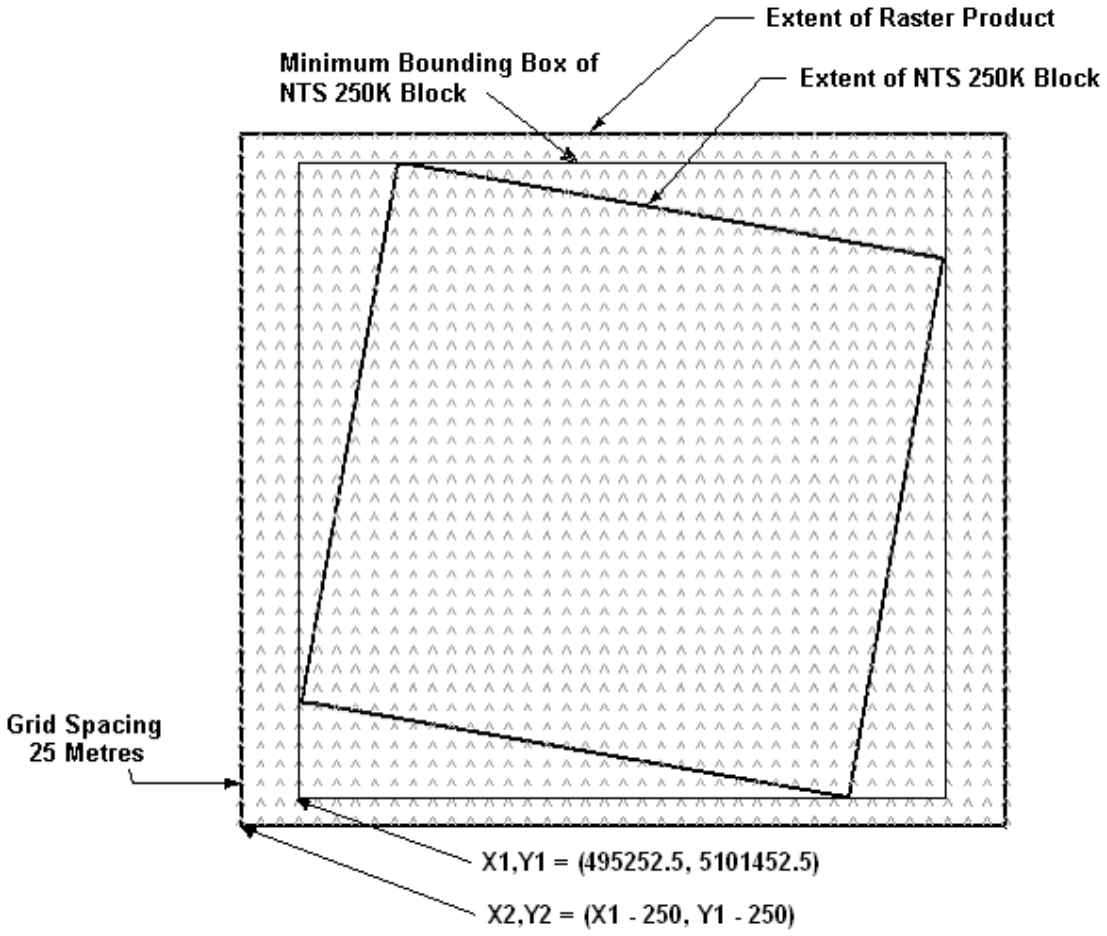
The elevation grid is derived from a Triangulated Irregular Network (TIN) build from Terrain Resource Information Management (TRIM) mass-points and breaklines. Slope, aspect, and hill-shades are derived from the elevation grid.

The BC DEM files use the National Topographic System (NTS) at 1:250,000 scale (250K blocks) as a delivery basis and have a grid spacing of 25 metres.

2 MAPPING SYSTEM

The 1:250,000 scale NTS quadrangles are each 1 degree of latitude by 2 degrees of longitude in size. Because the 250K blocks are not square in either of the BC DEM product projections (BC Albers and Universal Transverse Mercator) the block boundaries shall define the minimum possible extent of the square product files (as described below), and the block names shall be used in the naming of product files (as described in the file naming sub-section of each product section).

