Equations and Parameters for Wisconsin Coordinate Systems
WLIA Wisconsin County Coordinate System Task Force
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Sec *Content*

A. Introduction

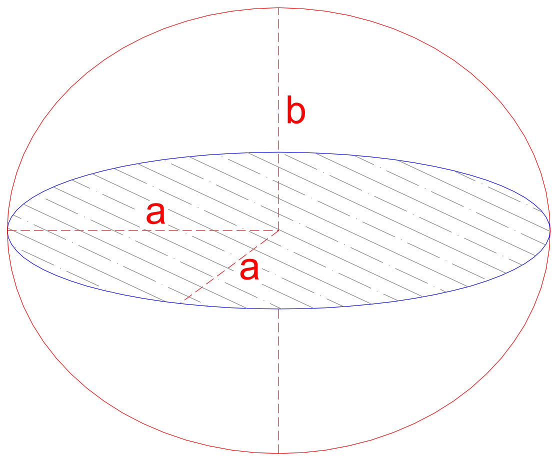
The purpose of this document is to assemble in a single location all equations and parameters for formally recognized Wisconsin coordinate systems. This includes County Coordinate and Wisconsin Transverse Mercator Systems as well as the more traditional State Plane and Universal Transverse Mercator Systems.

The equations in **Section C** are taken from NOAA Manual NOS NGS 5 *State Plane Coordinate System of 1983* by James Stem. Variable names and conventions are as they appear in the original document. The document is on line at:
  http://www.ngs.noaa.gov/PUBS_LIB/ManualNOSNGS5.pdf

Parameters for the Wisconsin Transverse Mercator and County Systems are taken from *Wisconsin Coordinate Systems* published by the Wisconsin State Cartographer's Office. Some nomenclature was modified to be consistent with the NGS equations. The publication is on line at:
  http://www.geography.wisc.edu/sco/pubs/wiscoord/wiscoord.php

B. Ellipsoids

B.1. Ellipsoid Nomenclature and Equations



a Semimajor axis of the ellipsoid

b Semiminor axis of the ellipsoid

f Flattening of the ellipsoid

e First eccentricity of the ellipsoid

e' Second eccentricity of the ellipsoid

Geometric relationships:

$$f = \frac{(a-b)}{a}$$

$$e^2 = \frac{(a^2 - b^2)}{a^2} = (2f - f^2)$$

$$e'^2 = \frac{(a^2 - b^2)}{b^2} = \frac{e^2}{(1-e^2)}$$

B.2. Reference Ellipsoids

parameter	*Clarke 1866*	*GRS 80*
a	6,378,206.4 m *(exact)*	6,378,137 m *(exact)*
b	6,356,358.8 m *(exact)*	6,356,752.3141403 m
Datum	NAD 27	NAD 83

C. Coordinate Conversion Equations

C.1. Methodology

Conversions:

Direct - geodetic (ϕ/λ) to grid (N/E or X/Y) coordinates.

Inverse - grid (N/E or X/Y) to geodetic (ϕ/λ) coordinates.

Parameters for the different Wisconsin systems are given in **Section D**. Parameters are considered exact.

The conversion equations are written to use west longitudes as positive values.

Equations to compute convergence and scale are given for both Direct and Inverse conversions. Scale and convergence correspond to the grid coordinate system being converted *to* (Direct) or *from* (Inverse).

For NAD 27 conversions Clarke 1866 ellipsoid parameters must be used; NAD 83 conversions use those of GRS 80. County Systems use modified GRS 80 values. These are described in **Section D.4.**

C.2. Lambert Conformal Conic Grid Mapping Equations

C.2.1. Notation and Definitions

ϕ	Parallel of geodetic latitude, positive north.
ϕ_s	Southern standard latitude.
ϕ_n	Northern standard latitude.
ϕ_o	Central parallel, the latitude of the true projection origin.
ϕ_b	Latitude of the grid origin.
λ	Meridian of geodetic longitude, positive west.
λ_o	Central meridian, longitude of the true and grid origin.
k	Grid scale factor at a general point.
k_0	Grid scale factor at the central parallel ϕ_o .
γ	Convergence angle.
N	Northing coordinate.

N_b The northing value for ϕ_b at the central meridian (the grid origin). Sometimes identified as the false northing.

N_o Northing value at the intersection of the central meridian with the central parallel (the true projection origin).

E Easting coordinate.

E_o The easting value at the central meridian λ_o. Sometimes identified as the false easting.

R Mapping radius at latitude ϕ.

R_b Mapping radius at latitude ϕ_b.

R_o Mapping radius at latitude ϕ_o.

K Mapping radius at the equator.

Q Isometric latitude.

a Semimajor axis of the ellipsoid.

b Semiminor axis of the ellipsoid.

f Flattening of the ellipsoid.

e First eccentricity of the ellipsoid.

