Toitu te whenua
Land Information New Zealand

Standard for Ross Sea Region Geodetic Datum 2000 Projections

LINZS25008

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TERMS AND DEFINITIONS

For the purposes of this standard, the following terms and definitions apply.

Term / abbreviation	Definition
coordinate	any one of a set of numbers used in specifying the location of a point on a line, in space, or on a given plane or other surface (for example, latitudes and longitudes are coordinates of a point on the Earth's surface)
coordinate system	a system for allocating coordinates to points in space in some specified way in relation to designated axes, planes, or surfaces. The simplest coordinate system consists of orthogonal coordinate axes, known as a Cartesian coordinate system
datum	a particular type of reference system in which coordinates are defined in relation to a particular reference surface by means of distances or angles, or both
ellipsoid	a surface formed by the rotation of an ellipse about a main axis. For the purposes of this standard, the ellipsoids used are oblate to match the general shape of the Earth. An oblate ellipsoid is one in which the semi-minor axis of the ellipse is the axis of revolution
Lambert Conformal Conic projection	a conformal conic projection in which geographic meridians are represented by straight lines which meet at the projection of the pole and geographic parallels are represented by a series of arcs of circles with this point as their centre
origin	the point from which the computation of a projection is evaluated
Polar stereographic projection	an azimuthal projection where a curved surface is projected onto a plane from a single point located at the Earth's pole diametrically opposite the hemisphere being projected (for example, southern hemisphere projections are projected from the north pole)
projection	a systematic method of representing the whole or part of the curved surface of the Earth upon another, usually flat, surface
Ross Sea Region	for the purposes of this standard Ross Sea Region includes the Ross Sea and that area bounded between longitudes 160° East and 150° West and south of latitude 60° South
RSRGD2000	Ross Sea Region Geodetic Datum 2000

Symbol	Definition
a	semi-major axis of reference ellipsoid
f^{-1}	inverse flattening of reference ellipsoid
E	Easting ordinate of computation point
E_0	false Easting of projection
k	point scale factor
k_0	scale factor at natural origin
N	Northing ordinate of computation point
N_0	false Northing of projection
γ	grid convergence
ϕ	latitude of computation point
ϕ_0	origin latitude
ϕ_1	latitude of the first standard parallel
ϕ_2	latitude of the second standard parallel
λ	longitude of computation point
λ_0	origin longitude