The bounds of each file shall be constructed such that the 250K block boundary is completely contained in the file, and there is at least a 250 metre buffer around the block minimum bounding box. The bounds shall be constructed such that the **centre** of each pixel in the raster (where the elevation is sampled) falls at a planar coordinate evenly divisible by 25.



All coordinates are based on the 1983 North American Datum. The vertical datum for elevation data is mean sea level as established by the Geodetic Survey of Canada (1928 Canadian Vertical Datum).

All elevations are calculated in metres above mean sea level.

3 FILE CONTENTS

3.1 Projections

The BC DEM files are produced in two planar projections, Universal Transverse Mercator (UTM) and BC Albers.

BC Albers is an Albers Equal Area Conic projection with the following parameterization:

```
PROJCS["BC_Albers",
  GEOGCS["GCS_North_American_1983",
    DATUM["D_North_American_1983",
      SPHEROID["GRS_1980", 6378137, 298.257222101]
    ],
    PRIMEM["Greenwich", 0],
    UNIT["Degree", 0.017453292519943295]
  ],
  PROJECTION["Albers"],
  PARAMETER["False_Easting", 1000000],
  PARAMETER["False_Northing", 0],
  PARAMETER["Central_Meridian", -126],
  PARAMETER["Standard_Parallel_1", 50],
  PARAMETER["Standard_Parallel_2", 58.5],
  PARAMETER["Latitude_Of_Origin", 45],
  UNIT["Meter", 1]
]
```

UTM is a Transverse Mercator projection with a central meridian for each “zone”. UTM zones are non-overlapping areas. British Columbia falls within UTM zones 7, 8, 9, 10 and 11. Each gridded data file is delivered in the UTM zone which its NTS 250K block falls within. The central meridians are: zone 7, -141°; zone 8, -135°; zone 9, -129°; zone 10, -123°; zone 11, -117°.

For example, the parameterization for UTM zone 10 is:

```
PROJCS["NAD_1983_UTM_Zone_10N",
  GEOGCS["GCS_North_American_1983",
    DATUM["D_North_American_1983",
      SPHEROID["GRS_1980", 6378137,2 98.257222101]
    ],
    PRIMEM["Greenwich", 0],
    UNIT["Degree", 0.017453292519943295]
  ],
  PROJECTION["Transverse_Mercator"],
  PARAMETER["False_Easting", 500000],
  PARAMETER["False_Northing", 0],
  PARAMETER["Central_Meridian", -123],
  PARAMETER["Scale_Factor", 0.9996],
  PARAMETER["Latitude_Of_Origin", 0],
  UNIT["Meter", 1]
]
```

3.2 No Data Values

Elevation, aspect, and slope files use the "no data" tokens defined in their file headers to indicate areas of no data.

Hill-shade files use "black" (RGB values 0,0,0) in areas of no data.

"No data" values occur in areas outside the bounds of the available TRIM source data. All areas with valid TRIM source data have valid raster pixel values. "No data" is also used for areas outside the NTS 250K block bounds for files in the BC Albers projection.

Format	No Data Value
USGS DEM	-32767
ESRI ASCII	-9999 (Given in NODATA_value header line)
TIFF	RGB Black (0,0,0)

3.3 NTS 250K Grid Masking

All BC DEM files are perfectly rectangular within their defined planar coordinate system. However, the NTS 250K block boundary inscribed within the files are not square. Therefore, within each file there are pixels which are **not within** the NTS 250K block the file purports to describe.

- For all files in BC Albers, pixels outside the NTS 250K block inscribed in the file shall have their value set to the appropriate "no data" value for their file format.
- For all files in UTM, every pixel in the file shall have a valid value, except those for which no data is legitimately available (areas outside the extent of the TRIM source data).

3.4 Water Bodies

All non-moving water bodies are assumed to be **flat**. The Enhanced Base Map (EBM) is used to provide the boundaries of lakes and oceans.

- Elevation pixels within wide rivers, swamps and marshes (moving water bodies) are left untouched.
- Elevation pixels within ocean areas are given an elevation of 0.
- Elevation pixels within a lake are given the value of the bottom quartile of elevations within the lake. So, for example, if the elevation values of pixels within a lake are (2,2,***2***,2,3,3,3,3,4,4), the lake would be given an elevation value of 2, the bottom quartile, and all the pixels would have their elevation value changed to 2.