C.2.2. Computing Zone/System Constants

Design parameters are used to compute constants for each zone or system. The linear unit is the same as that used for ellipsoid parameters (a and b) and the grid origin (N_b and E_o).

$$Q_s = \frac{1}{2}\left[ln\left(\frac{1+\sin\phi_s}{1-\sin\phi_s}\right) - e\ ln\left(\frac{1+e\sin\phi_s}{1-e\sin\phi_s}\right)\right]$$

$$W_s = \left(1-e^2\sin^2\phi_s\right)^{1/2}$$

Similarly for Q_n, W_n, Q_b, Q_o, and W_o upon substitution of the appropriate latitude.

$$\sin\phi_o = \frac{ln\left(\frac{W_n\cos\phi_s}{W_s\cos\phi_n}\right)}{Q_n - Q_s}$$

$$K = \frac{a\cos\phi_s\exp\left(Q_s\sin\phi_o\right)}{W_s\sin\phi_o} = \frac{a\cos\phi_n\exp\left(Q_n\sin\phi_o\right)}{W_n\sin\phi_o}$$

Note: $\exp(x) = \epsilon^x$
where ϵ=2.718281828... (the base of natural logarithms)

$$R_b = \frac{K}{\exp\left(Q_b \sin\phi_o\right)}$$

$$R_0 = \frac{K}{\exp\left(Q_o \sin\phi_o\right)}$$

$$k_o = \frac{\left(W_o \tan\phi_o R_o\right)}{a}$$

$$N_o = R_b + N_b - R_o$$

C.2.3. Direct Conversion

Geodetic to grid coordinates. Scale factor (k) and convergence angle (γ) are for the grid coordinate location.

$$Q = \frac{1}{2}\left[ln\left(\frac{1+\sin\phi}{1-\sin\phi}\right) - e\, ln\left(\frac{1+e\sin\phi}{1-e\sin\phi}\right)\right]$$

$$R = \frac{K}{\exp\left(Q \sin\phi_o\right)}$$

$$\gamma = \left(\lambda_o - \lambda\right)\sin\phi_o$$

$$N = R_b + N_b - R\cos\gamma$$

$$E = E_o + R\sin\gamma$$

$$k = \left(1 - e^2 \sin^2\phi\right)^{1/2} \frac{\left(R\sin\phi_o\right)}{\left(a\cos\phi\right)}$$

C.2.4. Inverse Conversion

Grid to geodetic coordinates. Scale factor (k) and convergence angle (γ) are for the grid coordinate location.

$$R' = R_b - N + N_b$$
$$E' = E - E_o$$
$$\gamma = \tan^{-1}\left(E'/R' \right)$$
$$\lambda = \lambda_o - \left(\gamma / \sin\phi_o \right)$$
$$R = \left(R'^2 + E'^2 \right)^{1/2}$$
$$Q = \frac{ln\left(K/R \right)}{\sin\phi_o}$$

Latitude computation is iterative. Solve as follows:

- Start with the approximation:

$$\sin\phi = \frac{\exp(2Q) - 1}{\exp(2Q) + 1}$$

- Compute a correction of $(-f_1/f_2)$ from:

$$f_1 = \frac{1}{2}\left[ln\left(\frac{1+\sin\phi}{1-\sin\phi} \right) - e\, ln\left(\frac{1+e\sin\phi}{1-e\sin\phi} \right) \right] - Q$$
$$f_2 = \left(\frac{1}{1-\sin^2\phi} \right) - \left(\frac{e^2}{1-e^2\sin^2\phi} \right)$$

- Add the correction to sin ϕ to obtain a new sin ϕ.

- Repeat twice more (for a total of three corrections), then solve ϕ .

Grid scale is computed from:

$$k = \left(1 - e^2 \sin^2\phi \right)^{1/2} \frac{\left(R \sin\phi_o \right)}{\left(a \cos\phi \right)}$$

C.3. Transverse Mercator Cylindric Mapping Equations

C.3.1. Notation and Definitions

ϕ	Geodetic latitude, positive north.
λ	Geodetic longitude, positive west.
ω	Rectifying latitude.
N	Northing coordinate on the projection.
E	Easting coordinate on the projection.
λ_o	Central Meridian.
E_o	False easting (value assigned to the central latitude).
S	Meridional distance.
ϕ_o	Latitude of grid origin.
N_o	False northing (value assigned to the latitude of grid origin).
S_o	Meridional distance from the equator to ϕ_o multiplied by the central meridian scale factor.
k_o	Grid scale factor assigned to the central meridian.
k	Grid scale factor at a point.
γ	Meridian convergence.
a	Semimajor axis of the ellipsoid.
b	Semiminor axis of the ellipsoid.
f	Flattening of the ellipsoid.
e^2	First eccentricity of the ellipsoid squared.
e'^2	Second eccentricity of the ellipsoid squared.
R	Radius of curvature in the prime vertical.
r_o	Geometric mean radius of curvature scaled to the grid.
r	Radius of the rectifying sphere.

C.3.2. Computing Zone/System Constants

Design parameters are used to compute constants for each zone or system. The linear unit is the same as that used for ellipsoid parameters (a and b) and the grid origin (N_o and E_o).