FOREWORD

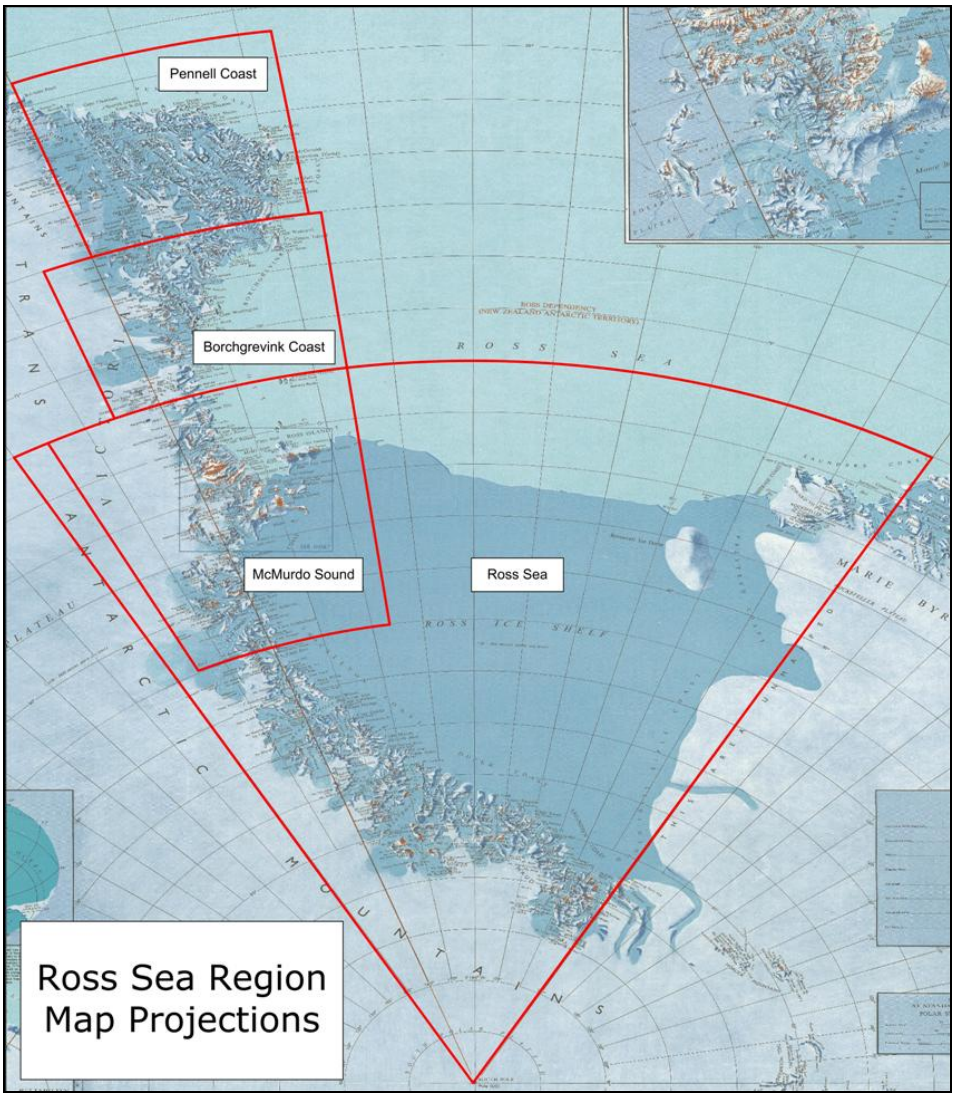
Introduction

A national geodetic system is a fundamental component of a nation's infrastructure. The unique property of a geodetic system is its ability to allow the integration of multiple geographically dependent data sources into a single geographic reference frame.

A fundamental element of a geodetic system is a geodetic datum. To enable data collected in terms of a geodetic datum to be portrayed on a map, map projections are required.

Purpose of standard

The purpose of this standard is to define map projections, shown below, for the Ross Sea Region in terms of the Ross Sea Region Geodetic Datum 2000.



Brief history of standard

This standard replaces:

(a) LINZ 2011, *LINZS25008: Standard for Ross Sea Region Geodetic Datum 2000 Projections*, Office of the Surveyor-General, LINZ, Wellington.

The standard replaces the explicit spatial extents of each projection with guidance on their recommended areas of use contained in the above standard, which was published on 21 March 2011.

(b) LINZ 2008, *LINZS25007: Standard for Darwin Glacier Lambert Conformal 2000 Projection*, Office of the Surveyor-General, LINZ, Wellington.

References

LINZ 2007, *LINZS25001: Standard for Ross Sea Region Geodetic Datum 2000*, Office of the Surveyor-General, LINZ, Wellington.

Moritz, H. 2000, *Geodetic Reference System 1980*, Journal of Geodesy, vol. 74, no. 1, pp. 128-133.

1 Scope

This standard defines several map projections in terms of RSRGD2000. These projections can be used for the provision and display of topographic and hydrographic data within the Ross Sea Region.

2 Intended use of standard

Spatial data provided to and supplied by Land Information New Zealand (LINZ) must comply with this standard when it is referenced by map coordinates in terms of the RSRGD2000 projections.

This standard may be used by other users of spatial data. Any person claiming conformance with this standard must use the parameters defining RSRGD2000 map projections as specified in this standard.

3 Ross Sea Region Geodetic Datum 2000 projections

3.1 McMurdo Sound Lambert Conformal 2000

(a) Spatial data provided to and supplied by LINZ must conform to this standard when it is referenced by coordinates in terms of the McMurdo Sound Lambert Conformal 2000 projection (MSLC2000).