3.5 Data Derivation

The elevation grid is derived from a TIN built from TRIM mass points and breaklines. All other gridded products are derived from the elevation grid.

3.5.1 Source Data

The BC DEM data set is derived from the TRIM DEM utilizing all available mass points and breaklines. The TRIM DEM data types used are:

DEMPoint::TRIM
definite/indefinite
Breakline::TRIM
sharp/round
hypsographic/hydrographic/anthropogenic

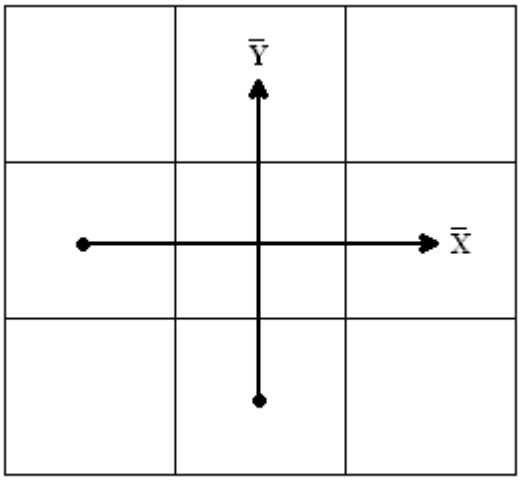
3.5.2 Elevation Data

The elevation grid is derived in the following manner:

- TRIM DEMPoint::TRIM and Breakline::TRIM features are used to build a TIN. Only the most current data is used (up to November 15, 2002). All retired and duplicate features are removed before building the TIN.
- All DEMpoints and breaklines are added to the TIN with zero tolerance. This means that no features are discarded as unimportant, every DEMpoint and breakline are included in the TIN model.
- All DEMPoints are added to the TIN model with equal weight. All Breaklines are added to the model as hard breaklines.
- Points are sampled from the TIN at 25 metre intervals using linear interpolation and written to a raster file of raw elevation data. Elevation values are sampled at the **centre** of the raster pixels. As a result, the edges of the raster files are offset by 12.5 meters, and the center of the raster pixels are at exact 25 metre increments in the planar coordinate system.

3.5.3 Slope / Aspect Data

Slope / aspect are both taken from the normal to the surface of the grid at a particular pixel location. The normal vector at a particular pixel is derived as the cross product of the north-south and east-west vectors formed by joining adjacent pixels.