$$n = \frac{a-b}{a+b} = \frac{f}{2-f}$$

$$r = a(1-n)(1-n^2)\left(1+\frac{9n^2}{4}+\frac{225n^4}{64}\right)$$

$\eta^2 = e'^2 \cos^2\phi$ (for any latitude, ϕ)

$$u_2 = -\frac{3n}{2}+\frac{9n^3}{16}$$

$$u_4 = \frac{15n^2}{16}-\frac{15n^4}{32}$$

$$u_6 = -\frac{35n^3}{48}$$

$$u_8 = \frac{315n^4}{512}$$

$$U_0 = 2(u_2 - 2u_4 + 3u_6 - 4u_8)$$

$$U_2 = 8(u_4 - 4u_6 + 10u_8)$$

$$U_4 = 32(u_6 - 6u_8)$$

$$U_6 = 128u_8$$

$$v_2 = \frac{3n}{2}-\frac{27n^3}{32}$$

$$v_4 = \frac{21n^2}{16}-\frac{55n^4}{32}$$

$$v_6 = \frac{151n^3}{96}$$

$$v_8 = \frac{1097n^4}{512}$$

$$V_0 = 2(v_2 - 2v_4 + 3v_6 - 4v_8)$$

$$V_2 = 8(v_4 - 4v_6 + 10v_8)$$

$$V_4 = 32(v_6 - 6v_8)$$

$$V_6 = 128v_8$$

$$\omega_o = \phi_o + \sin\phi_o \cos\phi_o \left(U_0 + U_2\cos^2\phi_o + U_4\cos^4\phi_o + U_6\cos^6\phi_o\right)$$

$$S_o = k_o\omega_o r$$

C.3.3. Direct Conversion

Geodetic to grid coordinates. Scale factor (k) and convergence angle (γ) are for the grid coordinate location.

$$L = (\lambda - \lambda_o)\cos\phi$$

$$\omega = \phi + \sin\phi\cos\phi\left(U_0 + U_2\cos^2\phi + U_4\cos^4\phi + U_6\cos^6\phi\right)$$

$$S = k_o \omega r$$
$$t = \tan\phi$$
$$\eta^2 = e'^2 \cos^2\phi$$
$$R = \frac{k_o a}{\left(1 - e^2 \sin^2\phi\right)^{1/2}}$$

$$A_1 = -R$$
$$A_2 = \frac{1}{2} R t$$
$$A_3 = \frac{1}{6}\left(1 - t^2 + \eta^2\right)$$
$$A_4 = \frac{1}{12}\left[5 - t^2 + \eta^2\left(9 + 4\eta^2\right)\right]$$
$$A_5 = \frac{1}{120}\left[5 - 18t^2 + t^4 + \eta^2\left(14 - 58t^2\right)\right]$$
$$A_6 = \frac{1}{360}\left[61 - 58t^2 + t^4 + \eta^2\left(270 - 330t^2\right)\right]$$
$$A_7 = \frac{1}{5040}\left(61 - 479t^2 + 179t^4 - t^6\right)$$

$$N = S - S_o + N_o + A_2 L^2\left[1 + L^2\left(A_4 + A_6 L^2\right)\right]$$
$$E = E_o + A_1 L\left[1 + L^2\left(A_3 + L^2\left(A_5 + A_7 L^2\right)\right)\right]$$

$$C_1 = -t$$
$$C_3 = \frac{1}{3}\left(1 + 3\eta^2 + 2\eta^4\right)$$
$$C_5 = \frac{1}{15}\left(2 - t^2\right)$$
$$F_2 = \frac{1}{2}\left(1 + \eta^2\right)$$
$$F_4 = \frac{1}{12}\left[5 - 4t^2 + \eta^2\left(9 - 24t^2\right)\right]$$

$$\gamma = C_1 L\left[1 + L^2\left(C_3 + C_5 L^2\right)\right]$$

$$k = k_o\left[1 + F_2 L^2\left(1 + F_4 L^2\right)\right]$$

C.3.4. Inverse Conversion

Grid to geodetic coordinates. Scale factor (k) and convergence angle (γ) are for the grid coordinate location.

$$\omega = \frac{\left(N - N_o + S_o\right)}{k_o r}$$

$$\phi_f = \omega + \left(\sin\omega\cos\omega\right)\left(V_0 + V_2\cos^2\omega + V_4\cos^4\omega + V_6\cos^6\omega\right)$$

$$t_f = \tan\phi_f$$

$$\eta_f{}^2 = e'^2\cos^2\phi_f$$

$$R_f = \frac{k_o a}{\left(1 - e^2\sin^2\phi_f\right)^{1/2}}$$

$$Q = \frac{\left(E - E_o\right)}{R_f}$$

$$B_2 = -\frac{1}{2} t_f\left(1 + \eta_f{}^2\right)$$

$$B_3 = -\frac{1}{6}\left(1 + 2t_f{}^2 + \eta_f{}^2\right)$$

$$B_4 = -\frac{1}{12}\left[5 + 3t_f{}^2 + \eta_f{}^2\left(1 - 9t_f{}^2\right) - 4\eta_f{}^4\right]$$

$$B_5 = \frac{1}{120}\left[5 + 28t_f{}^2 + 24t_f{}^4 + \eta_f{}^2\left(6 + 8t_f{}^2\right)\right]$$

$$B_6 = \frac{1}{360}\left[61 + 90t_f{}^2 + 45t_f{}^4 + \eta_f{}^2\left(46 - 252t_f{}^2 - 90t_f{}^4\right)\right]$$