(b) The MSLC2000 parameters are:

Projection name:	McMurdo Sound Lambert Conformal 2000
Abbreviation:	MSLC2000
Projection type:	Lambert Conformal Conic
Reference ellipsoid:	Geodetic Reference System 1980 (Moritz 2000)
Datum:	RSRGD2000
First standard parallel:	76° 40’ 00” South
Second standard parallel:	79° 20’ 00” South
Origin latitude:	78° 00’ 00” South
Origin longitude:	163° 00’ 00” East
False Northing:	5,000,000 metres North
False Easting:	7,000,000 metres East

COMMENTARY

MSLC2000 extents

If the MSLC2000 is used between 76°S - 81°S and 153°E - 173°W, it will provide a scale distortion of less than 0.1%.

The MSLC2000 may be used outside the recommended bounds. Users should assess the distortion error for themselves to ascertain the suitability of MSLC2000 to represent their data.

3.2 Borchgrevink Coast Lambert Conformal 2000

(a) Spatial data provided to and supplied by LINZ must conform to this standard when it is referenced by coordinates in terms of the Borchgrevink Coast Lambert Conformal 2000 projection (BCLC2000).

(b) The BCLC2000 parameters are:

Projection name:	Borchgrevink Coast Lambert Conformal 2000
Abbreviation:	BCLC2000
Projection type:	Lambert Conformal Conic
Reference ellipsoid:	Geodetic Reference System 1980 (Moritz 2000)
Datum:	RSRGD2000
First standard parallel:	73° 40’ 00” South
Second standard parallel:	75° 20’ 00” South
Origin latitude:	74° 30’ 00” South
Origin longitude:	165° 00’ 00” East
False Northing:	3,000,000 metres North
False Easting:	5,000,000 metres East

COMMENTARY

BCLC2000 extents

If the BCLC2000 is used between 73°S - 76°S and 157°E - 173°W, it will provide a scale distortion of less than 0.02%.

The BCLC2000 may be used outside the recommended bounds. Users should assess the distortion error for themselves to ascertain the suitability of BCLC2000 to represent their data.

3.3 Pennell Coast Lambert Conformal 2000

(a) Spatial data provided to and supplied by LINZ must conform to this standard when it is referenced by coordinates in terms of the Pennell Coast Lambert Conformal 2000 projection (PCLC2000).

(b) The PCLC2000 parameters are:

Projection name:	Pennell Coast Lambert Conformal 2000
Abbreviation:	PCLC2000
Projection type:	Lambert Conformal Conic
Reference ellipsoid:	Geodetic Reference System 1980 (Moritz 2000)
Datum:	RSRGD2000
First standard parallel:	70° 40’ 00” South
Second standard parallel:	72° 20’ 00” South
Origin latitude:	71° 30’ 00” South
Origin longitude:	166° 00’ 00” East
False Northing:	1,000,000 metres North
False Easting:	3,000,000 metres East

COMMENTARY

PCLC2000 extents

If the PCLC2000 is used between 69°30’S - 73°S and 160°E - 152°W, it will provide a scale distortion of less than 0.05%.

The PCLC2000 may be used outside the recommended bounds. Users should assess the distortion error for themselves to ascertain the suitability of PCLC2000 to represent their data.

3.4 Ross Sea Polar Stereographic 2000

(a) Spatial data provided to and supplied by LINZ must conform to this standard when it is referenced by coordinates in terms of the Ross Sea Polar Stereographic 2000 projection (RSPS2000).

(b) The RSPS2000 parameters are:

Projection name:	Ross Sea Polar Stereographic 2000
Abbreviation:	RSPS2000
Projection type:	Polar Stereographic
Reference ellipsoid:	Geodetic Reference System 1980 (Moritz 2000)
Datum:	RSRGD2000
Scale factor at natural origin:	0.994
Latitude of natural origin:	90° 00’ 00” South
Origin longitude:	180° 00’ 00” East
False Northing:	1,000,000 metres North
False Easting:	5,000,000 metres East

COMMENTARY

RSPS2000 extents

If the RSPS2000 is used between 76°S - 90°S and 150°E - 150°W, it will provide a scale distortion of less than 0.8%.