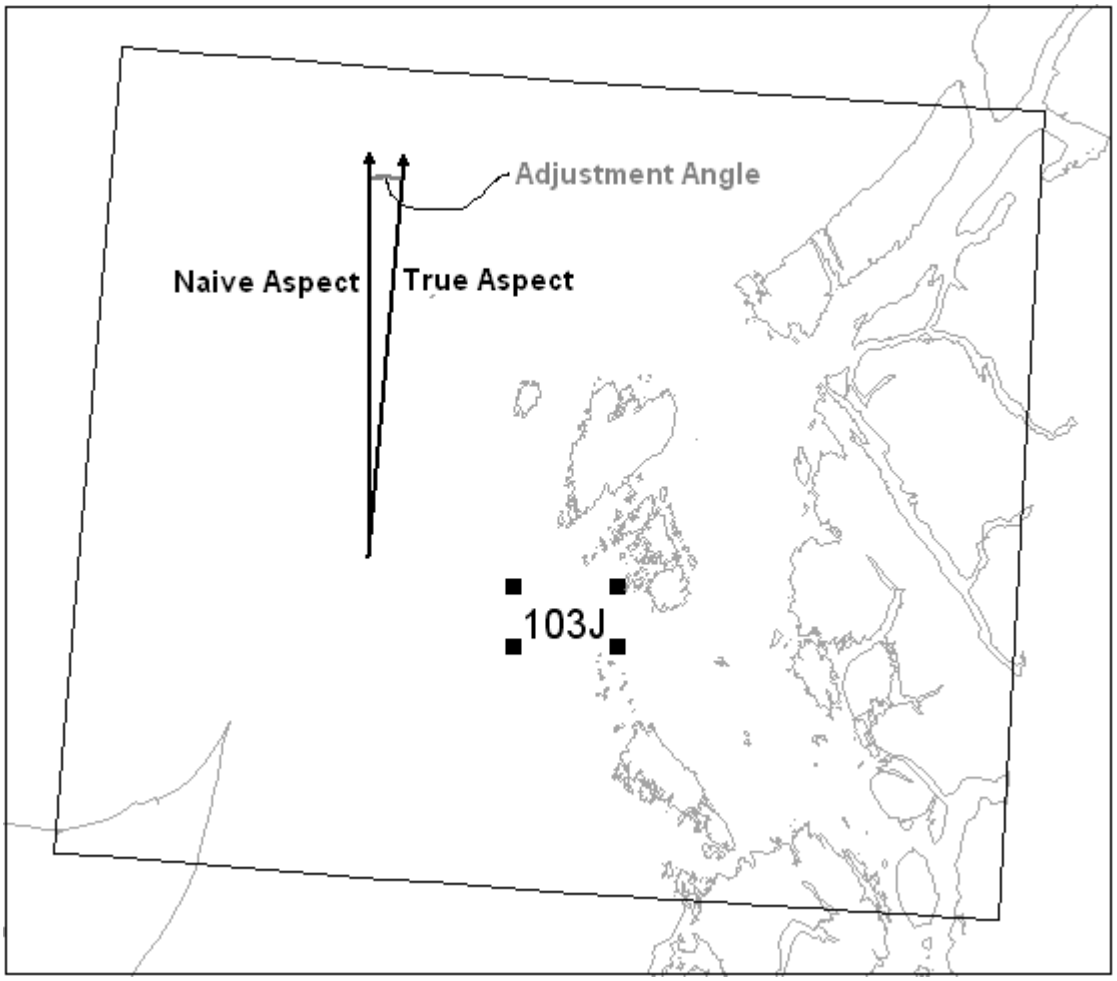


$$\bar{N} = \bar{X} \times \bar{Y}$$

Slope is expressed as integral degrees or integral percentage. Percentage slope is the rise over run of the normal vector. For example, a slope of 45° is equivalent to a slope of 100%.

Aspect is expressed in integral cardinal degrees, with true north at 0°. Naïve aspect is first calculated using the normal vector, then the naïve value is adjusted to the true value by using an adjustment value for the block. The adjustment value is derived by comparing "true north" (the direction of a line of longitude) for a point at the centre of the block with "local north" for the UTM or Albers coordinate plane.

If the slope of the normal vector for the pixel is less than 2°, then the pixel is presumed to be "flat" and therefore have no aspect. Flat pixels are given an aspect value of –1.



3.5.4 Hill-shade Data

Hill-shade is derived by comparing the normal value of a pixel to an imaginary "sun angle" vector and giving the pixel a lighter value if its normal is close to the sun angle vector, and a darker value if it is farther away.

The height of the sun angle for all hill-shade products was 45° above the horizontal.

The colouring of the elevation shaded hill-shade rasters is generated by mixing the hill-shade brightness values with a colour derived from the elevation of the pixel. The elevation colour ramp is as follows:

Elevation (m)	**Red**	**Green**	**Blue**
0	0x1A	0x10	0x81
0.1	0x6A	0xC9	0x81
1120	0xF0	0xE6	0x8C
2150	0xE9	0x85	0x6A
3200	0xFF	0xFF	0xFF

Elevations between colour ramp values are given a linearly interpolated colour. Elevations below the minimum ramp value are given the minimum ramp colour. Elevations above the maximum ramp value are given the maximum ramp colour.

4 FILE FORMATS

4.1 USGS DEM

The USGS DEM format is a standard format for the storage of raster digital elevation data. It is an ASCII file format consisting of a header record (Type A), data records (Type B) and an accuracy metadata record (Type C). The BC DEM format consists of a Type A record with standard header values given below, and an unmodified Type B record. The Type C record is not used in the BC DEM format.

The complete USGS DEM file format specification is available at http://rockyweb.cr.usgs.gov/nmpstds/demstds.html.

The following table describes the Type A record for the BC DEM file and the default values which are expected for the various fields.