$$B_7 = -\frac{1}{5040}\left(61 + 662t_f{}^2 + 1320t_f{}^4 + 720t_f{}^6\right)$$

$$L = Q\left[1 + Q^2\left(B_3 + Q^2\left(B_5 + B_7 Q^2\right)\right)\right]$$

$$\phi = \phi_f + B_2 Q^2\left[1 + Q^2\left(B_4 + B_6 Q^2\right)\right]$$

$$\lambda = \lambda_o - \frac{L}{\cos\phi_f}$$

$$D_1 = t_f$$

$$D_3 = -\frac{1}{3}\left(1 + t_f^{\ 2} - \eta_f^{\ 2} - 2\eta_f^{\ 4}\right)$$

$$D_5 = \frac{1}{15}\left(2 + 5t_f^{\ 2} + 3t_f^{\ 4}\right)$$

$$G_2 = \frac{1}{2}\left(1 + \eta_f^{\ 2}\right)$$

$$G_4 = \frac{1}{12}\left(1 + 5\eta_f^{\ 2}\right)$$

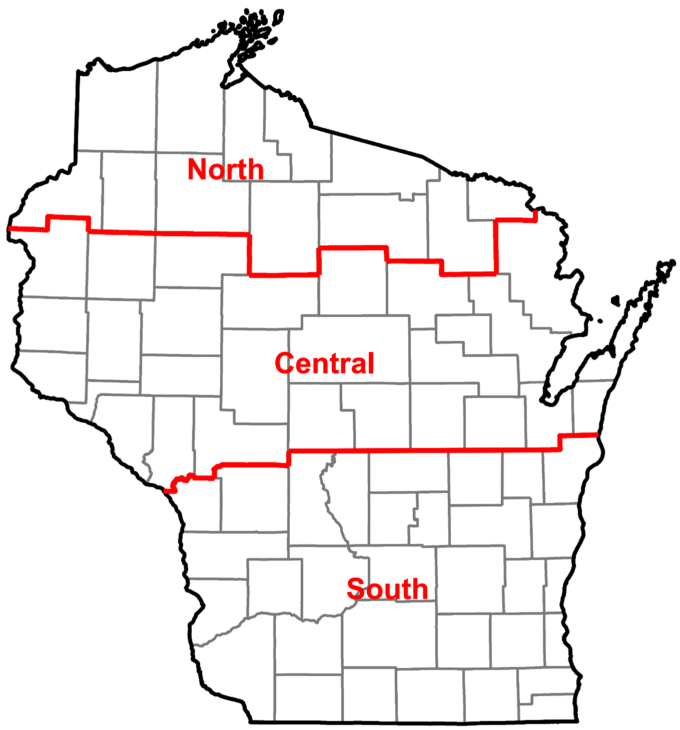
$$\gamma = D_1 Q\left[1 + Q^2\left(D_3 + D_5 Q^2\right)\right]$$

$$k = k_o\left[1 + G_2 Q^2\left(1 + G_4 Q^2\right)\right]$$

D. Wisconsin Coordinate Systems

D.1. State Plane

Wisconsin has three State Plane Coordinate (SPC) zones each based on a Lambert Conformal Conic projection. State Plane Coordinates are defined for NAD 27 and NAD 83 datums.



The following parameters are used in the **Section C.2.2** equations to generate respective zone constants.

Datum: NAD 27
Ellipsoid: Clarke 1866

	Zone	*North*	*Central*	*South*
	Code	4801	4802	4803
ϕ_s	South Std Par	45°34' N	44°15' N	42°44' N
ϕ_n	North Std Par	46°46' N	45°30' N	44°04' N
λ_o	Central Meridian	90°00' W	90°00' W	90°00' W
ϕ_b	Latitude of Origin	45°10' N	43°50' N	42°00' N
N_b	Origin Northing	0 ft	0 ft	0 ft
E_o	Origin Easting	2,000,000 ft	2,000,000 ft	2,000,000 ft

NAD 27 uses the US Survey foot (39.37 inches = 1 meter, exact) as the defining linear unit.

Datum: NAD 83
Ellipsoid: GRS 80

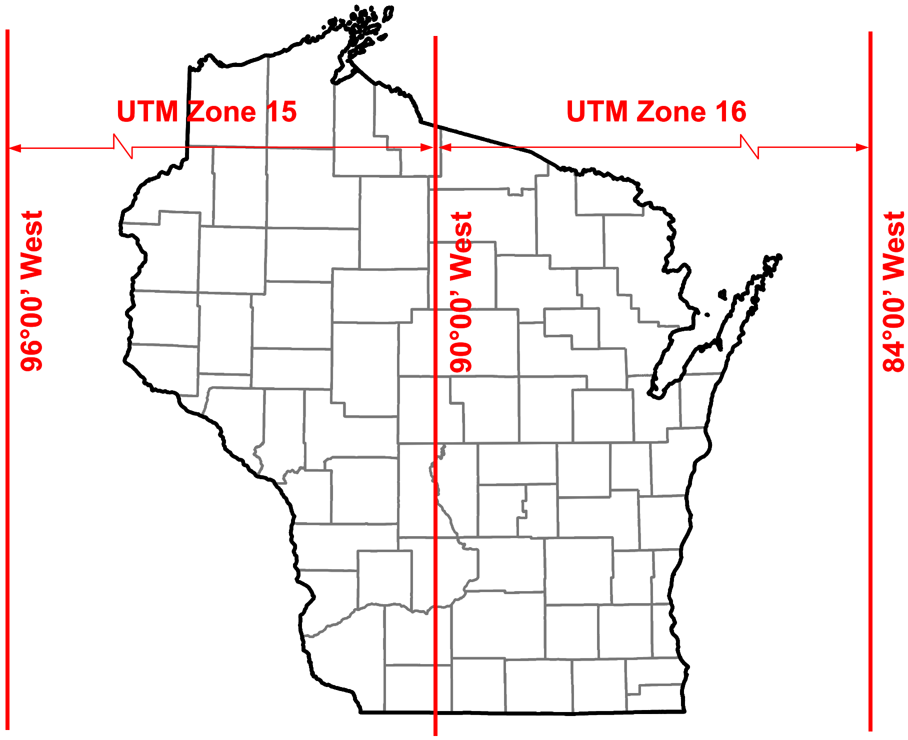
	Zone Code	*North* 4801	*Central* 4802	*South* 4803
ϕ_s	South Std Par	45°34' N	44°15' N	42°44' N
ϕ_n	North Std Par	46°46' N	45°30' N	44°04' N
λ_o	Central Meridian	90°00' W	90°00' W	90°00' W
ϕ_b	Latitude of Origin	45°10' N	43°50' N	42°00' N
N_b	Origin Northing	0 m	0 m	0 m
E_o	Origin Easting	600,000 m	600,000 m	600,000 m