The RSPS2000 may be used north of 76°S; however, users should assess the applicable scale distortion for themselves to ascertain the suitability of RSPS2000 to represent their data.

The RSPS2000 is centred on 180°E/W to provide a 'New Zealand up' projection. It may be used outside the 150°E – 150°W bounds to display regional datasets without any longitudinal induced distortion.

Appendix A: Lambert conformal coordinate conversion formulas

A.1 Preliminary computations

This section provides formulas to convert coordinates between geographic and the Lambert Conformal Conic projection.

$$e = \sqrt{2f - f^2}$$

$$m = \frac{\cos\phi}{\sqrt{1 - e^2 \sin^2\phi}} \text{ where } m_1 \text{ and } m_2 \text{ are calculated from } \phi_1 \text{ and } \phi_2$$

$$t = \frac{\tan\left[\left(\frac{\pi}{4}\right) - \left(\frac{\phi}{2}\right)\right]}{\left(\frac{1 - e\sin\phi}{1 + e\sin\phi}\right)^{\frac{e}{2}}} \text{ where } t_0, t_1 \text{ and } t_2 \text{ are calculated from } \phi_0, \phi_1 \text{ and } \phi_2$$

$$n = \frac{\ln m_1 - \ln m_2}{\ln t_1 - \ln t_2}$$

$$F = \frac{m_1}{n t_1^n}$$

$$\rho_0 = aF t_0^n$$

COMMENTARY

RSRGD2000 parameters

The following RSRGD2000 parameters are defined in *LINZS25001: Standard for the Ross Sea Region Geodetic Datum 2000*:

a	6,378,137 metres
f^{-1}	298.275 222 101

A.2 Formulas for conversion from geographic coordinates to Lambert Conformal Conic projection coordinates

This section provides formulas to convert geographical coordinates (eg latitude and longitude) to Lambert Conformal Conic projection coordinates (eg Northing and Easting).

$$t = \frac{\tan\left[\left(\frac{\pi}{4}\right) - \left(\frac{\phi}{2}\right)\right]}{\left(\frac{1 - e\sin\phi}{1 + e\sin\phi}\right)^{\frac{e}{2}}}$$

$$\rho = aFt^{n}$$

$$m = \frac{\cos\phi}{\sqrt{1 - e^{2}\sin^{2}\phi}}$$

Grid convergence

Grid convergence is the angle at a point between true and grid North. It is positive when grid North lies to the West of true North.

$$\gamma = n\left(\lambda - \lambda_{0}\right)$$

Longitude conversion

$$E = E_{0} + \rho \sin\gamma$$

Latitude conversion

$$N = N_{0} + \rho_{0} - \rho\cos\gamma$$

Point scale factor

$$k = \frac{m_{1}\left(t\right)^{n}}{m\left(t_{1}\right)^{n}}$$

A.3 Formulas for conversion from Lambert Conformal Conic projection coordinates to geographic coordinates

This section provides formulas to convert Lambert Conformal Conic projection coordinates (eg Northing and Easting) to geographical coordinates (eg latitude and longitude).

$$\rho' = \pm\sqrt{(E')^2 + (\rho_0 - N')^2} \quad \text{where } \rho' \text{ takes the sign of } n$$

$$E' = E - E_0 \qquad \sqrt{}$$

$$N' = N - N_0$$

$$t' = \left(\frac{\rho'}{aF}\right)^{\frac{1}{n}}$$

$$m = \frac{\cos\phi}{\sqrt{1 - e^2 \sin^2\phi}}$$

Grid convergence

Grid convergence is the angle at a point between true and grid North. It is positive when grid North lies to the West of true North.