Data Elmnt	Contents	Format (Fortran)	ASCII (Fortran)	Comments
1	File name	ALPHA	A40	Ex: 94l-albers-elevation.dem
1	Producer of data, Free format text	ALPHA	A40	Free format descriptor, containing information about the data producer. Set to: "BMGS - B.C. Gov. - Victoria"
1	Filler		29 bytes	Blank fill
1	SW geographic corner	INTEGER*2 REAL*8	2(I4,I2,F7.4)	SW geographic quadrangle corner ordered as: Long. = SDDDMMSS.SSSS Lat. = SDDDMMSS.SSSS
1	Process Code	ALPHA	A1	USGS-specific code indicating data processing method. Set to "0"
1	Filler		1 byte	Blank fill
1	Sectional indicator	ALPHA	A3	Not used in this case.
2	Origin code	ALPHA	A4	Free format mapping origin set to "BC".
3	DEM level code	INTEGER*2	I6	Code: 1 = DEM-1 2 = DEM-2 3 = DEM-3 Set to "1"
4	Code defining the elevation pattern (regular or random).	INTEGER*2	I6	Code 1 = regular 2 = random Set to "1".

Data Elmnt	Contents	Format (Fortran)	ASCII (Fortran)	Comments
5	Code defining the ground horizontal reference system	INTEGER*2	I6	Code 0 = Geographic 1 = UTM 2 = USA State-plane 3 = Albers Equal Area Set to code 1 for UTM product. Set to code 3 for Albers product.
6	Code defining the zone in the ground horizontal reference system.	INTEGER*2	I6	UTM: Set to UTM zone. E.g.: "10" Albers: Set to "0".
7	Map projection parameters	REAL*8	15D24.15	UTM: Set all values to 0. Albers: Set the following values in first 8 positions and 0 in the remaining 7 positions. All angles (latitudes, longitudes, or azimuth) are required in degrees, minutes, and arc seconds in the packed real number format +DDDOMMOSS.SSSSS. 6378137 (semi-major axis) 0.00669438002290 (eccentricity) 50.0 (1st standard parallel) 58.5 (2nd standard parallel) –126.0 (origin longitude) 45.0 (origin latitude) 1000000 (false easting) 0 (false northing)
8	Code defining the unit of measure for the ground horizontal coordinates throughout the file.	INTEGER*2	I6	Code 0 = radians 1 = feet 2 = metres 3 = arc-seconds Set to Code 2.
9	Code defining the unit of measure for the (vertical) elevation coordinates throughout the file.	INTEGER*2	I6	Code 1 = feet 2 = metres Set to Code 2.
10	Number of sides in the polygon that defines the coverage of the file.	INTEGER*2	I6	Usually n = 4

Data Elmnt	Contents	Format (Fortran)	ASCII (Fortran)	Comments
11	A 4,2 array containing the ground coordinates of the four corners of the file.	REAL*8	4(2D24.15)	The coordinates of the quadrangle corners are ordered clockwise beginning with the southwest corner. The array is stored row-wise as pairs northings and eastings.
12	A two-element array containing minimum and maximum elevations for the file.	REAL*8	2D24.15	The values are in the unit of measure given by data element 9 in this record (min., max.).
13	Counterclockwise angle (in radians) from the primary axis of the ground horizontal reference to the primary axis of the horizontal local reference system.	REAL*8	D24.15	Normally set to zero to align with the coordinate system specified in element 5. Expressed in radians.
14	Accuracy code for elevations	INTEGER*2	I6	When set to 0, this indicates that a record does not exist and that no Type C record will follow. Always “0” because there is no “C” record for this product.
15	A three-element array containing spatial resolution (x,y,z). Units of measure for these resolution elements are consistent with those indicated by data elements 8 and 9 in this record.	REAL*4	3E12.6	These elements are set to 25,25,1. These units should not be confused with data accuracy.
16	A two-element array Containing the number of rows and columns (m,n) of profiles in the file.	INTEGER*2	I6	Normally, the row value m is set to 1. Thus, the n value normally describes the number of columns in the file.
17	Largest primary contour interval.	INTEGER*2	I5	Present only if two or more primary intervals exist. This field is left empty.