NAD 83 datums use the meter as the defining linear unit.

The equations in **Sections C.2.3** and **C.2.4** are used to convert between Geodetic and State Plane coordinates.

D.2. Universal Transverse Mercator

Wisconsin is covered by two adjacent Universal Transverse Mercator (UTM) zones: 15 and 16.



UTM Zones are defined using the same parameters for both NAD 27 and NAD 83 datums:

	UTM Zone	*UTM 15N*	*UTM 16N*
λ_o	Central Meridian	93°00' W	87°00' W
ϕ_o	Latitude of Origin	0°00' N	0°00' N
N_o	Origin Northing	0 m	0 m
E_o	Origin Easting	500,000 m	500,000 m
k_o	Scale at Cen Mer	0.9996	0.9996

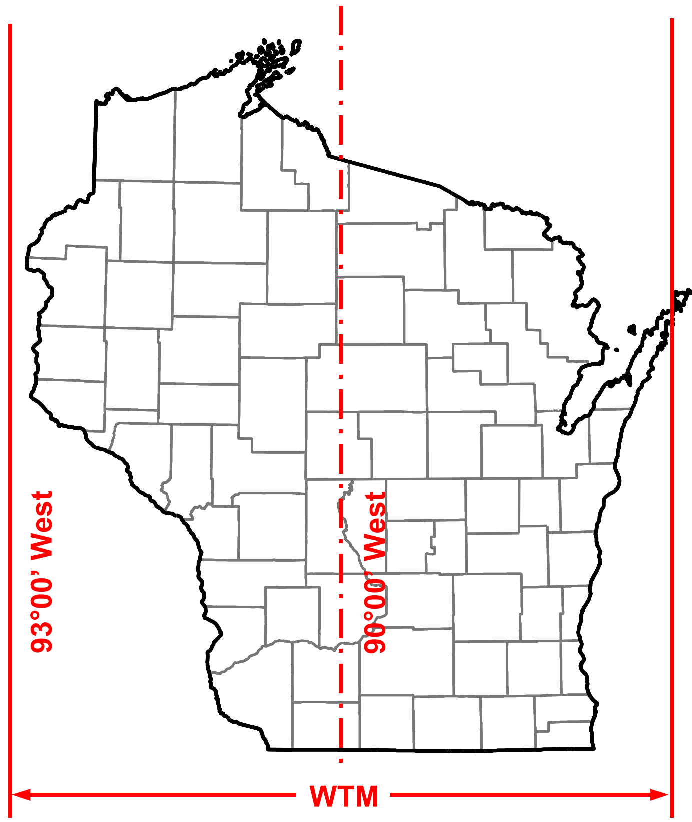
UTM systems use the meter as the defining linear unit.

The zone parameters along with corresponding ellipsoid values are used in the **Section C.3.2** equations to generate respective zone constants.

Equations in **Sections C.3.3** and **C.3.4** are used to convert between Geodetic and UTM grid coordinates.

D.3. Wisconsin Transverse Mercator

The Wisconsin Transverse Mercator (WTM) system is based on the UTM system with a shift to cover the state in one zone and an adjustment of the origin for more convenient local coordinate values.



WTM is defined for NAD 27 and NAD 83. A distinct "shift" of approximately 13 miles in northing and easting was introduced to the NAD 83 parameters to more easily distinguish the coordinate values:

		NAD 27	*NAD 83*
λ_o	Central Meridian	90°00' W	90°00' W
ϕ_o	Latitude of Origin	0°00' N	0°00' N
N_o	Origin Northing	-4,500,000 m	-4,480,000 m
E_o	Origin Easting	500,000 m	520,000 m
k_o	Scale at Cen Mer	0.9996	0.9996

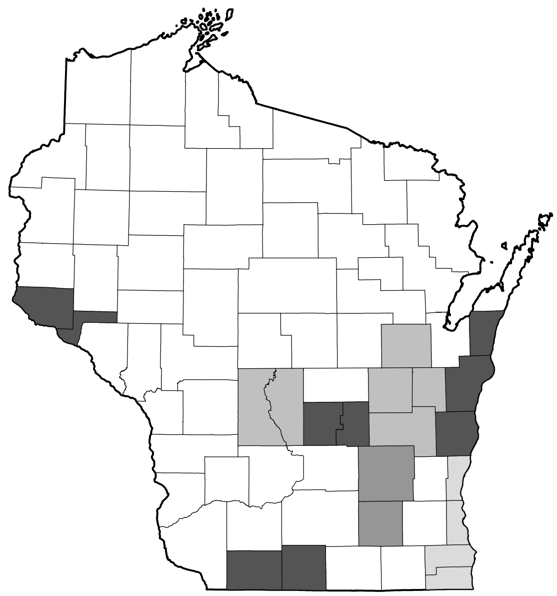
The WTM system uses the meter as the defining linear unit.