$$\gamma' = \text{atan}\left(\frac{E'}{\rho_0 - N'}\right)$$

Easting conversion

$$\lambda = \frac{\gamma'}{n} + \lambda_0$$

Northing conversion

$$\phi = \frac{\pi}{2} - 2\ \text{atan}\left(t'\left[\frac{1 - e\ \sin\phi}{1 + e\ \sin\phi}\right]^{\frac{e}{2}}\right)$$

which is solved iteratively, the initial value of ϕ is

$$\phi = \frac{\pi}{2} - 2\,\text{atan}\left(t'\right)$$

Point scale factor

$$k = \frac{m_1 (t')^n}{m (t_1)^n}$$

Appendix B: Polar stereographic coordinate conversion formulas

B.1 Preliminary computations

This section provides formulas to convert coordinates between geographic and the polar stereographic projection.

$$e = \sqrt{2f - f^2}$$

$$H = \left(\frac{1-e}{1+e}\right)^{\frac{e}{2}}$$

COMMENTARY

RSRGD2000 parameters

The following RSRGD2000 parameters are defined in *LINZS25001: Standard for the Ross Sea Region Geodetic Datum 2000*:

a	6,378,137 metres
f^{-1}	298.275 222 101

B.2 Formulas for conversion from geographic coordinates to polar stereographic projection coordinates

This section provides formulas to convert geographical coordinates (eg latitude and longitude) to polar stereographic projection coordinates (eg Northing and Easting).

$$t = \frac{\tan\left[\left(\frac{\pi}{4}\right) - \left(\frac{\phi}{2}\right)\right]}{\left(\frac{1 - e\sin\phi}{1 + e\sin\phi}\right)^{\frac{e}{2}}}$$

$$\rho = \frac{2\,a\,k_0\,t}{\sqrt{(1+e)^{(1+e)}\,(1-e)^{(1-e)}}}$$

$$m = \frac{\cos\phi}{\sqrt{1 - e^2\sin^2\phi}}$$

Grid convergence

Grid convergence is the angle at a point between true and grid North. It is positive when grid North lies to the West of true North.

$$\gamma = \lambda - \lambda_0$$

Longitude conversion

$$E = E_0 + \rho\,\sin\gamma$$

Latitude conversion

$$N = N_0 + \rho\,\cos\gamma$$

Point scale factor

$$k = \frac{2\,k_0\,H\,t}{m\,(1-f)}$$

B.3 Formulas for conversion from polar stereographic projection coordinates to geographic coordinates

This section provides formulas to convert polar stereographic projection coordinates (eg Northing and Easting) to geographical coordinates (eg latitude and longitude).

$$\rho' = \sqrt{\left(E - E_0\right)^2 + \left(N - N_0\right)^2}$$

$$t' = \frac{\rho' \sqrt{\left(1+e\right)^{\left(1+e\right)} \left(1-e\right)^{\left(1-e\right)}}}{2\,a\,k_0}$$

$$\chi = 2\ \text{atan}\left(t'\right) - \frac{\pi}{2}$$

$$m = \frac{\cos\phi}{\sqrt{1 - e^2 \sin^2\phi}}$$

Grid convergence

Grid convergence is the angle at a point between true and grid North. It is positive when grid North lies to the West of true North.

$$\gamma' = \text{atan}\left[\frac{E - E_0}{N - N_0}\right]$$

Easting conversion

$\lambda = \lambda_0 + \gamma'$ except where $E = E_0$, then $\lambda = \lambda_0$

Northing conversion

$$\phi = \chi + \left(\frac{e^2}{2} + \frac{5e^4}{24} + \frac{e^6}{12} + \frac{13e^8}{360}\right)\sin\left(2\chi\right) + \left(\frac{7e^4}{48} + \frac{29e^6}{240} + \frac{811e^8}{11520}\right)\sin\left(4\chi\right) + \left(\frac{7e^6}{120} + \frac{81e^8}{1120}\right)\sin\left(6\chi\right) + \left(\frac{4279e^8}{161280}\right)\sin\left(8\chi\right)$$

Point scale factor

$$k = \frac{2\,k_0\,H\,t}{m\left(1-f\right)}$$