Data Elmnt	Contents	Format (Fortran)	ASCII (Fortran)	Comments
18	Largest source contour interval unit.	INTEGER*1	I1	Correspond to the unit of the NTDB largest primary contour interval 0 = NA, 1 = Feet, 2= Metres. This field is left empty.
19	Smallest primary contour interval.	INTEGER*2	I5	Smallest or only primary contour interval. This field is left empty.
20	Smallest source contour interval unit.	INTEGER*1	I1	Corresponds to the unit of the smallest primary contour interval. 1 = feet, 2 = metres . This field is left empty.
21	Data source date.	INTEGER*2	I4	YYMM: two-digit year and two-digit month. MM = 00 for source having year only. This field is left empty.
22	Data inspection/revision date	INTEGER*2	I4	YYMM: two-digit year and two-digit month. This field is left empty.
23	Inspection/revision flag	ALPHA*1	A1	"I" or "R". This field is left empty.
24	Data validation flag	INTEGER*1	I1	0 = No validation performed 1 = RMSE computed from test points, no quantitative test, no interactive editing or review. 2 = Batch process waterbody edit and RMSE computed from test points. 3 = Review and edit, including water edit; no RMSE computed from test points. 4 = Reviewed and edited. Includes waterbody editing RMSE computed from test points. Set to 2.
25	Suspect and void area flag	INTEGER*1	I2	Code 0 = none 1 = suspect areas 2 = void areas 3 = suspect and void areas This field is left empty.
26	Vertical datum	INTEGER*1	I2	1 = local Mean Sea Level (MSL) 2 = National Geodetic Vertical Datum 1929 (NGVD 29) 3 = North American Vertical Datum 1988 (NAVD 88) Set to "1" .

Data Elmnt	Contents	Format (Fortran)	ASCII (Fortran)	Comments
27	Horizontal datum	INTEGER*1	I2	Code 1 = NAD27 2 = WGS72 3 = WGS84 4 = NAD83 This field is set to "4" .
28	Data edition	INTEGER*2	I4	Normally set to 1. This field is left empty.
29	Percent void	INTEGER*2	I4	If element 25 indicates a void, this field (right justified) contains the percentage of nodes in the files set to void. This field is left empty.
30	Edge-match flag	INTEGER*1	4I2	Edge-match status flag. Ordered West, North, East, and South. Explanation of codes: 1 = Edge-Matched 3 = Edge is external, no match required This field is left empty.
31	Vertical datum shift	REAL*8	F7.2	Vertical datum shift; normally set to 0. This field is left empty.

The following table describes the Type B record for the BC DEM file and the default values which are expected for the various fields.

Data Elmnt	Contents	Format (Fortran)	ASCII (Fortran)	Comments
1	A two-element array containing the row and column identification number of the CDED profile contained in this record.	INTEGER*2	2I6	The identification number ranges from 1 to m (rows) and from 1 to n (columns or profiles). Rows are normally set to 1 and should be Disregarded. The column identification is the profile sequence number.
2	A two-element array containing the number of rows and columns (m,n) of elevations in the profile.	INTEGER*2	2I6	This first element in the field corresponds to the number of rows or nodes in the profile. The second element in this field is normally set to 1, specifying 1 column per profile.
3	A two-element array containing the ground horizontal coordinates of the first elevation in the profile.	REAL*8	2D24.15	Ground horizontal coordinates according to element 8 in Logical Record Type A.
4	Elevation of local vertical datum for the profile.	REAL*8	D24.15	The values are in the units of measure given by data element 9 in Logical Record Type A. Set to 0.
5	A two-element array of minimum and maximum elevations for the profile.	REAL*8	2D24.15	The values are in the units of measure given by data element 9 in Logical Record Type A.
6	The array of m x n elevations for the profile. Elevations are expressed in units of resolution elements (metres).	INTEGER*2	mn (I6)	A value in this array would be multiplied by the spatial resolution value and added to the elevation of the local elevation datum for the profile to obtain the elevation for the point.

4.2 ESRI ASCII Grid

The ESRI Grid format is a simple ASCII format which includes several lines of spatial location and meta-data information as a header, followed by a stream of numeric information giving the pixel values.