The appropriate parameters along with corresponding ellipsoid values are used in the **Section C.3.2** equations to generate respective constants.

D.4. County Coordinates

D.4.1. County Systems; Enlarged Ellipsoids

The Wisconsin County Coordinate System (WCCS) consists of 59 separate grid systems covering 72 counties.



Adjoining counties shown with a common shade share a single coordinate system; unshaded counties each have a separate coordinate system.

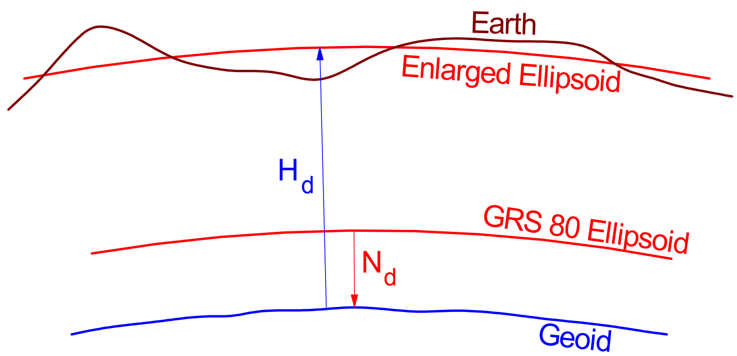
Three criteria affect each county system design:

- Median elevation, H_d
- Average geoid separation, N_d
- Projection type (conic or cylindric) with fit parameters

An enlarged ellipsoid for each system is defined by adding the system's median elevation and average geoid height to the GRS 80 semimajor and semiminor axes.

$$a = 6{,}378{,}137.000 \text{ m} + H_d + N_d$$
$$b = 6{,}356{,}752.314 \text{ m} + H_d + N_d$$

Geoid height is the distance from the ellipsoid to the geoid. Because the geoid is below the ellipsoid (i.e., closer to earth center) in Wisconsin for NAD 83, geoid heights are *negative*.



Since the semimajor and semiminor axes are changed, so are the flattening and first and second eccentricities. These can be computed from the ellipsoid equations shown in **Section B.1.** The new ellipsoid parameters must be used in projection equations to convert coordinates between County and Geodetic (or State Plane, UTM, WTM) Coordinates which in turn are referenced to the GRS 80 ellipsoid.

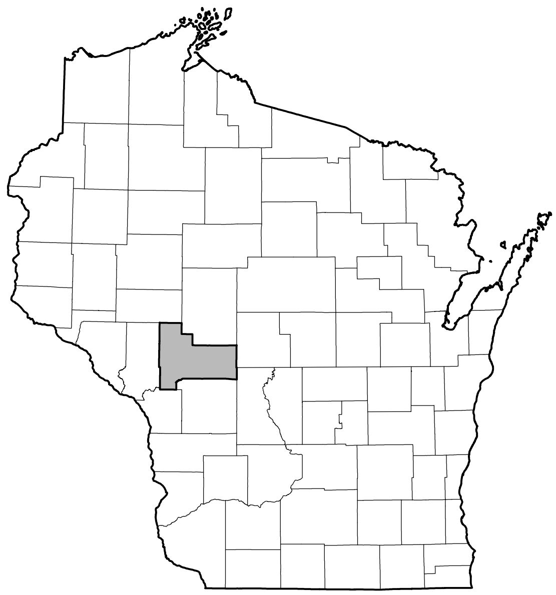
The respective projection is fit to the enlarged ellipsoid resulting in a grid system that is very close to the ground. Selection of projection type is based on geographic configuration of each county. Twenty-eight counties use conic projections while 44 use transverse cylindric projections. Projection parameters are summarized by county in **Sections E.4.2** and **E.4.3.**

Equations in **Sections C.2.2** and **C.3.2**, respectively, are used to generate system constants. Where ellipsoid parameters (a, b, f, e, e') are called for in the equations, parameters of the enlarged ellipsoid for the respective county system must be used.

Forward and Inverse conversions are performed using the equations in **Sections C.2** (conic) or **C.3** (cylindric). Enlarged ellipsoid parameters for the respective county system must used in the equations in place of GRS 80 parameters.

D.4.2. Jackson County Official Projection

Jackson County has its own coordinate system which predates the WCCS.



The *Jackson County Official Projection* does not use an enlarged ellipsoid and is instead referenced to the GRS 80 ellipsoid. It is based on a transverse cylindric projection using the following parameters:

λ_o	Central Meridian	90°50'39.46747" W
ϕ_o	Latitude of Origin	44°15'12.00646" N
N_o	Origin Northing	25,000.000 m
E_o	Origin Easting	27,000.000 m
k_o	Scale at Cen Mer	1.00003 53000

Equations in **Section C.3.2** are used to generate system constants.

Forward and Inverse conversions are performed using the equations in **Sections C.3.3** and **C.3.4**, respectively.

GRS 80 parameters are used for ellipsoid parameters in all equations.

D.4.3. WCCS Conic Projection Parameters

The following parameters are used in the **Section C.2.2** equations to generate the respective system constants. Enlarged ellipsoid parameters must be used in place of GRS 80 ellipsoid parameters in **Section C.2.**

County	$\mathbf{H_d}$ (m)	$\mathbf{N_d}$ (m)	λ_o (d.ms)	ϕ_b (d.ms)	$\mathbf{E_o}$ (m)	$\mathbf{N_b}$ (m)	ϕ_n (d.ms)	ϕ_s (d.ms)
Bayfield	304.801	-30.45	91°09'10"	45°20'00"	228,600.4572	0.0000	46°55'30"	46°24'50"
Burnett	304.800	-26.84	92°27'28"	45°21'50"	64,008.1280	0.0000	46°05'00"	45°42'50"
Chippewa	304.800	-29.26	91°17'40"	44°34'52"	60,045.7201	0.0000	45°08'30"	44°48'50"
Columbia	274.321	-34.99	89°23'40"	42°27'30"	169,164.3383	0.0000	43°35'30"	43°20'00"
Crawford	274.321	-32.29	90°56'20"	42°43'00"	113,690.6274	0.0000	43°20'30"	43°03'30"
Dane	304.801	-34.18	89°25'20"	41°45'00"	247,193.2944	0.0000	43°13'50"	42°54'30"
Eau Claire	274.321	-30.94	91°17'20"	44°02'50"	120,091.4402	0.0000	45°00'50"	44°43'50"
Green	304.801	-33.32	89°50'20"	42°13'30"	170,078.7402	0.0000	42°47'20"	42°29'10"
Green Lake	274.321	-35.72	89°14'30"	43°05'40"	150,876.3018	0.0000	43°56'50"	43°40'00"
Jackson *	304.810	-32.65	90°44'20"	43°47'40"	125,882.6518	0.0000	44°25'10"	44°09'50"
Lafayette	304.801	-33.32	89°50'20"	42°13'30"	170,078.7402	0.0000	42°47'20"	42°29'10"
Langlade	457.201	-34.08	89°02'00"	44°12'25"	198,425.1968	0.0000	45°18'30"	45°00'00"
Marathon	396.240	-32.64	89°46'12"	44°24'20"	74,676.1494	0.0000	45°03'23"	44°44'43"
Marquette	274.321	-35.72	89°14'30"	43°05'40"	150,876.3018	0.0000	43°56'50"	43°40'00"
Monroe	335.281	-33.29	90°38'30"	42°54'10"	204,521.2091	0.0000	44°09'40"	43°50'20"
Oneida	487.700	-30.84	89°32'40"	45°11'10"	70,104.1402	0.0000	45°50'30"	45°34'00"
Pepin	274.321	-30.05	92°13'40"	43°51'43"	167,640.3353	0.0000	44°45'00"	44°31'20"
Pierce	274.321	-30.05	92°13'40"	43°51'43"	167,640.3353	0.0000	44°45'00"	44°31'20"
Portage	341.377	-34.00	89°30'00"	43°58'00"	56,388.1128	0.0000	44°39'00"	44°11'00"

* These parameters are for the WCCS Jackson County System.
See **Section D.4.2** for the *Jackson County Official Projection* parameters.

D.4.3. WCCS Conic Projection Parameters *(continued)*

County	H_d (m)	N_d (m)	λ_o (d.ms)	ϕ_b (d.ms)	E_o (m)	N_b (m)	ϕ_n (d.ms)	ϕ_s (d.ms)
Richland	304.801	-33.71	90°25'50"	42°06'50"	202,387.6048	0.0000	43°30'10"	43°08'30"
Sawyer	476.721	-29.27	91°07'00"	44°48'50"	216,713.2334	0.0000	46°04'50"	45°43'10"
Taylor	426.721	-30.80	90°29'00"	44°12'30"	187,147.5743	0.0000	45°18'00"	45°03'20"
Vernon	304.801	-32.86	90°47'00"	43°08'50"	222,504.4450	0.0000	43°41'00"	43°28'00"
Vilas	518.161	-30.99	89°29'20"	45°37'30"	134,417.0688	0.0000	46°13'30"	45°55'50"
Walworth	274.321	-33.91	88°32'30"	41°40'10"	232,562.8651	0.0000	42°45'00"	42°35'20"
Washburn	365.761	-28.17	91°47'00"	44°16'00"	234,086.8681	0.0000	46°09'00"	45°46'20"
Waushara	304.801	-35.83	89°14'30"	43°42'30"	120,091.4402	0.0000	44°15'10"	43°58'30"
Wood	335.281	-34.63	90°00'00"	43°09'05"	208,483.6170	0.0000	44°32'40"	44°10'50"

D.4.4. WCCS Transverse Cylindric Projection Parameters

The following parameters are used in the **Section C.3.2** equations to generate the respective system constants. Enlarged ellipsoid parameters must be used in place of GRS 80 ellipsoid parameters in **Section C.3.**