Line #	Description	Format	Example
1	Number of columns in raster.	ncols <Number>	ncols 532
2	Number of rows in raster.	nrows <Number>	nrows 484
3	X coordinate of lower-left corner of file.	xllcorner <Number>	xllcorner 1248100
4	Y coordinate of the lower-left corner of file.	yllcorder <Number>	yllcorner 1229750
5	Cell size of the grid.	cellsize <Number>	Cellsize 25
6	Numeric value to use as the indicator of "no data" in a pixel.	NODATA_value <Number>	NODATA_value –9999
7-(nrows+7)	Elevation values. Starting at the top left corner of the raster and proceeding from left to right. One line for each row in the raster.	<Number> <Number> <Number> <Number> (Space-separated numeric values)	661 661 670 679 691 701 702

Example of the header and values of a very small ESRI ASCII grid.

```
ncols 5
nrows 4
xllcorner 1248100
yllcorner 1229750
cellsize 25
NODATA_value –9999
661 661 670 679 691
701 702 703 703 703
703 703 702 702 702
702 702 702 701 701
```

4.3 TIFF / TFW

The TIFF/TFW format is a paired "image and world" file format, where the image is a standard image format without geo-location information, and the "world file" is a small text file providing information about the spatial location, orientation and pixel size of the image file.

The TIFF file is a standard full-colour uncompressed TIFF image. TIFF file specifications are available online at http://www.libtiff.org/document.html.

The TFW file is a 6 line ASCII file with one numeric parameter on each line. The lines are as follows:

Line #	Description	Example
1	Pixel size in the X direction.	25
2	Rotation in the X direction (always zero)	0.0
3	Rotation in the Y direction (always zero)	0.0
4	Pixel size in the Y direction (always negative)	-25
5	X coordinate of the upper left corner of the image.	1223600
6	Y coordinate of the upper left corner of the image.	1683050

Example of a TFW file:

```
25
0.0
0.0
–25
122360
1683050
```

5 FILE NAMING

The generic file naming scheme is as follows:

block-projection-variant.type

All file names are completely in **lower case**.

The possible values of each file name component are as follows:

Component	**Description**	**Values**
BLOCK	The unpadded NTS 250K block number of the file.	For example: 92b, 104p, 114o
PROJECTION	The projection the file is in.	utm albers
VARIANT	The kind of data within the file.	elevation slope-pct slope-deg aspect hillshd-bw-315 hillshd-bw-225 hillshd-clr-315 hillshd-clr-225
TYPE	The format of the file.	dem asc tif tfw

For example, a complete set of BC DEM product files for NTS block 104p would consist of:

File Name	Description
104p-utm-elevation.dem	UTM Elevation (USGS DEM Format)
104p-utm-elevation.asc	UTM Elevation (ASCII Format)
104p-utm-slope-pct.asc	UTM Slope in Percentage
104p-utm-slope-deg.asc	UTM Slope in Degrees
104p-utm-aspect.asc	UTM Aspect
104p-utm-hillshd-bw-315.tif 104p-utm-hillshd-bw-315.tfw	UTM 315° Black and White Hill-shade
104p-utm-hillshd-bw-225.tif 104p-utm-hillshd-bw-225.tfw	UTM 225° Black and White Hill-shade
104p-utm-hillshd-clr-315.tif 104p-utm-hillshd-clr-315.tfw	UTM 315° Coloured Hill-shade
104p-utm-hillshd-clr-225.tif 104p-utm-hillshd-clr-225.tfw	UTM 225° Coloured Hill-shade
104p-albers-elevation.dem	Albers Elevation (USGS DEM Format)
104p-albers-elevation.asc	Albers Elevation (ASCII Format)
104p-albers-slope-pct.asc	Albers Slope in Percentage
104p-albers-slope-deg.asc	Albers Slope in Degrees
104p-albers-aspect.asc	Albers Aspect
104p-albers-hillshd-bw-315.tif 104p-albers-hillshd-bw-315.tfw	Albers 315° Black and White Hill-shade
104p-albers-hillshd-bw-225.tif 104p-albers-hillshd-bw-225.tfw	Albers 225° Black and White Hill-shade
104p-albers-hillshd-clr-315.tif 104p-albers-hillshd-clr-315.tfw	Albers 315° Coloured Hill-shade
104p-albers-hillshd-clr-225.tif 104p-albers-hillshd-clr-225.tfw	Albers 225° Coloured Hill-shade