County	H_d (m)	N_d (m)	λ_o (d.ms)	ϕ_o (d.ms)	E_o (m)	N_o (m)	k_o
Adams	274.321	-35.05	90°00'00"	43°22'00"	147,218.6945	0.0000	0.99999 9000
Ashland	365.760	-30.84	90°37'20"	45°42'22"	172,821.9456	0.0000	0.99999 7000
Barron	365.761	-29.83	91°51'00"	45°08'00"	93,150.0000	0.0000	0.99999 6000
Brown	35.800	-35.80	88°00'00"	43°00'00"	31,600.0000	4,600.0000	1.00002 0000
Buffalo	274.321	-30.33	91°47'50"	43°28'53"	175,260.3505	0.0000	1.00000 0000
Calumet	243.840	-35.75	88°30'00"	42°43'10"	244,754.8895	0.0000	0.99999 6000
Clark	365.761	-32.36	90°42'30"	43°36'00"	199,949.1998	0.0000	0.99999 4000
Dodge	274.321	-34.51	88°46'30"	41°28'20"	263,347.7267	0.0000	0.99999 7000
Door	213.360	-36.44	87°16'20"	44°24'00"	158,801.1176	0.0000	0.99999 1000
Douglas	304.800	-26.87	91°55'00"	45°53'00"	59,131.3183	0.0000	0.99999 4968
Dunn	304.801	-28.78	91°53'40"	44°24'30"	51,816.1040	0.0000	0.99999 7730
Florence	426.721	-32.87	88°08'30"	45°26'20"	133,502.6670	0.0000	0.99999 3500
Fond du Lac	243.840	-35.75	88°30'00"	42°43'10"	244,754.8895	0.0000	0.99999 6000
Forest	487.681	-33.16	88°38'00"	44°00'20"	275,844.5516	0.0000	0.99999 6000
Grant	274.321	-32.44	90°48'00"	41°24'40"	242,316.4847	0.0000	0.99999 7000
Iowa	304.801	-33.76	90°09'40"	42°32'20"	113,081.0262	0.0000	0.99999 7000
Iron	487.681	-30.39	90°15'20"	45°26'00"	220,980.4420	0.0000	0.99999 6000
Jefferson	274.321	-34.51	88°46'30"	41°28'20"	263,347.7267	0.0000	0.99999 7000
Juneau	274.321	-35.05	90°00'00"	43°22'00"	147,218.6945	0.0000	0.99999 9000
Kenosha	213.360	-34.66	87°53'40"	42°13'00"	185,928.3719	0.0000	0.99999 8000
Kewaunee	182.880	-34.02	87°33'00"	43°16'00"	79,857.7600	0.0000	1.00000 0000
LaCrosse	274.321	-32.02	91°19'00"	43°27'04"	130,454.6609	0.0000	0.99999 4000

D.4.4. WCCS Transverse Cylindric Projection Parameters *(continued)*

County	H_d (m)	N_d (m)	λ_o (d.ms)	ϕ_o (d.ms)	E_o (m)	N_o (m)	k_o
Lincoln	426.721	-31.90	89°44'00"	44°50'40"	116,129.0323	0.0000	0.99999 8000
Manitowoc	182.880	-34.02	87°33'00"	43°16'00"	79,857.7600	0.0000	1.00000 0000
Marinette	274.321	-35.28	87°42'40"	44°41'30"	238,658.8774	0.0000	0.99998 6000
Menominee	304.801	-35.20	88°25'00"	44°43'00"	105,461.0109	0.0000	0.99999 4000
Milwaukee	213.360	-34.66	87°53'40"	42°13'00"	185,928.3719	0.0000	0.99999 8000
Oconto	243.840	-35.42	87°54'30"	44°23'50"	182,880.3658	0.0000	0.99999 1000
Outagamie	243.840	-35.75	88°30'00"	42°43'10"	244,754.8895	0.0000	0.99999 6000
Ozaukee	213.360	-34.66	87°53'40"	42°13'00"	185,928.3719	0.0000	0.99999 8000
Polk	304.801	-28.13	92°38'00"	44°39'40"	141,732.2834	0.0000	1.00000 0000
Price	457.201	-30.31	90°29'20"	44°33'20"	227,990.8560	0.0000	0.99999 8000
Racine	213.360	-34.66	87°53'40"	42°13'00"	185,928.3719	0.0000	0.99999 8000
Rock	274.321	-33.65	89°04'20"	41°56'40"	146,304.2926	0.0000	0.99999 6000
Rusk	365.761	-30.01	91°04'00"	43°55'10"	250,546.1011	0.0000	0.99999 7000
Sauk	304.801	-34.52	89°54'00"	42°49'10"	185,623.5713	0.0000	0.99999 5000
Shawano	304.801	-35.75	88°36'20"	44°02'10"	262,433.3249	0.0000	0.99999 0000
Sheboygan	182.880	-34.02	87°33'00"	43°16'00"	79,857.7600	0.0000	1.00000 0000
St. Croix	304.801	-29.29	92°38'00"	44°02'10"	165,506.7310	0.0000	0.99999 5000
Trempealeau	274.321	-31.23	91°22'00"	43°09'40"	256,946.9138	0.0000	0.99999 8000
Washington	304.801	-34.66	88°03'50"	42°55'05"	120,091.4402	0.0000	0.99999 5000
Waukesha	274.321	-34.45	88°13'30"	42°34'10"	208,788.4176	0.0000	0.99999 7000
Waupaca	274.321	-36.07	88°49'00"	43°25'13"	185,013.9701	0.0000	0.99999 6000
Winnebago	243.840	-35.75	88°30'00"	42°43'10"	244,754.8895	0.0000	0.99999 6000